Literacy Studies: Perspectives from Cognitive Neurosciences, Linguistics, Psychology and Education

Hye K. Pae

Script Effects as the Hidden Drive of the Mind, Cognition, and Culture

With a Foreword by Charles A. Perfetti

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While language defines humanity, literacy defines civilization. Understandably, illiteracy or difficulties in acquiring literacy skills have become a major concern of our technological society. A conservative estimate of the prevalence of literacy problems would put the figure at more than a billion people in the world. Because of the seriousness of the problem, research in literacy acquisition and its breakdown is pursued with enormous vigor and persistence by experts from diverse backgrounds such as cognitive psychology, neuroscience, linguistics and education. This, of course, has resulted in a plethora of data, and consequently it has become difficult to integrate this abundance of information into a coherent body because of the artificial barriers that exist among different professional specialties.

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In Memory of my Paternal Grandmother, Maternal Grandmother, and Mother who shaped who I am with wisdom and courage.

Foreword

Do the form and function of writing systems influence the way we think?

Writing systems around the world vary both in how they look and how they work—which are not the same thing. Linear European-based alphabets spread out a handful of letters in a line, each corresponding to one or more basic sound (phonemes) of the language. In contrast, Chinese is written in a character system that places spaces between meaning bearing syllables. Differing from both, Korean is written in an alphabet—a handful of letters that correspond to basic sounds—but the letters are arrayed in squares separated by spaces, thus resembling the spatial layout of Chinese while giving the reader information about phonemes. Japanese borrowed the Chinese system, using the characters to correspond to meanings in a language unrelated to Chinese. But Japanese also uses a complementary system of syllable units, in which each graph corresponds to a spoken Japanese syllable. And these examples are just a handful of the world's written languages.

Such variety has the potential to lead to corresponding variety in cognition. This potential prompts Hye Pae's treatment of the complex set of inter-related issues that surround it. By focusing on the European alphabetic and East Asian writing systems (largely ignoring the abjads of Arabic and Hebrew and the multitude of alphasyllabaries of South Asia), she is able to explore much of the world's writing variety in just a few languages.

The idea that writing influences thinking can be considered a corollary of the hypothesis that language influences thinking. The long history of linguistic relativity, instantiated as the Whorf-Sapir hypothesis, and the conflicting conclusions from research, is a warning that a hypothesis of script relativity will prove resistant to conclusive confirmation. The question for script relativity is how to demonstrate causality, the same question that proved so challenging for linguistic relativity. Language and writing are deeply embedded in culture. Finding differences in patterns of thought that are correlated with writing system may be due to broader cultural factors that have influenced the development and survival of a writing system.

In the face of such obstacles, the strength of Hye Pae's treatment is the breadth of relevant research and scholarship she reviews, providing perspectives from writing scholarship, linguistics, behavioral reading research, neuroscience of reading,

sociology, and cross-cultural cognition. Finding convincing evidence for script relativity is a challenge. Hye Pae has provided a well-researched beginning for this quest.

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I am indebted to many individuals for this endeavor. At the very onset, I revealed my idea several years ago over lunch with Dr. Kwangoh Yi and Dr. Sungbong Bae from Yeungnam University in Korea when we met at a fine restaurant overlooking Haeundae ocean in Busan (Thank you for coming to Busan from Daegu to meet with me and for supporting the idea). It was the first time I specifically outlined my idea on this book. Verbalizing the idea had power, which allowed it to gradually grow into a solid project. Above all, I am very honored and grateful for having a Foreword from Dr. Charles A. Perfetti. His astute feedback on the book and generosity to write a Foreword humble me. His endorsement of a "beginning for [the] quest" is a big encouragement because it was one of my objectives for proposing the new hypothesis of *script relativity*. I am also grateful for the guidance provided by Dr. R. Malatesha Joshi, the General Editor of the series of *Literacy Studies: Perspectives from Cognitive Neurosciences, Linguistics, Psychology and Education* and by Helen van der Stelt and Natalie Rieborn from Springer. I greatly appreciate two reviewers' invaluable comments, one of which graciously enlightened me as to how some readers would react to the hypothesis, especially those readers with an opposing view of linguistic relativity. I appreciate the TOME (Toward an Open Monograph Ecosystem) publication award grant provided by the Provost Office of the University of Cincinnati and the University of Cincinnati Press, which makes this book available to everybody in the world who is interested in reading on an open access platform. I appreciate Dr. Keisha Love, Associate Vice Provost for Faculty Affairs and Special Initiatives, for her support in the course of ironing out the jurisprudence of the copyright issue between Springer and the University's Office of General Counsel. There were many colleagues who were kind enough to share their expertise by reading chapters to check for accuracy. My appreciation goes to Dr. Say Young Kim at Hangyang University in South Korea who read the chapter of neurolinguistic evidence, Dr. Sujin Kim at George Mason University for the Korean part, Eriko Sato at SUNY Stony Brook University for the Japanese part, and Dr. Fengyang Ma, Dr. Jing Sun, and Nan Yang at the University of Cincinnati for the Chinese part. I appreciate Dr. Catherine McBride at the Chinese University of Hong Kong for providing overall feedback. Notwithstanding their input, all

remaining errors in the book are mine. I appreciate the time and effort of Dr. Cheri Williams, Dr. Brian Schanding, and Kara Williams for editorial input. My appreciation also goes to my undergraduate research mentees, Snigdha Desaty and Kalia Cooper, for reading several chapters as a part of their research activity and for cross-checking references. Jerry Chang, whose editorial skill was exceptional, also read many chapters and provided very detailed editorial assistance. With his feedback, I was able to adjust some Korean expressions into American ones. Ria Chang was the one who first introduced to me Dr. Leonard Shlain's *The Alphabet versus the Goddes*s and *Art and Physics: Parallel Visions in Space, Time, and Light.* The juxtapositions and connecting dots among seemingly irrelevant concepts and subjects in a convincing way that were developed in these two books eventually led to this outcome. This book is written in memory of three wise and beautiful women, my paternal and maternal grandmothers and mother, who had shaped me in the way I am. My warm appreciation goes to my sister, Bae Euikyung, and my brother, Dr. Bae Youngseok, for their sustaining love and support as well as for being a role model while growing up (especially my brother). When I write another book in the future, it will be dedicated to Jerry and Ria. Many thanks to EVERYONE! 고맙습니다 (native Korean), 感謝합니다 (a mixture of Sino-Korean and native Korean)!

Prologue

"We infer the spirit of the nation in great measure from the language, which is a sort of monument, to which each forcible individual in a course of many hundred years has contributed a stone."

(Ralph Waldo Emerson (1803—1882))

"The story of reading reflects the sum of a series of cognitive and linguistic breakthroughs occurring alongside powerful cultural changes."

Maryanne Wolf (2007, p. 25)

"[The] appearances [of scripts] are the first aspect of writing that one notices, and differences in appearances might be relevant for how the brain handles variability in writing."

Charles A. Perfetti et al. (2007, p. 131).

This book is about how our minds are shaped by the written language in which we read. The thesis of the script[1]-mind connection spawned from my long query about idiosyncrasies I have found among cultures over the course of my life. It was developed based on my personal observations made as a layperson, reading experience accumulated as an avid reader, and research conducted as a psycholinguist. Due to its on-going nature, the thrust of this book is a working hypothesis.

Growing up in South Korea, I was discouraged, due to being a girl, to go to college by my father (because he did not want me to be independent). Korean men often recounted one of the key canons of Confucianism (in short, male dominance) and joked about the Chinese character for the husband (夫[2]), which has one stroke above the character for the sky (天). The views that the husband is higher than the sky and that a woman's true happiness or haven is in the husband's arms were

[1] The term *script* refers to a visual graphic form of writing. The phrase *writing system* refers to the mapping principles of how spoken language is encoded in writing.

[2] In fact, this character originated from a pictograph, as shown here  . However, the character has been interpreted as the husband being higher than the sky in Korea, which is a reflection of the male-dominance ideology influenced by Confucianism.

ubiquitous in the Korean culture about 30 or 40 years ago.[3] To make matters worse, not only did female teachers openly endorse in class the same notion of women's true happiness to be in their husbands' arms (alas, I heard it many times by many female teachers and even professors!), but also many mothers reinforced and relayed the ideology onto their daughters.[4] I wondered why Confucianism flourished more in Korea than in China where it originated.

I grew up and went to a school in the most (proud) conservative region in Korea until the third year of middle school, where Confucianism exerted a massive influence. My parents wanted me to transfer to a school in Busan, and I landed in a Christian mission school through random selection within the district, which was the norm in large cities for school assignment imposed by the government at the time. The mission school offered a Bible class every week and placed the Bible as the first subject in the report card before Moral Education (Moral Education was the first subject that appeared in typical school report cards, followed by the Korean Language, Math, English, and so on). My classmates were required by the homeroom teacher to turn in a Sunday service schedule before class every Monday as evidence of church-attendance the day before. Prior to that school, I had never gone to church, mainly because of no interest and no exposure to it. As punishment for not attending services on Sundays, I got the homeroom teacher's slap on my face on numerous Mondays in front of about 65 classmates. I wondered why Christianity flourished more in Korea than in any other country in Asia.

While I attended college in the 1980s, students' political demonstrations against the Korean (military) government were a major part of everyday college life. Many fellow students were arrested and tortured for initiating and participating in the protests. While working as a student reporter for the university press, I had to read Karl Marx's *Capitalism* because it was one of the must-read books for student reporters at the time. I still remember a heated discussion that I had with my fellow student reporters on whether the distribution of resources should be based on people's needs or people's abilities. This led to a debate on the ideal social system that would be like the family system in which resources would be distributed based on needs, while labor would be provided based on abilities. We were all mystified by a thought as to whether it would ever be possible in reality. I wondered why Communism flourished more in China than in Germany where Karl Marx was born.

When a book entitled *There Is No Japan* ("일본은 없다"[5]) was published in the 1980s by a Korean female journalist based on her encounters with the Japanese in Japan, it quickly enjoyed runaway success. The explosion in popularity was due mostly to the sensational title, given Korea's shame for the 36-year Japanese imperial occupancy from 1910 to 1945. Regardless of the author's intention, I was fascinated with the difference in the mindsets between the Koreans and the Japanese. I

[3] Thanks to the significant changes in the Korean culture, I have seen that women's status has been on the upswing in recent decades.

[4] Full-time home-makers were considered the best, whereas women in the workforce were viewed as having hard lives.

[5] The author was later accused of plagiarizing some of the contents by one of her acquaintances.

wondered why the Koreans and the Japanese were so different from each other despite the geographical proximity.

When I first came to the U.S., I was enthralled by the architecture, which I had previously only seen in books, TV, or movies. Architecture expresses its own tale and history. It reveals the thought and aim of the builder, materials that were available at the time of construction, and the primary functionality of the building. It also reveals aesthetic qualities that the builder embraced and valued in the past. I wondered why architectures in the East and the West were so different from each other.

Despite my father's discouragement, I managed to pursue higher education in both Korea and the U.S., and became a Full Professor at the University of Cincinnati in the U.S. Despite my indifference to Christianity in my middle school days, I started going to church after marriage in the hope of curing my husband's alcoholism. Despite not liking the military government, I was grateful for the opportunity of reading Karl Marx's book in my college days. Despite not having answers to why the Koreans and the Japanese were so different from each other, it became one of seeds that geminated the thesis of this book. Despite not knowing what makes architectures in the East and the West different from each other, the awareness makes me appreciate dominant architectural patterns and their beauty more deeply when I travel other countries in the East and the West.

My questions and thoughts rooted in my upbringing to adulthood were unorganized and jumbled in my head without seeking clear answers. When I read Leonard Shlain's *The Alphabet and the Goddess* a few years back, a light bulb quickly went off. All the pieces that were scattered as separate fragments suddenly came together in a string of gemstones—the script effect and *script relativity*!

Converging on Written Language

Trends and movements in any society go through ebbs and flows over time. Almost nothing is permanent. When something is persistent and tested by time in a culture, it must have durable compatibility with the undercurrent or unconsciousness of the members and the psyche of the culture.

Although Confucianism originated more than 2,500 years ago in China, it has not been as popular in China as it had been in Korea. One reason for that phenomenon might be Communism coming to power in China. The ideology of Communism placed more emphasis on equity and might not have been well-matched with the hierarchy of social class that Confucianism upheld. Why did Confucianism permeate into Korea more easily than China and Japan? Korean people might have been more comfortable with the basic tenet of Confucianism than any other philosophies that came from China, such as Taoism. Confucianism is one of many philosophical schools, but it had gotten to the degree that it was admitted as a religion in Korea. Logan (2014) claims in his book *The Alphabet Effect* that the alphabet promotes linear thinking and hierarchical reasoning, such as Syllogism. The canons of

Confucianism might have dovetailed nicely with the nature of the written language used in Korea, Hangul, which is the Korean alphabet.

Christianity is based on monotheism. Eastern ideologies and cultures are largely based on Nature and are more geared toward pantheism in which every living thing in Nature has its own sacred spirit which is everywhere. According to the 2015 Census data published by the Statistics Korea (2016), South Korea has Protestants at 19.7% of the population, followed by 15.5% Buddhists, and 7.9% Catholics. This remarkable percentage of the Western religions (Christians comprise 28% of the population in total) in South Korea is incomparable to those of China (2.3%[6]) and Japan (0.8%; since Japan has never reached 1% of Christians, they call it a "*1% ceiling*").[7] Christianity or monotheism might have been more congruent with the written language used in Korea than those used in China and Japan.

Although Karl Max was German, the ideology was more popularized and indoctrinated in China than in Germany or any other country in Europe. The totalitarian ideology might have been more congruent with Chinese characters which are read holistically rather than linearly or analytically as in English.

Architecture, in a sense, manifests who/what we are. It exhibits our philosophy, priority, value, preference, and surroundings. Eastern architecture is generally curved and round, but does not draw pivotal attention to the building per se. It rather focuses on its harmony with the surroundings. In contrast, Western architecture is linear and tends to be the center of the landscape. Especially, temples and churches are architecturally delicate, elaborate, and intricate sanctuaries, which show drastic differences between the East and the West. These differences might have resulted from the difference in scripts in which Easterners and Westerners have read over time. Interestingly, although the writing systems are distinctively different among Chinese, Japanese, and Korean, cultures and old architectural structures are very similar among the three countries.

The Script in Which You Read Makes You What You Are

Writing has immeasurable impact on our lives. As partial evidence, historical recounts tend to focus on literate societies. Although preliterate days constitute 99.9% of the five-million-year history of the human species, history before the emergence of writing around 3,000 B.C. receives only a slice of attention and treatment (Diamond, 1999). Such narrowly focused attention and accounts on the preliterate days in world history by historians, archeologists, and other specialists may suggest that writing has shaped the modern world or that it is impossible to trace back to days in antiquity that had no writing.

[6] Christianity in China, Wikipedia (2019).

[7] This phenomenon is consistent with the presence of ethnic churches established by immigrants in the U.S. Korean ethnic churches in the U.S. incomparably outnumber those of Chinese and Japanese immigrants in the U.S.

We are not born to read. Unlike oral language that comes naturally through exposure, time, and interaction, reading needs to be explicitly learned. This does not mean that oral speech and reading are binary concepts; rather, they are inextricably linked to each other. Although reading is a complex cognitive process, we tend to take reading for granted and become blind to the consequences of reading once we gain the mastery or automaticity of reading. This does not mean bypassing the important effect of reading. When we look at vanished languages in the world, most of them did not have a written language. Although no one has pointed it out yet, not having corresponding writing systems would be the main source of dead languages and currently disappearing or endangered languages in the world.

Reading is one of the most complicated forms of information processing, although it looks automatic and effortless. Dehaene (2009) summarizes the reading mechanism, which is a complex process, as follows:

> [O]ur gaze lands on a word and our brain effortlessly gives us access to its meaning and pronunciation. But in spite of appearances, the process is far from simple. Upon entering the retina, a word is split up into a myriad of fragments, as each part of the visual image is recognized by a distinct photoreceptor. Starting from this input, the real challenge consists in putting the pieces back together in order to decode what letters are present, to figure out the order in which they appear, and finally to identify the word (p. 12).

Hence, the consequences of reading may be greater than we think. It can shape our cognitive structures and neural networks. The "reading brain" works as an engine that drives our minds. It not only regulates our ability to analyze and classify incoming information in tandem with existing memory, but also serves as a springboard for new ideas.

The dietician's aphorism "you are what you eat" has a poignant truth to it. Can it be transposed to "you are what you read" or "the written language in which you read shapes your mind"? If the former is true for the physical aspect, the latter may be true for the mental aspect of what we are. If we are shaped by what we consume every day, we are to be shaped by the language we speak (*linguistic relativity hypothesis* or *Sapir-Whorf hypothesis*[8]) and the script in which we read everyday (*script relativity hypothesis*, which is the thesis of this book). Reading becomes essential in our lives more than ever before in the digital era with the availability of many forms of communication, such as emails, text messages, social media, open source digital platforms, and more. The script in which we read is complementary to our mental constructs, and its effect works in concert with cultural matrices in many ways.

[8] See Chapter 3 about this hypothesis. Chapter 3 discusses how this hypothesis was mistreated by a certain school of thought with no (systematic) empirical evidence.

My Indirect Answer to Yali's Question

Diamond (1999) masterfully explains why human societies in different continents have left such divergent footsteps over the past 13,000 years in his book entitled *Guns, Germs, and Steel: The Fates of Human Societies*. A New Guinean, Yali, with whom Diamond frequently conversed in New Guinea when he conducted his study as a biologist on bird evolution, once asked him a question: "Why is it that you white people developed so much cargo and brought it to New Guinea, but we black people had little cargo of our own?" (p. 14). This question has nothing to do with race, nor with biological superiority or inferiority. It was about the contrasting lifestyles of New Guineans to those of Europeans. Diamond states that Yali and he "both knew perfectly well that New Guineans are on the average at least as smart as Europeans" (p. 14) and "… in mental ability New Guineans are probably genetically superior to Westerners" (p. 21). Deeply engrossed in the Yali question, Diamond expounds upon the basic workings of cultural processes covering history, religion, the origins of empires, writing, crops, guns, germs, and steel in order to answer Yali's question. Diamond's answer funnels down to three factors, comprising European guns, infectious diseases, and steel tools as a proximate explanation that identifies the immediate cause of the difference between New Guineans and Westerners' lifestyles and mindsets. Diamond still leaves it as an open question by stating "… a host of issues raised by Yali's question remain unresolved. At present, we can put forward some partial answers plus a research agenda for the future, rather than a fully developed theory" (p. 408). The question of why human societies have the widely divergent pathways of development is also relevant to the thesis of this book. I would like to answer Yali's question as follows: It is most likely because Papua New Guineans do not have a unified writing system in the face of 832 living oral languages, whereas Westerners have the alphabet.[9] In this book I will explain why the writing system lays a core foundation for the development of our cognition, mentality, attention, and lifestyles, along with culture. Written language is likely to reinforce a certain sense of cultural coding.

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There are several books I have heavily relied on for the development of the thesis of this book. These are the books that have helped me to germinate the seed for this book. The first one is Leonard Shlain's (1998) *The Alphabet and the Goddess.* The late surgeon Shlain astutely juxtaposes a large variety of subjects in a new way and finds unity between seemingly irrelevant subjects.[10] He explains how the alphabet

[9] In a similar vein, as a Korean native, I believe that the driving engine that propelled South Korea's phenomenal economic development after the Korean War was the Korean alphabet, Hangul, and Koreans' high literacy rate. The case of North Korea is different. We do not know North Korean's literacy rate (or whether it reaches the tipping point or not) because of its being a closed society.

[10] Shlain's other books, *Art and Physics: Parallel visions in Space, Time, and Light* (1991) and *Leonardo's Brain* (2014) are also worth reading. Shlain's books offer a new view of the world through extraordinary connections, juxtapositions, and pairings he makes, although they lack scientific evidence and show, to some extent, loose analogies with few testable hypotheses.

fundamentally rewired the human brain and changed history, religion, and gender dynamics by covering from ancient Greek mythology to current human relations. In relevance to this book, he particularly articulates the different processes of words and images. The Shlain book led me to Logan's (2004) *The Alphabet Effect*. Richard Nisbett's (2003) book, *The Geography of Thought,* is profound with his and his colleagues' research results. He articulates how geography has molded the cultures of the East and the West. Maryanne Wolf's (2007) *Proust and the Squid* is another one. She elucidates how the evolution and development of reading have shaped the specialization of our brains (the reading brain) and our intellectual lives. Stanislas Dehaene's (2009) *Reading in the Brain: The Science and Evolution of a Human Invention* is another key resource on which I have greatly relied. It offers a full survey of reading and related workings of the brain. Each of these books has its merits with unique views and points. These books are written for the general public as trade books. I have also relied on numerous technical journal articles to support my claim of *script relativity*.

A myriad of social psychology studies[11] have shown that East Asians tend to pay attention to background information and process given information in a holistic manner, whereas European Americans are more likely to zero in on the foreground and process information in an analytical fashion. This is consistent with Hofstede's (1980) seminal cross-cultural study of collectivistic culture (e.g., Asians) versus individualistic culture (e.g., Americans).[12] Given that the three East Asian nations share cultural characteristics and architectural structures, the findings of these studies and these researchers' interpretations make sense. However, these findings *cannot* explain the non-monolithic dimensions and the drastic differences among the Chinese, Japanese, and Koreans with respect to values, practices, and religious choices. Importantly, the three groups do not have the common language and script. This point of the *similar culture yet different languages and scripts* among Chinese, Japanese, and Korean has hardly been discussed collectively within a single account. The aim of *script relativity* is to explain the differences and to address the niche that extant evidence *cannot* explain.

I have used both *emic* (i.e., insider's view) observations and *etic* (i.e., outsider's view) empirical research to present the thesis of this book in a fuller, deeper, and richer fashion than a mono-view. In other words, I have relied on my own subjective observations and interpretations as a Korean native for the *emic* point of view. I have also relied on objective theories, concepts, and research findings as a psycholinguist for the *etic* view. For example, South Korea has transformed its economy into a developed country within one generation from one of the world's poorest countries following the Korean War (1950–1953). The rapid economic growth was dubbed the "miracle on the Han river." Many economists and specialists of world affairs have identified the contributing factors to be the political will of leadership, Korean people's mentality based on Confucius ethics and morals, and patriotism or healthy

[11] See Chapter 6 for details.

[12] See Chapter 6 for details.

nationalism (Siruk, 2015). As a Korean native, I am in agreement on these factors. However, I believe that the powerhouse was more than those factors and that the driving force behind the rapid economic success of South Korea was the Korean writing system, Hangul, which is consistent with Logan's (2004) claim of the alphabet effect, or the co-use of Hangul and Hanja (traditional Chinese characters that are additionally used in South Korea; see Chapter 12 for the advantage of bi- or multi-script use). This claim becomes reasonable because nothing like the "miracle on the Han river" was materialized in history, even though the Koreans had strong leadership, such as King Sejong, in early years; Confucianism has been around since more than 600 years ago; and patriotism also manifested in earlier years, such as the March 1st Movement in 1919 during the Japanese imperialism (1910–1945). It is conceivable that the success was galvanized particularly by the high literacy rate of the Korean public due to Hangul's high learnability and the alphabet effect. Using the insider's *emic* view, I have developed my personal observation into a scientific discussion of script relativity (*etic*) so that other researchers can expand on this hypothesis to other languages and cultures.

The impetus for this book is to unpack the fundamental differences between the East and the West with respect to linguistics, psycholinguistics, neurolinguistics, and cultural dimensions. In essence, I have distilled all my curiosities down into *script relativity*, thinking that it is the hidden drive of the differences across cultures. Some may find my claim to be grossly exaggerated or oversimplified, especially given the prematurely and inadequately dismissed *linguistic relativity hypothesis*[13] by many psychologists in the 1960s through the 1980s. However, others may think that it makes (perfect) sense in many respects because the fundamental claim of *script relativity* fulfills a competitive plausibility among other possible assertions.

Another impetus for this book is to be optimistic for the future of the world for two reasons. First, as briefly mentioned earlier, we use digitally mediated texts more than ever before. Digital texts and Internet materials tend to include both words and images with overt and covert subliminal messages and advertisements. As research shows, words (the alphabet in particular) are processed in the left hemisphere, while images are processed in the right hemisphere (Dehaene, 2009). This will make our brains more balanced within the parameter. Second, several writing systems have adopted bi-script or multi-script use, such as Pinyin (Romanized Chinese), Kana and Romaji (Romanized Japanese), Aralish (Romanized Arabic), and Romanagari (Romanized Devangari). This may make us move toward convergence, rather than divergence, of the world because the degree of script effects would be decreased with the commonality that penetrates through written languages available on the globe.

No matter how sophisticated and profound a theory is, it is virtually impossible to interpret the multifaceted world in a crystal-clear and complete manner. It should be clearly noted that my premise is ONE way to interpret the way we see the world,

[13] See Chapter 3 regarding how the linguistic relativity hypothesis was inadequately dismissed and how it has been resurrected with more systematic evidence in recent decades.

the way we process information we come across, the way we make sense of the outer world, and the way we (re)structure our perception of reality. In other words, script relativity is a *proximate* (first-stage) explanation. A search for an ultimate cause or explanation should continue. In fact, answering the fundamental question is inherently an approximation, although the most authentic account can be possibly developed by considering alternatives and counter-interpretations.

I do not try to overturn anything that is known but try to provide a new perspective in order to explain the invisible force that makes crucial differences among the Chinese, Japanese, and Koreans in the face of common culture, geographical proximity, and racial makeup. As an extension, I also contrast the difference between the East and the West in a general sense. It is my hope that this book serves as a new footing that opens up for scientific discussion as well as a nexus for a mutual understanding of the East and the West and that it adds to a narrative plenitude for the understanding of the East and the West. I also hope that my optimistic view of the world culture to be converged in the future, rather than the "clash of civilizations" (Huntington, 2016), becomes a reality.

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Part I
Oral Language, Written Language, and Their Influences

Part I serves as introductory section to oral language, written language, and their influences on our thinking, including three chapters. Chapter 1 opens up a discussion of the role of spoken and written languages and reveals the thesis of this book, *script relativity*. It also sets the scope and parameter of the book, which center on Chinese, Japanese, and Korean as the representatives of the East and European Americans as the representatives of the West for contrastive purposes. Since written language is the major medium for the thesis of this book, *script relativity*, the evolution of written language is reviewed in Chapter 2. Chapter 3 introduces linguistic relativity and presents empirical evidence that supports linguistic relativity, and then preliminarily extends it to *script relativity* as an introduction.

Chapter 1
Language, Cognition, and Script Effects

"The central elements of any culture or civilization are language and religion."

- Samuel P. Huntington (1996, p. 59)

"… scripts differ because different kinds of writing suit different kinds of language."

- Geoffrey Sampson (2015, p. 265)

"… the ways we speak—the kinds of concepts lexically or grammatically encoded in a specific language—are bound to have an effect on the ways we think."

- Stephen C. Levinson (2003, p. 37)

Abstract This chapter begins with the discussions of what language is and the relationship between spoken language and written language, along with the early view of *language-is-speech* in linguistics as well as a *written-language bias*. A series of questions are posed and answered, covering whether we think differently according to the language we speak, whether language affects thinking or thinking affects language, and what the impact of literacy is. These questions are closely related to the linguistic relativity hypothesis. Based on empirical evidence for linguistic relativity, *script relativity* is proposed as an extension. Fundamental challenges in research into both linguistic relativity and script relativity are identified. The chapter ends with the introduction to this book, including the scope of the volume, terminology used throughout the book, and intended audiences.

Keywords spoken language · written language · thinking · cognition · linguistic relativity · script relativity

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Language is a system that we rely on for both interpersonal and intrapersonal communication. It is also one of the core elements of any culture or human civilization (Huntington, 1996), as one of the epigraphs indicates. Language consists of rules and principles by which arbitrary linguistic components are combined into words and sentences. Whatever we do and wherever we are, we live in a world of language to the extent that it is unfathomable to live a day without language. It is the same regarding written texts. Reading has become integral to our lives more than ever before in the digital era. With the availability of a myriad of communication means, such as emails, text messages, synchronous messages, and various forms of social media, we constantly subscribe to written texts. Information sharing is also unprecedented through open-source digital platforms. Although podcasts and video clips occupy a considerable portion of information sharing, text use both on paper and on screen is incomparable.

This book is about the script[1] in which we read affecting our cognition and thought patterns. Although reading is a complex cognitive process and needs to be explicitly taught, we take our reading ability for granted and tend to be blind to the impact of reading. This chapter surveys spoken language, written language, and their relationships, followed by an association between language and thinking focusing on the linguistic relativity hypothesis. The effects of literacy and orthography are also briefly discussed. Next, it introduces the main thesis of this book, *script relativity* (i.e., the script in which we read affects our cognition). Last, the scope of this book, operationalized terminology, and intended audiences are described.

1.1 What is Language?

Language is a hallmark that distinguishes human beings from other species. An African tradition has a keen insight into this aspect of language when people in a certain region of Africa call a newborn child a *kintu*, a "thing," until the child acquires a language. Once the child acquires the mother tongue, he/she can become a *muntu*, a "person" (Fromkin, Rodman, & Hyams, 2007). Since everybody can acquire the mother tongue effortlessly upon exposure, interaction, and time, spoken language is considered to be a biological endowment. Due to the innate faculty, we tend to forget fundamental interactions among language, the mind, and cognition.

Although language varies across cultures at the microscopic level, universal linguistic features govern human languages at the global level in two aspects. First, the common thread that penetrates all languages involves *universal grammar* that posits that language is biological and that more similarities than differences are found in all languages in terms of the properties of grammatical systems and the organization of lexicons (Chomsky, 1957). The universal linguistic rule provides us with a window into the operating principle of the human mind as a way to understand

[1] In this book, *script* and *orthography* are used interchangeably.

cognitive functions and the mind's organization (Fromkin, Rodman, & Hyams, 2007). Second, the creative aspect of language is another common thread among all languages. We can produce an infinite set of new sentences beyond learned expressions, and, at the same time, we can understand sentences that we have never heard of.

1.2 What is the Relationship between Spoken and Written Languages?

Historically, the term *language* referred to spoken language. In the discipline of linguistics, only spoken language was identified with language within the speech-oriented framework. A preoccupation with spoken language was predominantly championed by Ferdinand de Saussure, a Swiss linguist and the founder of modern linguistics, who proclaimed that linguistic study could not cover both the written and spoken forms of words. As an advocate of the *language-is-speech* claim, Saussure asserted that "[l]anguage and writing are two distinct systems of signs. The only reason the second [written language] exists is to represent the first [spoken language]. The object of linguistics is not defined by the combination of the written word and the spoken word; the latter constitutes its only object" (1916/1974, p. 45, cited in Hannas, 1997, p. 235). Householder (1969) also asserted that "[l]anguage is basically speech, and writing is of no theoretical interest" (Householder, 1969, p. 886, cited in Sampson 2015, p. 1).

This spoken language primacy and the rejection of the text-based view were the essential tenets of early linguistics. Written language was considered secondary to or derivative of spoken language with the belief that the function of language was to represent speech sounds. The sidelining of written language continued in the American tradition of linguistics. Bloomfield, a founder of American structuralism, insisted on the primacy of speech, as seen in "[w]riting is not language, but merely a way of recording language by means of visible marks" (Bloomfield, 1933, p. 21; cited in Linell, 2005, p. 28). This line of legacy continued to add confusion until the 1980s. DeFrancis (1989) asserted "all full systems of communication are based on speech. Furthermore, no full system is possible unless so grounded" (p. 7).

According to Sampson (2015), the essence of this spoken language primacy over written language stemmed from the belief in the biological nature of language acquisition and the dismissal of the cultural component of language. The spoken language primacy failed to take the interplay between language and culture into consideration. Since language symbolizes and expresses cultural reality, it is difficult not to consider the interplay in any linguistic discussion. Another problem with the *language-is-speech* view was a misunderstanding or misinterpretation of written language. Joyce (2016) states that this *language-is-speech* perspective results from considerable misconceptions, inconsistencies, and confusions about writing systems. Notwithstanding the view that speech and writing are "completely

independent, having quite different semiological foundations" (Harris, 2009, p. 46), spoken language and written language function indispensably and work in tandem to the extent that they complement each other.

A couple of factors were behind the sidelining of written language in earlier years. First, when linguistics started to pave its way to a science, the scientific community focused on "hard science" that relied on robust measurement (Hannas, 1997). Since it was not fully conducive to quantification for objective measurement, written language could not easily secure its place as a discipline because of a lack of solid methodology and theories established at that time. Second, behaviorism also played a role in the dismissal of written language. Behavioral linguists considered text-based language to be unfit for the new discipline's paradigm that was set based on their criteria.

In essence, spoken language and written language are not the counterforce to each other. The primacy of spoken language was gradually overturned due to the limitations of spoken language in terms of temporality and restricted utility due to our limited attention span, memory, retention, and recall. Ong (1986) asserts that spoken language does not provide a comparable condition to that of writing because writing overcomes time and space on which spoken language relies at the moment of communication. He claims that "writing…is the most momentous of all human technological inventions" (p. 35).

Recent discussions on spoken language and written language provide theoretical considerations on written signs and symbolism. Once linguistic inquiries were scientifically addressed in empirical research, a reverse phenomenon was observed. Specifically, Linell (2005) points out a paradox of written language dominance, arguing that most linguists have analyzed spoken language using theories and methods that are best suited for written language. He also notes that theories and models which have been developed in the science of written language have reversely influenced theories and models of spoken language. Linell (2005) dubs this phenomenon a "written language bias."

Although spoken language and written language have an indispensable relationship to the degree that written language represents spoken language, writing has taken a different trajectory than spoken language in the course of development. First, while spoken language is acquired without conscious effort on the condition of considerable time, exposure, and interaction, written language needs to be explicitly learned. Depending on the complexity of the writing system, a mastery of reading takes from a half day for smart learners or ten days for not-so-smart ones for Korean (see Chapter 5 for more information) to six years for Chinese (National Chinese Curriculum for Public Elementary Schools, 2000; see Chapter 5 for Chinese characters). Second, as opposed to spoken language that comes into our lives biologically and naturally, the sign systems and writing systems were invented in response to necessity. The first systematic writing system traces back to approximately 3,500 B.C., although pristine writing dates back to 10,000 B.C. Writing systems did not originate as an extension of spoken language as a means of storytelling or recording folklores, legends, or tales. The first sign system emerged to keep records of commercial transactions and to fulfill accounting purposes for the

preservation of private property (Logan, 2004). The notational system of numeric information for book-keeping evolved into writing systems over time (see Chapter 2 for detail). Hence, it is viewed not as a deliberate invention but as an incidental offspring of a strong sense of private property (Logan, 2004). In other words, oral tales are easier to remember than numeric information due to embedded storylines and narrative devices within tales. As a result, the necessity to create a notational system for accurate records of possessions and transactions through tallies and clay accounting tokens was greater than the demand to recall and transmit tales or legends.

1.3 Do People Think Differently According to the Language They Speak?

Along with the characteristics of language universals, language is culture-specific as well. Different cultures have different languages or different languages yield different cultures. There are between 6,000 and 7,000 languages that are estimated to be spoken around the world (UNESCO, 2018). Table 1.1 shows the top five languages that are spoken as a first language in the world as well as Japanese and Korean (because these two languages are discussed more extensively in the coming chapters). The table shows not only the number of countries in which each language is established and spoken, but also the number of people who speak the language as a first language.

What stands out from the table is that the number of Chinese speakers as a first language is close to the combined number of speakers of Spanish, English, Arabic, and Hindi. When it comes to the number of second language speakers, English is climbing the ladder in rank. More than two billion people speak English as a second or third language globally (UNESCO, 2018). The distribution of speakers of different languages offers a juxtaposition between the East with Chinese as a representative and the West with English as a representative.

The Chinese language is different from the other languages shown above in terms of language family, phonology, and linguistic characteristics. The writing

Table 1.1. The Rank and Number of Speakers of Languages as a First Language

Rank	Language	# Countries Spoken	# Speakers (million)
1	Chinese (Mandarin and Cantonese)	38	1,299
2	Spanish	31	442
3	English	118	378
4	Arabic	58	315
5	Hindi	4	260
9	Japanese	1	128
13	Korean	2	77.2

(Ethnologue Languages of the World, 2018)

system of Chinese defines itself as a unique script with not much similarity to European writing systems with respect to its representation, visual configuration, and syllabic structure. This uniqueness of Chinese characters and the large number of Chinese speakers have had a significant impact on the course of civilizations in Asia. China was the first civilization that emerged in Asia, and its culture was spread to almost all Asian countries.

Given different languages spoken on the globe, do people who speak different languages think differently? General consensus on the answer to this question is affirmative, although the source of *thinking differently* can be debatable. Linguistic diversity has yielded cognitive diversity in many respects among linguistic and cultural groups. First, attentional patterns are different. Research shows that Asians pay attention to the global picture or background of the scene, while Westerners tend to zero in on the center or foreground and main characters (Masuda & Nisbett, 2001; Ji, Peng, & Nisbett, 2000). Second, rhetorical structures are different. Asians are likely to be circular and hit around the bush in writing, whereas Westerners tend to show direct argument structures (Kaplan, 1966, 1983). Third, according to Hofstede, Hofstede, and Minkov's (2010) comprehensive cross-cultural study of 76 countries, Chinese culture is collectivistic, while American culture is individualistic. Collectivistic people value group cohesion, interdependence, moderation, and group identity over the self, and are unlikely to challenge authority or people in power for their own benefits. Individualistic people value self-determination, self-expression, freedom, and independence, and are more likely to challenge authority by calling for equity and equal opportunities. These differences between the East and the West are discussed in depth in Chapter 6; hence, an extensive discussion is reserved for the later chapter.

1.4 Does Language Affect Thinking or Does Thinking Affect Language?

In the face of linguistic diversity and cognitive diversity across cultures, a critical question that has been on the forefront of the debate on the relationship between language and thinking since the 1950s is whether language shapes thinking or thinking shapes language. An additional query centers on no relationship between language and thinking or independence of thinking from language. The first two views indicate causal relationships. For causality, certain criteria ought to be met. Hill (1965) identified nine criteria for a causal relationship, including strength (effect size), consistency (reproducibility), specificity (no spurious variables involved), temporality (no delays), biological gradient (exposure-incidence relationship), plausibility, coherence, experimental evidence, and analogy (similarities between the observed relationship and any other relationships). The characteristic of conditionality (if the cause disappears, the effect should disappear) can also be added to the criteria. These criteria are useful to determine the association with the causal

direction or null association between language and thinking. These criteria will be revisited in Chapter 8.

The first question (i.e., does language affect thinking?) is directly linked to the linguistic relativity hypothesis (a.k.a., Whorfian hypothesis, Whorfianism, Sapir-Whorf hypothesis[2]). This hypothesis postulates that language varies in grammar and semantic categorizations and that the structure of our language affects our habitual thinking and habitual behavior, which ultimately leads to fundamental effects on our thinking and thought patterns (Whorf, 1956; Lucy, 1997). The linguistic relativity hypothesis was generally considered to have two versions, consisting of the strong version of linguistic determinism (i.e., language *determines* our cognition) and the weak version of linguistic relativism (i.e., language *affects* our cognition). This classification was not provided by Whorf himself, but was posthumously made after Whorf prematurely died in 1941 at age 44 before being able to solidify his position.

Whorf's well-known words regarding the effect of language on human cognition are as follows:

> We dissect nature along lines laid down by our native language. The categories and types that we isolate from the world of phenomena we do not find there because they stare every observer in the face; on the contrary, the world is presented in a kaleidoscope flux of impressions which has to be organized by our minds—and this means largely by the linguistic systems of our minds (Whorf, 1956, p. 213).

Notably, the above words do not indicate that language *determines* our cognition. However, Whorfianism ignited a heated debate between the two extremes of proponents and opponents. A circle of researchers who support Whorfianism, such as Lucy (1992, 1997), Lee (1991), and Lakoff (1987), has consistently presented data for pro-Whorfianism. Despite their efforts, attention to the linguistic relativity hypothesis significantly waned while nativists gained their strong voice in the late 1950s and the 1960s (to the early 1990s). However, scientific interest in this topic has been resurrected since the late 1990s (see Chapter 3 for details). Even philosophical discussions on the cognitive functions of language have been revived underscoring the view that language is the medium of conscious propositional thinking as well as nondomain-specific thinking (Carruthers, 2002).

Another line of research that supports linguistic relativity is cross-language and second language studies. Traditional research on linguistic relativity has focused on the comparisons of monolinguals between or among language communities. Second language studies add another angle to the discussions and explanations for the linguistic relativity hypothesis through both within-group analysis and between-group analysis. Empirical evidence consistently shows robust effects of cross-language transfer (Akamatsu, 1999, 2003; Ben-Yehudah et al., 2019; Chikamatsu, 1996, 2008; Cho, & McBride-Chang, 2005; McBride-Chang & Ho, 2005; Pae, Kwon, & Lee, 2015; Wang, Koda, & Perfetti, 2003b), which is another set of evidence that supports linguistic relativity (see Chapter 8 for details). Since second language learning, which is different from automatic first language acquisition, requires the

[2] These terms are used interchangeably throughout this book.

involvement of a conscious and effortful cognitive function (especially for adults), second language skills can be viewed as an outcome of cognitive operation. In this regard, the notion of cross-language transfer fulfills the tenet of linguistic relativity.

It seems that the weak version of Whorfianism continues to attract scientific attention as a die-hard theory. In the midst of vehement criticism on the Whorfian hypothesis in the 1980s, Kay and Kempton (1984) highlighted the importance of rising above what Whorf had said (which was subject to interpretation) as follows:

> What either Sapir or Whorf actually believed on this topic is of course impossible to know, especially since the writings of both men are open to such varied interpretations. The question of what these two scholars thought, although interesting, is after all less important than the issue of what is the case. The case seems to be first, that languages differ semantically but not without constraint, and second, that linguistic differences may induce nonlinguistic cognitive differences but not so absolutely that universal cognitive processes cannot be recovered under appropriate contextual conditions (p. 77)

As Kay and Kempton (1984) pointed out, the focus of research should shift from what Whorf said to "the issue of what is the case," because a fixation on the interpretations of what Whorf said would not lead to the scientific advance of the theory in particular and that of applied linguistics in general. Given that Kay was one of the researchers who did not support the linguistic relativity hypothesis based on their research findings of color terms in the 1960s (see Berlin & Kay, 1969), Kay and Kempton's (1984) alert to linguistic diversity with constraints and to the possibility of its impact on nonlinguistic cognitive differences is notable.

The second question (i.e., does thinking affect language?[3]) has not been addressed as much as the first question. In fact, the opponents of the linguistic relativity hypothesis did not specifically nullify Whorfianism by conducting empirical research on this. In the face of a lack of evidence that supports the claim that thinking shapes language, studies of infants can shed light on the direction of causality from *thinking to language* or *language to thinking*. Perszyk and Waxman (2018) reviewed evidence in order to unfold the developmental link between language and cognition in infancy. According to them, language exerts a hidden power in early conceptual development through word learning or object-category learning. Learning categories serves as the fundamental building blocks of cognition, as infants establish a principled link between communicative signals and the cognitive process of categorization by the age of three months. Given that words are invitations to forming cognitive categories in infants (Perszyk & Waxman, 2018), the view of thinking affecting language is a moot point. Importantly, empirical evidence showing that thinking or cognition affects language is hardly found.

The third view (i.e., language does not influence thought; independence of thinking from language) was the reverse extreme of linguistic relativity because the second view is a moot point. This would be categorically difficult to prove because language and thought have an interlocking relationship, which is developed as early as infancy (Perszyk & Waxman, 2018). Strong oppositions to Whorfianism came from the

[3] A reviewer mentioned "thought influences language" rather than "language influences thought." Since there has been no evidence for the former, however, the claim is considered to be insignificant.

school of nativists, such as Noam Chomsky and Steven Pinker, whose assertions dominated the fields of linguistics and psychology in the 1960s (through early 1990s). Pinker (1994, 2007) has sustained his position until recently by calling Whorfianism "conventional absurdity" (1994, p. 47) and considers Whorfianism to be monocausal and deterministic. Pinker (1994) said "As a cognitive scientist I can afford to be smug about common sense being true (thought is different from language) and linguistic determinism being a conventional absurdity" (p. 57) and that "people understand reality independently of the words used to describe it" (2007, p. 124).

Devitt and Sterelny (1987) joined this line of opposition by stating that Whorfianism is "… rather banal; language provides us with most of our concepts" (p. 178). Devitt and Sterelny obviously delivered conflicting views within this single statement. Although they argued that the "argument for an important linguistic relativity evaporates under scrutiny" (p. 178), they ironically claimed that "most of our concepts" would be provided by language. The claim is closely related to Whorfianism. Gentner and Goldin-Meadow (2003) found their remark to be "a view far stronger than that of even the most pro-Whorf researchers" (p. 3). Given the inextricably intertwined nature of language and thought, regardless of being language as a lens (i.e., looking glass) or language as a mirror (i.e., reflection), the independence of cognition from language has not been supported by empirical evidence.

In order to better answer the three questions as to whether language influences thinking, whether thinking influences language, or whether there is no relationship between language and thinking, aforementioned Hill's (1965) criteria for causality are useful. While the first question generally meets the criteria, the second question does not (see Chapters 8 and 9).

Another way to consider is to rephrase the questions by focusing on the outcome of the influence; that is, whether thinking can be changed/restructured by language or whether language can be changed/restructured by thinking. First, empirical evidence supports the affirmative answer to the first question (see Chapter 3 for details). As an example, Majid et al. (2004) assert that language structures and restructures cognition based on the findings of their study of space. Interestingly, modern society adopts the idea of Whorfianism for the basis of linguistic prescription in an effort to avoid discrimination or marginalization against certain members in society; that is, modern society tries to change its language first in order to change its members' perception and thinking (Cook, 2011). Specifically, the use of gender-neutral or gender-inclusive language has been encouraged in pragmatics to avoid distinguishing roles according to gender in modern society (e.g., *chairperson* or *chair*, *police officer*, and *fire fighter* rather than *chairman*, *policeman*, and *fireman,* respectively). Another example is the use of people-first language by placing a person before a diagnosis to avoid dehumanization or marginalization (e.g., *a person with dyslexia* and *a person with diabetes* rather than *a dyslexic* and *a diabetic*, respectively).

Second, the affirmative answer to the second question of whether language can be changed/restructured by thinking is debatable. In fact, there has been no evidence supporting this view. Neologisms represent the evolving nature of language and typically do not result from the change of thinking but from the necessity to convey new discoveries, new social movements, popular culture, and new technology. New words are coined through many ways, such as borrowing, adding suffixes,

Table 1.2. Questions, Answers, and Evidence

Question	Answer	Evidence
1. Does language influence thinking?	Affirmative	Linguistic Relativity Hypothesis
(Can thinking be changed by language?)		(Whorfianism)
2. Does thinking influence language?	*Negative*/ Unknown	No evidence
(Can language be changed by thinking?)		
3. Do language and thinking have no relationship?	*Negative*	Significant cross-linguistic and cross-cultural differences
(Is thinking independent of language?)		

truncation or clipping, compounding existing words, or creating from scratch. However, neologisms themselves do not indicate that cognition influences language because they are responses to needs (e.g., when an unprecedented object is found in our lives, we assign a name to it; this is merely a response to the need to name the non-cognitive object).

Lastly, the answer to the third question of whether language or thinking cannot be changed/restructured by either of them because they are independent of each other is hardly deemed affirmative because language and thinking are fundamentally evolving and interconnected to each other. Table 1.2 summarizes the three questions, answers, and evidence at a glance.

In summary, the opponents of linguistic relativity (1) misinterpreted Whorfianism (i.e., "language *determines* thought" rather than "language *influences* thought"), even though Whorf never claimed linguistic determinism, (2) tended to debate not the real issues involved, but Whorf's lack of training in linguistics ("amateur" in Pinker's words), (3) were unable to present their own empirical evidence to counter-argue Whorfianism, (4) misinterpreted the findings of studies that essentially supported linguistic relativity, and (5) failed to acknowledge copious evidence that supported linguistic relativity. Especially Pinker (1994) made impressionistic opposition, as in his words that Whorfianism is "wrong, all wrong" (p. 47) because Whorf did not study Apaches, and Whorf "rendered the sentences as clumsy, word-for-word translations, designed to make the literal meanings seem as odd as possible" (p. 50). Despite the opposition, taken together, empirical evidence is in favor of the view that language affects thinking.

1.5 What is the Impact of Literacy?

Notwithstanding the relatively short history of written language, compared to those of spoken language and human inventions, the impact of written language is essentially incomparable to any other human invention in history (Logan, 2004; Man,

2000). Although it was not a deliberate invention, the advent of writing systems changed the way information was stored and used. Written words leave immortal echoes through written documents and convey messages using the medium of language. It allows us to travel from the past to the future or from the present to the past due to the benefit that written records not only go beyond memory, but also overcome the ephemeral nature of spoken words. Ong (1986) also stresses that the invention of writing as a means of recording sounds has fundamentally restructured human cognition. In a similar vein, Innis (1972) asserts that the art of writing provides us with a transpersonal memory, as we can have an artificially extended memory of objects and events by going beyond sight and recollection. It is writing that makes information transcend space and time, along with audio recordings. It is written documents that leave permanent imprints on our lives. It is reading that serves as a pathway to new knowledge. It is writing that distances the source of communication (the writer) from the recipient (the reader) beyond immediacy. Propelled by the invention of the metal printing press in the fifteenth century, writing became the main catalyst for spreading information and knowledge beyond horizontal space and longitudinal time. The current twenty-first century digitally mediated texts further accelerate the speed and spread of information at a phenomenal rate.

Of currently available scripts in the world, a dramatic difference in writing systems is found between the Chinese writing system and the alphabet. These two scripts are different in at least three interrelated ways. First, the level of arbitrariness is different between Chinese and the alphabet. Chinese logography[4] has evolved from pictographs, in which a character by and large represents a morpheme (although there is a small number of multi-character morphemes). Since Chinese is a logography primarily representing the meaning of an object or idea (logo = word; graph = written symbol; Taylor & Taylor, 2014), Chinese characters are less abstract and less arbitrary than English. In contrast, letters of the alphabet are largely arbitrary symbols to the extent that each letter does not represent the meaning of an object or concept, except for limited cases, such as plural and third-person{s}. Meaning is constructed from the linguistic assignment of combined multiple letters into a word in alphabetic orthographies. Second, the representation of the minimal unit is different in the two scripts. Each Chinese character represents a syllable that constitutes a morpheme, and it cannot be segmented into phonemes or graphemes, although it can be divided into strokes and radicals; therefore, it is called a morphosyllabic script (Leong, 1997). Although compound or composite characters are composed of phonetic and semantic components (i.e., radicals), a Chinese syllable does not allow for segmentation at the phonemic level or subsyllabic level, as in English or Korean. Third, relatedly, the flexibility in generating syllables or words is different in the two scripts. Since a character is an independent unit that

[4] Although this term is questionable because the Chinese writing system entails more characteristics than being a logography, this term is used here because it is appropriate within the context from the evolutionary perspective. A term morphosyllabary is used later when appropriate. Hence, the terms *logography* and *morphosyllabary* are used interchangeably in this book in general, although one term is at times used more favorably than the other depending on the context.

represents a morpheme as a syllable, the Chinese writing system does not provide the plausibility of combining characters to create another unit at the syllabic level, except for compound characters and compound words (which are still at the same syllabic level), and has more restricted options in the combinatorial rules of word formation than English. In contrast, an alphabet permits flexibility to generate new syllables under its phonotactic and graphotactic rules. Using about 20 to 30 letters, in principle, alphabetic scripts can create tens of thousands of syllables, whereas Chinese has only 400 or so syllables without considering tone differences (Taylor & Taylor, 2014).

Given the difference between Chinese characters and the alphabet in terms of the arbitrariness, the minimal linguistic representation, and syllables, it is possible to infer different ways of processing involved in reading logographic and alphabetic words. Logan (2004) asserts that "[t]he magic of the phonetic alphabet is that it is more than a writing system; it is also a system for organizing information" (p. 1). Decoding words in alphabetic scripts is a process of "organizing" a cluster of letters in a meaningful way. In a related vein, Shlain (1998) explicates the difference in the processing of images and the alphabet. Shlain's remark is relevant here because Chinese characters are an approximation of objects or concepts in a sense. He notes that the processing of objects (or images) and words takes different perceptual strategies due to the differences in the representation of the two stimuli. As the brain replicates and reflects the perceived world, objects (or images) are the mental reproductions of the world at sight. The brain simultaneously processes all parts of the object in an all-at-once fashion by integrating all parts synthetically into a gestalt (Shlain, 1998). Since they approximate reality, images or objects are more concrete than abstract. In contrast, reading words requires different processes than seeing images or objects. Given that letters of alphabetic orthographies do not represent the images of objects and that words are written in a linear sequence (except for the Korean alphabetic script, Hangul), alphabetic words are likely to be processed in a one-at-a-time manner[5] (Shlain, 1998). Based on these differences, Shlain (1998) summarizes that images or objects are processed in a concrete, whole, synthetic, spontaneous, and all-at-once manner, whereas alphabetic words are processed in a sequential, analytic, abstract, and one-at-a-time fashion.

Logan (2004) takes Shlain's (1998) differentiation of the processing of images and alphabetic words a step further to articulate the subliminal effect of writing systems on the human mind and cognition. Although their points of arguments are developed differently in their books, both Logan and Shlain make a clear juxtaposition between Chinese characters and the phonetic alphabet with respect to the structures, processing modes, and effects of the two scripts on our lives in general.

All reading processes are likely to promote and facilitate deductive reasoning, as evidenced by research on literate and illiterate people (Matute et al., 2012; Pegado

[5] One line of reading models formulated based on research evidence also supports the serial processing of letter strings of a word, while the connectionist model posits otherwise. Since the discussion of serial processing or parallel processing is beyond the scope of the given discussion, this book does not cover a series of models of reading.

et al., 2014; Wu, Wang, Yan, Li, Bao & Guo 2012). Skills of abstraction and analysis are developed and strengthened over time through the use of arbitrary signs and phonemic combinations to decode words. Reading the alphabet further reinforces the reader's thinking deductively, classifying information logically, and assembling words in a sequential order. Logan (2004) particularly dubs this phenomenon the *alphabet effect*. He also asserts that this tendency is the foundation of the development of the Western or European mode of thought. He summarizes that the essence of the alphabet effect entails abstraction, analysis, rationality, and classification, and asserts that these thought patterns, which are the intellectual byproducts of the use of the alphabet, are observed in a lesser degree among readers of Chinese characters or other nonalphabetic writing systems. Although this claim is contentious, the insight is worth noting because this is *one* way of understanding the difference in thought patterns between Westerners and Chinese readers; that is, abstract and theoretical tendencies for the West versus concrete and practical propensities for the East.[6] If there is a truth to Logan's claim, reading or a prolonged literacy activity becomes the hidden drive to the development of the Western and Eastern modes of thought. According to Logan (2004), Westerners are comparatively inclined to think in an abstract way resulting in theoretical science, formal logic, individualism, and systematic thought, as a consequence of reading alphabets, while Chinese tend to think in a concrete and practical fashion resulting in analogy, induction, and collectivism, as a consequence of reading logographies.

Differences in logic are also found in the East and the West. Logan (2004) ponders the consequences of prolonged literacy and indicates that deductive logic and abstract thinking are closely related to monotheism and codified law, which are the main kernels of Western culture. These are largely absent in the Chinese culture. In other words, the use of the alphabet propelled the development of abstract, logical, and systematic thought patterns of Westerners. This argument may be plausible given that, although Sumerians first developed written signs around 3,500 B.C. to 3,200 B.C, archeological evidence shows that it was not until the Greek alphabet appeared around 900 B.C. that noteworthy human activities and inventions were made. There was also a huge hiatus between the emergence of the Greek alphabet and the origin of human history that goes back to approximately 300,000 years ago, based on fossils attributed to homo sapiens. Due in part to the use of the logographic script, Chinese inventions were geared toward metallurgy, irrigation systems, animal harnesses, paper, ink, printing, gunpowder, rockets, porcelain, and silk. These differences yielded cultural differences between the East and the West.

Goody and Watt (1963) and Logan (2004) put forth the idea that a society or culture, which uses a more flexible writing system, such as the alphabet, tends to yield advances in scientific technology. Similarly, the efficiency of learning and widespread literacy lead to the democratization of knowledge and society. Diringer (1968) endorses the fact that the alphabet is a "democratic" script. Phonetic

[6] China has been considered to be the representative of the East, in a sense, because of its massive influence exerted on other Asian countries due to the size of terrain, number of people, and cultural advances. The reference used in this chapter follows this traditional norm, unless otherwise noted.

alphabets, wherein words can be formed through the combination of sounds or letters, make learning to read easier than that in logographies. Due to the heightened learnability of the alphabet, a vast spreading of human knowledge accelerates a democratization of learning. The advent of the movable-type Gutenberg printing press invented in Germany in 1439 revolutionized the spread of knowledge through book production, which contributed to the alphabet being spread as a democratic script in the West. With the economical utility of the writing system, the alphabet also contributed to cultural development and dissemination. It may be not coincidental that the currently available platforms of open-access to knowledge and resources are first and mostly provided by alphabetic cultures, which is consistent with the democracy of knowledge sharing.

It is easier for elite users of logography to control knowledge and information and to have a centralized governing bureaucracy. When the writing system is complex and difficult to learn, only privileged groups have access to it. If it is restricted to the elite or special groups, literacy is tied to power because only elite groups can use literacy to maintain their status quo, a certain social order, and their interest and to create a social gap between a literate culture and an illiterate culture by controlling and restricting information and knowledge (Goody & Watts, 1963; Logan, 2004; Wolf, 2007). In fact, ancient Chinese feudalist dynasties controlled literacy to exercise hegemony and power dynamics. This was possible because logographic scripts require years of study through rote memorization.

Beyond these discussions, empirical evidence consistently shows the impact of literacy as well as different writing systems yielding different cognitive consequences. The first evidence can be found in differences in cognitive processing and discrimination skills between literate and illiterate people. Petersson et al. (2000) attempted to elucidate differences in the functional organization of the brain between literate and illiterate groups and found that the pattern of interactions between brain regions associated with the functional-anatomical network for language processing was different between literate and illiterate subjects in the attentional modulation of the language network, the executive aspects of verbal working memory, and the articulatory organization of verbal output. A difference in cognitive processing between literate and illiterate subjects was also found in Chinese characters (Li et al., 2006; Wu, Li, Yang, Cai, Sun, & Guo, 2012). Research shows a robust effect of literacy on visual recognition irrespective of age of initial reading. Pegado et al. (2014) examined whether literate, illiterate, and ex-illiterate adults (who learned to read as adults) perform differently on a speeded same-different judgment task including letter strings, false fonts, and pictures. Literates showed stronger left-right mirror discrimination in letter strings, false fonts, and pictures than illiterates, while illiterates showed mirror generalization that showed no left-right mirror discrimination. Children studies also showed similar results. Matute et al. (2012) investigated the effect of literacy in children with illiterate and literate Mexican children aged 6 to 13 to find consistent results with those found in adults.

The second evidence comes from the effect of script directionality (i.e., right-to-left Arabic, Hebrew, and Urdu[7] vs. left-to-right European alphabets). Vaid and her colleague (1989) found that the direction in which a script was written exerted significant effects on nonlinguistic performance, such as line drawings and facial perception. Specifically, Vaid and Singh (1989) investigated the effect of reading habits among readers of Hindi, Arabic, and Urdu as well as illiterates, using a perception task of chimeric faces. They found significant group differences in the left visual field asymmetry such that Hindi (left-to-right directionality) readers showed the strongest effect, while Arabic (right-to-left directionality) showed the weakest effect. However, illiterates did not show a visual field bias. Vaid (1995) also examined whether there were differences in the starting location and drawing order as well as the facing of objects (bicycle, elephant, and profile) in free-hand figure drawing among children (9–13 years of age) of Hindi-English, Urdu-only, and Arabic-only readers. Results showed that Hindi-English readers tended to start their drawings on the top left of the page in the left-to-right drawing sequence, while Urdu- and Arabic-only readers preferred to begin on the top right of the page in the right-to-left sequence or zigzag order. Regarding the direction of figures, Hindi-English readers were likely to face the objects leftward more than the other two groups. Arabic children showed a more rightward-facing bias than Urdu counterparts with an exception of human face profiles. A more comprehensive study also supports the significant effect of script directionality on graphic representation. Specifically, Tversky, Kugelmass, and Winter (1991) examined cross-cultural and developmental trends of writing directionality on graphic productions. They examined graphic representations of spatial, temporal, quantitative, and preference relations organized by speakers of English, Hebrew, and Arabic. English-speaking children preferred to place stickers of their favorite food on square pieces of papers in the left-to-right direction, whereas Arabic-speaking children tended to place their stickers in the direction of right-to-left, with Hebrew-speaking children in-between.[8] The magnitude of impact of script directionality showed in the order of space, time, quantity, and preference with space the greatest and preference the lowest.

The third evidence comes from a series of empirical studies showing different scripts yielding different cognitive processes. Petersson, Reis, and Ingvar (2001) have reviewed recent behavioral and functional neuroimaging studies to find that learning an alphabetic orthography modulates the auditory-verbal language system in a significant way, indicating a significant interaction between auditory-verbal and written language. Specifically, literacy skills in alphabetic orthographies promote the sensitivity to sublexical phonological structures and hence have a modulatory effect on sublexical phonological processing. This suggests that literacy acquired

[7] Hindi and Urdu are identical on the spoken level in terms of common lexicons, phonology, and grammar, but are different drastically in the direction of reading and writing such that Hindi are written and read from left to right and Urdu from right to left (Vaid & Singh, 1989).

[8] Young Hebrew-speaking children are taught to write numbers and from left to right and perform arithmetic operations as such, whereas Arabic-speaking children are taught to perform arithmetic operation from right to left (Tversky, Kugelmass, & Winter, 1991).

through the phoneme-grapheme correspondence in an alphabetic orthography facilitates the awareness of an existing infrastructure of auditory-verbal relationships and, as a result, yields a modified language network in the brain to regulate the functional architecture of the brain. Petersson, Reis, Askelö, Castro-Caldas, and Ingvar (2000) have also found that learning to read in an alphabetic orthography significantly changes the auditory-verbal (spoken) language processing. Another line of evidence shows different visual discrimination skills according to different graph complexities of the same orthography with different scripts. Chinese written language provides a unique opportunity to investigate the effect of graph complexity due to the two scripts of traditional characters used in Taiwan (Mandarin) and Hong Kong (Cantonese) and simplified characters in Mainland China (Mandarin). Differences in perceptual skills between Chinese and Taiwanese readers can be attributable to the graph complexity of the two scripts (i.e., simplified characters and traditional characters, respectively). Chang and Perfetti (2018) report a significant complexity effect between Taiwanese and Mainland Chinese groups using a same-different perceptual judgment task and a pattern recognition task. Taiwanese outperformed their Chinese counterpart with higher accuracy and faster response times, suggesting the superior visual perceptual skills of readers of the traditional script which is more complex.

The last evidence has to do with the bilingual mind or biliteracy mind. If different language use results in differences in thinking and cognition, it can be deduced that bilinguals' or multilinguals' mind would be different from monolinguals' mind. An extension of this deduction is the mind of biliterate individuals. A copious body of literature shows significant effects of cross-scriptal transfer and robust differences in reading between scripts of first language and second language. Chapters 8 and 9 cover cross-scriptal influences and second language reading.

Taken together, the consequences of reading or literacy effects go beyond the superficial influences of languages. This is evidenced by the findings of different cognitive functions of literate and illiterate individuals, writing directionality effects, differential effects shown by the alphabetic readers and logographic readers, and different visual discrimination skills between readers of traditional and simplified characters. These findings cannot be explained by other theories and even by linguistic relativity. Script relativity is the goodness of fit to explain those findings.

1.6 What Are Challenges in Research into Linguistic Relativity and Script Relativity?

Although nativists themselves have not conducted psycholinguistic experiments to specifically test the linguistic relativity hypothesis, many researchers have carried out empirical research to test the strong and weak versions of the Whorfian hypothesis. The most prominent research on testing Whorfianism was on color codability and color terms by Brown and Lenneberg (1954) and Berlin and Kay (1969). Berlin

and Kay (1969) indicated that color perception was biological as the three common color names (i.e., *black*, *white*, and *red*) are generally found across cultures. However, Lucy (1992) raised a question about Berlin and Kay's interpretation of their findings (see Chapter 3 for more discussion). A series of studies were also conducted on number sense, object terms, and spatial terms (see Chapter 3 for a review). Conflicting results have been found in a multitude of studies. In a nutshell, evidence has converged on support for the weak version of the linguistic relativity hypothesis, although its strong version has hardly gained empirical support. Research evidence suggests that linguistic relativity was inadequately dismissed with no proper interpretations nor thorough reflections on and treatments of adequate experimental data. This premature dismissal by and large resulted not only from methodological challenges that linguistic relativity inherently entailed, but also from the different views and interpretations of Whorfianism.

Although opponents of linguistic relativity claim that the receiving end of linguistic influences in terms of causality should be nonverbal, the distinction between verbal and nonverbal processes is not straightforward. It is questionable whether perceptual domains, such as color, time, number, and space, are truly nonverbal, because not only are linguistic components involved in the development and use of such concepts, but also language serves as the medium of perceptual and conceptual knowledge from infancy (Perszyk & Waxman, 2018). Nonverbal motor tasks should be considered differently from the given discussion because motor activities, such as playing a musical instrument, playing golf, or driving a car, largely involve muscle memory that consolidates a specific motor task into memory through repetition to be able to perform the task without conscious effort. Therefore, the discussion on linguistic relativity should moves forward to address the individual dimensions of cognitive processes that are affected by language, instead of focusing on whether language affects thought or not.

The concept of linguistic relativity inherently crosses the disciplines of philosophy, anthropology, psychology, and linguistics. Therefore, it fundamentally bears methodological challenges (Lucy, 1997). First, again, since the concepts of color, number, object, and space are essentially interwoven with language, challenges are associated with properly teasing apart linguistic components from nonlinguistic workings. Second, there have been differing research findings depending on participant pools, tasks, and measures used in research on linguistic relativity. Method effects need to be first controlled in analysis by identifying and isolating intervening or spurious variables from the target variables in any research. Next, the unit of analysis must be clearly identified for adequate analysis. This is particularly important in comparing multiple language groups, which has been the case in the literature. Last, definitions need to be properly operationalized within the parameter of research in order to avoid misinterpretations of a given study and its results. Based on the nature of the interdisciplinary aspects of linguistic relativity (i.e., anthropology, psychology, linguistics), refined research methods taking those aspects into consideration were not fully developed to examine the layers of the interactions between language and cognition in the 1950s through the 1980s.

Notwithstanding the challenges, research findings that has been accumulated from cross-language or second-language studies during the past two decades provide new evidence in support of the linguistic relativity hypothesis. With the recent advance of technology, we can also look at our brain functions, activations, and networks upon speaking and reading different languages and scripts. Recent neurolinguistic evidence also supports linguistic relativity. In-depth reviews of current psycholinguistic and neurolinguistic studies as well as differences between the East and the West are provided in the coming chapters in this book (see Chapters 6, 8, and 9).

An identification or clarification of independent variables and dependent variables associated with script relativity can be useful. Research studies reviewed in this book generally use attention, perception, processing accuracy and speed, memory, inference, visual discrimination skills, sociocultural norms of individualism and collectivism, and rhetorical styles as dependent variables, while independent variables constitute operating principle (alphabet vs. logography), script configuration (linearity vs. block), symbolic representation (arbitrariness vs. iconic), the degree of graph complexity (traditional characters vs. simplified characters), and multi-script representation (phonogram vs. logogram). These key variables are shown in Table 1.3. These variables are revisited in the coming chapters when relevant literature is reviewed.

In conclusion, our worldview is the essential sense of our existence. However, it is not an identity per se nor a static entity. It is our way of understanding the outer world. Although there are many ways to contemplate how our worldview is molded, I take *one* route to understand what drives our mind to the formulation of our worldviews. As will be made clear in the forthcoming chapters, the written language or the script in which we read everyday has a significant impact on our thinking and cognition, which ultimately shapes our mind to understand and deal with the outer world. The magic of reading lies in the automaticity of reading once the skill is acquired and is manifested by its difficulty of resisting reading once text is exposed.

Table 1.3. Independent Variables and Dependent Variables

Independent Variables			Dependent Variables	
Script	*Operating Principle*	Alphabet (English, Korean) Logography (Chinese, Kanji)	***Thought***	Attention Perception Processing Accuracy Processing Speed Memory Inference Visual discrimination Social Norms Rhetoric Style
	Psycholinguistic Grain Size	Phonemic (English, Korean) Syllable (Chinese, Japanese)		
	Graph Configuration	Linearity (English) Block (Chinese, Japanese, Korean)		
	Symbolic Representation	Arbitrariness (English) Iconic Quality (Logography)		
	Graph Complexity	Traditional Chinese Characters Simplified Chinese Characters		
	Multi-Script Representation	Phonograms (Kana) Logograms (Kanji)		

Even nonsensory mental attitudes, such as judgment, decision, intention, and goal-setting, can be subliminally affected by written language as a consequence of literacy. I employ *script relativity* to explain all this. As shown in the epigraph, Sampson (2015) asserts that different cultures use different scripts as a result of evolution and goodness of fit for each other. At the onset of written language, the compatibility must have played a key role; that is, each script might have fulfilled the linguistic needs of spoken language. Logographic writing might work well for the Chinese spoken language, while English orthography might suit well English-speaking cultures. This assertion sounds feasible.

However, what is missing in the above assertion is that it cannot explain why European alphabets and Chinese characters have endured for more than 5,000 and 3,000 years, respectively, while other writings were comparatively short-lived. Just like Linell's (2005) notion of *the written language bias*, once the script solidified its way into one culture, its effect might have outweighed that of spoken language or at least weighed as much as its spoken language. My claim is that, once we have learned to read, the automaticity and irresistible tendency to read becomes the engine that drives our mind. In other words, we can control our spoken language, but we cannot control the processing of written language at the moment of text exposure. Since the brain is rewired once reading skills are acquired through neuronal recycling (Dehaene, 2009; Wolf, 2007), the extrapolation of the script→brain restructure→cognitive change is deemed reasonable. The opposite sequence is not tenable, however.

Levinson (2003) acknowledges that the language we speak is bound to have an effect on the way we think, as one of the epigraphs shows. As I mentioned earlier, linguistic relativity has generated a heated debate and a stockpile of research studies that are eventually in favor of linguistic relativity. It is now the time to rise above linguistic relativity. Within this context, *script relativity* is *one* way to explain the differences in the perception, cognition, problem-solving methods, and cultures of individuals between the East and the West as an endogenous factor above and beyond the extraneous factors, such as geography, ecology, or physical surroundings.

1.7 About the Book

1.7.1 Scope (and Limitation) of the Book

As explained in the Prologue, the seed for this book was planted unknowingly in my grade school days as a Korean native. It grew into a range of comparisons among the three East-Asian cultures—Chinese, Japanese, and Korean. After being relocated in the U.S. for my graduate study, the query again unknowingly developed into a larger scope of comparisons between American culture and the three East-Asian cultures. I intentionally exclude the abjads of Arabic and Hebrew and the South Asian alphasyllabaries because I personally do not know those scripts and because I want

other researchers who are well versed in those languages to test the script relativity hypothesis in the near future with my opening the door to script relativity. More importantly, the coverage of the three-East Asian scripts in relation to English provides a substantive ground to make my claim focused because, at times, too many branches weaken the stem. Since I only know American culture in the West, I use American culture to refer to the West in general. I acknowledge that this is a limitation. However, such a simplification or over-generalization is not without a precedent. Nisbett (2003) follows this generalization as well in his book, *The Geography of Thought*. In addition, Diamond (1997) acknowledges that the modern U.S. is a European-molded society. In a similar way to this representation, I use the three East-Asian countries to refer to Asian culture. Sometimes I use these cultures as an aggregated entity, and other times I separate them as appropriate in the context. It is because the three cultures are dissimilar to the extent that the differences go far beyond geographical proximity and cultural sharedness.

Religion has a profound effect on all societies and cultures as one of the primary forces for spiritual maturation, civilization, and progress at both individual and societal levels. The core framework of religion is different across cultures and societies. In general, Asian religions are based on Nature and the concept of harmony between Nature and human beings. South Korea, however, is an exception. As briefly mentioned in the Prologue, Christians outnumber Buddhists in South Korea (28% vs. 16%, respectively, Statistics Korea, 2016). The number of Christians in South Korea is incomparable to those of China and Japan, where the percentage hardly goes above 2% and 1% of the populations, respectively. This tendency is also found in ethnic communities in the U.S. The number of ethnic churches in Korean communities is incomparable to those in Chinese and Japanese communities in the U.S. Again, I try to interpret this phenomenon as a byproduct of script differences among the three cultures as an extension of linguistic relativity; that is, the dominance of Christianity in South Korea and the large number of ethnic churches in Korean communities in the U.S. result from the alphabet effect that is consistent with the monotheism in the West (Logan, 2004).

To reiterate, my thesis begins with the comparison among Chinese, Japanese, and Korean in terms of culture, spoken language, and written language, and then extends to American culture and written language. Despite its limitation, the discussion of the three East-Asian countries offers a unique and practical opportunity to interpret how the script in which we read affects our thinking, because China, Japan, and Korea share cultural characteristics to a great extent, but their languages (both spoken and written) are markedly different from one another. Although the three groups tend to be lumped together as Asians, their everyday practices and mindsets are different. Notwithstanding multiple ways to interpret the differences, I pick one way of interpretation—s*cript relativity*. Since I am the one who first proposes this hypothesis, it is other researchers' turn to directly test script relativity. This hypothesis is logically consistent, testable, falsifiable, generalizable, parsimonious, and empirically and pragmatically adequate.

This book can serve as an introduction to the Chinese, Japanese, and Korean scripts and cultures for individuals who are interested in these three East-Asian

cultures. Since it not only contains historical accounts of Chinese, Japanese, Korean, and the alphabet, but also covers diverse dimensions related to reading and the consequences of reading, this book can also be used as a reference resource for teaching, research, and technical reports as well as a textbook or a supplementary material in undergraduate and graduate courses in higher education in the world.

1.7.2 Terminology

Since it is virtually impossible to cover all Asian scripts and all alphabetic scripts within one book, again, representative concepts have been used. By "Asian culture" or "the East", I mean Chinese, Japanese, and Korean culture or the regions. By "Korea" or "Koreans", I mean South Korea or South Koreans. Likewise, by "the West" or "the alphabet", I refer to the American culture or American English as a representative term. Furthermore, the word "Americans" refers to European Americans rather than the melting-pot or salad-bowl notion of Americans.

I have tried to avoid jargon as much as possible. However, where its use is inevitable, I provide a definition of the term as necessary. Some words are used interchangeably. When this happens, footnotes are provided to indicate the interchangeable use of terms.

Regarding the key terms used in this book, a *writing system* refers to the operating principle reflected in the relationships between spoken language and writing. An *orthography* refers to "the set of rules for using a script in a particular language for spelling, punctuation, etc." (Cook & Bassetti, 2005, p. 3). A *script* refers to the specific graphic form of graphs. Perfetti and Liu (2005) note that "scripts can make a difference in reading, because they control the initial visual input that gets the process going" (p. 194). Scripts can be independent of the writing-language relationship, unlike the writing system and orthography (Perfetti & Liu, 2005). In this book, the term *script* also includes the writing orientation, internal structure, visual complexity, layout, and configuration of a writing unit, as these features characterize the graphic form of a given script. In reference to alphabetic scripts, letters and graphs are used interchangeably throughout this volume, unless otherwise noted.

In terms of the notation of transcription, phonemic transcriptions are indicated with the solidus / /, while phonetic transcription is enclosed within square brackets [ ]. Curly brackets { } are used for orthographic transcriptions, and angle brackets < > are used for morphemic transcriptions.

1.7.3 Intended Audiences

This book provides at least *one* view or an explanation of why Easterners and Westerners view the world differently. The book will be of interest to a wide range of researchers and practitioners in the disciplines of anthropology, philosophy,

applied linguistics, psychology, education, and cross-cultural communication. It will also be useful for students at both undergraduate and graduate levels. For a wide range of audiences, I have provided extensive background information as much as possible. For readers who selectively read, I have made each chapter self-contained and independent as much as possible. For this reason, readers who read this book from the beginning to the end may find some parts redundant. However, repetitions are sparingly used.

Chapter 2
The Emergence of Written Language: From Numeracy to Literacy

"HUMANKIND IS DEFINED BY LANGUAGE; but civilization is defined by writing. Writing made historical records possible, and writing was the basis for the urban societies of the Old World."

- Peter T. Daniels (1996, p. 1)

"Cognitively as well as sociologically, writing underpins 'civilization', the culture of cities."

- Jack Goody (1987, p. 300)

Abstract This chapter reviews how written signs first emerged and developed into systematic writing systems. The first sign system appeared to fulfill accounting purposes for the preservation of private properties in antiquity. Initial written signs, including plain tallies, complex tokens, and tokens in clay envelopes, are reviewed. Written signs before the emergence of the Greek alphabet, such as cuneiforms and hieroglyphs, are also reviewed. As agricultural culture and urbanization took place, writing systems became more multifaceted and systematized. The characteristics of true alphabets are discussed. For a comparison purpose, the Chinese writing system is briefly mentioned. The chapter ends with a discussion of the transition from numeracy to literacy.

Keywords initial written signs · Cuneiforms · Hieroglyphs · Greek alphabet · Chinese writing systems · from numeracy to literacy

As the two epigraphs show, there is an indispensable relationship among human beings, language, and writing in terms of civilization. Especially, writing was the enabler and propeller of human civilization. Writing paradoxically did not evolve from oral language. It stemmed from the need of notational schemes for bookkeeping and commercial transactions using materials available in the surroundings

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(Logan, 2004). Hence, it is viewed not as a deliberate invention but as an incidental offspring of a strong sense of private property. Since quantitative information is much more difficult to remember than tales or legends, due to no storylines, characters, and plots involved in tallies, notational systems emerged to overcome our limited memory span (Logan, 2004). Once it was systemically adopted for use, the token system rapidly evolved and changed the way in which information was presented, transferred, and stored. The token-based notational system evolved to the numeric system, and further laid a foundation for more sophisticated notational systems—that is, writing systems.

Everything waxes and wanes over time. Natural selection takes shape longitudinally. Some signs quickly or slowly died out, while others endured for more than 3000 years (e.g., Chinese characters). No matter where and how early signs emerged, the effort to establish systematic notational systems shows our ancestors' delicate intelligence. It was writing that drastically extended humans' cognitive capacities. Writing exerted a considerable impact on at least three areas which were not mutually exclusive. First, human efforts to preserve private property led to the development of a concept that symbols could be used to communicate one another beyond the limited temporality (time) and locality (space) of oral communication. The sign systems began to serve as a means of communication that was not restricted to "real time" and could be stored accurately by overcoming the constraints of our memory and avoiding (possible) misinterpretations. Second, written signs showed a possibility that an abstract concept (e.g., numbers) could be represented through a symbolic medium. Writing symbolically represented both concrete objects (e.g., grains, crops, or livestock) and abstract concepts (e.g., numbers) through knots in strings and marked lines on clay tokens, stones, or turtle shells. These graphic systems not only facilitated the abstraction of objects and concepts, but also promoted the understanding of conceptual relations between concrete objects and abstract signs. Third, the notion of the one-to-one correspondence in encoding between symbols and meanings gave rise to the sound-symbol correspondence in the writing system. These elements incubated the potential for the development of systematic writing systems.

Within this context, this chapter reviews the evolution of writing systems. It first overviews pristine notational systems and important milestones in the evolution of writing. The large portion of the chapter is devoted to the early forms of writing. In order to stay focused on the linear progression of writing in a global sense, the different trajectories of all writings on the globe are not reviewed in this chapter. It is virtually impossible to review the specifics of all writing systems in one chapter. The purpose is to survey the evolution of writing until the point of the advent of the alphabet and Chinese characters.

2.1 Initial Written Signs

2.1.1 Plain Tallies

A notational system for accounting purposes dates back to the period of 10,000 B.C. across many parts of the ancient world, while logograms and abstract numbers emerged approximately 5,000 years ago (3,000 B.C.). Early notational devices were made up of tallies in the forms of notched sticks, knotted strings, and etches on animal bones and shells (Logan, 2004). Although they did not carry intensive information, such as people involved in transactions, tallies demonstrated three significant cognitive implications. First, tallies showed the potential to visualize the quantitative concepts by means of concrete materials to save counting information, allowing for the storage of data so that users could rise above the ephemeral nature of the temporal moment. Second, tallies objectified the concept so that people involved in the transaction could understand the recorded content without confusion. Third, verbal information was transformed to nonverbal signs through the use of a metaphoric medium.

Although tallies fulfilled their primary purposes, the rudimentary system bore some limitations. Tallies were too simple to carry qualitative information associated with them, such as who did what and when in what context. Another limitation was that tallies could not indicate complex transactions. These limitations drove to more complicated recording devices.

2.1.2 Complex Tokens

The first tally system eventually increased in complexity, yielding the development of clay accounting tokens. As agriculture developed further, diverse staples, products, and commodities became available, which necessitated a more complex enumeration and accounting system. The concept of the unit of measurement started to develop accordingly.

The token system drastically changed data processing because mathematical concepts could be understood out of context by others and be translated into unambiguous tactile notions. With more meaningful and complex tokens, users were able to process a large amount of data simultaneously. They were also able to deal with different commodities concurrently through diversification. It further allowed for the classification of goods through organizing and reorganizing them into categories to fulfill book-keeping purposes. Logan (2004) noted that “the token system [was] the forerunner of the abacus as well as spreadsheet analysis” (p. 13).

The mathematical notation of tallies required at least three principles: (1) simplicity, (2) a one-to-one correspondence between an item and its corresponding mark, and (3) objectivity (Logan, 2004; Sampson, 2015). First, the recording system should not be complex so that everyone involved in transactions could easily

understand the meaning of marks or tokens for the transparency of transactions. As a man-made artifact for accounting, tokens were gradually shaped into an organized marking system such that the system was easy to recognize and simple enough to be systematically reproduced. This was achieved by assigning each token to a discrete referent. Second, the principle of simplicity was achieved through the symbolic invention under the principle of a one-to-one correspondence. This meant that each mark had uniqueness for an independent meaning to avoid ambiguity. Through the one-to-one correspondence, it could be recognized and understood by all members involved in the commercial activities. Last, the notational system should also be objective. The objectivity was facilitated by the standardization of each sign. Early notational systems associated with goods or staples were quickly developed to satisfy these three conditions.

2.1.3 Tokens in Clay Envelopes and More

As more complex transactions frequently occurred, in need was a collective means that could be used as a receipt or a consolidated tool containing all tokens involved in a single transaction. Clay envelopes emerged to serve that purpose. Over the course of the token system development, clay envelopes at first functioned as containers of a number of plain tokens, as tokens were stored in a group within a sealed clay envelope. Since the envelope was made of clay, the content was not visible. The lack of visibility of contents in clay balls and envelopes prompted an effort to overcome the drawback for efficiency. Early accountants pressed numeric information or tokens on the wet and soft surface of the envelope in the form of a stylus cut in order to indicate the content of an envelope and transactional specifics involved in multiple transactions. The surface was also marked with the seals of individuals involved in the transactions. Therefore, it functioned as a receipt of a transaction and a documentation of contracts or agreements.

Notably, these impressed signs made the envelope carry redundant information, due to the duplicate data indicated in both inside (i.e., the number of tokens stored inside the envelope) and the outside surface of the envelope (i.e., what was written outside of the envelope). The curved envelopes quickly progressed to two-dimensional flat tablets with impressed tokens on the surface. The evolution of envelopes into tablets marked a major breakthrough of information transmission and processing. This was a harbinger of creating written signs that represented tokens, paving the way for a major quantum leap to the creation of written signs that captured the notion of speech-sound and word-meaning relationships as a major step of abstraction. Eventually, the flat tablet became the prototype of all two-dimensional writing surfaces we use these days, including the pages of a book, the display monitor of a computer, and digital tablets that are currently in use.

Early writing accelerated the development of metaphorical thinking and created a perceptual, cognitive, and mental condition that was conducive to the invention of more sophisticated writing systems (Logan, 2004; Wolf, 2007). This evolution

resulted in the development of abstract numerals as quantitative notations and written words as qualitative records, leading to a crucial change of concepts. Clay tokens, such as cylinders, pyramids, discs, and balls, became systematized such that the signs could serve as a means of communication for universal use. In other words, tokens were further developed to convey meaning that individuals from different sociocultural communities could understand, regardless of the language they spoke.

The mode of abstraction motivated users to develop more sophisticated and complex systems that accommodated unmet needs with the rudimentary notational system. Through transforming verbal information to nonverbal data, the use of tallies and accounting systems gradually exerted a remarkable impact on human cognition and the human mind. The notational system reinforced the use of hand-eye coordination and fine motor skills essential for writing (Logan, 2004; Sampson, 2015). Token markings required the uniformity of shapes across recording signs and repeatable symbols as well as the arrangement of signs in a way that the user (or the reader) could grasp the whole field of data at a single glance. The volume, concreteness, and tactility of three-dimensional objects were lost with the two-dimensional tablet. The increased abstraction resulting from transferring three-dimensional data to two-dimensional tokens promoted the user's observational skills at a single glimpse. The visual thinking or acuity reinforced the skills of classification, analysis, uniformity, repeatability, and the power of the visual (Logan, 2004).

In summary, the development and enrichment of the token system and writing comprised largely five linear sequential stages: (1) plain tokens such as knotted strings and wedge-shaped marks, (2) complex tokens such as carved animal bones, (3) tokens stored in clay envelopes, (4) impressed logograms on clay envelopes containing tokens inside so that both interior and exterior could bear notational information, and (5) impressed logographs on two-dimensional clay tablets (Logan, 2004). Each stage established an important milestone for the emergence of cuneiforms, hieroglyphs, the early forms of alphabets, and finally the alphabet. A brief review of cuneiforms and hieroglyphs as precedents of the alphabet is in order.

2.2 The Origin of the Alphabet

Although they served as receipts of transactions and documentations of contracts, as stated earlier, clay envelopes had a shortcoming that contents were not visible. To overcome the disadvantage of being opaque, our ancestors impressed tokens onto the wet surface of the envelope. This technique allowed them to see the contents without breaking the envelope. This essentially resulted in the "unexpected and certainly unplanned side effect of creating the first two-dimensional logograms" (Logan, 2004, p. 19), which were two-dimensional visual signs that abstractly represented the written form of single words. This transformation yielded chain reactions that led to the invention of logographic writing, phonetic coding, and abstract numerals. It pushed a shift away from the use of the tactile sense (i.e., three-dimensional tokens) to the more abstract visual sense (i.e., two-dimensional written

signs). This established a sound basis for more developed written signs such as cuneiforms and hieroglyphs.

Although pictograms are considered the forerunners of writing, pictography does not qualify as writing (Daniels, 1996) because it does not entail specific linguistic forms. Daniels (1996) defines writing as "*a system of more or less permanent marks used to represent an utterance in such a way that it can be recovered more or less exactly without the intervention of the utterer*" (emphasis in original; p. 3). Based on this definition, writing is essentially connected to spoken language. This is consistent with Perfetti and Liu's (2005) notion that writing encodes spoken language. Daniels (1996) continues to claim that "each type of script entails about the same amount of effort to record the same amount of information" (p. 26). Although alternative classifications are possible, the tripartite classification of logography, syllabary, and alphabet remains the most popular (Daniels, 1996). As the alphabet is the most widely used script, the road to the advent of the alphabet is briefly reviewed below.

2.2.1 Cuneiforms

Around the fourth millennium B.C. (3300–3200 B.C.), an advanced form of writing emerged by Sumerians in lower Mesopotamia situated between the Tigris and Euphrates rivers (now Southern Iraq). Cuneiforms in wedge-shaped marks etched into clay tablets could inform us of a complex civilization established about 5,000 years ago. The word *cuneiform* was derived from the Latin word *cuneus*, meaning *nail*, which referred to the script's wedge-like appearance (Wolf, 2007). Given that the token system for accounting purposes led to the advent of the Sumerian writing system, the record of counting became the precursor of writing in Mesopotamia. As the society grew more complex, a more centralized administration was necessary. Since writing was useful for proper record-keeping, the use of writing for administrative purposes expedited the development of writing.

Archaic Sumerian writing used limited vocabulary that was context-bound. This was not sufficient enough to express sophisticated information, such as the quantities of material objects, people involved in transactions, and the units of measurement (Sampson, 2015). As such, the Sumerian cuneiform gradually lost pictographic elements and became more abstract and sophisticated by gaining more logographic elements. The logographic system at the time conveyed the meanings of objects and concepts through writing, but did not represent the sound of oral language in writing. Powell (1981) called the early Sumerian signs "mnemonic" (p. 421). However, Sampson (2015) is not in agreement with him on the reference to the *mnemonic* sign because "… archaic Sumerian writing appears to be a genuine writing system, of the logographic type: graphs of the script stand for morphemes of spoken Sumerian" (p. 43). Given that Sumerian characters also represented syllables in oral language, it was called a logosyllabary, making Sumerians' cuneiform the world's first syllable (Wolf, 2007). Although some scholars may assume that all writing systems were

originated from the Sumerian script or genetically related to one another, Sampson (2015) notes that the monogenesis hypothesis is untenable, as "… Chinese writing would be seen as a clear case of a system that developed quite independently of western Asia" (p. 56).

The cuneiform script underwent substantial changes in the outward shape of the graphs over time. Pictograms first used around 3,000 B.C. were rotated 90° anti-clockwise, and then changed into more abstracted glyphs around 2600 B.C., and finally simplified wedge-shaped signs were adopted by Assyrians from the early 1st millennium B.C. until the script's extinction. The systematic 90° rotation might have had to do with holding the tablet and stylus when writing (Sampson, 2015). Since pressing lines into the clay was not always easy, the shapes of the individual graphs were modified; continuous curved lines were replaced by pointy shapes like a wedge or nail. This led to the name "cuneiform," which simply means "wedge-shaped" (Sampson, 2015).

Cuneiform fulfilled the linguistic needs of the Sumerian, because it was built upon the basic structures of syllables and four vowels, whose forms and meanings could be modified by prefixes and suffixes (Man, 2000). However, the syllabic script bore ambiguities. Sumerian cuneiforms had words and syllables that mixed up spelling, sound, and meaning. As found in other written languages, some words were spelled differently but sounded the same with different meanings (homophones; e.g., in English, *too*, *two*, and *to*; *one* and *won*), or spelled the same but differed in meaning (homographs; bat: English, animal *bat* and baseball *bat*; bank: financial *bank* and river *bank*), or sounded the same but differed in both spelling and meaning (e.g., in English, the '*bill*' sound in *building* or *ability*; Man, 2000).

2.2.2 Hieroglyphs

While Sumerians made inscriptions materialize into a cuneiform system, Egyptians developed their own hieroglyphic system. Given that the Egyptians and Sumerians had massive contact and trade with each other at the time, the Egyptians might have developed their own writing system based on Sumerians' idea of writing (Logan, 2004). Two hundred years after the Sumerian writing system emerged, Egyptian writing hieroglyphs were invented by Semitic tribesmen residing in the Sinai in 3000 B.C. The word *hieroglyphs* was derived from the ancient Greek for "sacred carvings." Hieroglyphs were first carved on stone and were later written on papyrus with brush and ink (Logan, 2004). Like cuneiforms, Egyptian hieroglyphics were a mixture of logograph and phonogram, although vowels were largely unused and phonographic symbols were used in the sequences of three, two, or one consonant (Sampson, 2015).

Unlike the Sumerian writing system, Egyptian hieroglyphs appeared without a long incubation period. Egyptians developed two parallel writing systems. One was the hieroglyphic system which was formal writing, and the other was hieratic which was a cursive script written on papyrus with brush and ink for written record. Both

hieroglyphic and hieratic systems adopted pictographic signs with phonetic elements through the addition of foundational signs in a manner similar to those of the Sumerian-Akkadian system (Logan, 2004).

The Egyptians also developed a mixture of uniconsonantal, biconsonantal, and triconsonantal signs to represent all sounds of their spoken language, using approximately 400 signs in total. Although these phonetic signs had the potential to be developed into a more systematic writing system, compared to the logographic cuneiforms, due to being a phonetic alphabet, hieroglyphs did not spread widely nor lived long. The Egyptians might have conservatively restricted their use. Wolf (2007) notes that elites in power probably wanted to keep the complex system to themselves in order to maintain its monopoly on reading and learning and did not want to simplify their writing system. Her observation about the knowledge monopoly is similar to Goody and Watts' (1963) statement on *oligoliteracy* (i.e., literacy is restricted to the elite). The idea of using the large number of written signs was lost in the course of civilization, however. The Seirites, Semitic tribesmen of the Sinai who mined copper and traded it with the Egyptians, borrowed from the Egyptians the idea of using a small number of consonants to create a vast number of words. Importantly, this was one characteristic of an alphabet. The Seirites were the first people who attempted to write their written signs in an alphabetic manner (Wolf, 2007).

2.3 The Road to Alphabetic Writing Systems

Both hieroglyphs and cuneiforms served as the seedbed from which the alphabet spawned (Logan, 2004). The idea of alphabetic writing was borrowed from the Egyptian hieroglyphs by adopting uniconsonantal signs that were the simplest feature of the Egyptian system (Logan, 2004). As briefly mentioned earlier, the hieroglyphic system might have been kept purposely complex by elites so that they could maintain the monopoly of knowledge and privileges (Logan, 2004; Wolf, 2007). Since laypeople were not able to use hieroglyphs as much as they wanted to, the necessity to simplify the writing system became great enough for the powerless to develop a writing system that aligned with their spoken language by adopting uniconsonantal signs which were available at that time. The Proto-Sinaitic alphabet included consonants without vowels.

The word *alphabet* was originally derived from the Semitic alphabet whose first and second letters were *aleph* (meaning *ox*) and *bayit* (meaning *house*), respectively. Based on these two graphs, the first two letters of the Greek alphabet, *alpha* and *beta*, were created, which in turn became the word *alphabet* (Logan, 2004; Man, 2000).

There was another alphabetic inscription that was found in three areas in Palestine which was considered 100 or 200 years older than the Sinai inscriptions dating back to 1500 B.C. (Logan, 2004). There were 15 signs of the inscriptions in total, and the representation was extremely pictorial. The level of abstraction was also limited,

compared to the Sinai inscriptions. For these reasons, the alphabetic inscription in Palestine is not considered as the first alphabet by linguists.

Another type of writing was found on a different continent. Maya hieroglyphs were developed around 300 B.C. as the writing of the Maya civilization of Mesoamerica in modern-day Mexico, El Salvador, Guatemala, Honduras, and Belize. Maya hieroglyphs were a mixture of logograms and phonetic signs representing syllables (Kettunen & Helmke, 2006). Maya writing primarily used images (pictographs), and was found in stone carvings and scrolls as well as on stucco, wood, pottery, and cloth artefacts. It is known that Maya writing was used until the Spanish conquered the Maya in the sixteenth and seventeenth centuries. The effort to decipher the glyphs is still in progress.

All in all, the Phoenician alphabet was the source of two Semitic alphabets: the early Hebrew alphabet and the Aramaic alphabet. These two alphabets used the Phoenician alphabet at first, but the people developed their own national characters, beginning in 850 B.C. for Hebrew and 750 B.C. for Aramaic, and kept 22 letters of the Phoenician alphabet (Logan, 2004).

The Aramaic script served as the foundation for the birth of many more alphabets. Before the Arabic script was developed, the Neo-Assyrian Empire and later the Persian Empire adopted Aramaic as their official language and script. Gradually, the Aramaic alphabet started to spread to Central Asia and the Indian subcontinent. After the fall of the Persian Empire, the people of these regions developed their own writing systems which were alphabetic, based on the Aramaic alphabet. Thus, the alphabets of India, Afghanistan, and Turkestan were an offspring of Aramaic (Logan, 2004; Wolf, 2007). The Aramaic script also motivated a number of other scripts to be developed in the Middle East, including the Palmyrene script used in Manichean texts from 44 B.C. to A.D. 272, the Syriac script which served as the sacred script of the Assyrian Christian Church from A.D. 200 to the present, and the Nabatean script from 150 B.C. to the sixth century A.D. The Nabatean script directly drove the effort to the development of classical Arabic. The Arabic script, in turn, directly influenced the contemporary Persian script (Logan, 2004; Sampson, 2015).

Although the monogenesis hypothesis may not apply to all scripts available in the world, consensus meets on the claim that all Western alphabetic scripts were derived from the Semitic alphabet. This assumption was made because the creators spoke a Semitic language (possibly Phoenician) and because the properties of Semitic spoken languages influenced certain structural properties of the script (Sampson, 2015). The "Semitic" language is related to the "Afro-Asiatic" or "Hamito-Semitic" family of languages, which are spoken from the Levant westwards to the Atlas and southwards as far as Nigeria, Ethiopia, and Somalia (Sampson, 2015). The two best-known scripts in the Semitic branch are Arabic and Hebrew. The most notable characteristics of the Semitic scripts have consonant graphs but no vowel letters. Although they descended from the Semitic alphabet, many alphabets, including the Roman alphabet, have vowel letters in the inventory. Due to the very reason that Arabic and Hebrew lack vowel graphs, Sampson (2015) claims that it is convenient to reserve the term "Semitic script" for the original Semitic alphabet.

Hebrew and Arabic scripts remain similar to their common ancestor, except for the outward shapes of the graphs (Sampson, 2015).

2.3.1 The Greek Alphabet

When the Greek writing system emerged, the alphabet reached its crescendo of writing. The Greek alphabet was the first writing system that represented the sound system of spoken language, which was the most radical script among all writing systems available until that time (Ong, 1986). The Greek alphabet started to emerge around 900 B.C. and took shape based on the earlier Phoenician alphabet in the Archaic Period (750–480 B.C.; Threatte, 1996). The Greek alphabet was the first full-fledged alphabetic script that had distinct graphs for both consonants and vowels. Before the end of the fourth century B.C., the Greek alphabet existed in many different dialectal variations. When the Euclidean alphabet used 24 letters in the order from *alpha* to *omega*, it became the standard that has carried on until today. This became the ancestor of the Latin and Cyrillic scripts. The Greek alphabet originally had a single case for each letter, but the uppercase and lowercase letters were developed during the modern era.

2.3.2 True Alphabet

Man (2000) asserts that one of the major roots of Western identity can be found in the alphabet. The alphabet manifests the essence of simplicity (Man, 2000). At the heart of alphabetic writing systems are phonemes as the minimal linguistic unit. Goody and Watts (1963) put forth an interesting linguistic claim that each culture's phonemic inventory is the most extreme and the most universal example of cultural selection. Their assertion was based on the notion that the number of sounds of which human beings can articulate is vast but gets narrowed down over time to accord with their language. Alphabetic scripts incorporate the universal byproduct of cultural selection (that is, phonemes) effectively in their writing systems by using about 40 of the phonemes in each writing system. With the inventory of about 40 phonemes, alphabetic writing systems can have a large number of syllables. For example, English has more than 10,000 syllables using 36 to 44 phonemes; Spanish has 25 or 26 phonemes [5 vowels and 19 (+1) consonants including allophones and diphthongs]; and there are 39 phonemes in French [17 vowels and 20 (+2) vowels] as well as 45 phonemes in German (17 vowels and 25 consonants). All alphabetic writing systems conform to the alphabetic principle, meaning that letters represent the sounds of oral language (not morphemes like Chinese characters) and that multiple phonemes are combined to form a syllable in the word.

Although the feasibility of using phonemes in the writing system is universal, not all languages utilize phonemes as the minimal sound unit in the system. For

example, Chinese characters are not composed of phonemes but represent syllables. Japanese is the same. Due to the combinatory rule for phonemes to produce syllables, the numbers of syllables are far greater in alphabetic scripts than those of syllabic scripts, such as Chinese and Japanese, which have 400 syllables without considering tones and about 100 syllables, respectively (Taylor & Taylor, 2014). The system of the graphic representations of alphabetic languages allows users to learn to read and write easily because learners do not need to memorize the large number of characters through rote memorization as in when learning to read in Chinese.

2.4 Chinese Writing System

Although the monogenetic hypothesis that all writings evolved from the same genesis was advocated by Gelb (1952), Sampson (2015) questions the monogenesis, thinking that Chinese characters might be developed independently of other writing systems. The record of the outset of Chinese characters is lost from the archaeological record or has not been found yet (Bagley, 2004). Since the two ends of Asia are connected by land, cultural borrowing from each other can be assumed. Hence, it is still debatable whether Chinese characters were developed in a completely independent manner or not. The earliest Chinese writing samples were found in the form of divination texts that were carved on bones and turtle shells in approximately 1320 B.C. (Bagley, 2004; Siqi, 2018). Although the carved word signs included names, dates, and items of sacrifice, archaeologists still could not determine what preceded the carved word signs. The shape of the characters and the context in which they were used indicated a well-developed scribal class, which suggested a complex society the Chinese established in antiquity. Since a more in-depth coverage of Chinese characters, along with Japanese Kanji, is reserved to Chapter 5, I keep the discussion of the Chinese logographic system short in this chapter.

2.5 From Numeracy to Literacy

This section serves as a chapter summary in relation to the evolution from numbers to written signs. In the time of hunters and gatherers, the tally and token systems remained largely static as they fulfilled the notational needs at the time. When agricultural civilization emerged, socioeconomic situations became more complex and began to change gradually. The tally and token systems grew elaborated and were modified to meet the demands of more sophisticated commercial transactions and trades in a new form of society (Logan, 2004). When the urbanization of Sumer at Uruk gradually took place between 3350 B.C. and 3100 B.C., tokens were used for tax payments, the distribution of rations, and the control of irrigation systems which were essential for all agriculture (Logan, 2004; Sampson, 2015). The coercive

taxation and redistribution systems forced the token system to go through a major transformation. It started to function as an administrative tool for the political and commercial control of agriculture. It also yielded chain reactions in new information processing associated with abstract numeration, logographic writing, and phonetic coding (Logan, 2004; Sampson, 2015).

Urbanization required more complex accounting systems due to the increased number of social interactions and items to be enumerated. Such necessity yielded the systematic ways of encoding, which led to the repeated use of the small number of signs by combining the signs. This led to the invention of alphabetic writing, which uses the small number of signs to create the large number of words under the blending rule of multiple signs. This was very akin to the alphabetic principle which means that the minimal unit corresponds to phonemes and that graphs group together to form a syllable.

The emergence of a new writing system is a reflection of the complexity and necessity that users came across at the time. As sociocultural situations became complicated, the users encountered a new level of complexities involved in their lives. The advent of the first primitive alphabet writing, known as the Proto-Sinaitic script, materialized in the Sinai and Canaan in the first half of the second millennium B.C. (Logan, 2004). This was the cornerstone for the development of the more full-fledged Greek alphabet that included both consonants and vowel graphs. This chapter has reviewed a historical trajectory of writing systems in different continents as a part of the introductory part of the book, PART I. Chapters 4 and 5 in PART II provide more detailed accounts of the characteristics of the alphabet and the development of Chinese characters.

Chapter 3
From Linguistic Relativity to Script Relativity

> *"The very fact that a significant scientific novelty so often emerges simultaneously from several laboratories is an index both to the strongly traditional nature of normal science and to the completeness with which that traditional pursuit prepares the way for its own change."*
>
> - Thomas Kuhn (2012, p. 65)
>
> *"… brain imaging demonstrates that the adult brain contains fixed circuitry exquisitely attuned to reading."*
>
> - Stanislas Dehaene (2009, p. 4)

Abstract This chapter reviews the evolution of the linguistic relativity hypothesis and how it was dismissed. The opponents of linguistic relativity misinterpreted the hypothesis itself and research results. With new interpretations and more scientific research findings, the hypothesis has gained rekindled interest in recent years. Empirical evidence for linguistic relativity is reviewed from the perspectives of first language influences on cognition, including color, motion, number, time, objects, and nonlinguistic representations, and from the prism of cross-linguistic influences. The chapter drives the discussion from linguistic relativity to the introduction to script relativity. The chapter ends with the claim that, among other factors that can explain cross-linguistic and cross-scriptal influences, script relativity has the greatest competitive plausibility to explain the consequences of reading.

Keywords linguistic relativity · evidence of L1 influences on cognition · cross-scrital evidence · semiotic relativity · script relativity · competitive plausibility

Does the language we speak shape the way we think about the world? This question has been debated for more than a half century, and was developed into the tenet of

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the *linguistic relativity hypothesis* or the Sapir-Whorf hypothesis[1] formulated in the 1950s. Ever since it came to prominence in the linguistic field, the linguistic relativity hypothesis has been highly controversial in such disciplines as anthropology, psychology, education, and linguistics. Lucy (1997) noted that "[f]ew ideas generate as much interest and controversy as the linguistic relativity hypothesis…" (p. 291). Twenty years after Lucy's (1997) claim, it remains largely the same. What is different from before, however, is that more rigorous scientific studies with multiple approaches and methods have been conducted to test and elucidate linguistic relativity in recent decades. What has made the hypothesis so controversial and, at the same time, so interesting? The long-standing die-hard interest, despite intense criticisms by a certain school of thought, suggests that the hypothesis has something significant at the core. The premise of the language-thought connection has also led to more sophisticated questions as to whether language functions as a lens or a mirror (or both).

Kuhn's (2012) notion of the paradigm shift applies to linguistic relativity as well. As one of the epigraphs above shows, Kuhn (2012) explains the development of paradigm shifts in science. Kuhn uses the phrase *normal science* to refer to traditional scientific activities, including answering specific questions, collecting data, and making interpretations based on data collected. According to Kuhn (2012), in the process of normal science, *anomalies* emerge, which cannot be explained by an existing paradigm. When anomalies have accumulated against a current paradigm, the scientific discipline calls for *extraordinary research*, which is exploratory in nature, to address the anomalies accrued. As a result of extraordinary research on the anomalies, a new a paradigm is formed, which refers to a paradigm shift. A paradigm shift encounters resistance. As the new paradigm gradually gets accepted and goes through gestalt-like changes, however, the old paradigm eventually die (Kuhn, 2012). In the long run, the new paradigm becomes the dominant one.

The controversy of linguistic relativity has led to a wide range of laboratory studies as a traditional approach (i.e., normal science) and established a foundation for a paradigm shift by extensively exploring linguistic and nonlinguistic domains as extraordinary research in relevance to our thinking. Hacking (2012) notes that "[w]e have a tendency to see what we expect, even when it is not there. It often takes a long time for an anomaly to be seen for what it is, something contrary to the established order" (Hacking, 2012, p. xxvi). The opposition to Whorfianism has shown the inability to explain differences shown by different language groups. With the technological advances, brain imaging research has become available. Especially given that adults' brains are reshaped as a result of literacy (see the second

[1] It is known that the term Sapir-Whorf Hypothesis was first used as a later invention by Harry Hoijer, one of Sapir's students, although Sapir and Whorf neither formerly advanced the theory together nor co-authored any works. Carnes (2014) even claims that "… Sapir's inclusion in the 'Whorfian' context is erroneous… Sapir was vigorously speculative but at the same time far more circumspect than Whorf in his estimate of the rule of language in the formation of ideas" (p. 263). In this volume, the terms linguistic relativity and Whorfianism are used interchangeably.

epigraph), the impact of reading on our cognition warrants a new treatment as a paradigm shift.

Since the linguistic relativity hypothesis has gone through an unprecedented cycle of acceptance and dismissal for more than five decades, this chapter first reviews the heated debate over the hypothesis, focusing on the evolution and dismissal of the hypothesis, followed by accounts of why and how it was dismissed. Next, empirical evidence that has been accrued in multiple disciplines in recent decades is reviewed. This chapter ends with an expansion on the linguistic relativity hypothesis to the *script relativity hypothesis*.

3.1 The Evolution and Dismissal of the Linguistic Relativity Hypothesis

The idea of the linguistic relativity hypothesis was incubated in the early 1900s, evolving from an ethnolinguistic inquiry. The idea that language and thought were intertwined was first indirectly expressed by Wilhelm von Humboldt, who saw language as the key to understanding the worldviews of its speakers and who observed relations between language and the mind in his cultural study of *kawi*, a literary language in Java (Odlin, 2005). The proposal was more refined by Franz Boas, Edward Sapir, and Benjamin Lee Whorf in the mid-1900s (Koerner, 1992). Among them, Whorf became the primary figure of the linguistic relativity hypothesis with his research into the language of Hopi Indians of Arizona and his comparison of temporal markings between the Hopi and English in the 1930s. Whorf attempted to explain the way in which language and syntactic systems affected human perception and ideas through his study of the Native American language. Whorf (1940) argued "… the background linguistic system (in other words, the grammar) of each language is not merely a reproducing instrument for voicing ideas but rather is itself a shaper of ideas…" (p. 212; cited in Koerner, 1992, p. 181). Although Whorf lacked an advanced degree in linguistics and was a fire prevention engineer and inspector for an insurance company with a degree in chemical engineering from the Massachusetts Institute of Technology, his insights were considered prudent in providing anecdotal ethnographic evidence and were highly regarded by linguistic authorities, such as Boas, Sapir, Bloomfield, and Lucy. Lucy (1997) notes that, although Whorf did not have formal training in psychology and linguistics, his work in linguistics is still considered to be of outstanding quality. After Whorf's premature death in 1941 at age 44, a book entitled *Language, Thought and Reality* was published posthumously in 1956 compiling unpublished papers that he had left behind. The thesis of Whorfianism was continuously developed by linguists, psychologists, and anthropologists who investigated the effect of habitual use of language on habitual thinking and cognition.

Although Whorf himself did not put forth the strong deterministic effect of language on thinking, the hypothesis was later interpreted in two versions: (1)

linguistic determinism as a strong version that posits that language *determines* thought and cognition and (2) *linguistic relativity* as a weak version that postulates that linguistic categories and habitual use of language *affect* our thought patterns (Pinker, 1994). The first view was the main source of strong opposition and quickly fell out of favor among scholars. The second view has received both acceptance and extreme dismissal over time. However, it has been repeatedly espoused by many scholars who argue that language indeed influences certain areas of cognition or cognitive processes.

Although many scholars believe that Whorf subscribed to linguistic determinism, another camp of scholars, such as Lee (1997) and Lucy (1992, 1997, 2016), reinterprets Whorf's view based on his words, and claims that Whorf did not subscribe to the linguistic deterministic view. Schwanenflugel, Blount, and Lin (1991) seem to join the camp of Lee (1997) and Lucy (1997). They note that "Whorf's major points appear to be arguments against the simplistic view that languages are directly translatable, category for category and word for word. His linguistic analyses were accordingly designed to highlight differences in grammatical and lexical patterns and to argue that a speaker must adhere to the patterns of his/her specific language in order to be understood" (p. 73).

Two types of examples are dominant in cross-linguistic comparisons under the notion of linguistic relativity: Lexical differentiation and grammatical differentiation. At the lexical level, Whorf argued that the way in which languages differentiate concepts in domains was different according to the culturally significant meaning assignment showing the high concentrations of differentiation in words in some domains and low concentrations in others. A well-known example is the statement that the Eskimo languages, including Yupik and Inuit, have a much larger number of words for "snow" in the lexicon than English. Whorf claimed that "[w]e [English speakers] have the same word for falling snow, snow on the ground, snow hard packed like ice, slushy snow, wind-driven snow--whatever the situation may be. To an Eskimo, this all-inclusive word would be almost unthinkable..." (Carroll, 1956, p. 216). Another example is that the American Indian language of Hopi uses an umbrella word to refer to everything that flies except birds; that is, the same word is used for insects, airplanes, aviators, etc. (Carroll, 1956). Whorf's lexical examples received criticisms that resulted from a different view on morphological differentiations. Regardless of the focus of the debate, it suggests that each language has its own way of differentiating lexical domains, which is different across languages. The real question is whether or not linguistic variations yield differences in thinking and thought patterns.

At the syntactic level, languages differ in the use of word order or morphology to represent meaning. Whorf claimed that grammatical classifications or distinctions would also impact individuals' ways of thinking. Relatedly, the syntactic ordering of subject-verb-object (SVO) is the norm in English. In principle, each sentence begins with a noun or pronoun, followed by a verb (and then by another noun or noun phrase or ends with only S+V). This overt rule may reinforce a reliance on the subject and its action or description. Li and Thompson (1976) dub English a subject-prominent language. In contrast, Japanese and Korean use an SOV order, in which

the subject is most of the time omitted in the sentence. Even objects are at times omitted in the sentence, but the speaker and the listener do not have difficulty understanding the meaning of the sentence or message. Japanese and Korean are called topic-prominent languages or context-bound languages in that sentences are structured around a given topic and that contextual cues play a significant role in deciphering the sentence. The SOV word order and null-subject usage in the Japanese and Korean languages may have to do with context-focused problem-solving strategies Japanese and Korean people typically use, as discussed in Chapter 6.

Whorf's hypothesis indicating that the habitual use of language affects habitual thinking and behavior has been challenged mostly by nativists or universalists from the 1960s through the 1980s. Opponents, such as Chomsky and Pinker, criticize Whorf's hypothesis for implausibility or lack of logic in the accounts of how language affects thought and for Whorf's arguments being in the form of anecdotes and speculations without hard evidence. The nativists argue that all languages share a common underlying structure that is largely innate. They believe that linguistic differences across languages are at the surface and do not make differences in the universal linguistic processes of the brain. Since they believe that all human beings possess the same set of psychological faculties, biological construction, and neural configuration, similar cognitive patterns are expected to show in language use across different language speakers; as a result, cultural variability is of less importance.

As a vehement opponent, Pinker (1994) criticizes Whorf's hypothesis, in his book *The Language Instinct*, to be a "conventional absurdity: a statement that goes against all common sense…" (p. 47). He also mentions "… the more you examine Whorf's arguments, the less sense they make" (p. 50) and "[a]s a cognitive scientist I can afford to be smug about common sense being true (thought is different from language) and linguistic determinism being a conventional absurdity" (p. 57). He goes on asserting that "[p]eople do not think in English or Chinese or Apache; they think in a language of thought" (p. 72), which is a meta-language *mentalese* and that "[k]nowing a language… is knowing how to translate mentalese into strings or words and vice versa" (p. 73).

As shown in his words, Pinker equated Whorfianism with the strong version, *linguistic determinism*, which can be seen as a misinterpretation of Whorf's claim. Considering that the notion of strong and weak versions of Whorfianism was posthumously invented by other scholars, there is no evidence that Whorf himself claimed the determinism. In his later book, Pinker (2007) continues to debunk the linguistic relativity hypothesis by again relying on the strong version of linguistic determinism. Ironically, he essentially acknowledges linguistic relativity, as shown in his own words "[l]et me say at the outset that language surely affects thought--at the very least, if one person's words didn't affect another person's thoughts, language as a whole would be useless" (p. 125). However, he still erroneously sticks with the determinism and tries to make Whorfianism "banal" (p. 126).

Malotki (1983) was an anthropologist who rejected Whorfianism. He argued that the Hopi language contains a series of time-related linguistic features, such as tense, metaphors for time, and time units (e.g., days, weeks, months), as opposed to Whorf's claim. Lee (1991, 1997) directly refuted Malotki's (1983) analysis of

adverbial particle "tensors" to be problematic and invalid. Lee also contended that, since his interest was geared toward showing that Hopi was similar to English, Malotki overlooked how Hopi grammar and time concepts were different from English.

There was an additional group of scholars who were opposed to linguistic relativity. Following Lenneberg's line of inquiry, Berlin and Kay (1969) continued color research and indicated that the formation of color terminology was universal based on the three core color names (i.e., *black, white,* and *red*) commonly found across cultures. Berlin and Kay endorsed universal typological color principles, which were regarded to be determined by physical-biological universals, not by linguistic factors. However, Lucy (1992) criticized Berlin and Kay's interpretation of their findings, arguing that the results of their study actually did not disprove linguistic relativity in color naming mainly because of questionable assumptions and data-related problems that were contained in their study of basic color terms. Due to the controversial accounts of linguistic relativity and conflicting research results, the debate has been continuing.

3.2 Rekindled Interest in the Linguistic Relativity Hypothesis

In the midst of the criticism on the linguistic relativity hypothesis, Fishman (1982) attempted to expand on Whorfianism as an intrinsic cultural value. He suggested that Whorfianism be the third kind above and beyond the linguistic relativity and linguistic determinism hypotheses. This third kind of hypothesis supports ethnolinguistic diversity as an intrinsic value of societal assets to promote pan-human creativity, problem solving, and mutual cross-cultural acceptance. He viewed this third kind as a "valuable humanizing and sensitizing effect on the language-related disciplines" (p. 1).

This line of refocusing on the linguistic relativity hypothesis continued in the late 1980s and early 1990s when cognitive linguistics solidified its way. Lakoff (1987) argues in his book *Women, Fire and Dangerous Things: What Categories Reveal about the Mind* that language is used metaphorically and that our knowledge is organized by the mapping of idealized cognitive models which are a by-product of category structures and cultural metaphors. In his elaboration on cultural metaphors, Lakoff (1987) revisits linguistic relativity focusing on how linguistic categorizations influence mental categories. He asserts that opponents have used different parameters to describe linguistic relativity to the degree that their criticisms are not fully grounded in the tenet of linguistic relativity. He also stresses that misunderstanding and confusion got in the way of opposition by noting "[t]he point is to show that there is not one concept of relativism but literally hundreds and that much of the emotion that has been spent in discussion of the issue has resulted from confusions about what is meant by 'relativism'" (p. 304). Lakoff (1987) continues to assert that the dismissal of relativism was a result of "… scholarly irresponsibility,

fuzzy thinking, lack of rigor, and even immorality" (p. 304). When it comes to different conceptual systems across languages, the degree, depth, nature, and locus of variations need to be scientifically addressed above and beyond the monolithic system issue.

A stockpile of studies accumulated by Lucy (1992, 1997), Lee (1991), and Levinson and colleagues (Bowerman & Levinson 2001; Gumperz & Levinson, 1996; Levinson, 2003) shows how the linguistic relativity hypothesis was misinterpreted, and also suggests a nuanced approach to study how language is intertwined with speakers' cognition and mental processes. Levinson (2003) points out how the view of Simple Nativists was "simply ill informed" (p. 28). He continues indicating that "… Simple Nativism has outlived its utility; it blocks a proper understanding of the biological roots of language, it introduces incoherence into our theory, it blinds us to the reality of linguistic variation and discourages interesting research on the language-cognition interface." (2003, p. 43).

Hunt and Agnoli (1991) indicate from a perspective of cognitive psychology that thought is related to variations in the lexicality, syntax, semantics, and pragmatics of language, and that different languages bring up different challenges and support for the cognition of diverse speakers. They also note that "[t]he Whorfian hypothesis is properly regarded as a psychological hypothesis about language performance and not as a linguistic hypothesis about language competence" (p. 387). Rediscovering Whorf's insights, Lee (1997) argues that relativism has significant implications for pedagogy and education such that accepting the language-mind-experience relationship would facilitate teaching and thinking.

Another effort to rethink and reformulate linguistic relativity has been made with an anthology entitled *Rethinking Linguistic Relativity* edited by Gumperz and Levinson (1996). The compilation of articles focuses on cognitive and social aspects of linguistic relativity ranging from the cognitive processes of spatial semantic categories to the linguistic and cultural relativity of inference, including both pro-Whorfianisn and anti-relativist perspectives. The collection covers language-specific effects on cognition as well as cross-linguistically and cross-culturally specific and universal constructs. In addition, it covers not only language and linguistic structures that are situated within particular cultural contexts, but also the ramifications of linguistic and cultural concepts as well as language use and the variability of language. This line of resurrected interest has been extended to conceptual discussions in cross-language or second language studies (Bylund & Athanasopoulos, 2014; Casasanto, 2008; Cook & Bassetti, 2011).

3.3 Empirical Evidence for Linguistic Relativity

Lucy (1997) laments that, although linguistic relativity has drawn a long-standing historical interest from scholars of multi-disciplines, there has been a paucity of empirical studies, compared to other subjects. There are several reasons for the lack of empirical studies. First, as indicated in Chapter 1, it has to do with the

interdisciplinary nature of the hypothesis, which makes the specialization of approach and methodology difficult to reconcile among different disciplines (Lucy, 1997, 2016). Second, it is related to the fact that, as briefly discussed earlier, some scholars equate Whorfianism with determinism, which has led to misinterpretations, unjust treatments of the hypothesis, and prejudices and biases (Lucy, 1997). Third, the intricately interwoven nature of language and cognition has also made empirical research challenging. Whorf discussed many linguistic classifications, but they were difficult to disentangle without assessing language independently of cognition. Boroditsky (2001) also points out a challenge involved in research of linguistic relativity. Although comparison studies have been conducted in different languages, a lack of instruments that are comparable to and reliable in each language imposes huge difficulties in the interpretation of results. The next challenge is related to nonlinguistic tasks used in the research. Although tasks are claimed to be nonlinguistic, it is difficult to ensure that nonlinguistic tasks are not reinforced or affected by the participant's language due to the nature of interrelatedness between language and cognition and between language and human behavior. Last, Whorf's views did not fit well with the tradition of behaviorists in psychology that prevailed at the time nor with subsequent nativism that was pioneered by Chomsky in the 1950s.

Lucy (1997) summarizes empirical research into linguistic relativity in three main approaches, focusing on *language*, *thought*, and *reality* as the central orientations: structure-centered, domain-centered, and behavior-centered approaches. The *structure-centered approach* focuses on the lexicogrammatical structures of languages and examines structural differences in languages between two languages as well as their possible implications for thought and reality (e.g., number, gender, aspect markings). The three key elements of language, thought, and reality are closely interrelated such that "[l]anguage embodies *an interpretation* of reality and language can *influence* thought about that reality" (Lucy, 1997, p. 294; emphasis in original). Human thought not only is closely linked to perception and attention, but also regulates the personal, sociocultural, and linguistic systems of classification, inference, and memory. The *domain-centered approach* involves the domains of experienced reality as well as the way in which a language encodes and construes semantic categories (e.g., color, time, space). The last *behavior-centered approach* concerns practical matters in relation to the behavioral aspects of the linguistic system (e.g., usage-based analysis).

Besides the three main foci on *language, thought,* and *reality*, other conceptual and methodological considerations are worth mentioning. First, the parameter of *differences in languages* needs to be defined. This has been addressed by looking at the presence or absence of a particular linguistic marker in languages under comparison. Another way is to address how the differences, if any, are manifested in languages being compared. Second, if a language shapes or affects the speaker's cognition or thought patterns, the degree to which the language *affects* cognition needs to be defined, clarified, and identified. Third, *differences in cognition or thought patterns* also need to be defined. Since cognition and thought patterns are latent constructs, they are difficult to measure. Therefore, research has taken an indirect route to examine color perception, time perception, number perception, and

so on. As indicated in Chapter 1, the opponents of linguistic relativity claim that evidence should come from nonverbal behavior in order to make linguistic relativity tenable. However, it is difficult to draw a distinct line between language and cognition because these two have an interlocking relationship that has been formed since infancy (Perszyk & Waxman, 2018). Although perceptual and conceptual domains, such as color, time, number, and space, can be considered nonverbal, it is still an open question because linguistic representations associated with these concepts are bound to be activated in the performance of tasks that elicits color, time, number, and space concepts.

With these issues related to research in Whorfianism in mind, a review of scientific evidence that supports or refutes linguistic relativity is in order. Research on first language influences on thinking is first reviewed and then studies of cross-language transfer in relation to linguistic relativity are discussed.

3.3.1 Studies of First Language Influences on Cognition among Various Language Communities

3.3.1.1 Color

Zipf's (1935) law refers to the inverse relationship between the frequency of a word and its rank in the frequency table as well as a negative correlation between the length of a word and its frequency of usage. The higher the frequency of a word, the shorter the word. This notion was used in Brown and Lenneberg's (1954) study of color codability based on the relationship between codability and ease of expression. Brown and Lenneberg asked college students to name 24 different colors and examined their reaction time. They found that colors with longer names (meaning less codable or less focal, according to them) took longer time, produced less agreement among the participants, and produced less consistency from one time to another.

Given that Brown and Lenneberg's (1954) study used only English, linguistic relativity could not be fully addressed without a comparison between (at least) two language groups. Berlin and Kay (1969) investigated color terms and codability in 20 different languages. They took the nativist's position that color recognition and coding were an innate physiological process rather than a form of cultural acquisition that relied on a premise of cross-linguistic regularities and constraints involved in the coding of colors and biological sources of color patterns. They noted universal restrictions on the number of basic color terms across languages. They claimed that all color terms of all languages could be broken down into 11 color terms that were monomorphemic, which appeared in a five-level hierarchy in languages: (1) black and white, (2) red, (3) yellow, green, and blue, (4) brown, and (5) purple, pink, orange, and grey. If one language had just two basic colors, the terms would be *black* and *white* (e.g., New Guinean people). If one language has three basic colors, it would be *black*, *white*, and *red*, and so forth, according to the hierarchy. This

hierarchy was extended as evidence that human physiology would determine the categorization of color terms and put constraints on linguistic variations on color classification and perception. Berlin and Kay interpreted their findings as anti-Whorfianism.

Early studies of the lexical codability of colors showed that more codable colors (i.e., aforementioned focal colors) were better remembered than less codable colors in nonlinguistic tasks. Agrillo and Roberson (2009) revisited Brown and Lenneberg's (1954) color study by comparing communication accuracy and recognition memory with varying distractor arrays for color items in order to overcome or control for the influence of context and task demands on the results. Unlike the findings of Brown and Lenneberg's (1954) study, Agrillo and Roberson found that colors that were easier to name showed no recognition advantage for memory in a randomized array of distractors which was more akin to real life situations outside the laboratory setting. They concluded that the eight basic colors were not inherently more codable and memorable than other colors.

In another study, Kay and Kempton (1984) compared color categorization between English speakers and speakers of Tarahumara, a Uto-Aztecan language of northern Mexico, who did not have a distinction between *green* and *blue* and had instead a collective term *siyóname* meaning *green* or *blue*, in order to examine whether the lexical difference would result in a distinct judgment of the distances between the two colors. In Experiment 1, 56 triads of color chips were presented, in which three chips were shown at a time, and participants were asked which of the three chips was most different from the other two (a.k.a., a "pick an odd one out" method). Two chips were distinct in the colors of green and blue, while the hue of the other item was somewhere in between green or blue. English speakers tended to exaggerate the distinction of colors close to the lexical category boundary of blue and green, whereas Tarahumara did not show the tendency. In other words, English speakers clearly distinguished the green and blue chips based on the lexical category, while Tarahumara speakers did not distinguish the blue-green contrast. Kay and Kempton interpreted this result as a clear Whorfian effect in the direct subjective judgment of colors. When speakers are forced to judge color discrimination, they may use the lexical classification of the judged objects as if discrimination is related to the required dimension of judgment as long as the task does not block this connection. Under this assumption, Experiment 2 eliminated the subject's use of the color name strategy to examine whether or not participants used a *name strategy* as a cognitive mechanism when discriminating between blue and green colors according to their lexical categories. The participants made discriminations based on the distance between the two colors but not on the lexical category, which showed no group difference. Results indicated that no sensitivity to lexical category boundaries was found in English speakers and that the Whorfian effect found in experiment 1 disappeared when the use of their color names was removed from the experiment.

Roberson et al. (2000, 2005) investigated perceptual judgments and memory in different language groups whose basic color terms were different. They found that differences in color cognition between different language groups yielded significant effects on perception and memory for colors (Roberson, Davies, & Davidoff, 2000).

In order to overcome limited evidence from a tiny and remote language community, Roberson et al. (2005) studied a large language community of semi-nomadic tribesmen in Southern Africa and found a different cognitive organization of color was involved in both English and semi-nomadic tribesmen's language with five color terms (Roberson et al., 2005). Roberson et al. (2000, 2005) suggested that categorical perceptions were language-dependent given the close interaction found between language and cognition, supporting the cultural relativity hypothesis.

Research has also been conducted to investigate whether having a word for a concept influences visual color perception. Given that English and Russian color terms are different in the color spectrum (while English has a single word for *blue*, Russians use different color terms for light blue *goluboy* and dark blue *siniy*), Winawer et al. (2007) examined whether the difference in color terms made differences in color discrimination. They tested native speakers of English and Russian in a speeded color discrimination task using two shades of blue. Russian speakers were faster to discriminate two shades when they fell into different shades used in Russian (one *siniy* and the other *goluboy*) than the same shades (both *siniy* or both *goluboy*). In order to determine whether words were unconsciously activated, they asked Russian participants to perform a verbal task at the same time when making their color discrimination. The reaction time advantage of different shades of *goluboy* and *siniy* disappeared. The different results of the verbal dual tasks indicated that the task of discriminating color shades was facilitated by the unconscious activation of verbal categories. English speakers showed no difference in discriminating the two blue shades. Winawer et al. (2007) concluded that color categories in language influenced color discrimination in simple perceptual color tasks and that the effect of language was disrupted by verbal interference. These findings are a piece of evidence for pro-Whorfianism.

Özgen and Davies (2002) also examined categorical color perception and claimed that color perception could be learned through repeated practice, such as laboratory training. They interpreted the findings of four experiments as support for the linguistic relativity hypothesis, claiming that "language may shape color perception" (p. 477). Lu, Hodges, Zhang, and Wang's (2012) study was also in a similar line. They investigated the effects of Chinese color names on recognition in the left and right hemispheres using color naming and color memory. Results showed that, unlike previously assumed, linguistic effects on color discrimination were not constrained in the left hemisphere. They suggested that the right hemisphere's relative speciailzation of color discrimination and the left hemisphere's relative speciailzation of linguistic discrimination might have yielded varing degrees of effects on timing. Gibson and colleagues (2017) also conducted a large-scale study of 110 languages using the World Color Survey. They found cross-language similarity in color naming efficiency as well as differences in overall usefulness of color across cultures.

Importantly, Kay and Regier (2006) seem to support this line of reasoning. They acknowledge that there are universal constraints on color categories, but, at the same time, differences in color categorization across languages yield differences in color cognition and perception. This is a significant advancement for linguistic

relativity, compared to the claim made in Berlin and Kay (1969), which was anti-Whorfianism.

Motion

Another set of studies in relation to linguistic relativity is an encoding pattern of motion events. Athanasopoulosa and Albright (2016) adopted a perceptual learning approach to the linguistic relativity hypothesis to examine the way English speakers categorize motion events by training them in an English-like way (aspect language) and in a Swedish-like way (non-aspect language) using the conditions of with and without verbal interference in English. Results showed that verbal interference effects were salient only in the within-language condition (i.e., English speaker' categorizing events in an English-like way) but not in the between-language condition (i.e., English speakers' categorizing events in Swedish-like way). This suggests a selective language influence on the classification of motion event cognition among English speakers. Gennari, Sloman, Malt, and Fitch's (2002) study also examined lexicalizing patterns of motion events among English and Spanish speakers using two nonlinguistic tasks of recognition memory and similarity judgment. They found a linguistic effect in the similarity task with verbal encoding only, indicating that language-specific encoding patterns were observed in the form of language-dependent regularities involving the lexicalization of motion events.

Choi and Bowerman (1991) reported that children learning English and Korean showed different patterns of lexicalization of motion as early as 17-20 months. American children tended to quickly generalize spatial words of path particles, such as *up*, *down*, and *in,* to both spontaneous and causal changes of location. In contrast, Korean children were more likely to use different words for spontaneous and cause motion expressions. These findings indicated that children's language acquisition was influenced by the semantic organization of their native language from the early phase of language acquisition. This suggests that language input and cognition interact with each other from the beginning of learning about motion and space.

3.3.1.2 Number

An attempt to redefine a Whorfian effect as a processing difference according to the language spoken has been made through research on numbers. Brysbaert, Fias, and Noël (1998) examined number sense and numerical encoding among French- and Dutch-speaking students. Whorfian effects on numerical cognition was examined using the Dutch number naming system in which the order of tens and units was reversed (e.g., 24 is read 'four-and-twenty'). In Experiment 1, the researchers used two conditions of mathematical addition problems: (1) different order of the combination of two- and single-digit operands (e.g., 20 + 4 vs. 4 + 20) and (2) different presentation modality (i.e., Arabic numeral vs. oral). A significant difference was found between the two language groups in the presentation modalities. Experiment 2 showed that the difference disappeared when the participants were asked to type in their answers instead of verbal response. This indicated that the difference found in the methods of presentation might be related to input or output processes rather

than the mathematical addition operation per se. Although numerical cognition could be independent of the language system, the authors did not completely dismiss the possibility of Whorfian effects on human cognition.

Lucy (1992) also examined relationships between grammatical number markings and cognition among speakers of American English and Yucatec Maya. English speakers use *obligatory* plural markings to accord with associated countable nouns, whereas Yucatec speakers *optionally* indicate plural terms. The two groups of different language speakers performed differently in nonverbal experimental tasks with a preference made based on the lexical structure of their native language. Specifically, English speakers showed a preference for shape-based classifications, while Yucatec speakers demonstrated material-based categorizations. This is an interesting study because not all languages have obligatory plural markings as shown in English. For example, the Japanese and Korean languages do not require number agreement between the subject and the verb as well as between the number marking and related countable nouns in the sentence. Specifically, the Korean language does not require number agreement between the subject and the verb or other grammatical elements within the sentence, but has a specific classifier that collocates with a given noun. For example, the phrases *three books* and *three dogs* in English are expressed as *book three kwon* (*kwon* is a designated classifier for books) and *dog three mari* (*mari* is a designated classifier for animals). Although no empirical data are available on this as of today, it is possible that these kinds of linguistic differences yield differences in shape-based, material-based, or animacy-based categorization as well.

Scientific attention has been paid to morphological differences in number coding between East-Asian languages and English as well as its effect on children's conceptualization on numbers, and, ultimately, their mathematics performance. The number naming system in English is less straightforward than that of the East-Asian languages. In English, for example, the number name for 11 is hardly related to the unit name for 1, although the decade names for 13 through 19 are consistent with the unit names 3 through 9. The three Asian languages have a systematic code of number names from 11 and beyond; that is, the decade name followed by the unit name. For example, 11 and 12 are coded as literally *(one) ten one* and *(one) ten two*, respectively, and so forth. Likewise, the names for 21 and 22 are literally *two ten one*, *two ten two*, respectively, and so on. The numbers greater than 100 follow the same rule. This consistent way of combination does not require the use of new additional words to refer to numbers, unlike the number names from 13 to 19 in English. Notably, the English number names for 13 through 19 have inconsistent combinations because they consist of the unit name *before* the decade name, which is different from the other number names (i.e., names for 20 and onward). In short, the three East-Asian languages code the number names by the principle of place-value structure, meaning that the numeric values of multi-digit numbers are represented by the position of constituent digits in the structure of descending power from left to right (e.g., $123 = \{1\} \times 10^2 + \{2\} \times 10^1 + \{3\} \times 10^0$).

Based on these formal place-value structures of numbers, research has been conducted on the effect of the numeric name system on mathematics performance among students of different language groups. Miura et al. (1988, 1994) carried out

cross-national comparisons of mathematics performance among American, Chinese, Japanese, and Korean children (1988) and among Chinese, French, Japanese, Korean, Swedish, and American children (1994). The results of two studies showed differences in cognitive representations of numbers and their effects on math achievement. Children with the three East-Asian languages consistently outperformed their peers of European and American backgrounds. The researchers attributed the East-Asians' outperformance to numerical language characteristics. In other words, East-Asian children tended to construct decade blocks and unit blocks in a systematic way to show the place value, showing a better understanding of the place-value structure of the number system. However, children from France, Sweden, and the U.S. showed a preference for a collection of unit blocks to represent numbers as a grouping of counted objects. Furthermore, Asian students showed a greater flexibility in mental number manipulations than their counterparts. Miura et al. (1988, 1994) concluded that the systematic numeric characteristics expressed in the three East-Asian languages might facilitate the learning of mathematics, especially arithmetic.

Differences in the naming speed of the numbers have also been found among different language groups. Miller et al. (1995) found that Chinese children were faster in counting between 11 and 99 than English-speaking children, although there was no difference in the range of numbers between 1 and 10 and beyond 99. This difference may be attributable to the systematic number name structure between 11 and 99, as explained earlier. Additional studies also indicated that Chinese speakers pronounced numbers faster than English speakers. Hoosain and Salili (1987) noted that working memory capacity did depend on the time-based duration of sounds rather than the item-based number chunks. They reported that Chinese speakers' pronunciation speed was faster and their sound duration for numbers was shorter than those of English speakers in their three experiments with English- and Chinese-speaking undergraduate students. They also reported Chinese speakers' greater digit spans than those of English speakers. They suggest that pronunciation speed for numbers in language affects the mental capacity for the speaker's cognitive manipulation of numbers.

It seems plausible that East-Asian children take advantage of the greater regularity embedded in their languages than English when they acquire number names and number sense. Ng and Rao (2010) have indicated in a comprehensive review that the Chinese language offers benefits for math learning and that the language is a contributing factor to the early attainment of math skills, although language, culture, cultural beliefs, and educational systems are interrelated. Klein et al. (2013) also show that a direct comparison of Italian-speaking children to German-speaking children further corroborates the previous findings that language affects cognitive number processing. They conclude that numerical development can be language-universal, but it might be modulated by language.

Another study with an Amazonian tribe provides an interesting piece of evidence that challenges the idea that people have an innate mathematical ability. Frank et al. (2008) argue that the number is a cognitive technology for creating mental representations for accurate memory. The Pirahã, an Amazonian tribe of hunters-gatherers in

remote northwestern Brazil, have no words that express exact quantity (not even *one*), although they have words to express the quantities "one," "two," and "many" (Everett, 2005). These number words do not refer to counting numbers, but are rather signifying relative quantities (e.g., *one* for any quantity between one and four; *two* for as many as six). Frank et al. (2008) carried out two experiments for an investigation of the number language (Experiment 1) and numerical abilities (Experiment 2). They showed that the Pirahã could perform exact matching tasks with the large numbers of objects when the tasks did not involve memory. However, their responses were inaccurate on matching tasks when involved with memory. These results suggest that language for the exact cardinal number is a cultural invention rather than a linguistic universal. They also indicate that number words do not change our underlying number representations, but instead are a cognitive technology for keeping track of the cardinality of large sets across time, space, and modality (Frank et al., 2008). Although the results do not support the strong version of Whorfianism, they do suggest that language influences cognition and memory.

3.3.1.3 Time

The concept of time has also been studied. Universalists view time as a universally abstract concept, while relativists stress that different languages frame and express time differently. Boroditsky (2001) investigated the concept of time perceived by native speakers of Mandarin and English by looking at whether time is perceived horizontally or vertically because Mandarin and English encode time concepts differently in the languages. She demonstrated different ways of indicating time in English and Chinese, showing that English speakers tended to express time horizontally, while Chinese were likely to express time vertically. Specifically, Mandarin speakers responded faster when March and April were presented in a vertical display. In contrast, English speakers' judgment was faster when March and April were presented in a horizontal array. She offered support for the weak version of linguistic relativity by concluding that the native language was a tool that shaped habitual thought and cognition of abstract concepts. Although January and Kako (2007) rebutted Boroditsky's (2001) conclusion in a replication study, the inconsistent findings have not prevented from maintaining continued research interest in time perception.

Bylund and Athanasopoulos (2017) investigated how people construct their mental representations of time passage and estimate time among native speakers of Spanish and Swedish as well as Spanish-Swedish bilinguals. The Swedish language describes time in terms of length (i.e., *long* or *short*), while the Spanish language estimates it in terms of volume (i.e., *big* or *small*). When the participants were asked to measure the time duration (i.e., how much time had passed) while watching on the computer screen either a line gradually growing or a container being filled or both, "Swedish speakers were misled by stimulus length, and Spanish speakers were misled by stimulus size/quantity" (Bylund & Athanasopoulos, 2017, p. 911). Based on the language-specific interference found in the duration reproduction task,

they asserted that language could play a powerful role in transforming our psychophysical experience of time, based on the robust presence of preferred expressions of time duration in magnitude according to the native language; that is, the *long-short* concept in Swedish and the *big-small* concept in Spanish. Bylund and Athanasopoulos' (2017) bilingual data showed a different interference effect depending on the language used in the context. When the word "duración" (*duration* in Spanish) was presented first, bilinguals were likely to rely their time estimate more on how full the container was than how much the line grew. When they were prompted with the word "tid" (*duration* in Swedish), they measured the time estimate merely by the distance that the lines that had made by growing. These results were not counterevidence to linguistic relativity. The researchers concluded that humans' mental representation of time was malleable in the form of a "highly adaptive information processing system" (p. 911). Montemayor (2019) recently suggests that the mechanism for time perception be examined in a broader context (i.e., early and late time perception) of time cognition and perception to overcome the narrow scope of termporal properties of time. He states that time perception provides researchers with new possibilities to invenstigate linguistic modulation through the interface between semantic categorization and mental representations in different forms.

3.3.1.4 Object

Conceptual categories pertaining to object names seem to be constructed as early as when children learn their mother tongue, if not before. Gopnik and Choi (1990) examined an early semantic and cognitive development among Korean-, French-, and English-speaking children by having them perform object-permanence, means-ends problem solving, and categorization tasks. Gopnik and Choi found that Korean children used significantly different forms than English-speaking children in encoding disappearance and success-failure words. English- and French-speaking children developed categorization and naming earlier than did Korean children. A longitudinal study (Gopnik, Choi, & Baumberger, 1996) showed that Korean-speaking children used not only more means-ends and success-failure words, but also more verbs than English speakers. These results are consistent with the observation that Korean-speakng mothers used more verbs and fewer nouns than English-speaking mothers (Gopnik, Choi, & Baumberger, 1996). In an observational study, they found that Korean mothers tended to emphasize actions, while English-speaking mothers tended to emphasize categorical names. Consistent with the previous study, Korean-speaking children were delayed in categorization but superior in means-ends abilities, compared to English-speaking counterparts. These findings suggest that differences in linguistic input and linguistic usage influence children's cognitive development through two-way interactions between language and cognition in the early phase of language acquisition.

The specification of object position was also examined. Koster and Cadierno (2018) examined whether the perception of placement is universal or not using

German and Spanish verbs. They examined categorization (Experiment 1), recognition memory (Experiment 2), and object orientation (Experiment 3). Null effects were found in the categorization and mental simulations of object orientation. However, German speakers demonstrated better recognition memory for object position than did Spanish-speaking counterparts. Although it did not show fully involved mental processes in the perception of placement, the study demonstrated robust language-specific effects involved in the specification of object position. More studies in this line are warranted for a better understanding of the interface between language and perception.

3.3.1.5 Nonlinguistic Representations

Nonlinguistic representations were also examined using musical pitch. Dolscheid, Shayan, Majid, and Casasanto (2013) used nonlinguistic psychophysical tasks to investigate the mental representation of musical pitch among native speakers of Dutch and Farsi. The two languages encode pitches differently; Dutch describes pitches using adjectives of *high* or *low*, while Farsi describes pitches using terms *thin* or *thick*. Performance differences were found in two pitch-reproducton tasks between the two groups. The Dutch-speaking group was further trained to describe musical pitches as in Farsi (i.e., *thin* or *thick* in description). Training actually made Dutch participants describe pitch in a similar way to that of Farsi speakers, which provided psychophysical evidence for linguistic relativity. The authors concluded "[l]anguage can play a causal role in shaping nonlinguistic representations of musical pitch" (p. 613).

3.3.1.6 Other Areas

The framework of the linguistic relativity hypothesis has been addressed in diverse areas. Gender issues were examined in a social identity analysis through the prism of the linguistic relativity hypothesis (Khosroshahi, 1989). Sign language was also used to examine a Whorfian effect. Xia, Xu, and Mo (2019) investigated deaf people's color perception using visual search and oddball tasks. Both behavioral and electrophysiological findings showed that sign language affected the perception of color categories among deaf people and concluded that the nature of language influenced perception and thought. Considering little relevance of these studies to the thesis of this book, albeit important in terms of addressing linguistic relativity, the review of these studies is limited here.

Also examined was how language or grammatical usage could make workers misconstrue dangerous situations in the workplace. Strømnes observed that the linguistic features of Swedish prepositions could represent space in three dimensions, while Finnish cases could represent space in two dimensions coupled with a third dimension of time or duration. In other words, the Swedish language describes movement in detail in three-dimensional spaces, whereas the Finnish language

places emphasis on static and holistic relationships between or among people. This could be extended to the linguistic difference between Indo-European languages and Uralic languages. Indo-European languages (e.g., Swedish, Norwegian, English) tend to form coherent temporal entities in a way that actions are explained linearly from the beginning to the end in the setting. In contrast, Uralic languages (Finnish, Hungarian, Estonian) tend to describe static settings with minimal movement of the person in a way that settings are expressed with the global sentiment of people involved within the setting. Due to these linguistic differences in the emphasis placed in the situation, the Finns tend to organize their work environment in a way that individual workers are more focused (i.e., person-centered) than the work process for overall production. This lack of emphasis on the overall temporal organization of production processes is likely to lead to frequent disruptions in production, and ultimately result in higher occurrences of work-related accidents than Swedish-speaking counterparts. (summarized from Lucy, 1997; see pp. 303-304).

3.3.2 Studies of Cross-Language Influences

The debate over the linguistic relativity hypothesis has been mainly involved in the monolingual mind. However, Neo-Whorfianism exemplifies universal constraints and cross-cultural regularities. As such, linguistic relativity has been resurrected as an active research topic in psycholinguistics and studies of a second language (L2) or a third language (L3). Jarvis and Pavlenko (2007) employed the linguistic relativity hypothesis as a framework of crosslinguistic influences on bilinguals' and multilinguals' minds and learning additional languages regardless of the directionality of cross-language influences (i.e., L1 to L2, L2 to L1, or L2 to L3). The new wave of studies of L2 learning in recent decades in a wide range of areas, including phonetics and phonology, speech perception, lexical access, morphology, reading, and pragmatics, has provided a different perspective on the accounts of linguistic relativity as well as a groundwork for continued research on linguistic relativity.

Negating, at times, helps better explain the phenomenon under consideration. If language does not influence our thoughts, why do speakers of different languages display different perceptions, different worldviews, and different behavioral patterns? If language does not affect our cognition, why do we observe cross-language transfer and how should we interpret it? On a flip side, if our cognition affects language, why does language not change as a result of different thoughts? Language does evolve. However, it hardly evolves due to the change of our thinking or cognition. New words are coined in response to necessity, new technology, new discoveries, or social movements.

Empirical evidence of second language studies generally concurs with the paradigm of linguistic relativity. Bylund and Athanasopoulos (2014) suggest that linguistic relativity be a new approach to L2 research. They underscore neo-Whorfianism in studies of L2 acquisition with refined methodological and theoretical prerequisites for linguistic relativity research, and encourage the use of nonverbal methods

to examine the effects of linguistic relativity among L2 speakers to avoid argument circularity (which was one of Pinker's criticisms about linguistic relativity). In order to demonstrate the extent and the nature of cognitive restructuring in L2 learning as a function of learner variations, Bylund and Athanasopoulos (2014) also call for an identification and delineation of cognitive mechanisms related to the associative learning involved in L2 acquisition and nonverbal behavior. Factors characterizing individual learner trajectories, such as L2 proficiency, L2 contact and use, learning context, and age, need to be taken into account in recalibrating nonverbal behavior among L2 speakers. Pavlenko (1999) also offers a new look at the bilingual mind. Pavlenko (1999) attempted to interpret L1-based description of events among speakers of Russian and English within the framework of the linguistic relativity hypothesis. Although her focus is semantics and concepts in bilingual memory, the results of her study are essentially in support of the relativistic approach.

Recent studies have attempted to tease apart the extent, dimension, and directionality of cross-language transfer. L2 research is especially effective in filling gaps presented in the debate about linguistic relativity. Odlin (2005) adopts the linguistic relativity hypothesis as a theoretical framework to explain cross-linguistic influences, especially to explain conceptual transfer from L1 to L2 or from L2 to L1. While highlighting the intersection between L2 acquisition and linguistic relativity, Odlin (2005) uses the concept of "binding power" of language to the mind or cognition. He points out that even highly skillful speakers of L2 "never free themselves entirely of the 'binding power' of L1" (p. 3) in L2 comprehension or production because cognitive templets are established in L1. By a similar token, Slobin (1996) proposes *thinking for speaking* as a moderate version of linguistic relativity, and notes that an L1-specific worldview affects the subsequent learning of another language.

Pederson et al. (1998) examined spatial relations using prepositions among 13 typologically and genetically different languages. Their linguistic data revealed that prepositions showed functional similarities, but represented different semantics across languages. Their nonlinguistic data showed a correlation between the cognitive frame of reference and the linguistic frame of reference in the same referential domain of spatial arrays among the languages. For example, Dutch speakers used direct deictic locations and gestures (e.g. *this one*; explicit pointing) to recall the location of objects, while speakers of Arandic, a language belonging to the Pama-Nyungan language family spoken in Australian, used their linguistic system of absolute Geo-cardinal-derived (and intrinsic) information (e.g., *north, south*) to recall the same objects. Speakers of languages using the absolute frame of reference, such as Tzeltal (Mayan language spoken in Mexico) and Longgu (or Logu; Austronesian language spoken in the Solomon Islands archipelago), tended to show more accurate recall of the location of objects than those who use the relative frame of reference, such as Japanese.

L1 effects on personality perception was also examined (Chen, Benet-Martinez, & Ng, 2014). Chinese-English bilinguals showed more dialectical thinking and differences between self-ratings and observer-ratings of personality when they use Chinese rather than English. They indicate that language affects personality

perception and that culture-related linguistic cues are perceived differently according to the language used to fulfill a specific demand.

Since studies of Chinese, Japanese, and Korean in relation to English are reviewed more in-depth in Chapters 8 and 9, I keep this section (of cross-language influences) rather short in this chapter. An expansion on linguistic relativity to script relativity is in order.

3.4 From Linguistic Relativity to Script Relativity

Lucy (1997) classified three levels of potential linguistic influences on thought: (1) semiotic level, (2) structural level, and (3) functional level. The semiotic level concerns "whether having a code with a symbolic component (versus one confined to iconic-indexical elements) transforms thinking" (p. 292). This inherently refers to the semiotic relativity of thought. The second level, structural level, involves a question of whether the morphosyntactic configuration of meaning affects thought or not. This is basically what the traditional linguistic relativity posits. The last functional level concerns a question of whether the use of language in a particular way affects thought or not. This largely has to do with the context or setting in which language is used (e.g., casual setting vs. academic setting).

Among these three levels, what is most related to my claim, *script relativity*, is the first level of Lucy's (1997) classification. Semiotic relativity has not been investigated or drawn scientific attention so far in the discussion of relativism. Given that linguistic relativity has been saturated for more than a half century, for better or worse, we can easily identify what is known so far and what is unknown so far. It is time to extend the linguistic relativity hypothesis to a s*cript relativity hypothesis*. In this regard, my claim is to extend semiotic relativity to *script relativity*. Semiotics is the study of signs, symbols, or sign processes. Although it includes nonlinguistic sign systems, semiotics primarily refers to the linguistic study of signs or symbols because meaning-making is crucial in semiotics.

Signs are by and large arbitrary. The arbitrariness of signs refers to the absence of natural connections between a sign and its sound or between a sign and its meaning. As most written signs are assigned arbitrarily within the writing system, arbitrariness is one of linguistic characteristics that is common among almost all languages. Although a Chinese logographic character signifies a meaning, the Chinese writing system is not free from arbitrariness. This is heightened in simplified characters. Strictly speaking, Chinese is not purely logographic because some signs refer to the morphemes of the word, while others indicate their pronunciation. In this sense, Chinese is a morphosyllabary, as indicated in Chapter 1. Since scripts rely on cultural conventions, each script has a unique convention that evolves over time.

Just like linguistic relativity that postulates that habitual language use results in a unique set of habitual thought and thinking patterns, habitual reading of a particular script has the great potential to yield unique thought processes or patterns in the

reader's mind as an embodied experience. As mentioned in Chapter 1, Logan's (2004) book entitled *The Alphabet Effect* captures this point well with the focus on the alphabetic script (regardless of criticisms that the book has received for Eurocentrism and the inaccurate presentation of Chinese characters). Dehaene (2009) notes, as one of the epilogues shows, that brain imaging shows that the fixed neural networks and circuitry of skilled adults' brains delicately adjust to reading. This suggests that prolonged literacy rewires our brain to be conducive to reading. Hence, it is natural to surmise the consequences of literacy, as many scholars (Goody & Watts, 1963; Logan, 2004; Ong, 1986) postulated before brain imaging technology becomes available.

The concept of the paradigm shift is related to linguistic relativity. The existing paradigm of anti-Whorfianism cannot explain why the same phenomenon is viewed and interpreted differently by different linguistic and cultural groups. This inability can be seen as Kuhn's (2012) term *anomalies* that nativists or opponents of linguistic relativity cannot explain. The anomalies have been addressed by extraordinary research of structure-centered and domain-centered subjects as well as L2-related inquiries with advanced research tools, including brain-imaging. Accrued findings have formed a new paradigm, which is neo-Whorfianism. If the paradigm shift from anti-Whorfianism to neo-Whorfianism is tenable, the extension of linguistic relativity, which is *script relativity*, has a sound ground. Hence, it can be said that *script relativity* is an offspring of the new paradigm shift.

Since I will gradually develop the thesis, *script relativity*, throughout this book, I use this section as a signal to a more in-depth discussion of the thesis in the following chapters in Part II, and, therefore, I keep this section rather short. In the meantime, I would like the reader to think about *competitive plausibility* between the pro-Whorfianism and the anti-Whorfianism. If Whorfianism is more plausible to explain how our perception and thought patterns are molded, I ask the reader again to think about how we are affected by what we read everyday. If you are a bilingual and biliterate individual, I ask you to think about the script-shifting between your most comfortable script in which you read and less comfortable script. If you are like me, you are likely to see differences in reading two scripts. I can sense differences in my eye movement and attention I pay within the passage during reading in Korean and English. I will cover the alphabet and nonalphabetic scripts in the following chapters for a comparison purpose. The Chinese, Japanese, and Korean writing systems are considerably different from the Roman alphabet. Although it is classified as an alphabetic script, the Korean writing system is discussed along with Chinese and Japanese as a batch of the East-Asian scripts due to its unambiguous syllabic configuration. In the following Part II section, discussed are the alphabet, the three East-Asian scripts, the difference between the East-West, and psycholinguistic and neurolinguistic evidence of *script relativity*.

Part II
From the Script to the Mind and Culture

Part II serves as the body of this book. It first reviews the evolution of the alphabet. In comparison, Chinese, Japanese, and Korean writing systems are extensively discussed. Since language has an interlocking relationship with culture, cultural differences between the East and the West are reviewed. The consequences of reading are summarized. Linguistic evidence that supports *script relativity* is reviewed. Finally, neurolinguistic evidence that suggests *script relativity* is also reviewed. Part II ends with a statement that, since *script relativity* is a new hypothesis, there have not been studies available that directly tackle script influences on our cognition in reading science. Just like linguistic relativity that has taken the vast amount of research for several decades to have it accepted by many scientists, if not all, much more research is needed to endorse or dismiss *script relativity*.

Chapter 4
The Alphabet

"Simply put, the invention of the alphabet reconfigured the world."

- Leonard Shlain (1998, p. 66)

Abstract This chapter discusses the characteristics of the alphabet as a writing system. It first describes the classifications of writing systems and the criteria for an ideal writing system, including representability, producibility, and interpretability. The alphabet is considered to be a more efficient writing system than Chinese characters in that it takes only 20 to 30 graphs to represent the entire repertoire of spoken language. This enhances learnability because learners do not have to rote-memorize thousands of syllables or characters. An ideal orthography is also discussed. Finally discussed are the strengths and weaknesses of the alphabet as a writing system.

Keywords classifications of writing systems · the alphabet · representability · producibility · interpretability · efficiency · ideal orthography

Shlain (1998) is apparently not alone in acclaiming the impact of the alphabet on the world. The efficiency and effects of the alphabet have been well documented and acknowledged in the literature (Havelock, 1976, 1986; Man, 2000; Logan, 2004; Wolf, 2007). The alphabet is a writing system in which graphemes represent the phonemes of spoken language as the minimal sound unit. The Phoenician alphabet (first known as the Proto-Canaanite script) is viewed as the first phonemic script and the forerunner of most modern alphabets, such as Greek, Arabic, Roman (Latin), Cyrillic, and Hebrew. The Roman alphabet, the Greek alphabet, and the Cyrillic alphabet (used for Russian and Bulgarian) are three representatives of the alphabet (Sampson, 2015).

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The first true alphabet is considered to be the Greek alphabet.[1] The Roman alphabet was basically derived from the Greek alphabet. Although they look different in shape from each other, more than half of the capital letters in the Roman alphabet are similar to those in the Greek alphabet, and several others can be seen as minor deviations from the Greek alphabet in shape (Sampson, 2015). The Cyrillic alphabet used for Russian and other Slavonic languages was developed as an upshot of the Byzantine mission to the Slavs by Cyril and Methodius in the 860s when Slavonic language had not yet been written systematically (Sampson, 2015). Since the missionaries and the culture were brought to the Slavs from Greece, the Cyrillic alphabet was primarily influenced by the Greek alphabet. As the Greek script was the genesis of the Roman-letter system and the Cyrillic writing system, the Greek alphabet is considered to be a paragon of humans' intellectual achievement as the alphabet.

Based on the genetic affinity with the Greek alphabet, the monogenesis hypothesis secures its ground for European alphabets. Claiming that the Roman alphabet, Greek alphabet, Cyrillic alphabet have a common root, Sacks (2003) remarks that "[a]mazingly, with the sole exception of Korea's Hangul script…, all of today's alphabetic scripts have a common origin" (p. 2). Sacks (2003) further claims that the "Roman alphabet is a third cousin to the Arabic alphabet, a second cousin to the Cyrillic alphabet, and a grandchild of the Greek alphabet" based on the pedigree of the scripts (p. 2).

Man (2000) asserts that the idea of the alphabet was "one of humanity's greatest ideas" (p. 1), despite its multifarious forms among alphabetic scripts. Havelock (1986) argues that the Greek alphabet "chang[ed] the character of the Greek consciousness…and in fact could be held responsible for creating the character of a modern consciousness…" (p. 10, cited in Sampson, 2015, p. 104). Before the alphabet was invented, information was shared from memory and through recitation because the public's accessibility to earlier writings was limited. Thus, the Greeks get credit for transforming the *works of recitation* into the *works of literature* (Man, 2000).

This chapter discusses the characteristics of the alphabet in light of its functionality as a script. Before discussing alphabetic characteristics, the classification of writing systems is in order to provide a global outline of writing systems. English is primarily discussed as the representative of the alphabet in this chapter. Other writing systems such as Arabic, Hebrew, Korean, and Chinese are mentioned occasionally only for comparison purposes. There is no attempt made to explore them

[1] Another view of the first alphabet involves a script found in Wadi el-Hol, Egypt, which is believed to be invented around 1900-1800 BC (see Wolf, 2007, pp. 51-53). This script bore some elements of the early Egyptian consonantal system and later Semitic Ugarit script. Some scholars view this script as a bridge between the syllabary and the alphabet, but the scarcity of writing evidence makes a thorough analysis difficult. A subsequent script, the Ugaritic system (originated from the kingdom of Ugarit, which is now the northern coast of Syria), is also considered the first alphabet, but it has both syllabary and alphabet characteristics.

extensively in this chapter because Arabic and Hebrew are beyond the scope of this book[2] and because Korean and Chinese are discussed in Chapter 5.

4.1 Classifications of Writing Systems

Writing is a system for recording and conveying messages through a set of written signs. Based on this notion, Adams (1990) defines three criteria for an ideal writing system as follows:

- The system must be capable of representing the range of expressions that its culture wishes to record or convey.
- The symbols must be reasonably easy to produce.
- The written message must be interpretable in the sense that it must readily symbolize for the reader what it was intended to symbolize by the writer (p. 14).

The first criterion, *representability*, involves the purpose of writing. Pictograms have a high level of representability in that the use of pictures to represent objects or concepts is possible in a mutually agreeable manner within a language group. A drawback of pictograms is that the interpretation of complex pictograms is not straightforward due to the ambiguity or opaqueness of the iconic value of the symbol (Adams, 1990). The second criterion, *producibility*, is related to the functionality of writing. Pictograms have a limited capacity to produce new words because of their limited repertoire and because they cannot embed linguistic properties within the signs. Logographs have a wider capacity than phonograms to produce new words. However, it is difficult to assign each logographic character to every morpheme or word in spoken language. The third criterion, *interpretability*, involves the practicality of writing. Pictograms can satisfy the third criterion to a large extent, given that symbols can be interpretable due to the description of the physical attribute of the object (e.g., {木} and {月} meaning a <tree> and <moon>, respectively). However, the requirement for the one-to-one correspondence between pictures and meanings restricts the range of expression and interpretability in pictograms due to the lack of the iconic transparency or interpretational accessibility of the system. Adams (1990) notes that no existing writing system satisfies all three of these criteria and that all writing evolves over time.

If a more liberal interpretation is granted to the above criteria, it can be said that all currently used writing systems have survived through natural selection by meeting these criteria. Written signs in a culture have evolved in the most feasible way to represent its spoken language. Therefore, *representability* is one of the key elements of written language. Regarding *producibility*, through the combinatorial rules of graphemes, written signs reflect the creative aspect of syllables and words in a

[2] It is because I base my argument on the three East-Asian scripts in comparison to English as representative foundations. An augmentation of script relativity to Hebrew and Arabic is the next step.

systematic way. This feature is the most dominant in alphabetic writing systems in that graphs are combined to form a syllable. However, Chinese characters also have the creative aspect because they at times combine characters to make new characters with radicals (semantic radicals and phonetic radicals) as well as combine characters to make compound words. Hence, producibility is embedded in all existing writing systems. The last concerns *interpretability,* in which not only should symbols be understood, but also common meanings are construed by readers. Written symbols are a medium for a shared understanding of a cluster of graphemes (i.e., words) in alphabetic scripts and characters in a logographic script within the linguistic community.

Depending on the criterion used for classification, the different types of writing systems can be categorized. Sampson (2015) classifies *writing* into semasiographic and glottographic systems. Semasiography is also called Blissymbols or Blissymbolics, which is viewed as an ideogram comprising several hundreds pure symbols (e.g., the symbol ⊥1 consists of the Bliss-character for *person* and the number 1 meaning the *first person pronoun*). Blissymbols was invented by Charles Bliss (a.k.a., Karl Kasiel Blitz, 1897–1985) who was a chemical engineer of the Austro-Hungarian Empire (currently in Ukraine). Inspired by Chinese characters, he developed the Bliss system in Shanghai and Sydney from 1942 to 1949. Importantly, these symbols do not correspond to the sound of any language at all. Since the symbols are not associated with any spoken language, semasiography is not considered a full-scale writing system; rather it is viewed as a theoretical possibility or the written signs for mathematics in a limited domain (Sampson, 2015). In contrast, glottographic systems function as full-blown writing systems, as they represent the sounds of spoken language. Glottography is broken down into logographic and phonographic systems. Logographic signs are rather iconic due to the use of graphic symbols that suggest meaning, while phonographic systems use arbitrary signs that do not necessarily suggest meaning. Logography represents morphemes, whereas phonography represents phonological units. Sampson (2015) breaks phonography into three subsystems: (1) syllabic, (2) segmental, and (3) featural. However, Sampson (2015) does not provide clear examples of each category, except for an explanation of "syllable-sized elements of English—the, cat, etc." (p. 33). As he mentions "… European orthographies are (at least approximately) segmental" (p. 33; parenthesis in the original), the minimal unit of European alphabets is the phoneme. Sampson's (2015) classification calls for a clearer rationale for or an explanation of the subcategorization of the phonography into the three subsystems. He acknowledges the questionable categorization of the featural system as in "… 'featural' script (an ugly term, but no better alternative is available)…" (p. 33; parenthesis in the original). The problem associated with this classification is twofold: First, the unit of his classification is not on the same scale across the three subcategories. Specifically, the branches of *syllabic* and *segmental* refer to the phonological unit, while the branch of the *featural* refers to the description of articulation manner and place. Second, Sampson designates Korean Hangul to a featural script, which is partially correct and partially incorrect. As described in Chapter 5, the atomic five consonants of Hangul describe the shapes of articulatory organs, but

extended consonants are hardly featural. Vowels represent the trinity of the universe (i.e., *heaven, earth,* and *human beings*). Therefore, the term *featural* does not sufficiently represent Hangul.

Gelb (1952) and Daniels and Bright (1996) note that the tripartite classification of logography, syllabary, and alphabet is the most common, although other alternatives are possible. This classification is feasible because all three of these writings can be seen as different scripts which are, strictly speaking, different in terms of the writing systems (Perfetti, 2003). Perfetti (2003) provides examples of the three writing systems in Chinese, Japanese Kana, and Korean Hangul for logography, syllabary, and alphabet, respectively, which are similar in a visual form but are different in the nature of the writing system (see Perfetti, 2003, specifically Figure 1 on page 5 for the example and his description). The Roman writing system can also be classified into three types: (1) abugida (alphasyllabary, Devanagari and other South Asian scripts), (2) abjad (consonantals, Hebrew and Arabic which do not generally depict vowels), and (3) alphabet (Cyrillic, Latin or Roman). The word *alphabet* stemmed from the Latin word *alphabetum*, which came from the Greek ἀλφάβητος (*alphabētos*) that originated from the first two letters of the Phoenician alphabet, *aleph* (meaning <ox>) and *bet* (meaning <house>). However, not all alphabets begin with *a* followed by *b.* Man (2000) notes that "Ogham, the Old Irish system, began BLF; Germany's medieval script, Runic, started with six letters after which it is named, the futhark ('th' being a single letter). Ethiopic began h-1" (p. 9). Accordingly, Man (2000) questions the use of the definite article *the* in front of the word *alphabet* as in "*the* alphabet," which needs to be further discussed in linguistics.

4.2 What Characterizes the Alphabet?

The alphabet refers to a general writing system that provides a greater flexibility than Chinese logography in the formation of the syllable, which is a byproduct of combining graphs of consonants and vowels. The minimal grain size corresponds to the phoneme in spoken language and the grapheme in written language, as opposed to the syllable being the minimal unit in the Chinese writing system. This feature allows about two dozen symbols in the inventory to represent the entire repertoire of spoken sounds by combining the symbols into a larger unit, such as syllables and words (Man, 2000; Wolf, 2007). The great contribution of the alphabet is the practicality or economy derived from the reduced number of symbols in a writing system as well as the efficiency that the limited number of signs bring to the extent that learners do not need to rote-memorize thousands of syllables or words like Chinese (Wolf, 2007). Since the alphabet uses a limited number of written signs, readers learn how to assemble individual signs or letters into a syllable or a word instead. Due to the nature of this blending principle, almost anyone can learn to read an alphabetic script without much trouble with proper training and learning time. The alphabet is often used in contrast to other types of orthographies whose letters represent syllables (e.g., syllabaries), morphemes or semantic units (e.g., Chinese or morphosyllablary), or mora (e.g., Japanese Kana or moraic syllabary).

Logan (2004) notes that, of all writing systems, the phonetic alphabet is regarded as the most efficient and economical transcription of speech into written codes, because it takes only 20 or so letters to create syllables that are enough to represent spoken language in text through a systematic blending of letters. From the perspective of encoding, the alphabet introduces a double level of abstraction in writing; that is, one level is arbitrariness between written symbols and phonemes, and the other level is representability of the letters of the alphabet. From the viewpoint of decoding (or reading), written language facilitates analytic processes through segmenting each word into phonemes as well as converting of visual signs to sounds. This explains why phonemic awareness skills are one of the critically important predictors of fluent reading in alphabetic scripts for children (National Reading Panel, 2002; Schatschneider et al., 2004).

The question of what makes a script an alphabet has drawn many scholars' attention over time. This leads to a question about a true alphabet. There are several features that characterize the alphabet. The first feature involves the alphabet's use of a standard ordering or collation, which means the assembly of written signs in a certain order. The fundamental rule of blending written signs works in accordance with phonotactic or graphotactic rules. The direction of placing the letter cluster is not monolithic although all Roman scripts are written in horizontal linearity. There is an alphabetic script that does not subscribe to the Roman script's linearity, however. Specifically, the Korean script, Hangul, is written in a square-like block. In appearance, Korean syllables resemble Chinese characters, but the nature of the writing system is close to English to the degree that a syllable block is composed of multiple graphemes. Another feature has to do with each graph's mapping unit. Again, each graph of an individual sound in the alphabet maps at the phonemic level, not at the syllabic level, as the minimal unit of sound in the language. The alphabetic principle constitutes not only graphs' representation of sounds, but also the blending of graphemes to form a syllable and a word. Although the alphabetic principle is universal among alphabetic scripts, the degree of the phoneme-grapheme correspondence varies across languages. Although an ideal practice would be a one-to-one letter-sound correspondence with perfect fidelity, this perfection is hardly achieved in practice (Adams, 1990; Sampson, 2015; Venezky, 2004).

Similar to Adams' (1990) criteria for writing systems, Wolf (2007) summarizes three criteria for being an alphabet, based on the stipulations made by a classicist Havelock (1976). First, a limited number of letters or characters with an optimal range between 20 and 30 letters successfully addresses the repertoire of the sound system within the language through a combination of the individual sounds. Since human attention and cognition have a limited span that does not allow for recalling a vast number of letters at a given time, it is efficient to handle a restricted number of letters. Using a minimal notational system to express a spoken language unambiguously is a great feat in human civilization. This provides cognitive efficiency and an economical use of our memory and effort that are involved in reading (Wolf, 2017).

Second, a comprehensive set of letters successfully conveys the minimal sound unit of the language. Again, in English, the minimal grain size of sounds

corresponds to the phoneme. The alphabet inventory includes 26 letters, but three letters (*c*, *x*, and *q*) are not used as the phonetic signs. The remaining 23 letters make 44 different speech sounds. This means that some phonemes do not exist in the alphabet letter inventory (e.g., [tʃ], [ʃ], [ð], [θ], [dʒ], [ʒ], [ŋ], [ə], [æ], [ə], [ʌ], and [ɔ]).

Last, orthographic depth refers to the degree of the grapheme-phoneme correspondence in a writing system. On the continuum of orthographic depth, orthographies that are close to the regular correspondence between symbols and sounds are called shallow orthographies, while orthographies that are skewed toward the irregular correspondence are called deep orthographies. The systematic rule of the letter-sound correspondence governs a given orthography regardless of the degree of consistency. The level of consistency varies across orthographies within the alphabetic system. The nature of English's being a deep orthography (i.e., the letter-sound correspondence is irregular and inconsistent; e.g., the "a" has different sounds in *h<u>a</u>ve*, *s<u>a</u>ve*, *<u>a</u>lter*, *<u>a</u>llow*, etc.) stems in part from the disparity between the number of letters and the number of phonemes (i.e., 23 vs. 44, respectively) and the large number of letter combinations (i.e., more than 100 combinations of graphemes to produce 44 phonemes). In contrast, Finnish is considered to be a shallow orthography. Psycholinguistic studies of reading processes and processing demonstrate that human abilities to extract orthographic regularities upon lexical input are efficient and strong such that complex patterns and irregularities involved in text yield only a small challenge with literacy practice, although the time period required for literacy acquisition can vary (Venezky, 2004). This seems to be true given that, with literacy instruction, typically developing children are able to gain the mastery of reading in English and Chinese, although deep orthographies take longer time to learn to read than shallow orthographies (Ziegler & Goswami, 2005).

Historically, earlier writing did not satisfy the criteria for being an alphabet that Wolf (2007) summarizes. The Greek alphabet (750 B.C.) was the first alphabet that met the above-mentioned criteria. In this regard, the Greek alphabet is considered an archetype of intellectual triumph in human history. The advent of the alphabet invited significant leaps in human cognition and power of thought. In a similar vein, Man (2000) asserts the idea of an alphabet is one of humanity's greatest ideas, and sums up the features of the alphabet as having *uniqueness*, *simplicity*, and *adaptability*. According to him, the alphabet is *unique* because it is efficient to record human speech. The alphabet is *simple* because the sound system of a language can be captured within the inventory of 20 to 30 graphemes. The alphabet is *adaptable* because "all human speech can be symbolized by two or three dozen meaningless marks" (p. 3).

Wolf (2007) identifies and underscores the characteristics of the alphabet. She makes three claims as follows:

- The alphabet is more efficient than all other writing systems.
- The alphabet stimulates novel thought best.
- The alphabet facilitates reading acquisition through enhanced awareness of speech (pp. 60–69).

First, the alphabet's efficiency mainly comes from the limited number of written signs that expresses the entire repertoire of oral language in the linguistic system. The limited number of written signs is incomparable to those of 900 cuneiforms, thousands of hieroglyphs, and tens of thousands of Chinese characters (Wolf, 2007). It should be noted that the efficiency refers to the capacity of the limited written signs' representations of oral language, not to the reader's efficiency. The Chinese reader's fluency shows that reading efficiency is not restricted to only readers of alphabetic scripts. Another example for reading efficiency with nonalphabetic scripts is the Japanese reader's fluency. As discussed in Chapter 5, Chinese and Japanese children's reading scores on the international comparison tests always rank on the top, whereas American children mark in the middle in rank.

Second, Wolf (2007) endorses Havelock's (1976) and Olson's (1977) hypothesis that the efficiency of the alphabet, the Greek alphabet in particular, made an unprecedented transformation in human cognition and stimulated novel thought by liberating people from the oral tradition. It is not that the alphabet exclusively has contributed to the generation of novel thoughts, but that the increased efficiency provided by the alphabet has made novel thoughts more possible for more people. This led to the democratization of information sharing, which is the revolution in our intellectual history. The Greek alphabet allowed the Greeks to have intellectual ascendancy that other ancient cultures did not provide. The Greek alphabet contributed to the democratization of knowledge in the sense that the alphabet was easier for everyone to learn than other script antecedents.

Finally, the invention of the alphabet required a thorough assessment of the sound system of oral language. It required that the entire speech stream be analyzed and segmented into individual sounds, which are phonemes. Efforts to match the grapheme and phoneme correspondence were materialized. Given that the speech stream can be segmented into each sound, the awareness of the sound facilitates learning to read more easily than other writing systems such as Chinese characters.

The ideal orthography would be a script that shows the advantage derived from cognitive efficiency and the economical use of memory and effort in reading and writing by having the one-to-one correspondence between the grapheme and the phoneme within the system. The one-to-one symbol-sound correspondence means the presence of a unique symbol for each distinctive sound and vice versa. In practicality, such orthography or script is nonexistent (Venezky, 2004). Deviations from the ideal one-to-one grapheme-phoneme orthography result from the necessity of distinguishing homophones, displaying permissible letter strings for words, and retaining morpheme identity within the word (Venezky, 2004).

Venezky (2004) identified the types of deviations from the one-to-one principle in English. First, the mismatch between symbols and sound categories (phonemes) resulted in a departure from the one-to-one letter-sound correspondence. In English and most other languages using Roman alphabets, the number of phonemes is greater than that of letters (again, 44 phonemes and 26 letters in English). Second, there is a discrepancy between spelling units and sound units in the order of presentation. For example, the words *where* and *which* have reversed pronunciation of the initial two letters as in /hw-/ or pronounce only one letter as in /w/. Another example

is final /əl/ sound in the words *bottle* and *little*, wherein the spelling and sound are reversed (Venezky, 2004). Third, there are redundant symbols, as in the trigraph *sch* for /sk/ in the word *school*. Doublets of consonants are another example for this: *manner*, *fulfill*, and *formatted*. Fourth, silent letters also contribute to the deviations from the one-to-one principle. The silent final "e" (e.g., *large, blue,* and *some*) is another example of this case. The final sounds of the words *damn*, *autumn*, and *hymn* are silent, but the final "n" is kept to retain morpheme identity because the final "n" is not silent in some inflected and derivational forms of words (e.g., *damnation*, *autumnal*, and *hymnal*, respectively). Fifth, the morphemic constancy and etymological principle lead to different sounds in derivational words. For example, the words *mechanic* and *machine* both retain "ch" spelling that reflects their Greek and Latin origins. Last, scribal constraints are also found as a deviation from the one-to-one principle. In English, graphotactic patterns adopted by late medieval scribes impose most of the scribal constraints in order to make reading easier. For example, a digraph "dl" does not appear as the onset position of a word because "dl" is implausible as a syllable-initial sequence in English (Venezky, 2004).

The utility of the phonetic alphabet has also been underscored. The alphabet that has signs for individual consonants and vowels is considered a "more economical and convenient instrument for representing sounds" than syllabaries, such as Chinese and Japanese (Goody & Watt, 1963, p. 316). Phonemic systems are easier to learn to read and write and to communicate abstract ideas than pictographic and logographic systems (Goody & Watt, 1963; Hannas, 1997; Logan, 2004). Although each letter is an arbitrary symbol in the alphabet that lacks a particular meaning, the limited number of graphs (generally 20 to 30 graphemes in phonetic alphabets) as well as their combining rules to form syllables do not demand the rote memorization of thousands of syllables. As a result, the burden of cognitive load and extra-resources required are likely to be mitigated in reading an alphabetic script.

4.3 Strengths and Weaknesses as a Script

As the alphabet is considered an efficient script (Man, 2000; Wolf, 2007), there are several strengths as a writing system. First, since it uses the small number of letters in the inventory, the alphabet allows for the economical use of memory and effort in learning to read and write, compared to Chinese characters (Wolf, 2007). The high degree of representability of speakable expressions with the limited number of letters ranging from 20 to 30 letters makes the alphabet "the apex of all writing" (Wolf, 2007, p. 55). Second, the alphabet does not have a monopoly on intellectual accomplishment. Coupled with the printing technology, the alphabet has contributed to a wide range of information distribution and sharing. Hence, it is considered a democratic script, as opposed to the three major syllabic systems, including cuneiforms, hieroglyphs, and Chinese characters, that were subject to a possibility of being confined to literate elites.

Regarding shortcomings, firstly, the high degree of abstraction involved in the script may be considered a challenge as a writing system. Due to the use of a limited number of written signs, learners need to learn how individual signs work and how to assemble them into a meaningful syllabic unit or a word. The nature of the alphabetic principle that governs the blending rule of the limited sign system is one of the strengths of the alphabet. However, this strength simultaneously imposes a shortcoming such that the limited number of letters enhances abstractness in the symbolic significance of the letters. The great number of children with reading disabilities in the U.S. may have to do with this abstraction embedded in the writing system. The incidents of reading disabilities in Japan and Korea are much lower than those of the U.S. Specifically, Uno, Wydell, Haruhara, Kaneko, and Shinya (2009) found that Japanese second graders to sixth graders have much lower rates of reading disabilities than those of U.S. students with different incidents of reading disabilities across the types of scripts: 0.4% for Hiragana, 1.4% for Katakana, and 6.9% for Kanji. Since a discussion of this aspect is beyond the scope of this chapter, no further information is provided (see National Center for Education Statistics, 2020). Relatedly and secondly, the alphabet can have opaque producibility because of the disparity between letters available in the inventory and phonemes represented in the spoken language. One letter may have multiple sounds to accommodate the larger number of phonemes than available letter signs, as shown in English. The letter "a" has multiple sounds in the context of being a monograph as in *approve*, *car*, *have*, *save*, *hall*, and *fare*, and in the context of having a neighboring vowel as in *heat*, *boat*, *instead*, *reach*, *learn*, *aisle*, *hair*, and *stay*. The digraph sign "ch" has two different sounds as in *church* and *monarch.* A third one has to do with the space required to write, compared to Chinese logography. Since English graphemes are spread linearly, more printing space is needed than Chinese characters. In addition, while Chinese, Japanese, and Korean can be written horizontally or vertically, English has only one horizontal printing orientation. This characteristic may not necessarily be a shortcoming but a matter of script affordance.

In the following chapter, the history and characteristics of the Chinese, Japanese, and Korean writing systems are reviewed. The strengths and weaknesses of each script are also discussed.

Chapter 5
Chinese, Japanese, and Korean Writing Systems: All East-Asian but Different Scripts

Abstract The three East-Asian scripts—Chinese (characters and Pinyin), Japanese (multi-scripts), and Korean (alphabetic Hangul)—are discussed. Under each script, a brief historical account of the given writing system, the key features of the script, and the strengths and weaknesses as a script are described. The commonalities and differences among the three scripts are next discussed. Since it is claimed that Asian orthography, particularly Chinese characters, curbs Asians' creativity (Hannas, 1997, 2003), East-Asian students' performance in international comparison tests is reviewed in comparison to that of American counterparts. Finally discussed are the implications of script differences among the three writing systems for script relativity.

Keywords script differences · Chinese characters · Pinyin · Kanji · Kana · Hangul · implications for script relativity

If there is a truth to the "McLuhan Equation" shown above, differences in the "medium" can result in differences in the message conveyed. Based on McLuhan's (1964) words, Federman (2004) notes that "… the medium of language extends our thoughts from within our mind out to others … since our thoughts are the results of our individual sensory experience…" (p. 2). Therefore, it is possible that the medium of written language plays a role in the extension of our thinking and cognition.

Historically, China exerted a massive impact on Korea and Japan in many respects. With the immense influence of China on Korea and Japan, the three countries have common cultural traditions. According to Taylor and Taylor (2014), Chinese, Korean, and Japanese are closely related geographically, historically, culturally, and racially such that they can be discussed within one book. However, they are not monolithic. Although they share cultural heritage, the three countries have different oral and written languages from one another, except for the partial use of Chinese characters

"The medium is the message." Marshall McLuhan, (1964, p. 9)

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in Japanese and Korean[1] written languages. Since their oral languages do not have common genetic affinity[2], the adoption of Chinese characters in the Japanese and Korean writing systems was not seamless. Chinese characters or words are used as Sino-Japanese or Sino-Korean words, which means the use of Chinese characters in Japanese and Korean pronunciation, respectively, on top of their native lexicons. For example, the character {人}, that has a shared meaning of a <person>, is pronounced differently across the three countries: /rén/ in Chinese, /hito/ in Japanese, and /in/ in Korean. Possibly due to the differences in both oral and written languages, the people of the three countries exhibit differences in many aspects, even though Westerners tend to lump the people together by physical appearance.

This chapter mainly discusses the three East-Asian scripts—Chinese, Japanese, and Korean—in terms of the medium of written language. These East Asian scripts are clear deviations from the monogenesis hypothesis in which all scripts in the world are assumed to stem from one writing, the Sumerian script. Sampson (2015) notes that "[b]y now… the argument against monogenesis is conclusive" (p.57). Each of these three scripts bears significant implications for literacy and their effects. The extent to which commonalities shared among the three scripts as well as major differences among them cannot be found in any other three languages in the world. Sampson (2015) notes that Korean is "much more different from Chinese than one European language is from another" (p. 144). This is also true for the lack of typological affinity between Chinese and Japanese. Although Sampson's (2015) reference was made to spoken language, the same extends to written language. Despite the differences among the three scripts, Chinese script was not only ancestral to the Japanese writing system, but also the motivation for the invention of the Korean writing system, Hangul.

Based on their idiosyncratic characteristics, this chapter elucidates how the three scripts are similar and how they are different from one another. Chinese script is first discussed, followed by Japanese and Korean. Given the vast influence of Chinese on Korean and Japanese, Chinese characters are more extensively covered than the other two. Under each script, a brief historical account of scriptal evolution is first provided, followed by the linguistic features of each script. Finally, the strengths and weaknesses of each script are identified.

5.1 Chinese Script

China brought itself to the forefront of the entire region of East Asia in antiquity. China invented printing, the compass, gunpowder, porcelain, paper, and silk before the West. Moreover, China had more technological advances than western Eurasia

[1] Chinese-derived Hanja are used in Korea. However, the use of Hanja has been discouraged by the government since the 1980s.

[2] Chinese belongs to the Sino-Tibetan language family. It was traditionally considered that Japanese and Korean belonged to the Altaic language family. Recently, a linguistic camp classifies both languages as language isolates. The debate over the language family still continues.

until about A.D. 1400 (Diamond, 1999). According to Sampson (2015), half of all books ever published in the world were written in Chinese before 1900[3]. The explosion of publications in Chinese was possibly due to the inventions of block printing around A.D. 600 and movable wooden type printing around A.D. 1040, which was way before Gutenberg's mechanical movable type printing invented in Germany in 1439 (Man, 2000).

Chinese is the most commonly spoken language in the world among over 1.3 billion people (Ethnologue, 2005; Wikipedia.org, 2019). Chinese is spoken by Chinese natives and those who have Chinese heritage in Mainland China, Taiwan, Singapore, Hong Kong, Malaysia, Thailand, and Vietnam, as well as by Chinese immigrants in European countries, North America, and Australasia. The use of the Chinese writing system alone is on par with the use of *all* alphabetic scripts.

Concerning the representation of written language, Chinese has been considered to comprise pictograms (mainly by nonlinguists; e.g., {月} depicting <moon>; {木} depicting <tree>), ideograms (e.g., {一} meaning <one>; {三} meaning <three>), and logograms (e.g., {花} <flower>; {开花} <blossom>). The common designation is a logography (*logo* = word; *graph* = written symbol), representing the meaning primarily and the sound secondarily (Taylor & Taylor, 2014). Based on the feature that a character represents a morpheme in a syllabic unit, a term *morphosyllary* has been used to refer to the Chinese writing system (Leong, 1997).

Some scholars claim that Chinese characters are inefficient for learning, compared to the alphabet, because it takes long to learn to read in Chinese due to the vast number of characters to master (Hannas, 1997; Man, 2000; Wolf, 2007). Notwithstanding their inefficiency and complexities, Chinese characters have endured for more than 5,000 years. The Chinese writing system is the only one, among all writing systems invented before 1,000 B.C., which is still used by a great number of people in the world. This causes a number of questions to arise: What has made the Chinese writing system endure so long, despite its inefficiency? Is it the case that precedence or tradition surpasses convenience or efficiency? In addition, if it was inefficient, how could Chinese native students excel over their counterparts in the world in reading, as shown in the results of an international test (PISA, 2018)? If there is a truth to the claim of Chinese characters being inefficient and if Hannas' condemnation of Chinese script is justified, how could the Chinese writing system exert an immense influence on the Japanese writing system? This does not fit well with the notion of natural selection. The remaining part of this chapter attempts to address these questions in terms of historical considerations, scriptal characteristics, and cultural compatibility.

[3] Man's (2000) assertion based on an estimate by John DeFrancis is even higher than Sampson's estimate (2015), as shown in his remarks "Chinese printed matter exceeded that of all the rest of the world combined" (p. 58).

5.1.1 A Brief Historical Account

5.1.1.1 The Origin of Chinese Writing

The emergence of Chinese characters is rich in history and distinctive in writing. Although some archeologists trace the origin of Chinese characters back to about 8,000 years ago, a credible account goes back to the Neolithic times around 5000 to 3000 B.C. (Dematte, 2010; Taylor & Taylor, 2014). Evidence from the Yangshao culture developed in the middle and lower runs of the Yellow River in northeast China (a.k.a., the cradle of Chinese civilization) shows painted pottery, stone implements, and incised signs in farming communities (Taylor & Taylor, 2014). Simple linear signs and pictures of animals, such as fish and frogs, resembled characters engraved in oracle bones, which suggests that these Neolithic signs might be the harbinger of Chinese characters.

The earliest full-fledged Chinese writing is considered to have been developed during the period of 1300–1200 B.C. under the Shang dynasty (1675–1029 B.C.[4]). Written signs preserved on bronze vessels and divination bones were found in Anyang county, Henan Province in China, which was the last capital of the Shang dynasty (Bagley, 2004). The Anyang writing includes divination inscriptions for oracle texts on animal bones (mainly oxen bones), either interior or exterior turtle shells, bronze inscriptions, and other inscriptions written on shells, jades, stones, pottery, wood, and bamboo slips. Early bronze scripts representing clan names, which were decorative and pictorial, were written with a brush in the varying degrees of thickness (Taylor & Taylor, 2014). In the early twentieth century, numerous excavations discovered over 175,000 pieces of bones and shells, bearing over 4,500 different characters, in the Anyang area (Taylor & Taylor, 2014). Although the Chinese writing system has evolved for more than 3,000 years, there has been little change in the style of writing, except for the simplification of characters (Lu & Aiken, 2004).

5.1.1.2 Debate over the Origin

Although the Anyang evidence is the main interpretation of the origin of Chinese writing, it is still uncertain when, where, why, and how the Chinese script was invented, because it is possible that archaeological evidence and records of pre-Anyang inscriptions have not yet been discovered, have perished, or have been nonexistent. The explanation of the origin of the Chinese script makes three assumptions. The first hypothesis is stimulus diffusion, meaning that footsteps toward the Chinese written signs can be traced back to Mesopotamia. This hypothesis is open to

[4]The ruling period of the Shang dynasty varies across resources (e.g., According to *Bamboo Annals*, the Shang dynasty ruled from 1556 to 1046 BC). The years reported in this chapter are based on the *Xinhua Dictionary* (新华字典), which is widely considered a reliable source.

questions. Deringer (1996) claimed that "[t]he general conception of writing might perhaps have been borrowed, directly or indirectly, from the Sumerians, but not a single sign taken from the Sumerian system can be found. A dependence on Egyptian hieroglyphics is still more unlikely" (p. 66).

The second hypothesis, which is the oldest and most persistent interpretation, is that the precursors of the Anyang script were lost, and we can only assume the trajectory based on clan signs on Anyang bronzes. For example, some early oracle inscriptions on bones disappeared with the collapse of the Shang dynasty (Deng, 2018).

The third hypothesis is a sudden invention of full writing with no archaeological trace. This hypothesis posits that a few gifted officials (perhaps diviners) discovered the value of a sign system that could represent oral language and invented full writing without evolutional footsteps (Bagley, 2004). A legendary tale is actually available to fulfill this line of assumption as follows.

> Long, long ago, in the golden age, there was a dragon horse which came up out of the Yellow River with curious symbols traced upon its back, and revealed them to Fu-hi (the first of China's legendary primeval emperors). This potentate copied them and thus acquired the mystical characters, which later became the skeleton of I King [*I Ching* or *Yijing*; *Book of Changes*], the Canon of Changes, one of the Five Canons [Confucian classics]. And under the third primeval emperor, Huang-ti [Huang Di], the minister Ts'ang Kie proceeded further along the path of invention and fashioned the first primitive characters, by copying footmarks of birds made in the sand. (Karlgren, 1923, p. 32, cited in Taylor & Taylor, 2014, p. 36)

The competing hypotheses regarding the origin of Chinese writing (i.e., gradual evolution vs. sudden invention) raise questions about the dynamics and timing of the development of Chinese writing. They also raise a question on the nature of writing as the function of social and cultural phenomena. An independent development of a script typically takes a form of evolution over time. As shown in the cases of Mesopotamia and Egypt, writing is likely to have developed from an earlier sign system by undergoing an extended period of evolution before establishing the status of an efficient tool of language-recording (Demattè, 2010). Like the Korean writing system, Hangul, it is possible that a new writing system is invented out of the blue as a result of top-down governance or as a secondary writing system that complements the primary writing. However, this has been scarce in history.

In favor of the view of a gradual development rather than a sudden invention, Demattè (2010) used four criteria to identify valid evolutionary evidence for Chinese as follows: (1) intentionality and structural coherence of shapes and systematic use, (2) morphological relationships with bronze and bone scripts of the Shang dynasty, (3) an expansion of regional systems over time, and (4) emergence out of the relative socio-political complexity. Based on these criteria, Demattè (2010) concludes that the Chinese writing system evolved from Dawenkou, Liangzhu, and Shijiahe graphs. The forms and usage patterns of these graphs indicate that these signs could fulfill the objectives of simple recording tasks without phonology and syntax. Although it is debatable whether these three signs meet the definition of writing, Demattè (2010) argues that Dawenkou, Liangzhu, and Shijiahe graphs did serve as

the beginning thread of the mature Chinese writing of the Shang oracle bone inscriptions and that non-linguistic signs also influenced the emergence of the writing system.

Studies of the early Mesopotamian epigraphic corpus indicated that writing was inscribed to control the production of agricultural goods, animal husbandry, and transactions (Bagley, 2004; Logan, 2004; Lu & Aiken, 2004). Despite the lesser degree of intensity, the Chinese Anyang writing was also used for managing agricultural bases, craft enterprises, and commercial applications. The earliest archeological evidence for Chinese shows that pottery inscriptions, including the numeric information of products and transactions, had the highest frequency of occurrences, suggesting that the purpose of early writing was for counting and book-keeping (Lu & Aiken, 2004). One difference from the Mesopotamian writing was for divination purposes, such as the genealogies of ancestors who received sacrifices and the schedules of sacrifices as well as the king's military campaigns (Bagley, 2004). As full writing is the byproduct of social and political functions as well as activities of administrative applications, ownership assurance of goods, divination records, and royal display were likely to be a collective impetus for the development of Chinese writing.

5.1.1.3 A Road to Modern Characters

Following the Shang dynasty, the Western Zhou dynasty (circa 1046–771 B.C.) reigned, followed by the Eastern Zhou dynasty (Taylor & Taylor, 2014). The Eastern Zhou dynasty was broken down into two periods: Spring and Autumn (770–476 B.C.) and Warring States (475–221 B.C.). During the Warring States period, society went through significant changes as the powerful lost their power, aristocratic privilege, and hereditary ruling class. After the powerful lost control over the monopoly of writing, non-aristocrats started to use writing. As a result, a variety of script styles were developed in different Warring States. When the Warring States was unified in the third century B.C., the first emperor, Qin Shi Huang (a.k.a., Qin Shi Huang Di)[5], strived to standardize the varied shapes of characters used at the time in a small-seal script (*xiaozhuan*) by simplifying the traditional Western Zhou great-seal script (*dazhuan*). The small-seal script was used mainly for inscriptions on stones and formal engravings (Taylor & Taylor, 2014). The Qin emperor's standardization of Chinese characters served as a catalyst for unifying Chinese people who spoke diverse dialects. The emperor was the first monarch who could read and required literacy to be included in the regimen of emperor training.

The small-seal script, which was the orthodox script in the Qin period, was the last form of old Chinese writing. The simplified seal characters evolved into a clerical script (*lishu*), which was named on the basis of its use by official clerks and got

[5]The first emperor's achievement was also recognized in the standardization of coins, weights, measurements, and the expansion of the Great Wall. Taylor and Taylor (2014) note that the word China originated from *Qin* spelled *Ch'in* based on the Wade-Giles Romanization system.

popularized at that time with writing on bamboo strips (Bagley, 2004; Taylor & Taylor, 2014).

In the Han dynasty (206 B.C.–A.D. 220), the modified clerical script paved its way to orthodox writing. As demands for official documents grew greater, writing on bamboo strips was replaced with writing on silk and paper with brushes. The clerical script gradually evolved into the standard script (*kaishu*) during the late Han dynasty. The advent of printing technology in the late Tang (618–907) and early Song (960–1279) dynasties led to the more prevalent use of the standard script. In handwriting, a shorthand version of the clerical and standard script became highly cursive, called "grass script" (*caoshu*) describing the "dance of the brush." Among a variety of cursive versions, "modern cursive" (*jincao*) was the most common. A semi-cursive form of "running script" (*xingshu*) was also developed, which was one of the two most commonly used scripts in the Tang dynasty, along with the standard script. In modern China, the traditional characters have been simplified several times since 1935, which became the orthodox form of characters.

5.1.2 Features of Chinese Script

Sampson (2015) summarizes the features of the Chinese writing system, which are not mutually exclusive. First, syllables are demarcated such that syllabic boundaries are clear and unambiguous. This is different from English in which syllable boundaries are opaque within the word. Relatedly, there is no space used between words. Since each character is written in a square block, sentences are legible without spaces between words. Second, morphemes are co-representative with syllables, as a morpheme generally corresponds to a syllable[6]. Since the minimal writing unit corresponds to the syllable, there is no morpheme available at the phonemic level. This is also different from English in which a fraction of a syllable represents a morpheme as shown in the plural marker "s" in *cat*<u>*s*</u> or the past-tense marker "ed" in *walk*<u>*ed*</u>. Third, there are neither inflections that occur at prefix or suffix levels (i.e., no coalescence of roots with affixes) nor morphophonemic alternation. Chinese is not subject to inflections as in Japanese, Korean, and English. For this reason, Sampson (2015) claims that Chinese is an isolating language, in which each word form typically comprises a single morpheme. Last, although each character is written independently, Chinese is not entirely monosyllabic because compound words are the norm and there is the small number of polysyllabic morphemes/words (see footnote 6 in this chapter). Mandarin has fewer than 1,300 distinct syllables (Hannas, 1997). Since no language can survive with only a few thousand monosyllabic words, DeFrancis (1984) notes that the belief of Chinese to be monosyllabic is a myth.

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[6] Chinese has a small number of polysyllabic morphemes with a pair of sound-meaning compound characters, especially for plants and small animals (e.g., {蝴蝶} */húdié/* <butterfly>). Other cases are associated with adjectives (e.g. {忐忑} /tǎntè/ <nervous>; {黃澄澄} /huángdēngdēng/ <very yellow>).

Another feature that is pivotal within the Chinese writing system is the presence of the subcomponent of the character, called *radicals* (i.e., *bushou)* including 541 radicals (Chinese Radical Position Frequency Dictionary, 1984, cited in Wang, Perfetti, & Liu, 2003a). Simple characters can stand alone as independent characters (e.g., {子} /zi/ <child>; {月} /yuè/ <moon>) and can be used as the subcomponent of the compound character as the radical (the independent character {火} /huǒ/ <fire> becomes {灬} located at the bottom of the character as the radical; {水} / shuǐ/ <water> becomes {氵} located to the left of the character as the radical; {刀} /dāo/ <knife> becomes {刂} located to the right of the character as the radical). Radicals constitute semantic radicals suggesting meaning and phonetic radicals suggesting sound in the forms of side-by-side, top-to-bottom, closed inside–outside, and open inside-outside. However, semantic and phonetic radicals within characters are not highly reliable in terms of character identification.

There are also compound words. Chinese compound words have systematic ways of combining two characters, and, in general, have three types of morphological construction, including *subordinate* (one character supports another; e.g., {房型} /fáng xíng/, house + model, layout of house), *coordinative* (two characters equally contribute to the meaning; e.g., {蔬果} /shū guǒ/, vegetable + fruits, <vegetable and fruits>), and *attributive* (the descriptive character precedes a noun, verb, or adjective; e.g., {天价} /tiān jià/ sky + price, <high price>; {速递} – /sù dì/ fast + to pass <express delivery>). Kuo and Anderson (2006) further classify the structures of compound words into five types by categorizing the *attributive* compound words into three types, including subject–predicate (e.g., 公立 /gōnglì/ public-establish, public), verb–object (e.g., 吃饭 /chīfàn/ eat-meal, to eat), and verb/adjective-complement (e.g., 改进 /gǎijìn/ change-forward, improve; see also Sun, 2020; Sun, Zhao, & Pae, 2020).

5.1.2.1 Simplified Characters

A simplification of the traditional script took place by reducing the number of strokes and by changing the shapes of the graphs in order to decrease the complexity of characters and relieve the burden of writing (e.g., traditional characters → simplified characters: {開} → {开}, {燈} → {灯}, {廣} → {广}, {學} → {学}, {葉} → {叶}, {關} → {关}). The graph simplification did not make Chinese characters lose the status of being a logography, as Sampson notes "[t]he simplified graphs are as logographic as those they replace…" (p. 193).

The effort to simplify characters began in the late twentieth century with cursive written text. The first effort for simplification yielded 324 characters introduced in 1935. The government of the People's Republic of China authorized simplified characters that were prescribed in the *List of Simplified Chinese Characters* for use in Mainland China since the 1950s and 1960s to promote literacy. The People's Republic of China issued the first phase of simplified characters in two documents. The first document was published in 1956 and the second one in 1964.

The second attempt for simplification was promulgated in 1977, but it never materialized due to the public's confusion and the unpopularity of the second effort for simplification. The unsuccessful attempt culminated with the Cultural Revolution (1966–1976) which occurred to preserve the communist ideology and Mao Zedong's doctrine by eradicating capitalist and traditional values from the Chinese society. Due to the apprehension created by the Cultural Revolution and Mao's death in 1976, the second phase of simplification was not successful. The government withdrew the second-phase simplification and endorsed the 1964 document with minor changes. The revised *List of Simplified Chinese Characters* comprising 8,105 simplified characters (including 45 newly recognized characters and 226 characters that were not explicitly acknowledged in the previous document) was officially endorsed for use by the State Council of the People's Republic of China in 2013. Not all Chinese-speaking countries have adopted simplified characters, however, as Taiwan, Hong Kong, and Macau still use traditional Chinese characters.

The method of simplification involved structural simplification by replacing or omitting some components and by adopting new character forms. The simplified form made greater use of phonetic substitutions than the traditional forms. Before the reform, the average of strokes per character was 11 to 12, depending on characters considered in the sample. Based on the count of 2,000 most frequently used simplified characters, the stroke count dropped from 11.2 (traditional) to 9.8 (simplified) strokes, on average, indicating a 12.5% drop. The figure rises to 16.2% of drop in the simplified version for running text (DeFrancis, 1984; Hannas, 1997).

Simplification resulted in more obscure radicals. According to Matthews' Chinese-English Dictionary, 830 characters out of 7,773 entries have lexicographically obscure radicals (Hannas, 1997). This number comprises 11% of the radicals in the inventory that are obscure, based on lexicographic standards. However, Hannas (1997) asserts that simplification has made readers become less dependent on the morphemic representations of characters because simplified characters lose ideographic illustrations, and paved the way to the phonetic writing addendum, Pinyin.

5.1.2.2 Pinyin[7]

Due to the complexity of characters, an effort to facilitate reading led to a creation of Pinyin (literally <spelling sounds>), which is a system for transcribing the sounds of Chinese. The Pinyin system was developed in the 1950s and was formally adopted in 1958 as a notational tool. The Chinese government revised it several times. Pinyin uses the Roman alphabet (except the letter {*v*} due to the nonexistence of its sound in standard Mandarin) as well as diacritics for tone to indicate pitch contours rather than the sounds of characters. Since 1979, Western publishers have accepted Pinyin as the standard. This is why the name {毛澤東} (traditional) or {毛

[7] The Chinese transliteration system or phonetic symbol for Taiwanese Mandarin is Zhuyin (注音).

泽东} (simplified; /Máozédōng/) is now spelled "Mao Zedong" rather than "Mao Tse-tung" (Sampson, 2015). The International Organization for Standardization adopted simplified characters as an international standard in 1982, followed by the United Nations in 1986. Taiwan adopted Pinyin in 2009, but it is partly used for the purposes of international events, not for educational purposes. Another phonetic symbol, 注音符號/注音符号 /zhùyīn fúhào/, is used for transliteration or annotation of sounds only for Taiwanese Mandarin.

5.1.2.3 The Number of Characters and Their Complexity

As for the estimate of characters, there have been efforts to quantify characters in use. The first notable effort was made by the lexicographer Xu Shen who included 9,353 characters in the *Shuowen Jiezi* ("*The Explanation of Simple Characters and Analysis of Composite Characters*") in A.D. 121. The second attempt was made by 30 scholars under the Qing emperor Kangxi when the authority defined 47,035 characters to include in the *Kangxi Dictionary* in 1716. The third notable attempt was made by the Chinese Character Analysis Group in Taiwan when it identified and defined about 74,000 entries in the 1980s, including 49,300 standard characters and additional 24,700 variants (which took different forms of characters but had the same meanings and sounds as standard characters). More recently, *The Dictionary of Variant Characters* (*Yitizi Zidian*) included 106,230 entries in 2004 (Taylor & Taylor, 2014). Hannas (1997) shows another estimate, as in "[t]he *Chung-wen Ta-tz' utien (Zhongwen dacidian*), which appeared in thirty-eight volumes between 1962 and 1968, held the record at 49,905 characters until eclipsed by the recent appearance in the People's Republic of China of *Hanyu dazidian* which has nearly 60,000 entries" (p. 131).

The large number of characters indicates that there is no theoretical and practical limit to the number of characters in the writing system. In principle, the increasing number of characters can be infrequently observed because new characters can be created to address newly emerging concepts, new tools, or new discovery (e.g., newly created character {熵}/shāng/ for <entropy>, using the existing radical {火} /huǒ/ <fire> indicating <energy> and {商} /shāng/ <quotient> referring to the physics term *entropy* being defined in a form of division) on top of creating new compound words using existing characters (e.g., {电脑} /diànnǎo/, *electric* + *brain*, <computer>). A large-scale study conducted by the National Publication Bureau of China in 1975 counted a total of 24,213,955 characters that appeared in various outlets, such as science, newspaper, arts, literature, and politics, but only a little over 6,000 different characters were used for the total number of characters examined in the study (Taylor & Taylor, 2014). Another estimate shows a similar count; the number of characters currently in use in Chinese is about 7,000 (Zhou, 1987, p. 22,

Table 5.1. A Wide Range of Character Strokes

Character	# Stroke	Meaning
一	1	one
木	4	tree
林	8	grove
森	12	forest
龍	16	dragon
鬱	29	melancholy
	64	exorcism
	64	too talkative

(Modified from Table 3–6, Taylor & Taylor, 2014, p. 53)

cited in Hannas, 1997, p. 132; see also Table 3–5 in Taylor & Taylor, 2014, p. 49). However, Mandarin has fewer than 1300 distinct syllables (Hannas, 1997), as indicated earlier.

The complexity of characters ranges from one stroke to more than 60 strokes. The character meaning number <one> is written with one horizontal line stroke {一}. The character meaning <melancholy> has 29 strokes {鬱}. The most complex character has 64 strokes, albeit rare usage. Table 5.1 shows characters from the simplest to the most complex. A systematic form of addition is observed in the case of singlet {木} that becomes a doublet {林} and further a triplet {森}. An extreme case of addition is found in the character at the bottom of Table 5.1. The character has duplicates up to four times within a single character with the character {龍} meaning <dragon> twice at the top and twice at the bottom.

5.1.3 Strengths and Weaknesses as a Script

Whatever script a culture adopts, the writing system practically reflects linguistic, psychological, and cultural features of the nation at the surface level. Although a logography can be considered inefficient because of rote-memorization and longer time taken to master than the alphabet (Hannas, 1997; Man, 2000), Chinese characters may fulfill the linguistic needs of spoken Chinese and be conducive to Chinese culture. The logographic characteristics of the Chinese writing system bear several linguistic strengths. Given this is a semi-concluding section for the Chinese writing system, some overlap is inevitable. First, due to its logographic characteristics, in principle, each morpheme in Chinese has its own graph. This means that, in general, the huge number of characters corresponds to the number of morphemes or words in the language. The *Kangxi Dictionary* of 1716, which

was the largest Chinese dictionary, contained about 47,036 graphs. In comparison, the *Oxford English Dictionary* included "less than a third of the period covered by a major Chinese dictionary" in the eighth century (Sampson, 2015, p. 194). The large number of characters to learn requires the learner to take unbearable time until mastery. There may be a trade-off, however. Mattingly (1972) notes that phonographic writing systems, such as English, may show "… more reading successes, because the learning time is far shorter, but proportionately more failures too, because of the greater demand on linguistic awareness" (p. 144). If this is true, the time and effort to learn to read in Chinese may be rewarding because an analysis for syllabic parsing and a synthesis of letter clusters to make sense of a word are not necessary when decoding Chinese characters. Based on Mattingly's (1972) statement, reading Chinese characters, once they are acquired, does not require linguistic awareness of subsyllabic units, such as phonemes, onsets-rimes, or bodies-codas, because it is unnecessary; as a result, it may lead to efficient reading overall by going through *direct* processes without assembling processes of consonant and vowels. Notably, an international comparison of students' achievement in reading constantly shows Chinese students' reading success (this is revisited in a later section of this chapter in more detail). If there is a truth to Mattingly's argument, the outstanding performance of Chinese students would not be accidental. Undoubtedly, the payoff for Chinese would be the cultural dedication to learning at home and school.

Second, in principle, a Chinese character represents a morpheme such that each morpheme is an invariant of the syllable, except for the small number of polysyllabic morphemes. The nature of monosyllabic morphemes allows for no theoretical limit to how far the inventory of characters can expand (Hannas, 1997). This is evidenced by about 60,000 entries of characters in *Hanyu dazidian* (Hannas, 1997). Due to its self-sufficient nature of morphology, Chinese did not have to borrow morphemes from other languages to any significant extent (Sampson, 2015).

Last, the writing orientation of Chinese characters offers greater flexibility than that of English. Since they are written in blocks, Chinese characters can be written either horizontally or vertically depending on space availability or the author's intention. Although the left-to-right writing direction has been the norm since 1949[8], characters used to be written vertically right-to-left across the top of the page until the later time of the Qing Dynasty (A.D. 1892).

As for the weaknesses of Chinese characters, the most obvious drawback has to do with the large number of individual tokens and the complexity of their signs. The large number and the complexity of Chinese characters make children take much more time to learn to read than any other written language. In general, it takes six years for children to learn to read in Chinese (The Curriculum and Teaching Materials Research Institute, 2009). In response to the challenge of mastering such

[8] Vertical writing direction still remains in Taiwan, especially newspapers and magazines, along with the use of horizontal text.

a large number of characters, the Ministry of Education of the People's Republic of China (2011) published the *Curriculum Standards for Chinese Characters in Compulsory Education*, which spelled out the numbers of characters that were expected for students to acquire at different grade levels. Grades 1–2 are expected to be able to read 1,600 and write 800 commonly-used characters; Grades 3–4 are to read 2,500 and write 1,600 characters, cumulatively; Grades 5–6 are to read 3,000 and write 2,500 characters accumulatively; and Grades 7–9 are to read 3,500 characters accumulatively.

Inputting logographs into computers or electronic devices is not as easy as letters or graphs in the alphabet (Sampson, 2015). In order use computers or devices, individuals first type the Pinyin for the character of interest and then select the proper suggestion from the pop-up bar with a mouse or select the number associated with a suggestion to enter it. The speed of typing graphs or words per minute is quite comparable with that of European-language typists (Sampson, 2015). However, non-professional typists or learners of Chinese apparently go through an extra-step in Chinese typing.

Another shortcoming may be the large number of homophones, although it is difficult to consider this a weakness. Since Chinese characters represent more than speech, Chinese users can distinguish sight words that have the same sound quality using different tones. A homophone{谐音} /xié yīn/ in Chinese refers to words that have the same pronunciation but different meanings, origin, or word form. Due to the use of tones indicating the meaning of the spoken word, Chinese has an abundance of homophones. Perfetti, Liu, and Tan (2005) note that "[m]odern-day usage incudes 420 distinct syllables (disregarding tone) mapped onto about 4,574 characters … on average, 11 characters share a single pronunciation … Tone disambiguates a large number of these cases, but ample ambiguity remains (about four homophones for each character)" (p. 44). Table 5.2 shows an extreme case of the same sound with different tones. It is a 64-character story using a one-sound word /shi/ with different tones. The title, story, and its translation are shown in Table 5.2. below.

Regardless of strengths or weaknesses, pragmatically, a relatively small number of characters accounts for most print materials. This makes Chinese more accessible to learners of Chinese because they can identify characters or read Chinese with a mastery of a small segment of the character inventory. DeFrancis (1984) analyzed a corpus of 900,000 characters of written texts to find that the most frequently used 100 characters account for 47%, and 1,100 characters accounted for 90% of the text. Of 30,000 characters drawn from nine different types of publications, 1,017 characters accounted for 90%, and well-chosen 4,000 characters accounted for 99.8% (Hannas, 1997). Recently, the Ministry of Education of the People's Republic of China (2013) published a list of commonly used characters in modern Chinese, including 3,500 characters in the first tier, 3,000 characters in the second tier, and 1,605 characters in the third tier, totaling 8,105 characters. The estimates of DeFrancis (1984), Hannas (1997), and the Ministry of Education of the People's Republic of China (2013) consistently show the small number of characters used in practical usage.

Table 5.2. An Example of a One-Sound Word with Different Tones in a Story

Original Story Yuen Ren Chao (1930)		Translation	
石室詩士食獅史 (original title by Yuen Ren Zhao) **[**施氏食獅, widely used title)**]**		Story of Stone Grotto Poet: Eating Lions[a]	
石室詩士施氏, 嗜獅, 誓食十獅。施氏時時適市視獅。十時, 適十獅適市。是時, 適施氏適是市。施氏視是十獅, 恃矢勢, 使是十獅逝世。氏拾是十獅屍, 適石室。石室濕, 氏使侍拭石室。石室拭, 氏始試食是十獅屍。食時, 始識是十獅屍, 實十石獅屍。試釋是事。		A poet named Shi lived in a stone room. He was fond of lions and swore that he would eat ten lions. He constantly went to the market to look for ten lions. At ten o'clock, ten lions came to the market, and Shi went to the market. Looking at the ten lions, he used his arrows to make the ten lions dead. Shi picked up the corpses of the ten lions and took them to his stone room. The stone room was damp. Shi ordered a servant to wipe the stone room. As the stone den was being wiped, Shi began to eat the meat of the ten lions. During the meal, he began to realize that the ten lion corpses were in fact ten stone lions. He then tried to write down this story	
Characters in tone variations			
Shi, First tone		**Shi, Forth tone**	
詩	poet, poem	室	room
獅	lion	士	person
施	name, apply	嗜	to have the habit of
失	lose	(施)氏	demonstrative
屍	carcass	誓	swear, pledge
濕	damp	適	arrive, adapt, suitable
		是	yes, this one
Shi, Second tone		視	look, see
識	know, knowledge	恃	apprehend, depend
石	stone	勢	situation, power
食	eat	逝	leave, pass
十	ten	世	world
時	hour	市	market
拾	to pick up	拭	wipe, clean up
實	true, reality	試	try
		釋	explain, record
Shi, Third tone		事	thing, event
史	story		
使	order, send		
始	start		

[a]This title was the original title written in English by the author Yuen Ren Zhao (1930).

5.2 Japanese Multi-Scripts

Japan is composed of four main islands, comprising Hokkaido, Honshu, Shikoku, and Kyushu, as well as numerous small islands surrounding the southeast of the Korean peninsula in the Pacific Ocean. Its population consists of 127 million people, which is 2.5 times more than that of South Korea.

Rather than inventing their own writing system, the Japanese adopted the Chinese writing system on a massive scale, resulting in Chinese characters being ancestral to Japanese scripts (i.e., Kanji, {漢字}; literally <Chinese characters>). In the process of borrowing the Chinese writing system, the Japanese modified the original Chinese pronunciation to integrate the sounds of the Japanese language into writing. However, Japanese oral language is very different from Chinese in terms of phonological, morphological, and syntactic features with no genetic ties to it. Due to the typological difference between the two languages, the process of borrowing Chinese characters to encode Japanese oral language was not smooth. The end-result was "a mixed system, partly logographic and partly phonographic" (Sampson, 2015, p. 208).

Simply based on the complexity involved in the mixed system, DeFrancis (1989) asserts that the Japanese "ended up with one of the worst overall systems of writing ever created" (p. 138). Sampson (2015) argues that there is no rival to Japanese writing in complexity among both ancient and modern scripts. Coulmas (1989) also notes that the Japanese script is "… to be the most intricate and complicated writing system ever used by a sizable population" (p. 122). Sproat (2010) adds an account that "Japanese is a complex system, certainly the most complex writing system in use today and a contender for the title of the most complex system ever" (p. 47). Fischer (2001) also joins the line of the assessment of the Japanese writing system to be the most complicated form of writing ever devised. Even a Japanese senior diplomat who later became the Minister of Education, Viscount Mori Arinori, declared that the whole language system of Japanese, both oral language and written language, should be abandoned, and that English should be spoken and written instead (Sampson, 2015).

The Japanese's attempt to develop their own script was virtually absent from ancient Japanese society. Sampson (2015) provides a justification as to why the Japanese "never made a clean break to a different kind of script" (p. 208). He attributes the Japanese's lack of attempts to have their own script to the Japanese culture, which was shaped by an aristocratic class during the period of the script development. The aristocratic class had more interest in defining and producing civilized cultural norms than values and goals placed in reading and writing. As a result, Japanese culture became delicate and intellectually profound rather than openly practical (Sampson, 2015).

5.2.1 A Brief Historical Account

There are three main types of scripts used in Japan: Kanji, Kana, and Rōmaji {ローマ字}. Kanji are a Chinese-derived script. Kana are a supplementary script and have two subtypes: Hiragana and Katakana. Rōmaji are a phonemic alphabet mainly used for loanwords. If Arabic numerals are counted in the classification, Suji, {数字}[9] would be the fourth type. A brief historical review of Kanji and Kana development is in order.

5.2.1.1 Kanji

The earliest writing in Japanese in the form of Chinese classics dates back to the fourth century when the great cultural influx took place from the Paekje (or spelled as Paekche or Baekje) kingdom of Korea. Due to the geographical location, Korea served as an intermediary of cultural transmission between China and Japan. As the nation was unified in the late fourth century, the Japanese became politically and socially stable and were ready to accept Chinese culture. Among objects such as seals and bronze mirrors that had Chinese characters inscribed, a sword engraved with a text written in characters is still preserved in a shrine in Japan, which was sent by the Paekje kingdom in the late fourth century (Taylor & Taylor, 2014). In the 6th and 7th centuries, Sinitic culture, including Buddhism, Confucianism, medicine, calendar, and arts and crafts, was ushered into Japan via Paekje scholars (Frellesvig, 2010). Aristocrats, high-ranking officials, and Buddhist monks played an important role in getting Chinese culture permeated into Japanese lives on a large scale between the seventh and eighth centuries. As the state needed many literate officials, an institute called the *Daigakuryō* <the University> was founded to train future officials (Taylor & Taylor, 2014). Two history books, the *Record of Ancient Matters* (*Kojiki*, A.D. 712) and the *Chronicle of Japan* (Nihon Shoki, A.D. 720), were written in Kanji in the eighth century. Kanji was solely used as the script until the two forms of Kana syllabary, Katakana and Hiragana, were created to supplement Kanji in the ninth century.

Although about 50,000 Kanji characters were listed in the *Great Sino-Japanese Dictionary*, a far smaller number of Kanji is commonly used. Taylor and Taylor (2014) report that 5,000 different Kanji were used in Japanese literature according to a study conducted in 1981. In newspapers and magazines, fewer than 3,000 Kanji are used, and, of these 3,000 Kanji, 2,000 characters account for about 99% of its use.

[9] Precisely speaking, Suji, 数字, have several referents according to different numeric systems: アラビア数字 referring to Arabic numerals (e.g., 1, 2, 3), 漢数字 Chinese numerals (e.g., 一、二、三、四), and ローマ数字 Roman numerals (e.g., I, II, III).

Kanji are associated with dual-reading or dual-pronunciation: (1) *On'yomi* reading (*On* Chinese reading) and (2) *Kun'yomi* reading (*Kun* Japanese reading). For example, the character {花} meaning <flower> has two readings: /ka/ in *On* reading and /hana/ in *Kun* reading. On top of these dual readings, in the old days, Kanji were read with the multiple sounds. For instance, the character {生} had six meanings (i.e., <life>, <birth>, <growth>, <physiology>, <pupil>, and <raw>) and was read in 19 different sounds (10 official sounds, 2 unofficial sounds, and 2 unusual *Kun* readings; see Taylor & Taylor, 2014, p. 279).

Japan has gone through a series of postwar writing reforms on Kanji use since the mid-nineteenth century. The key reform took place in 1946 with a promulgation of *Tōyōkanjihyō* {当用漢字表}, including a list of only 1,850 Kanji for daily common use with the government's officially approved *Kun* and *On* readings. The reform discouraged the use of Kanji other than those included in the list. Newspapers tried to use the 1,850 Kanji by adding Katakana transliteration in brackets or by writing only Kana instead of Kanji. However, other publications and official documents used Kanji beyond the approved list of Kanji. Accordingly, the government periodically published short supplementary lists to include more "rehabilitated" Kanji that were missing from the 1946 list. Moreover, the 1946 list did not sufficiently cover proper nouns, such as personal names and place names, that were in common usage (Sampson, 2015).

In 1981, the Japanese government issued another guideline, in which Jōyōkanji {常用漢字} included a list of 1,945 frequently used characters (see Table 1 in Hannas, 1997, p. 45). Of 1,945 characters, the government limited *On* reading to 2,187 sounds and *Kun* reading to 1,900 sounds, totalling 4,087 sounds. This meant that some characters still had multiple sounds due to different *On* or *Kun* readings. Of the 1,945 common Kanji, 1,168 characters have both *On* and *Kun* readings, 737 characters have only *On* readings, and 40 characters have only *Kun* readings (Tamaoka, et al., 2002, cited in Taylor & Taylor, 2014, p. 277). The Jōyōkanji list of 1,945 characters was revised with some additional characters to include 2,136 Kanji in November 2010 (Joyce & Masuda, 2018).

To make matters more complicated, there are heteronyms that are spelled the same but have different sounds and meanings (e.g., {lead} /li:d/ or /led/ in English). For example, the disyllabic Kanji word {生物} has different meanings depending on which way it is read: *On* reading *seibutsu* meaning "living thing" or *Kun* reading *namamono* meaning "raw food."

There are additional notational systems called *Ateji* ({当て字}, sound-based assigned Kanji) and *Jukujikun* ({熟字訓}, meaning-based assigned Kanji). *Ateji* are a way of using Kanji for their phonetic values disregarding their meanings. For example, the Japanese word *sushi* is written {寿司}. Neither of the two characters is related to fish or food ({寿} means *longevity of one's life* and {司} means *to administer*), but the sounds of the characters accord with the sound of the word *sushi*. *Ateji* were phonetically used for native words or loanwords in the past, but recently Katakana are used for loanwords. *Jukujikun* is another way of using Kanji for their semantic values disregarding their sounds. For example, *kesa,* a native Japanese word that means "this morning, is written {今朝}. Neither of the two

characters represents any part of the sound of the word *kesa,* but the meanings of the characters jointly represent the meaning of the word *kesa*: {今} means *now* and {朝} means *morning*.

As indicated earlier, the Japanese reduced the number of Kanji in 1946. The motivation for reducing the number of Kanji was multifaceted. One explanation is that, during World War II, accidents frequently occurred, mainly caused by army recruits whose Kanji reading skills were not good enough to read weapon manuals. Because of dangerous incidents that were the result of soldiers with the low level of Kanji reading, the army restricted the number of Kanji use for weapon parts to 1,235 (Hannas, 1997). Another account is an economic burden that newspaper publishing industries had to carry in order to stock the full range of Kanji in the press inventory. More recently, the advance of word-processing technology added the burden as well because the keyboard could not afford the large number of graphs. Sampson (2015) forecasts that "while the spoken Japanese language remains essentially what it is now, moving to a phonographic script would be utterly impractical" (p. 230).

5.2.1.2 Kana

Although Kanji had been used for a few hundred years since their first introduction in the fourth and fifth centuries, Kanji was not sufficient to address all sounds of the Japanese language as well as all grammatical morphemes such as particles and postpositions. The major problem stemmed from the typological difference between the Chinese and Japanese languages. As an agglutinative language in which words are composed of multiple morphemes or affixes, Japanese has a considerable number of inflectional morphemes. Although Chinese Kanji were fairly well suited to writing content words, inflections were difficult to effectively notate in Kanji. Therefore, Kana came into existence out of the necessity for a phonograph in addition to Kanji's semantic referents. Kana fundamentally remained as a complementary function rather than an autonomous supplant of Kanji. The foundation for the multiscript writing system was established during the seventh and eighth centuries (Taylor & Taylor, 2014). The Japanese created supplementary symbols, Kana, in the ninth, which were phonetic in nature. The present Kana system was codified in 1900. The 1946 reform spelled out the rules for Kana usage (Hannas, 1997; Taylor & Taylor, 2014).

Although how the term Kana was settled can be debatable, the dominant assumption is that the term originated from *karina* (*kari* means "borrowed" and *na* means "name" or "letter") to make a reference to the fact that Kana were borrowed from the sounds of Kanji. Another meaning for *kari* is temporary, unofficial, or nonregular. *Karina* ended up becoming Kana after *kanna* was used for a while. This suggests that Kana are a secondary or second-class script to Kanji (Taylor & Taylor, 2014).

There are two types of Kana. The first is Hiragana ({平仮名} <easy Kana> or <plain Kana>), which was originally used for informal writing. The second is

Table 5.3. The Distributions of Different Scripts Used in News Outlets

	Kanji	Hiragana	Katakana	Punctuation & symbols	Arabic numerals	Latin alphabet
Asahi newspaper (1993)*	41.38%	36.62%	6.38%	13.09%	2.07%	0.46%
Magazines (1994)**	26.87%	35.66%	15.99%	21.49%***		

Note: * Chikamatsu et al. (2000; cited in Joyce & Masuda, 2018)
** Igarashi (2007; see Table 2.1)
*** The percentage represents a collapsed number out of the three categories.

Katakana ({片仮名} <side Kana> or <partial Kana>), which was originally used for official purposes, such as documents. Each type of Kana comprises 46 signs augmented by two diacritics. Nowadays, Hiragana are more frequently used, while Katakana are mainly used for foreign names and terms recently borrowed into Japanese and optionally used for emphasis and onomatopoeia. Kana are used to notate inflectional affixes, grammatical particles, many adverbs, and loanwords with European origins. In contrast, Kanji are used to write content words, such as nouns including both native Japanese and Sino-Japanese nouns, verbs, and adjectives.

The use of different types of scripts varies according to the purposes of usage. The use of newspapers and magazines shows different proportions of the script types. Table 5.3 displays the distributions of different types of scripts used in news outlets.

There is another notational system. *Furigana* (small-sized Kana that indicate the proper pronunciation of Kanji characters) is the additional Kana written to the right of Kanji if the text is written vertically or above if the text is written horizontally to clarify the writer's intention. *Furigana* use declined after World War II with restricted use in children's books. However, the government officially endorsed the use of *furigana* in documents for adults in 1981 (Sampson, 2015). Recently, *Furigana* use was extended to indicate English translation to identify the intended meaning in the context. However, *furigana* are occasionally used in a creative form and cross-linguistic boundaries used by second language learners (Sato, 2018).

5.2.2 Features of Japanese Script

There are four types of vocabulary in Japanese: native words, Sino-Japanese words (Chinese-derived words in Japanese pronunciation), loanwords, and hybrid compound words (a mixture of Sino-Japanese and Japanese endings or a mixture of Japanese native words and loan words; Taylor & Taylor, 2014). These four types tend to be written in different scripts among Kanji, Kana, and Rōmaji. For example, the word {消しゴム} /keshi-gomu/ means an <eraser>. The first two syllables {消し} / keshi/ form a nominal verb meaning *to erase* and is a native Japanese word,

while {ゴム} /gomu/ is *katakana*, meaning <rubber> or <gum>, which is a loanword from the English word *gum*. Regarding the loanword *gomu* {ゴム}, note that, since the canonical Japanese syllable is CV, the CVC English word *gum* could not be directly used in Japanese. Therefore, an epenthetic vowel was added to the end of the word *gum* to make *gu-mu*, which became /gomu/ {ゴム}. Another example is the loanword from the English one-syllable word *ham*, which becomes a two-syllable word {ハム} <hamu> in Japanese to conform to the norm of CV syllables.

According to Taylor and Taylor (2014), the distribution of the word types based on dictionaries published in 1969 includes 53% Sino-Japanese, 37% native words, 8% loanwords, and 2% hybrid words (p. 260). Over time, the proportion of loanwords has increased. Specifically, in 1960, the composition of new words was as follows: 3.6% native words, 40.2% Sino-Japanese words, 43% loanwords, and 13.2% hybrid words. However, the distribution of new words in 1980 was changed into the following: 1.9% native words, 28.8% Sino-Japanese words, 57.6% loanwords, and 11.7% hybrid words.

There are several features in Japanese, which cannot be found in other languages. First, as discussed earlier, the most conspicuous feature of the Japanese writing system is mixed scripts. The paucity of phonetic clues in Chinese characters led to the use of the supplementary Kana script. Although Western linguists have pointed out the Japanese mixed scripts to be the most intricate and complicated writing system in the world (Coulmas, 1989; Sampson, 2015; Sproat, 2010), the advantages of the Japanese writing system have not been discussed. Notwithstanding the complexity and inefficiency as a writing system, the impact of reading the multi-scripts needs to be addressed.

Second, the Japanese language has a smaller inventory of sounds and syllables than those of Chinese and Korean. The small sound system of Japanese is used to produce a "small inventory of extremely simple syllables" (Taylor & Taylor, 2014, p. 258), which mostly comprises V or CV syllables. The Kana characters are used to represent five vowels (/a/, /e/, /i/, /o/, and /u/) and 16 consonants (p, t, k, b, d, g, s, h, z, j, r, m n, w, N and Q, where N represents a syllable-final nasal consonant and Q represents a syllable-final consonant that is a part of a geminate consonant; Taylor & Taylor, 2014). Japanese does not have closed syllables (i.e., CVC syllables), except when N or Q is used in a syllable's final position. The Japanese uses a prosodic unit or phonological unit called a *mora*, which is a time/weight unit that represents one beat. Like open short syllable (CV or V syllables), N and Q is counted as one mora, while a syllable with a long vowel (CVV or VV syllables) is counted as two moras[10] in Japanese. A mora is an important sound unit in Japanese because each mora is represented by one Kana character except when the syllable-initial consonant is palatalized (e.g., {きゃ} /kya/). There are 108[11] moras in Japanese which has fewer syllables than Chinese (Taylor & Taylor, 2014). Chinese has about

[10] Some Japanese linguists residing in Japan do not distinguish moras from syllables, while others distinguish them.

[11] The number of moras varies depending on how moras are counted. An inclusion or exclusion of allophones and obsolete sounds that exist only in scripts makes the difference.

400 syllables, and, if tones are considered, the number rises up to 1,300 syllables (Taylor & Taylor, 2014).

Third, Japanese has abundant derivational and inflectional morphology as an agglutinative language. For example, the root /mot/ meaning <hold> can have many derivatives as follows: *motsu*, "hold" (plain); *motʃimasu*, "hold" (polite); *motanai*, "not hold" (plain); *motʃimasen*, "not hold" (polite); *motta*, "held" (plain), *motʃimaʃita*, "held" (polite); *motanakatta* "did not hold" (plain); *motō*, "be about to hold" (plain); *motʃimʃō*, "be about to hold" (polite); *motʃi*, "holding" (noun), and *motte*, "(is) holding" (Sampson, 2015, p. 209).

Fourth, like Chinese, there is no marking for word boundaries. Words are simply written one after another without space between them. Due to the nature of mixed scripts, readers can discern word boundaries according to different types of scripts (i.e., Kanji or Kana), but not from space between words.

Next, before the Chinese simplified their script in the 1950s, the Japanese simplified some of their graphs to reduce the number of strokes. Hence, the simplified characters are different between Chinese and Japanese (e.g., 廣-广-広; 氣-气-気; 關-关-関; 齒-齿-歯; 應-应-応; 單-单-単; 圓-圆-円 in the order of traditional character, Chinese simplified character, and Japanese simplified character, respectively). Compared to the Chinese simplification, the Japanese simplification was minimal (Sampson, 2015). As for the simplified version of Japanese Kanji, the *Tōyō Kanji* published in 1946 listed 1,850 characters, including 131 simplified forms. They were expanded to about 300 by the 1949 law on character shapes.

Hannas (1997) notes that an average of 3,120 characters are in use in Japanese, which is less than half the number used in Chinese. The most commonly used 1,500 characters account for 96 to 97 % of all appearances of characters in contemporary Japanese magazines, and 2,000 characters represent the coverage of 98.5 to 99 % (Saiga, 1971, cited in Hannas, 1997, p. 215).

5.2.3 Strengths and Weaknesses as a Script

The characteristics of the Japanese writing system bear some strengths and weaknesses as a script. As for strengths, first, the comparatively simple sound inventory that includes 108 *moras* (Taylor & Taylor, 2014) with simple syllabic structure (mostly CV structure) may be useful for foreigners to learn Japanese as a second language or a foreign language. The simple syllabic structure of CV and V with five vowels and 16 consonants may promote learners to acquire the sound system quickly. *Kana*, which are moraic units, can visually inform learners of Japanese with proper rhythm, proper prosodic divisions, and proper pronunciations of a Japanese word, whereas Rōmaji can mislead them mainly because of the absence of some sounds in the Japanese sound system (e.g., the Japanese liquid sound is not actually /l/ or /r/, but is an approximated sound between /l/ and /r/).

Second, like Chinese, Japanese can be written either horizontally or vertically. Although the Japanese have not officially given up writing in vertical columns, the

current trend favors the left-to-right horizontal orientation. While school books and technical materials are typically printed horizontally, general-interest or entertainment books such as novels are still printed in right-to-left vertical columns. A more dominant use of the horizontal orientation in these days results from the default setting of the Japanese word-processor program (Sampson, 2015).

Third, the multi-script system provides learners of Japanese with flexible scaffolding for writing and reading in Japanese. They can write solely in Hiragana if they do not know Kanji. They can write some English words in Katakana if they have not yet mastered the set of Japanese scripts. They can guess the meanings of words based on some basic Kanji characters and some components of Kanji called *bushu* (radicals). Furigana written in the right or above Kanji characters also provide a cue to the pronunciation of Kanji characters.

Concerning weaknesses, due to the complexity involved in using the multi-scripts, learning to read Kanji and the two types of Kana (i.e., Hiragana and Katakana) may require a slightly longer time than other orthographies to gain mastery in reading. Second, the large number of homophones in Sino-Japanese vocabulary can add another complexity, although it is not necessarily considered a weakness (because it can be a mere characteristic of the script). The large number of homophones in Sino-Japanese morphemes and words resulted from the fact that when the Japanese imported Chinese characters, they could not retain tones. As a result, some syllables ought to be simplified to reflect the Japanese syllable structures (e.g., {県}, {権}, {件}, {験}, {圏}, {研}, {券}, and {謙} are pronounced as /ken/).

Third, Kanji impose obstacles in the way of computerization. However, the Japanese have found a way to accommodate the challenges. They type the onset of the pronunciation of the Kanji character in Latin letters and then select the target Kanji among candidates with a mouse click. It is very similar to the way in which the Chinese type in the keyboard using Pinyin and then select the target Chinese character with a mouse click, a number-key stroke, or an arrow-key stroke. Furthermore, learners of Japanese can take advantage of software that automatically provides Furigana to overcome the difficulty of reading Kanji.

Despite the complexity of the script, Japan has a high literacy rate and low rate of reading disabilities among school-aged children (Taylor & Taylor, 2014). Sampson (2015) notes "… many aspects of Japanese culture, including its writing, were greatly elaborated—made exquisite and intellectually rich rather than straightforwardly functional" (p. 208). The inefficiency of the multi-script does not prevent Japan from becoming one of the technologically and economically leading nations in the world.

5.3 Korean Script, *Hangul*

Korea is a small country with a population of 73 million including both South Korea (50 million) and North Korea (23 million). The U.S. is about 99 times bigger than South Korea (Texas is 7 times larger than South Korea) and 82 times larger than

North Korea. Due to its geographical location between China and Japan, in history, Korea not only was a cultural transmitter from China to Japan, but also was a target of the neighboring nations for imperialism. After World War II, Korea was divided into two countries of the Republic of Korea in the south and the Democratic People's Republic of Korea in the north. Unlike the Japanese who massively borrowed Chinese characters, the Koreans enjoy their own script, which is an alphabetic script, Hangul. Although they have different political, economic, and social systems, the two Koreas use the same oral language and written language (South Korea call the script Hangul, while North Korea Chosungul).

Man (2000) argues that, although the perfect alphabet may be a remote ideal, it is possible to have a better alphabet than the Western alphabet. In reference to the Korean writing system, Man (2000) argues that "[w]e know this [to have a better alphabet] because there is an alphabet that is about as far along the road towards perfection as any alphabet is likely to get" (pp. 108–109). He goes on indicating "[i]n its simplicity, efficiency and elegance, this alphabet is alphabet's epitome, a star among alphabets, a national treasure for Koreans…" (p. 109). Sampson (2015) also acknowledges that "Hangul must surely rank as one of the great intellectual achievements of Mankind" (p. 165). This line of recognition started in the 1960s when scholars gave credit for "perhaps the most scientific system of writing in general use in any country" (Reischauer & Fairbank, 1969, p. 435, cited in Sampson, 2015, p. 143) and "the world's best alphabet" (Vos, 1964, p. 31, cited in Sampson, 2015, p. 143). Hangul successfully enjoys the advantage that the alphabet provides by having the minimum number of graphs necessary to express Korean spoken language unambiguously.

5.3.1 A Brief Historical Account

Since old Korea became a unified nation in A.D. 700, the nation evolved into an independent and sophisticated society. Under the influence of China, the old Koreans adopted Chinese culture, trade, literature, and language. However, the adoption of Chinese culture did not go seamlessly because the Korean language has no genetic ties with the Chinese language. Sampson (2015) notes that "Korean is much more different from Chinese than one European language is from another" (p. 144) and "[n]ot only is Korean genetically unrelated to Chinese, but the two languages are different in type" (p. 144). Despite the differences, the Koreans borrowed vocabulary from Chinese and some of them are still used as Sino-Korean words. However, "the grammar is purely Korean" (Sampson, 2015). Korean word order (i.e., SOV syntactic structure) and agglutinative properties are very similar to those of the Japanese language.

In medieval Korea, both woodblock presses and movable wooden type printing methods were used. Although movable wooden or porcelain type printing was invented in China around 1040 (Man, 2000), Korea was the first country in the world to invent a movable *metal* type printing machine during the Goryo dynasty in

1377. This was 78 years earlier than the Gutenberg Bible with 42 lines per page published in 1455. The first publication that used the movable metal type printing technology was a book of Buddhist teachings, *Jikji*, written by a monk named Baekun {白雲}. This historical feat had been buried for a long time because a French missionary to Korea took *Jikji* to France and the book has been in the Collection of the National Library of France since 1890. The credit for the first movable metal printing in the world was finally granted in 1972 when a Korean scholar, Dr. Byungsun Park, found it in the national library in France. In September, 2001, *Jikji* was registered in the *Memory of the World,* which is the UNESCO's worldwide program that strives to record, preserve, and disseminate treasured archive masterpieces and collections on the globe. Unlike wooden block printing that could publish only one book at the same time, movable metal type printing allowed for information to be spread widely. The increasing availability of books revolutionized the accessibility of knowledge that was once reserved to the elite, coupled with the invention of the alphabet which was much easier to learn than logography.

A new dynasty, Chosun, was established in 1392 by escaping from Mongol-Chinese control. Confucianism was adopted as the new dynasty's official ideology. The fourth Chosun king, Sejong, came to reign in 1418 at the age of 22. King Sejong renovated and reorganized a research institute {集賢殿} by recruiting specialist scholars and restructuring rituals and protocols. He revised the calendar, standardized weights and measures, and set the guidelines for the study of history. Of the 308 books he produced, 114 were printed using the movable metal type press method mentioned earlier (Man, 2000). During his 32-year reign, he established the foundations of the dynasty that lasted five hundred years. He is regarded as Korea's best and brightest scholarly monarch, and his statue is at the heart of the city in Seoul, the capital city of South Korea. At the center of his numerous inventions is the Korean alphabet Hangul.

Before Hangul was invented, Chinese characters had been reserved for elites. Ordinary people had used crude writing systems (i.e., *Idu* {吏讀}, for prose transcription or for grammatical markers; *Hyangchal*[12] {鄕札}, for lyric texts and local letters and poetry; *Kugyul*, {口訣} for an annotation of Chinese texts and insertions for oral recitation) that partially adopted the sounds and shapes of Chinese for the writing of their oral language. Despite these indigenous notational systems, ordinary people could not read Sejong's books published using the metal printing press because they were written in Chinese.

King Sejong became increasingly concerned that his books and other written materials could not be read by ordinary people. Several attempts to reapply Chinese characters to the creation of a new script did not work. With a keen understanding of the differences in the linguistic system between Chinese and Korean, he was determined to create a new writing system that would be easy to learn to read. This

[12] After *Hunminjungum* was promulgated, *Hyangchal* was moribund, but *Idu* and *Kugyul* were still in use for a while afterwards.

original idea entailed challenges for persuading the Chinese-speaking scholar-bureaucrats and for uprooting the traditions of the dynasty establishment.

In the winter of 1443, the 28th year of Sejong's reign, a new script was finally devised from its secretive gestation and was published as the *Correct Sounds for the Instruction of the People*[13]. Sejong's *Introduction to* <훈민정음> /hun min jung um/ encapsulated his purpose in a classic statement:

> The sounds of our language differ from those of China and are not easily conveyed in Chinese writing. In consequence, among the ignorant, there have been many who, having something to put into words, have in the end been unable to express their feelings. I have been distressed by this, and have newly designed a script of 28 letters, which I wish to have everyone practice at their ease and use to advantage in everyday life (Man, 2000, p. 113).

Sejong believed that the script was easy to learn to read and had no doubt about the benefits and capacity to capture all sounds in the universe.

> A wise man may acquaint himself with [the graphs] before the morning is over. An ignorant man can learn them in the space of ten days… there is no usage not provided for, no direction in which they do not extend. Even the sound of the winds, the cry of the crane, the cackle of fowl and the barking of dogs—all can be written. (Man, 2000, pp. 113–114).

There has been debate over King Sejong's role in the invention process of Hangul. The first interpretation is a *command hypothesis*. He might have ordered his subjects of scholars to devise a script that was easy to learn to read. The second is a *cooperation hypothesis*. This hypothesizes that King Sejong collaborated with his scholar-subordinates in the development of the script. These two views have been widely accepted until recently. A new hypothesis that recently emerged, *independence hypothesis*, posits that King Sejong himself independently and secretively devised the script[14] (Yeon, 2010). Although it is impossible to prove this, it was possible that King Sejong experimented by himself the newly designed script to ensure efficiency for learning before publicizing it. This new hypothesis is more convincing in consideration of the delicate diplomatic relations with China at the time when the dynasty's cultural dependence on China was immense. Historical records that are still available show that the group of scholars who were immediate subordinates to King Sejong were against the new script upon promulgation. Based on these factors, the third hypothesis of King Sejong's independent invention is more plausible and gains more weight than the first two. Beyond its first name of the

[13] The Korean phrase 훈민정음 /hun min jung um/ has also been translated into the *Standard Sounds for the Instruction for the People* (Sampson, 2015). The literal translation is the *Correct Sounds for the Instruction for the People*.

[14] There is a legend associated with King Sejong's scheme that he devised before the official promulgation. The King was concerned about how the new script would be accepted by the public due to the heavy reliance on China and Chinese characters at that time. In an effort to make the new script more acceptable, he concocted a scheme. He wrote each graph he created in honey on a large leave fallen from the tree in the palace garden. When he walked into the garden with his subordinates in the following morning, the King found large leaves with magically etched graphs because insects had eaten the honey and the leaf fiber underneath. He claimed that the graph was brought to them from heaven as a gift.

writing system <훈민정음> /hun min jung um/, the currently used neologism Hangul (literally meaning the *Great Script*) came to existence in 1910 by a Korean linguist, Ju Sikyung, and his colleagues.

Despite King Sejong's authority and effort to spread the script, the solid establishment of Hangul as an official script in Korea took some time. Bureaucrats and scholars in the Chosun dynasty still kept their Chinese for over four centuries. It was April 7, 1896 when the first newspaper was published in Hangul only. Unfortunately, during Japanese occupation between 1910 and 1945, Hangul use was prohibited under the Japanese imperialism. After Korea's post-war division into two Koreas, South Korea endorsed both Hangul and Hanja (Chinese origin with Korean pronunciation). However, North Korea committed to use Chosungul (North Korea use this word to refer to Hangul) only by abandoning Chinese characters entirely since 1946 under its Communist dictator, Kim Ilsung, the grandfather of Kim Jungeun who is the head of the current regime.

5.3.2 Features of Hangul

5.3.2.1 Consonants and Vowels

Korean consonants and vowels correspond to Korean phonemes, unlike Chinese and Japanese whose written unit corresponds to a syllable and a mora, respectively. Clear is the visual distinction between consonant and vowel letters in Hangul. Perhaps the most distinct feature of Hangul is the shape of the basic consonant letters that reflects articulatory properties of the phoneme they represent. When Sampson (2015) classifies Hangul as a *featural script*[15], he basically relies on this characteristic of Hangul. Although his classification of *phonography* into *syllabic, segmental,* and *featural* scripts is questionable because of the inconsistent criterion used for the taxonomy, Sampson is on point about Hangul's featural characteristics. The Korean consonants graphically reflect the shapes of the articulatory vocal organs, such as the tongue, palate, and lips when the sounds are articulated.

The formation of consonants was systematic. Starting from the pictographic sign { ㅁ }, 28 consonants were created. Given the sign { ㅁ } means the <mouth> / kŏu/ in Chinese (/kʊ/ in Korean), the starting point of the consonant is considerably

[15] As discussed in Chapter 4, Sampson's (2015) classification of Hangul as a *featural* script is problematic because not all graphs meet this description (especially vowels) and because the criterion of the classification is not consistent. He classified the *phonographic* system into *syllabic*, *segmental*, and *featural* writing. The first two (*syllabic* and *segmental*) writing systems are divided by the unit of the script, while the last one, *featural*, is based on the depiction of graphs.

meaningful. Based on this graph {ㅁ}, two additional graphs were created; when the graph {ㅁ} is divided in half by a diagonal line starting from the top left corner, it results in two new graphs {ㄱ} /g/ and {ㄴ} /n/. The graphs of {ㄱ} and {ㄴ} represent the shape of the tongue during articulation, either raised in the back towards the velum or with the tongue blade lowered, respectively. The {ㅇ} graph indicates either the null (∅) onset consonant or the open airstream of nasalization (/ŋ /), depending on where it appears in the syllable. Depicting the airstream obstructed around the alveolar ridge, {ㅅ} /s/ is the alveolar fricative consonant. Drawing upon the five base consonants, consisting of {ㅁ}, {ㄱ}, {ㄴ}, {ㅇ}, and {ㅅ}, additional consonants were created by adding a stroke or two (i.e., {ㅁ} → {ㅂ} → {ㅍ}; {ㄱ} → {ㅋ}; {ㄴ} → {ㄷ} → {ㅌ}; {ㅅ} → {ㅈ} → {ㅊ}; and {ㅇ} → {ㅎ}). Figure 5.1 shows the systematic gradation in the consonant and vowel formation.

Rooted in practicality, Hangul vowels reflect the notion of Neo-Confucianism. The opposites of *yin* (meaning the female, passive, dark, wet, and cold principles)

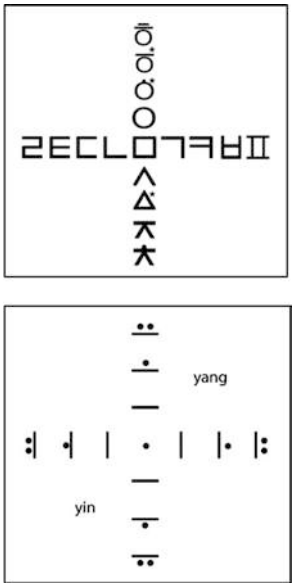

Figure 5.1. Consonant Formulation (top) and Vowel Formulation (bottom) in *Hangul*
Note: * These signs are not currently in use.
Reprinted from Pae (2018) with permission by John Benjamins.

and *yang* (meaning the male, active, bright, dry, and hot force) are harmonized within the vowel inventory. The elaboration of three basic universe symbols is shown in the use of a vertical for Man { ㅣ }, a horizontal for Earth {ㅡ}, and a circle for Heaven { · }. The vowel sounds are either 'bright' (yang) or 'dark' (yin) depending on the position or shape of the articulatory organ upon the articulation of each sound. For example, when the <heaven> stroke { · } is attached to the right of the <human> stroke { ㅣ } or above the <earth> stroke {ㅡ}, *yang* vowels are created (i.e., { ㅏ }, { ㅑ } and {ㅗ}, {ㅛ}, respectively, with the <heaven> symbol becoming a little more elongated stroke than the original { · }). When the *heaven* stroke is combined with the *earth* stroke to the left or underneath, *yin* vowels are created (i.e., { ㅓ }, { ㅕ }, and {ㅜ}, {ㅠ}, respectively). The use of the three atomic symbols of the dot, horizontal stroke, and vertical stroke under the combinatorial rule results in 21 mutually exclusive vowel letters in total, comprising 10 bases and 11 compound vowels.

5.3.2.2 Syllables

Two characteristics stand out from the syllabic structure of Hangul. First, the union of a consonant and a vowel is a reflection of the *yin-yang* complementarity in that the consonant sets the articulatory context and the vowel complements it to make the solid sound for a syllable. Hence, neither the consonant nor the vowel can fully function without the other in terms of articulation, although each graph has its sound value. Second, the visual configuration of the syllable is clear and unambiguous to the extent that syllabic parsing within the string of letters is unnecessary. In addition, the segments (i.e., consonants and vowels) are written in square blocks, wherein all the consonants and vowels are packed within restricted formats.

With the combinatorial rule of the consonant and the vowel, 11,172 syllables can be created in Hangul. These comprise 399 CV syllables (19 onsets x 21 vowels) and 10773 CVC and CVCC syllables (19 onsets x 21 vowels x 27 final consonants). Of these possible syllables, 2,350 syllables have high frequency in use, while 8,822 syllables have low frequency in use.

The syllabic unit is similar to those of Chinese and Japanese. Despite the visual similarity among Chinese, Japanese, and Hangul, Hangul is different from Chinese and Japanese in that letters represent the sound of oral language and that a syllable is composed of more than one phoneme/grapheme to represent a syllable (i.e., alphabetic principle). The distinct syllabic block as well as the conformity to the alphabetic principle make Hangul stand out among all scripts used on the globe.

Due to its clear syllabic block, Hangul can be written vertically or horizontally like Chinese and Japanese. When it first came into existence in the fifteenth century, it was written vertically. Until about three decades ago, all newspapers and many books were printed vertically. However, almost all print materials are currently printed in the horizontally linear sequence.

5.3.3 Strengths and Weaknesses as a Script

Questions of "good" or "bad" oral language do not arise in linguistics because the axiom of equal goodness of spoken language has been held (i.e., each spoken language is equally good enough to serve its purpose for the speakers of a particular language). This widespread assumption that "all spoken languages are equally 'good,' equally structurally subtle, equally efficient" is accepted partly for ideological reasons and respectable justifications because "spoken language is in a sense functionally self-defining" (Sampson, 2015, p. 7). However, Sampson (2015) stipulates two conditions that make a writing system "good" or "bad" depending on the answers to two questions below:

- "How efficiently does the system function for those who have already mastered it?
- How easy is it to learn?" (p. 6)

The first condition refers to efficiency for skilled readers and the second is about learnability for emergent readers. Korean Hangul fulfills these two conditions to be a good writing system. Regarding the efficiency of reading Korean, lexicon megastudies projects show that Korean readers' lexical decision rate is the fastest (620 ms), followed by 646 ms for Chinese, 654 ms for Dutch, 740 ms for French, and 784 ms for English (see Table 5, Tse et al. 2017; Table 2, Yi et al. 2017). When he promulgated the newly developed script in the fifteenth century, King Sejong stated that smart learners would be able to learn to read within one morning and not-so-smart learners will take about 10 days to master the script. This is indirectly supported by fact that the majority of Korean children master decoding of Hangul at the age of 3 or 4 before kindergarten (Taylor & Taylor, 2014).

Although there are no empirical data available for the claim of the attrition of literacy skills, my personal experience makes me think that Korean readers may experience a minuscule degree of the attrition of reading rate in Hangul even after no use of the script for a while. I have personally asked many Korean immigrants who have lived in the U.S. more than two decades or who have lived longer in the U.S. than in Korea about their experience of reading Korean. Everybody to whom I have spoken has reported neither trouble nor (perceived) decrease in the reading rate of Korean. In contrast, I have seen many Chinese colleagues who self-report their forgetfulness of Chinese characters with their reduced use of Chinese written text. I also have a similar experience with Chinese characters. I was able to read and write about 1,000 characters while I was in high school in Korea, but the ability significantly declined with no use and no exposure to Chinese characters for a while in the U.S. This anecdotal account can provide a good basis for an empirical study of the attrition of reading skills among speakers of the three East-Asian languages.

Regarding the weaknesses of the Korean writing system, I cannot come up with a shortcoming as a script. The Korean oral language is rather complex. However, the

writing system serves King Sejong's original purpose well (i.e., to combat illiteracy through a script that is easy to learn). The high literacy rate in Korea proves, in a sense, the script's effectiveness. The invention of Hangul was the point of departure from the history of cultural and linguistic dependence on Chinese. Had it not been for Hangul, the Koreans might have been in the continuation of the past under immense Chinese influences.

5.4 Commonalities and Differences among the Three Scripts

5.4.1 Commonalities

The three scripts of Chinese, Japanese, and Korean have commonalities in such a way that syllabic units are clearly distinguished in text. Due to their unambiguous syllabic units, the three scripts can be written either horizontally or vertically depending on space availability or for aesthetic purposes. This flexible writing orientation cannot be found in Western scripts.

Another commonality has to do with an artistic expression of scripts. Calligraphy is one of the major art forms surrounding the East-Asian scripts. The use of the brush for calligraphy makes the hand move up and down easier than moving horizontally; therefore, the aesthetic embellishment through calligraphy is typically found in the vertical form, which is facilitated by the syllabic configuration in a block. Although Western alphabetic scripts have various fonts or show aesthetic qualities in handwriting, the degree of flexible aesthetic touches associated with scripts are not similar to calligraphy.

5.4.2 Differences

The main source of variations among the three scripts of Chinese, Japanese, and Korean stems from the differences in their spoken languages (Sampson, 2015). The differences among these three scripts primarily come with the typological difference. In short, the Chinese writing system is a logography or a morphosyllabary. The Japanese writing system is multi-scripted. The Korean writing system is an alphabet. Due to the dominant syllabic structure and syllabic functioning, Korean is also considered to be an alphasyllabary (Taylor & Taylor, 2014). A term of *alphabetic morphosyllabary* is also proposed to capture all characteristics involved in the Korean writing system. Given that more than 70% of the Korean lexicon comprises Sino-Korean words, the term alphasyllabary does not address the considerable morphological component embedded in the Korean writing system (see Pae, Bae, & Yi, 2020).

Relatedly, due to the difference in the nature of script, a difference is also observed in the number of syllables. Japanese has a little over 100 syllables. Chinese has about 400 without counting tones (with tones, it has about 1,300 syllables; Taylor & Taylor, 2014). Resulting from the comparatively limited number of syllables, homophones are more prevalent in Chinese and Japanese than other scripts. Korean has more than 11,000 possible syllables, although 2,350 syllables are frequently used.

Another difference among the three scripts is syllabic structures. Compared to English, the three scripts have much fewer syllabic structures. Chinese has five, Japanese has three, while Korean has five. The classification can be different when another criterion is applied. Table 5.4 shows the syllabic structures of Chinese, Japanese, and Korean, compared to that of English.

Table 5.4. A Comparison of Orthographic Syllabic Structures among the Three East-Asian Languages in Contrast to English

Syllabic Structure	English	Chinese †	Japanese †	Korean
V	a	啊 /a/ auxiliary tone word	絵 /e/ <picture>	아** /a/ (null word)
CV	to	打 /dǎ / <hit>	眼 /me/ <eye>	가 (/ga/ null word)
VC	an	按 /àn/ <press> (the button)		안** /an/ (inside)
CCV	the*	(吃 /chī/ <eat>)		
CVC	set	看 /kàn/ <look>	本/hon/ <book>	각 /gak/ (angle)
CVCC	west			값* /gab/(price)
CVVC	read			
CVCCC	worst			
CVCVCC	silent			
CCVC	scan			
CCVCC	sprint			
CVCCC	birth*			
CCVCC	thing*			
CCCVCV	strike			
CCVCCC	graphs*			
CCCVCC	strong*			
CCVCCCC	flights*			
CCVCCCCC	twelfths*			
CCCVCCCCC	strengths*			

Note: † Since Chinese and Japanese are syllabic languages, they do not allow for this kind of presentation without the support of Pinyin. However, they are included in this table for comparison purposes. The classification is based on pronunciation, which is different from the orthographic syllabic structures. This is why the Chinese and Japanese parts are presented in gray.

* Although the spelling of the words accords with the syllabic structures, the number of phonemes are different from that of graphemes because some digraphs have one phoneme (e.g., thing [θɪŋ]) or a silent (e.g., strike).

** The syllable has a null-sound place holder consonant in the onset position; hence, the consonant should be treated differently in orthography from other consonants that have solid sound values.

5.5 Asian Students' Performance in Core Subjects

There are scholars who have speculated the negative impact of the Chinese writing systems on Asian students' academic achievement. Hannas (1997, 2003) is one of them, as seen in his remarks that "… East Asians are wasting their youth and resources learning about language. Notwithstanding their efforts, the system's inherent difficulties predispose those societies using Chinese characters to low literacy rates and other maladies, especially among the young…" (Hannas, 1997, p. 125). He goes on saying "[c]reativity is snuffed out by the task of memorizing endless rules that lead nowhere. Science fails to take root. Liberal ideals are lost on the mass of people whose reading skills are inadequate…" (Hannas, 1997, 125). Hannas (2003) asserts in his book entitled *The Writing on the Wall: How Asian Orthography Curbs Creativity* that Asians' inability to be creative stems from the character-based writing system. Although Hannas may have a point in terms of the Western perspective of creativity, the results of an international comparison study of 15-year old students' reading, math, and science skills generally show otherwise. If Hannas is right about the negative effect of Chinese characters, Chinese and Japanese students' performance of reading and other subjects (due to reading being a foundational means for learning other subjects) should be behind that of European and American students. However, Asian students' performance in reading, math, and science rank on top among their international peers[16].

The Program for International Student Assessment (PISA), orchestrated by the Organization for Economic Cooperation and Development (OECD), reports international comparison data of 15-year-old students' reading, mathematics, and science every three years since 2000. There are other international comparative assessment programs, such as the Progress in International Reading Literacy Study (PIRLS; assessing fourth-graders literacy skills every 5 years since 2001) and the Trends in International Mathematics and Science Study (TIMSS; assessing math and science achievement of grades 4 and 8 every 4 years since 1995). However, PISA is the one which includes all countries of interest here. PISA measures general and functional skills as well as cross-curricular competencies, including collaborative problem solving. PISA 2015 reports students' core academic skills in more than 70 countries and education systems. Table 5.5. shows the rank in the subjects of reading, math, and science among students of the three East-Asian countries and American students.

In 2009 and 2012, the Chinese data relied solely on students from Shanghai, which is the largest and wealthiest city in China. The most current 2015 data include three more provinces other than Shanghai given that Shanghai is not

[16] A reviewer asked whether time spent studying and being tutored was controlled in the international comparison study. PISA and PIRLS did not control for the variable. East Asians tend to spend extra-time studying English and math by getting external help through learning institutes or tutoring, but hardly reading.

Table 5.5. East-Asian and American Students' Performance on the Core Subjects in an International Study (PISA)

	Reading	Math	Science
2015			
Chinese (B-S-J-G*)	27	6	9
Japanese	8	5	2
Korean	7	7	11
American	24	40	25
2012			
Chinese (Shanghai)	1	1	1
Japanese	4	7	4
Korean	5	5	7
American	25	36	28
2009			
Chinese (Shanghai)	1	1	1
Japanese	8	9	5
Korean	2	4	6
American	17	31	22

Note: * This refers to the four PISA participating China provinces: Beijing, Shanghai, Jiangsu, and Guangdong. When this chapter was written, the 2015 data was the most recent one available. The PISA's 2018 test results are now available

representative of China. The average reading score of China in 2015 is not as good as those of math and science. Other countries that use Chinese characters, such as Hong Kong and Singapore, excel in reading. Singapore marks the top in rank in the three subjects in 2015. It is difficult to come to a conclusion with only one-year data that Chinese students' reading skills lag behind their peers in most other Asian countries.

Based on the comparison data, globally speaking, there is little evidence that Chinese characters impede East-Asian students' performance, as Hannas (2003) claims. When Hong Kong and Singapore where Chinese is used are included in the pool of the comparison, the data become even stronger as students in those countries excel in all subjects. Overall, 15-year old American students are not on par with their East-Asian counterparts in the three core subjects. This indicates that, even though it takes six years on average to master them, Chinese characters per se do not hinder East-Asian students' learning. Especially Japanese students mark high in rank in reading, whose written language comprises a large portion of Chinese-derived Kanji.

Hannas (1997) also makes comments on the Koreans as follows: "Rather than an indictment of present orthographic practice, the ability of Koreans to excel in today's competitive world without writing Chinese characters is a clear tribute to the superiority of the hangul script…" (p. 137). He seems to be partially right with regard to the Hangul alphabetic effect, considering the rapid economic growth shown since the Korean War (1950–1953). However, he fails to identify the specific areas on which the script has had an effect. Hanna (1997, 2003) seems to highlight

the negativity of Chinese characters based on value judgment. Importantly, the effect of interest is not about good-or-bad value judgment on the scripts but about differences among those scripts.

Logan (2004) claims that Chinese mathematics is more algebraic than geometric and that Chinese logic primarily relies on analogy and inductive reasoning, which is different from Western logic that is based on matching and deductive reasoning. He continues to note that, although the Chinese showed advances in some areas such as technology, arts, philosophy, and religious thought, the Western Industrial Revolution was different from Chinese technology.

There is a myth in U.S. K-12 settings and the U.S. general public that Asian students excel in math. The myth also claim that Asian students are only good at arithmetic not in geometry. In a similar vein, Nisbett (2003) questions "[w]hy do nonlogical Asians tend to do so much better in math and science than Americans?" (p. 189). He identifies a misconception as well as differences in cultural values and practices between the East and the West. He indicates that "[w]e don't actually find East Asians to have trouble with formal logic, we just find them to be less likely to use it in everyday situations where experience or desire conflicts with it" (p. 188). He also points out that cultural norms of emphasizing the *Middle Way* (this concept is discussed in the next chapter) do not go hand in hand with logic and that the traditional East-Asian culture places high values on literature, arts, and music as the proper pursuits of the *cultured* person. This is consistent with Taylor and Taylor's (2014) point that China's and Korea's long-lasting civil-service examinations, which was a royal ticket for the highest rung within the social hierarchy, only focused on Confucian Classics, neglecting math and science. In relation to Logan's (2004) claim that Asian *thinking* is more concrete, practical, and less abstract due to the effect of less abstract logographic characters, Nisbett (2003) states that " … Asian superiority in math and science is paradoxical but scarcely contradictory" (p. 189).

5.6 Implications of the Script Differences for Script Relativity

If McLuhan's "the medium is the message" is right, the medium through which we read should have a substantial impact on what we read, how we read, and how we process the message. Script is a vehicle through which our reading takes place. Reading is at the apex of information processing, which involves multifaceted cognitive functions, automaticity, and being difficult to suppress reading when text is visible. Chinese, Japanese, and Korean writing systems are all East-Asian but different scripts in the face of collectively shared culture among the three nations. This fact provides a unique opening for considerations of script effects above and beyond

linguistic relativity and culture. This becomes conceivable when we reflect on the intrinsic differences among the Chinese, Japanese, and Koreans as well as their cultures in terms of social norms, philosophies, and especially religious choices as mentioned in the Prologue. In order to further understand the foundations and manifestations of East-Asian cultures, the next chapter discusses the multiple underpinnings of variations between the East and the West in terms of extrinsic and intrinsic differences.

Chapter 6
The East and the West

Abstract This chapter reviews the cultural aspects of the East and the West. A wide range of differences between the East and the West is discussed in terms of the extrinsic and intrinsic differences. The extrinsic differences comprise architecture, the mode of clothing, everyday practices, and language and script, while the intrinsic differences consist of culture and value systems, attention and perception (holistic vs. analytic), problem solving (relation vs. categorization), and rhetorical structure (linear vs. roundabout). The locus of these differences is identified with respect to philosophical foundations and the characteristics of Eastern and Western cultures. The prevalent interpretations of the differences between the East and the West center on Diamond's (1999) guns, germs, and steel, Nisbett's (2003) geography of thought, and Logan's (2004) alphabet effects. However, these interpretations cannot explain differences in ideologies, religious practices, and societal values among Chinese, Japanese, and Koreans. Therefore, script relativity becomes a new interpretation of the engine behind the differences among the three East-Asian nations and between the East and the West.

Keywords East · West · extrinsic differences · intrinsic differences · philosophical underpinnings · new interpretation

The origin of and differences between Eastern and Western cultures have been extensively discussed in such disciplines as anthropology, philosophy, archeology, psychology, and applied linguistics. Nisbett (2003) asserts, as shown in the epigraph above, that Westerners find their intellectual heritage from the Greek, while Easterners give credit to Chinese tradition. This chapter does not aim to be a comprehensive survey of the characteristics of the East and the West. Although there are multiple ways to understand the two hemispheres of the globe, my discussion in this

"More than a billion people in the world today claim intellectual inheritance from ancient Greece. More than two billion are the heirs of ancient Chinese traditions of thought. The philosophies and achievements of the Greeks and Chinese of 2,500 years ago were remarkably different, as were the social structures and conceptions of themselves. And the intellectual aspects of each society make sense in light of their social characteristics." Richard E. Nisbett (2003, p. 1)

H. K. Pae, *Script Effects as the Hidden Drive of the Mind, Cognition, and Culture*, Literacy Studies 21, https://doi.org/10.1007/978-3-030-55152-0_6

chapter is based on empirical findings in social psychology regarding Eastern and Western cultures. First, cultural differences between the East and the West are illustrated in light of extrinsic manifestations and intrinsic indications. Differences in architectural structures, clothing, everyday practice, and language and script are reviewed as extrinsic exhibitions. Culture and value systems, attention and perception, problem solving strategies, and rhetorical structures are discussed under intrinsic indications. As a way to explain the underlying workings for the overt and covert differences, the major philosophical underpinnings in the East (Confucianism, Taoism, and Buddhism) and the west (Aristotle) are discussed, along with Diamond's (1999) view of human history and civilization, Nisbett's (2003) analysis of geographical and social psychology, and Logan's (2004) claim on the alphabet effect. Ultimately, I look at the differences between the East and the West through the lens of *script relativity*, which mainly rests on findings by other scientists who have studied the differences between the East and the West from the perspectives of social psychology, cognitive psychology, applied linguistics, and communication.

Since empirical findings reviewed in this chapter primarily come from adult studies, criticisms may arise for the skewed pool toward adult participants in research. However, relying on adults rather than children for measuring particular constructs makes more sense because adults show more *stabilized* characteristics than children's still developing (relatively) transient traits. The dichotomy of the East and the West can also invite criticisms because cultures and human characteristics are not monolithic. However, a generalization or grouping can be the first step toward an understanding of a given phenomenon. Although the use of dichotomous concepts can simplify the phenomenon, the binary distinction can also provide insights into group differences. Taking more variables, such as age, gender, educational systems, religion, and ethnicity, into account would be the next step to investigate the intricacies of the given phenomenon. As operationalized definitions are provided in Chapter 1, the term *Asians* used in this chapter refers to peoples from the three East-Asian countries of China, Japan, and Korea. Likewise, the word *Westerners* refers to European Americans, as the modern United States is a European-molded society (Diamond, 1999).

6.1 Differences between the East and the West

It is difficult to explain differences between the East and the West within a single chapter. The differences can be discussed largely by two dimensions, however: extrinsic and intrinsic dimensions. The first is a phenomenon that is overtly seen and tangible, while the other is a covert and hidden engine that drives us to live our lives in our own ways. The Chinese, Japanese, and Koreans share a common culture in general, but their languages and scripts are different from one another. This point of the *common culture yet different languages and scripts* has rarely been addressed collectively, although culture and language/script have been treated as separate constructs or approaches to the understanding of the East Asian people and traditions.

6.1.1 Extrinsic Differences

6.1.1.1 Architecture

Architecture is one example of an overt and extrinsic cultural product that reveals esoteric qualities manifested differently in the East and the West. Architecture is an art form of synthesis that communally reflects our values, aesthetics, culture, and surroundings. The architecture of modern days has become homogeneous in the East and the West such that the city landscapes of Beijing, Tokyo, Seoul, New York, and London are pretty much similar to one another. However, ancient architectural structures were different in the two hemispheres of the globe. Architecture not only reveals the philosophical and aesthetic standards of the builder, but also displays materials that were available at the time of construction.

Every society has the religious place in the form of the church, the mosque, or the temple (or shrine) at which people are gregarious for spiritual maturity. The places are architecturally elaborate and intricate monuments of spiritual sanctuaries. The ecclesiastical architecture is the prototype of architecture in each society, given that the religious architecture is imbued with arts, beliefs, and values of the particular culture and society. Although architectural styles have changed in response to changing beliefs, practices, and traditions, there are salient differences in the ecclesiastical architecture between the East and the West. Old Asian temples are generally built with wood, and are round and circular and not overly protuberant from the surroundings. They are rather harmonized with Nature and the natural scenery and have symmetry-driven structures with variations. However, Western churches are in general rectangular and have sharp pinnacles with geometric shapes. These differences between the East and the West can be an expression of subliminal workings of social member's mind.

6.1.1.2 Clothing

Just like language and architecture, clothing is a human-specific practice. Evidence suggests that humans began wearing clothes that were made up of animal skins or other natural resources somewhere from 100,000 to 500,000 years ago. Primitive bone needles are dated back to 61,000 years ago and were discovered in Sibudu Cave in South Africa (Backwell, dErrico, & Wadley, 2008). The earliest silk production from the cocoon of domesticated silkworms was made in China in sometime between 5000 and 3000 B.C. Silk Road was the route for exchange of luxury textiles between the East and the West, which facilitated the development of the great civilizations of China and the West. Lemire and Riello (2008) make note of a long interaction between Asia and Europe in the fashion system. The European use of silk and printed cotton textiles from Asia took place in the early establishment of modern fashion. The Europeanization of Asian textiles reflects intellectual, commercial, and aesthetic relationships between Europe and Asia (Lemire & Riello,

2008). Despite the long history of interaction between the East and the West, the tradition of clothing is still different across cultures.

Most human societies have their own forms of clothing that adapt to geographical and meteorological conditions. Different cultures use clothing in different ways depending on climate, ecosystem, religion, and value systems. The trajectory of changes over time also varies across cultures due to the difference in their values. Clothing also reflects a society's beliefs and customs, and expresses the member's sense of beauty and aesthetic qualities. In some cultures, clothing is used for specific purposes, such as the expressions of prestige and decorations of magic or cult. For example, emperors used excessively decorated garments with golden crowns. Top officials in ancient dynasties had different animal prints embroidered on their gowns to demonstrate their power and rankings within the system. Shamans wore clothes of extraordinary colors and patterns with brightly decorated accessories or beaded fringes. Archeological findings and arts illustrate different clothing customs across cultures and societies, especially between the East and the West.

Beyond these differences between the East and the West at the global level, idiosyncrasies are found among people from China, Japan, and Korea at the regional level. Although the physical appearance of East Asians is similar to one another, I can quickly discriminate Koreans from Chinese and Japanese people more by the way they dress than by facial features or other physical characteristics. The way we dress is likely to underpin the mode of expressions of personal and group values.

6.1.1.3 Everyday Practice

Social psychologists have shown that Eastern culture is group-oriented, while Western culture is individual-centered (Hofstede, 1980; Hofstede, Bond & Minkov, 2010; Nisbett, 2003; see *Intrinsic Differences* below for more detail on collectivism versus individualism). This idea is demonstrated in language use as well as other social and cultural practices. The use of the first-person singular pronouns "me" and "my" is generally discouraged in Asian culture. For example, the Koreans emphasize the plural concept and discourage the first-person singular use. The Koreans use the phrase "*our* mother" or "*our* brother" instead of "my mother" or "my brother" (when the singular form is used in Korea, it is understandable but sounds awkward). An extreme example for the reluctance of the first person singularity is found in the phrase "*our* lover" or "*our* sweet heart" to refer to "my lover" or "my sweet heart." This is an example of how language expresses the speaker's ideology and value systems of a culture, especially the group-oriented mindsets of the Koreans (see Culture and Value Systems below for more detail).

Another example of group orientation found in everyday practice in China, Japan, and Korea is the order of information arrangement for the sender and the receiver that we place on the envelope for mail. The American way is to write the receiver's and sender's names first and then gradually move on to a larger unit ending with the state name or the country name. The East-Asian way is completely opposite to this practice. Chinese, Japanese, and Koreans write the largest unit first

(i.e., the country or city names) and then gradually narrow it down to the sender or the receiver name on the envelope for mail. This example shows how our value systems are expressed in our everyday activities.

6.1.1.4 Language and Script

Each language has its own unique characteristics. Given that it has been time-tested and endured for a long period of time, language is inextricably connected to the speaker's mind and cognition (Lenneberg, 1967; Levinson, 2003). A debate over the causal path of effects from language to thought or from thought to language would be a chicken-egg debate at the surface level, but what is obvious is its indispensable link between the language we speak and our mind. Benjamin Lee Whorf already conceptualized this in the early 1940s. As discussed in Chapter 3, the Linguistic Relativity Hypothesis (i.e., language shapes thought) was dismissed prematurely and inadequately. Recent evidence from the acquisition of a second or additional language has been added to the reinvigoration of the Linguistic Relativity Hypothesis. Another layer is the writing system or script we use in our everyday lives. Reading has become an integral part of our lives in the twenty-first century with the immense use of hypermedia and social media. Not a single day does pass by without reading traditional text or digital text. The habitual and long-term use of written text is likely to affect the undercurrents of our cognition and the way we process information. Since language and script are continuously discussed throughout this book, no further elaboration on language and script is made in this section.

6.1.2 Intrinsic Differences

6.1.2.1 Culture and Value Systems

One's identity is largely a function of one's role and membership in a group or within a culture. Culture refers to shared values among a group of people. Depending on the value system a group of people shares, cultural orientation is broken down into collectivism and individualism. A collectivistic society is characterized on group cohesion, interdependence, moderation, self-control, and group identity over the self. Collectivistic people work together to create group harmony and consensus, and seek benefits for the whole group over the individual. Viewing the group as a super-organism, collectivists emphasize group cohesiveness and harmony, advocate common values, and demonstrate in-group orientation. In contrast, members of an individualistic society are oriented around the values of self-determination, self-expression, freedom, and independence (Hofstede, 1980).

According to Hofstede (1980), the construct of collectivism or individualism is neither right or wrong nor opposite, but it is considered two distinct values. Not every society or culture is at one end or the other end of the continuum of social

values, but the majority of social members tend to lean toward one over the other in many sectors of their lives. Dominant values in each society shape individuals' intricate software for the development of social values, communication styles, and shared consciousness. Although each nation's value systems can be traced back to its early history, a multitude of recurring factors contribute to the foundation of the culture.

A couple of proverbs poignantly deliver the contrast between collectivistic and individualistic norms. The Asian proverbs "The nail that stands out gets pounded down" and "Pointy stone meets chisel" are sharply juxtaposed with the American adage "The squeaky wheel gets the grease." This contrast further signifies the difference between the East and the West. Standing out among group members or seeking personal attention and benefits is not encouraged in Asia in general because the virtues of modesty and humility supersede the individual benefit. However, speaking up and being heard are encouraged in America.

Hofstede (1980) conducted a seminal cross-cultural study making comparisons along the continuum of collectivism and individualism with each cultural dimension representing an opposite pole. The dichotomy of collectivism and individualism was challenged by other theorists because the nature of culture is more complex than the binary unidimensional aspect. However, Hofstede's (1980) conceptualization is still influential and has a useful point in a sense that it is one way to explain the phenomenon. According to him, individuals who endorse a high degree of collectivism prioritize communal goals over individual goals. Its contrasting tendency is found in individualists.

The criticism that collectivism-individualism is unidimensional has been addressed in a more recent study by Hofstede and colleagues. Hofstede, Bond, and Minkov (2010) have conducted one of the most comprehensive cross-cultural studies of 76 countries and scored each country on a scale of 1 to 120 (1 representing the lowest and 120 representing the highest) for six dimensions using factor analysis. According to Hofstede (1980), culture is the programming of the mind that is shared by a distinct group of people. Six dimensions of culture are covered in the model of national culture as follows: (1) power distance, (2) individualism versus collectivism, (3) masculinity versus femininity, (4) uncertainty avoidance, (5) long-term pragmatic orientation versus short-term normative orientation, and (6) indulgence versus restraint.

The dimension of *power distance* concerns how a society handles inequity among people. It refers to the extent to which less powerful members of the society accept the unequal distribution of power within a culture and tolerate a hierarchical order and the unequal distribution of power. Individualists are likely to be self-sufficient and self-reliant. They tend to have a low power distance rather than the unequal distribution of power. They prioritize individual goals over communal goals. Collectivistic individuals tend to show the opposite.

The second scale of *individualism* versus *collectivism* refers to the extent to which loosely-knit or close-knit social frameworks are accepted by social members. The self-image tends to be expressed in the use of the pronoun "I" or "we." Individualists prefer to use the singular pronoun "I", while collectivists are likely to

use the plural form "we." Regarding the third dimension, *masculinity* prefers competition, heroism, assertiveness, and material rewards for success, while *femininity* favors cooperation, modesty, caring for the weak, and consensus. The fourth dimension of *uncertainty avoidance* refers to the extent to which social members bear uncertainty and ambiguity to cope with the future. It is usually manifested by rigid or relaxed codes of belief, behavior, and attitude. The existential goals of *long-term* or *short-term orientation*, which is the fifth dimension, involve interpreting the past to deal with the challenges of the present and the future. The long-term orientation involves fostering virtues related to effort, persistence, and frugality, and tends to have futuristic mentality by focusing on relational order, interrelatedness, perseverance, and thrift. It also maintains time-honored traditions and norms with a more conventional mentality emphasizing face-saving and personal stability. The short-term orientation values virtues related to instant gratification, personal steadfastness and stability, and the past and present. The last dimension, *indulgence versus restraint*, refers to the degree to which members have control over desires and impulses in pursuit of happiness. The former tends to allow for free gratification, while the latter suppresses or regulates impulses or needs gratification using stringent social norms.

Figure 6.1. shows a comparison of the scale scores of the three East-Asian people and Americans by dimension. Consistent with Hofstede's (1980) original hypothesis, Chinese people show the highest level of power distance, while Americans show the lowest. High power distance tends to be observed in collectivistic cultures. The higher scale of the Chinese than those of the Japanese and South Koreans may have to do with the difference in their political climates. Collectivistic people are less likely to challenge authority or people in power in order to protect group wellbeing and established order. Individualistic people are inclined to challenge authority, by calling for the legitimate use of power and a reduction of power differences between or among social classes. As shown in Figure 6.1., differences are found among the four groups of people across Hofstede's dimensions. Notable differences between Easterners and Americans are observed in the dimensions of Individualism,

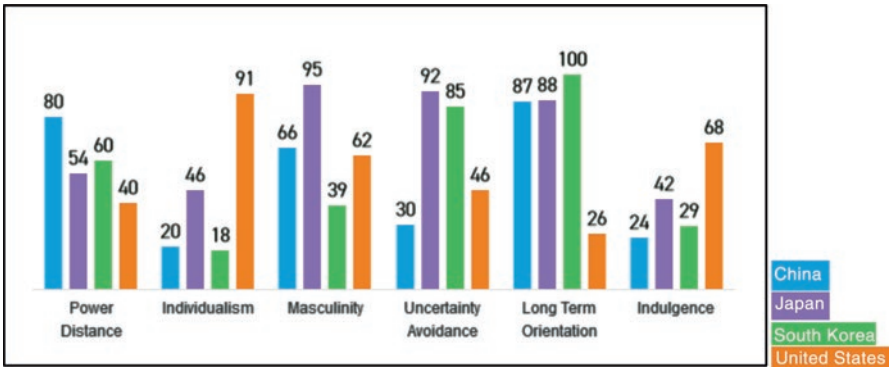

Figure 6.1. Cultural Scales among Chinese, Japanese, Koreans, and Americans.

Table 6.1. Traits of Collectivistic and Individualistic Cultures

Dimension	Collectivism	Individualism
Identity	"We" identity	"I" identity
Control	Relational	Independent
Goals	For Group	For Oneself
Sense of Being	Sense of Belonging	Sense of independence
Preference	Consensus	Freedom
Thrust	Harmony with others	Sense of Competition
Pursuit	Harmony	Uniqueness
Social Relationship	Hierarchy	Horizontal
Actualization	Group goals	Personal needs and desires
Social Communication	Indirect communication	Direct communication
Work	Work in group	Work alone

Indulgence, and Long-Term Orientation. Americans show higher scores on Individualism and Indulgence, but lower scores on the Long-Term Orientation. Within the three Asian groups, there are variations in Individualism, Masculinity, and Uncertainty Avoidance. This demonstrates that the three cultural groups are not monolithic.

Based on Hofstede's (1980) and Hofsted et al.'s (2010) studies, Table 6.1. summarizes the characteristics of collectivistic and individualistic cultures. The contrastive traits can be directly and indirectly observed among ethnic groups within the U.S. and among people from different continents around the globe. Under the framework of cultural differences between the East and the West, empirical studies in relation to attention and perception, problem-solving strategies, and rhetorical structures are reviewed below.

6.1.2.2 Attention and Perception: Holistic versus Analytic

Differences in attentional and perceptual patterns between Easterners and Westerners have been investigated in social psychology. Predominant findings converge on robust differences in cultural members' attention to the foreground and the background of the scene for Westerners and Easterners, respectively. Easterners tend to attend to context-dependent information in a holistic way, while Westerners are likely to pay attention to context-independent information in an analytic fashion (Masuda & Nisbett, 2001; Miyamoto, Nisbett, & Masuda, 2006; Nisbett, Peng, Choi, & Norenzayan, 2001). Specifically, Masuda and Nisbett (2001) showed Japanese and American students short video clips of underwater scenes including fish, small animals, water plants, and small rocks, and asked them to describe what appeared in the video clips. American students primarily described the characteristics and motions of the fish (i.e., the focal object) in the foreground (e.g., large, rapidly moving, bright colored). In contrast, Japanese students paid more attention to the context and relationships between the fish and the context (e.g., background

objects, location of the fish in relation to other objects). East-Asians' tendency to focus more on the context is also found in conceptual tasks. Chinese and other East Asians are more likely to attribute individuals' behaviors to situational conditions, while Americans tend to attribute behaviors to individuals' dispositional characteristics rather than uncontrollable situational factors (Choi, Nisbett, & Norenzayan, 1999). This line of findings has been consistent with the evidence from neuroscientific research (see Goto, Ando, Huang, Yee, & Lewis, 2010; Masuda, Russell, Chen, Hioki, & Caplan, 2014) and eye movement data (Ueda & Komiya, 2012).

Using the change-blindness paradigm (i.e., people are at times blind to changes happening in the environment), Masuda and Nisbett (2006) investigated how perception and cognition are qualitatively different between East Asians and Westerners using still photos and animated vignettes with changes in the focal object and the context. Results showed that American participants were more sensitive to changes in the focal objects than in the periphery or context, while East Asians were sensitive to contextual changes by attending to the entire field and relations among objects within the field. Americans were less likely to detect changes made in the background than in the foreground, on average, and were less sensitive to situational cues or constraints on a speaker's behavior than East Asians. Asians tended to show the opposite. These results suggest that cultural variations exist as a function of basic perceptual processes.

As an extension of Masuda and Nisbett's (2006) study, Miyamoto, Nisbett, and Masuda (2006) conducted a study that examined the role of the physical environment in perception using still pictures of scenes from small, medium, and large cities in Japan and the U.S. Both objective and subjective analyses of the pictures showed that Japanese settings have more ambiguous contours of buildings and more complexity in settings than American counterparts. Consistent with previous findings, Japanese students were more attentive to the context than were European Americans (Study 1). When the pictures of the three cities were presented as primes, the group difference disappeared. In other words, both Japanese and American students who were primed with Japanese settings paid more attention to contextual features than those who were primed with American scenes. The researchers interpreted the results as the physical environmental effects on perceptual patterns. The implication of this result is important in that Miyamoto et al. (2006) have identified the physical setting as a (causal) factor that affects (or reinforces) the patterns of perception. More studies are needed to corroborate the findings of this study. If Miyamoto et al.'s claim is correct, it is possible that reading, in which we pay more conscious attention and effort in a daily activity, would exert a greater effect than scenes due to more cognizant attention we pay in reading than in looking at scenes. We hardly pay mindful attention to buildings or physical environments unless we have specific intention to do so.

Easterners' collective and interdependent tendency is consistent with their worldview and beliefs that things are not monolithic. Westerners' individualistic and independent traits accord not only with their focus on particular objects in isolation from the context, but also with their belief that they can control the object's behavior because all events are governed by rules (Nisbett, 2003). The force or drive

that makes differences between the East and the West is a self-reinforcing homeostatic system that is related to the fundamental nature of the mind (Nisbett, 2003). According to Nisbett (2003), the effect is a domino-like sequence as in "the social practices promote the worldviews; the world views dictate the appropriate thought processes; and the thought processes both justify the worldviews and support the social practices" (p. xx).

In a similar vein, my doctoral students and I are conducting a cross-cultural study of argument structures and descriptive tendencies using a picture book (Sun, Luo, & Pae, 2020). A picture book, *Frog, Where Are You?*[1], was shown to adult native speakers of Chinese, Korean, and English to examine how these language groups conceptualize the story based on a series of pictures. One of assumptions is that the two Asian groups would use more hedges, such as *sort of*, *a little*, *kind of*, *maybe*, and *seem*, than does the American counterpart. Hedge words in the forms of adjectives, adverbs, or clauses are a tool used to soften the degree of confidence, passion, or tension associated with an expression or to express politeness. They can be viewed as a form of euphemism or a tool of epistemic modality. Asian students seem to use more hedge words in order to mitigate assertiveness in a message, which accords with the predominant Asians' tendencies mentioned earlier. This is consistent with the finding that Japanese speakers show "greater reliance on what is arguably as general a noun as could be chosen" with the overuse of *thing* instead of specifying what it is (Schanding & Pae, 2018), as shown in an argumentative essay written by a native Japanese speaker: "The majority of Japanese may think that **it is not [a] good thing** that public matter assumes religious image and [that] also Japan becomes a religious nation" (bold in original, p. 72).

Consistent with Masuda and Nisbett's (2006) study, the results of our study also show that Asian students are more likely to describe the surroundings of the scene than the main characters' activities or attributes. For example, in the description of a scene depicting a boy (main character) and a dog looking at an empty jar in the bedroom, a Korean participant stated the following: "It's dark outside because there's a moon and the window is a little open. There's one bed with the lights on. Beside the kid, there's a piece of clothes." This participant's account is filled with background descriptions rather than the main character's unexpected finding that his pet frog has run away (Sun et al., 2020).

A typological difference is also found. The Chinese and Korean languages are topic-prominent languages, whereas English is a subject-prominent language. Asian students tend not to produce an extraposed subject clause (i.e., a subject clause that is moved to the end of the sentence) by using the nonreferential subject "it." For example, the sentence "Finding the frog was difficult" tends to be produced, as opposed to a sentence like "It was difficult to find the frog," which is more likely to be produced by a native speaker of English as a standard expression (Sun et al., 2020).

[1] This is a wordless black-and-white picture book containing 24 pictures with a storyline of a boy and his dog's effort and adventure in finding their pet frog that ran away from their house.

In most cases, the subject in Japanese and Korean is not mentioned in the sentence when the subject is obvious within the context. For example, the sentence "I love you" can be understood by the speaker and the listener with the verb only ("love") without the subject and the object in Korean. The subject omission is possible in Korean and Japanese because who does what to whom is decipherable without mentioning within a particular context. This is different from English, which has the more rigid sentence structure in that the subject is mandatory except for imperative sentences. The omission of the subject (and object at times) shows Asians' focus on the situation rather than the actor or agent of the verb action. This is consistent with findings of previous studies showing Asians' attention being placed more on contexts than main characters (Masuda & Nisbett, 2006).

6.1.2.3 Problem Solving: Relation versus Categorization

Reasoning and problem solving styles are found to be different across cultures as well. Research shows that East Asians prefer identifying relationships in information processing, while Westerners prefer categorizing objects (Nisbett & Miyamoto, 2005; Chua, Boland, & Nisbett, 2005; Ji, Zhang & Nisbett, 2004). The tendency of East Asians to focus on relationships between objects and events as well as contexts is consistent with previous findings. European Americans tend to categorize objects based on their properties and tend to decontextualize objects from their contexts in an orderly way (Chua, Boland, & Nisbett, 2005; Ji, Peng, & Nisbett, 2000; Nisbett, 2003; Nisbett, Peng, Choi, & Norenzayan, 2001).

Ji, et al. (2004) conducted two mini-studies of categorization. In Study 1, they included four groups of participants including speakers of (1) Chinese residing in Mainland China, (2) Mainland and Taiwan Chinese residing in the U.S., (3) Hong Kong and Singapore Chinese in the U.S., and (4) European Americans. The researchers presented to participants a set of three words (e.g., *monkey*, *panda*, and *banana*; *postman*, *uniform*, and *policeman*) and asked them to find which two of the three words were most closely related to each other. Results showed that Chinese bilinguals tended to organize objects in a more relational way (i.e., monkeys eat bananas) than in a categorical way (i.e., monkeys and pandas are both animals) regardless of the language in which they were tested (i.e., Chinese or English). When Chinese-English bilinguals were compared by locality, Chinese students residing in the mainland and Taiwan where Chinese was the societal language were more likely to focus on relations when being tested in Chinese than in English. However, Chinese students from Hong Kong and Singapore where both Chinese and English were spoken as the societal languages tended to be equally relational when they were tested in Chinese and English. In Study 2, they also used a categorization task, but it was slightly different from that of Study 1, such that either relational or categorical grouping was possible within a set of three words (e.g., *carrot*, *rabbit*, and *eggplant; teacher*, *doctor*, and *homework*) with the two groups of participants: Chinese in Mainland China and Hong Kong Chinese in Hong Kong.

Consistent with the findings of Study 1, the results showed that Chinese participants from Mainland China showed a stronger tendency for recognizing or identifying relationships in Chinese than in English. In contrast, Hong Kong Chinese participants showed a preference for strong relationships in both Chinese and English with no language effect.

Of interest in the results of Ji et al.'s (2004) study is a significant language effect found in Chinese students from Mainland China and Taiwan. The two groups of Chinese students seem to differentiate categorizations depending on the language they use at hand. They categorized the word stimuli in a more relational way when they were tested in Chinese than when tested in English. The same results were found regardless of the localities of the U.S. or China. However, the language effect disappeared in the bilingual groups from Hong Kong and Singapore. The researchers interpreted the age of English acquisition and the living environment as the sources of the difference found in the Chinese participants between the two Chinese-spoken localities (Mainland and Taiwan), which showed a language effect, and the dual-language-spoken localities (Hong Kong and Singapore where both Chinese and English are spoken), which showed no language effect.

Westerners' tendency to pay attention to categorization as a way of problem-solving strategies leads to the assumption that they use rules and principles or follow linear logic to understand the properties of objects and behaviors of animals and humans. Easterners focus on relationships and functions within the context. Although it may be overgeneralization to conclude that Westerners tend to attend to categories and that Easterners are more likely to focus on relationships within the context, this comparison gives rise to important implications for understanding the nature of thought, thought processes, and cognitive tools that each cultural group uses to make sense of the world. Overall, these research findings furthermore offer a global understanding of the sense of self, the mind's workings, and belief systems between Westerners and Easterners.

6.1.2.4 Rhetorical Structures: Linear vs. Roundabout

Kaplan (1983) observes that "speakers of different languages use different devices to present information, to establish the relationships among ideas, to show centrality of one idea as opposed to another, to select the most effective means of representation" (pp. 140–141). This observation is summarized in the notion of *contrastive rhetoric* (a.k.a., intercultural rhetoric), indicating that, when an individual expresses his/her ideas in a second language (L2), the individual's first language and culture have an impact on L2 writing in terms of discourse structures and the organization of writing. Contrastive rhetoric has become a research interest in cultural thought patterns and the ways in which an individual's rhetorical structures influence argument or rhetorical patterns in L2. Studies of contrastive rhetoric examine similarities and differences in writing across cultures. Contrastive rhetoric has been criticized for its theoretical foundation and methodological practice as well as overgeneralization. Kubota and Lehner (2004) assert that "…contrastive rhetoric has

tended to construct static, homogeneous, and apolitical images of the rhetorical patterns of various written languages" (p. 9).

With the publication of *Contrastive Rhetoric: Cross-Cultural Aspects of Second-Language Writing* (Connor, 1996), contrastive rhetoric has been reinvigorated in L2 writing. Regardless of its criticism for oversimplification and skewed use of adult subjects, Kaplan (1966) had a valid point in cross-cultural differences of rhetorical or narrative structures. According to him, English speakers (including Germanic languages, such as German, Dutch, Norwegian, and Danish) tend to communicate in a direct and linear way without much digression. In contrast, Asian people are likely to beat around the bush to avoid a direct statement and to take various perspectives into consideration. The notion of contrastive rhetoric is consistent with empirical findings that have been reviewed in this chapter.

Hall (1989) also noted that collectivists tend to subscribe to a high-context communication style relying on relationship dimensions. Reading between the lines is at times necessary for Asians because beating around the bush is not uncommon. Being direct or getting right to the point can be regarded as disrespectfulness or being rude. In contrast, individualistic individuals are likely to have a low-context communication style, showing a tendency of precise, direct, and specific modes of communication. The ability to articulate thoughts and ideas eloquently is encouraged in individualistic cultures. The explicit mode of communication among individualists is used focusing on content in order to avoid misunderstandings and confusions between the speaker and the listener.

To summarize, the differences between the Easterners and Westerners have been found in behavioral research in social psychology, applied linguistics, and communication. Irrespective of research methods, tasks employed, participant groups, and the modes of inquiry, fairly consistent findings have been accumulated to indicate robust differences existing between Easterners and Westerners. In the following section, I attempt to tease apart reasons behind the difference from several perspectives.

6.2 What Makes the Differences between the East and the West?

Observational and empirical evidence has shown that distinct differences exist between the East and the West in cultural milieus, group members' attention and perception, problem-solving strategies, and rhetorical structures. If Eastern and Western cultures are truly different from each other and if Easterners and Westerners think in a truly different way, what makes the differences? What are the underlying sources of the variations? Notwithstanding several ways to answer these questions, the discussion in the rest of this chapter primarily relies on philosophical considerations, Diamond's (1999) interpretation of the world civilization, Nisbett's (2003) view of the geographical difference between the two hemispheres of the globe, and Logan's (2004) alphabet effects.

6.2.1 Philosophical Underpinnings

The word philosophy derives from the Greek word *philosophia* (φιλοσοφία; *philein*, φιλεῖν <to love> and *sophia*, σοφία <wisdom>), meaning the *love of wisdom*. Since wisdom is the ability to think and act appropriately based on accumulated knowledge, experience, insight, and common sense, the way in which the *love of wisdom* is manifested within a group of people would become an underpinning of a particular culture. The way to seek wisdom was dissimilar between the East and the West in antiquity.

6.2.1.1 Aristotle in the West

Western philosophical thinking centers around the Greek philosophies of Socrates, Plato, and Aristotle, although a pre-Socratic philosopher (Thales of Miletus, 624–546 B.C.) existed. The key figure was Socrates (469?–399 B.C.) who studied under Sophists, but transformed the Greek philosophy into a modern philosophy. He used the so-called *Socratic Method* by questioning everyone in order to examine people's views and philosophical problems in logic, and to enlighten them by asking questions in a way that they would get to realize that they knew nothing. He died in 399 B.C. from an execution of drinking a poison hemlock for allegedly corrupting the youth through his philosophical logic and enlightenment.

Plato (429?–347? B.C.) was a disciple of Socrates. He founded the Academy of Athens. Although Socrates did not record his teaching, Plato recorded a number of dialogues that used the Socratic method of inquiry. Plato established a school, which remained for 900 years, and was dedicated to teaching philosophy, mathematics, and theoretical astronomy. Plato's student was Aristotle (384–322 B.C.). He was considered an astute philosopher and scientist. His accomplishment spanned a wide range of disciplines, including aesthetics, poetry, theater, music, rhetoric, logic, physics, biology, metaphysics, zoology, and politics. He crystalized a rule of logic called syllogism. A syllogism refers to a logical argument that comprises a main premise (general statement), a minor premise (specific statement), and a conclusion that is deduced from the two premises, based on deductive reasoning (e.g., Main premise: *All humans are mortal*; Minor premise: *Socrates is a human*; Conclusion: *Therefore, Socrates is mortal*). Aristotle devised syllogisms in order to prevent bad arguments made in the political assembly and the agora. Given that logic is applied by pruning all irrelevant branches in order to leave only the principle or the formal structure intact, syllogisms were a continuation of the Greek tendency to decontextualize arguments as a way to solve contradictions.

Aristotle followed Plato's footsteps by opening his own school in Athens in 335 B.C. The caliber of Aristotle's teaching included all-encompassed subjects, consisting of biology, medicine, anatomy, psychology, meteorology, physics, chemistry, mathematics, music, metaphysics, rhetoric, political science, ethics, and literary criticism. His wide range of knowledge and philosophy made him the most

influential philosopher and scientist of Western civilization under the influence of Socrates and Plato. Aristotle's syllogism formulated the history of Western logic and thought by laying a foundation for the major branches of Western philosophy. It is not surprising that geometry was much developed by the Greeks because proofs rely on formal logic and the resolution of contradictions (Nisbett, 2003).

6.2.1.2 Confucianism, Taoism, and Buddhism in the East

While Aristotle was the foundation of the Greek philosophical tradition, Confucianism (also known as Ruism; {儒教} /rújiào/, <Ru Doctrine>) and Taoism (or Daoism[2]; {道} /dào/, literally <the Way>) established the Chinese philosophical groundwork. The founders of Confucianism and Taoism, Confucius (551–479 B.C.) and Laozi (exact year unknown), respectively, lived in the same era, but were different in their philosophical emphases. Confucianism emphasized rigid rituals, social order, and male dominance, while Taoism emphasized harmony with the universe and egalitarian ideology by rejecting rigidity and boundaries. Both philosophies were human-based and offered practical guides to living, but lacked a deity.

The tradition of Confucianism was developed based on the teachings, values, and theology of Confucius. Confucianism emphasizes humanistic values in order to be in harmony with the law of the universe or heaven ({天} /tiān/), including familial and social harmony, filial piety ({孝} /xiào/), benevolence ({仁} /rén/), and ritual norms (simplified character{礼} traditional character{禮} /lǐ/). Confucianism accepts unequal relationships between people with little resistance to maintain the stability of the group or society. It also values the family's prototype and promotes virtuous behaviors, such as education, tenacity, perseverance, and patience. Confucianism has five key canons, focused on obligation between emperor and subject, between parent and child, between husband and wife, between older brother and younger brother, and between friend and friend. These canons require the child's respect for the parent, the wife's obedience to her husband, and a younger sibling's submission to an older one.

Taoism was different from Confucianism with respect to the goal of philosophy. The two traditions permeated into Chinese culture in different degrees for more than 2,500 years. Confucianism seeks to gain social harmony in a structured society primarily focusing on five relationships mentioned above. In contrast to Confucianism's adherence to social rules, Taoism pursues harmony and balance in life under the *yin* and *yang* forces of Nature. Taoism focuses on the *Tao*, which is translated into the *Way*. The *Tao* denotes the principle of everything that exists, comprising the source, the pattern, and the substance of Nature. Taoism is pantheistic with a philosophical emphasis on the formlessness of the *Way* rather than anthropomorphic concepts of God. It focuses on *compassion, frugality,* and *humility*

[2] Given that pinyin notation is *Dào*, Daoism may be more suitable than Taoism.

as the Three Treasures of basic virtues, as well as naturalness, simplicity, and freedom.

Laozi used the metaphor of flowing water to explain the ideal path to wisdom, as shown in his words "[t]he great Tao flows everywhere, both the left and to the right…it holds nothing back. It fulfills its purpose silently and makes no claims" (Tao Te Ching, no. 34; cited in Shlain, 1998, p. 187). Laozi emphasized *wu-wei* (simplified characters {无为}, traditional characters {無爲} /wú wéi/), where *wu* refers to "nothing" or "there is no…," and w*ei* refers to any intentional or deliberated action. A common translation would be "action without intention." *Wu-wei* is in accordance with the *I Ching* or *Yi Jing* ({易經} /yìjīng/ <The Book of Changes> or <The Classic of Changes>) that proposes that the universe works harmoniously with Nature according to its own way without exerting the person's *will*. Breaking the natural rhythm against the cycles of changes or disrupting the natural harmony is discouraged. Harmony with the natural universe is accomplished by nonaction (wu-wei). The opening lines of the *Tao Te Ching*, a keystone book of Taoism, are as follows:

道可道非常道 (*dào kě dào fēi cháng dào*)
"The Tao that can be told is not the eternal Tao"
名可名非常名 (*míng kě míng fēi cháng míng*)
"The name that can be named is not the eternal name."

From the viewpoint of Taoists, anything that is to tell is to assign meaning within the context. There is always *something* unsaid or undescribed, or that *cannot* be said nor described. Anything that is to name is to *define* the characteristic of something or to set the parameter of a given object or concept. However, there is always *something* in the object or construct that *cannot* be named or defined accurately and universally. Therefore, Taoists rise above the visible entity by not defining or categorizing *Tao* or anything.

Early Taoism drew its cosmological ideas from the notion of *yin* and *yang*, which was influenced by the oldest classic of Chinese culture, *I Ching*, which illustrates a philosophical system about how to be in harmony within the cycles of Nature. The two accompanying forces of *yin* (the feminine, dark, shadow, and passive force) and *yang* (the masculine, bright, light, and active force) come together to achieve complementarity and to reach completeness. As shown in Figure 6.2, the *yin* and *yang* wholeness contains two connected parts of a white swirl and a black swirl, which make the sum of a perfect circle[3]. This signifies that everything in the universe has two opposite forces (*yin* and *yang*). Notably, a black dot is inside the white twirl to signify "yin within yang," while a white dot is inside the black twirl to signify "*yang* within *yin*." The whole symbol indicates the interdependent nature of the *yin* and *yang* opposites and the concept of interpenetrating opposing forces to complete

[3] This *yin* and *yang* symbol is embedded in the Korean national flag.

Figure 6.2. Ying and Yang Symbol

each other for a harmonious wholeness. Mutual influences and wholeness are more valued than the individual's self-benefits.

The Asian philosophy of wholeness and wholesome harmony is permeated in social norms as well as medical practices. The old Asian medicine is based on *yin-yang* and five universal elements, including soil {土}, tree {木}, fire{火}, metal {金}, and water {水}. The *soil* is the balancing element for the four seasons (connected to bodily organs *spleen* and *stomach*); the *tree* is the first expanding element[4] symbolizing life and growth (connected to bodily organs *liver* and *gallbladder*); the *fire* is the second expanding element symbolizing the origin of energy (connected to bodily organs *heart* and *small intestine*); the *metal* is the first shrinking element symbolizing justice (connected to bodily organs *lung* and *large intestine*); and the *water* is the second shrinking element and the source of life energy (connected to bodily organs *kidney* and *bladder*). Herbal medicine focuses on promoting the equilibrium of the body and on preventing physical problems through harmony and wholesome relationships among all body parts rather than on putting interventions on health problems. Hence, Asian medicine shows reluctance to perform surgery, which is different from Western medical practice. Dissection was not introduced to China from the West until the nineteenth century (Nisbett, 2003). Acupuncture works in a similar practice with the philosophy of harmony between the body and Nature. The principle of acupuncture is based on the body's vital energy and the interconnectedness of all body organs as a holistic organism, and, in turn, the human body represents the universe as a miniature. Acupuncturists believe that each area in the palm and the bottom of a foot represents a particular body part and insert small needles at the right pressure point for the body part to be taken care of.

Another illustration of the emphasis of organic relationships within the universe is found in the practice of *fengshui* (simplified characters {风水} traditional characters {風水}, literally meaning <wind-water>). *Fengshui* refers to Chinese geomancy, which is a pseudoscience. It claims to use energy ({氣} /qi/) or invisible forces that bind the universe, earth, and humans to harmonize the individual with his/her surroundings. It covers the altitude, prevailing wind, orientation toward the

[4] As the yin-yang opposites signify, all things of the world move in the cycle of appearing-and-dissolving or contracting-and-expanding.

compass, and proximity to various bodies of water in the surroundings. There is no equivalency to *fengshui* or its counterpart found in the West[5] (Nisbett, 2003).

Along with Confucianism and Taoism, Buddhism was another key philosophy that contributed to the culture and the people's minds in China and the East. The Buddhist philosophy consists of the teachings and reflections of Buddha (between sixth and fourth century B.C.). As Buddhism was spread across Asian countries beyond India, it became trans-regional and trans-cultural. It endorses the concept of *self-less* (i.e., no fixed personal identity due to constant changes) and *emptiness* (i.e., nonexistence or the ephemerality of everything). Buddhism involves beliefs and practices of transcendental divinity and the spiritual insight of natural *emptiness*. The Buddhist philosophical tradition traveled to China from India and continued to develop in the Tibetan and East Asian Buddhist traditions.

Taoism, along with Confucianism and Buddhism, has permeated into Chinese history, tradition, philosophy, and public wisdom. Confucianism has gone through a rise and fall according to China's political doctrines and regime's politics. Despite the differences across Confucianism, Taoism, and Buddhism, the three philosophical traditions share commonalities in seeking harmonization. There is an old painting that can be found on the Internet, which portrays three men, Confucius, Laozi, and Buddha, laughing by a river stream, which is entitled "Confucianism, Taoism, and Buddhism Are One". The paining symbolically shows Chinese people's tolerance and agreeable interpenetrations of religious ideas such that different views can come together in harmony. Hence, religious wars in the East have been rare in history (Nisbett, 2003; Shlain, 1998).

6.2.2 *Characteristics Typically Found in Easterners and Westerners*

Based on the aforementioned empirical findings in social psychology, cognitive psychology, and applied linguistics, Table 6.2 summarizes key characteristics demonstrated by Easterners and Westerners. The nature of the characteristics is not binary. However, they were summarized for the purpose of juxtaposition.

For Asians, the world and Nature are simply too complex and their subcomponents are too interactive to be categorized in a simplistic way. Therefore, they focus on relationships among subcomponents of the world and Nature. The lack of interest in categories and classifications might have prevented Asians from discovering laws that allow them to explain classes of events or objects. Under the traditions of Confucianism and Taoism, the Chinese were inclined to look outward toward their peers and upward toward authorities in carrying out their economic, social, and political business (Nisbett, 2003). As research shows, Westerners have the tendency

[5] A reviewer pointed out Western geomancy as a possible equivalent to *fengsui*. I view that Western geomancy and *fengsui* are different from each other, as Nisbett (2003) mentions.

Table 6.2. Characteristics Implicitly and Explicitly Demonstrated by Westerners and Easterners

Dimension	Easterners	Westerners
Attention and Perception	Relationship	Objects
Habits of organizing the world	Relationships	Categories
Organization of Knowledge	Inductive	Deductive
Reasoning	Proposition	Logic
Application of logical rules	Not likely	Use of logical rules
Composition of the world	Substances	Objects
Beliefs about controllability of the environment	Incontrollable/Adaptable	Controllable
Tacit assumptions about Nature	Change	Stability
Preferred patterns of explanation for events	Cast a broader net of the environment	Focus on objects
Debate	Avoid conflict and dissonance	The free marketplace of ideas
Application of dialectical approaches	Seek the *Middle Way*	Insist on correctness of one's belief
Causal Inference	Context-centered	Specific item-centered
Science and Mathematics	Algebra and Arithmetic	Geometry
Medicine	Holistic approach; Prevention-oriented	Analytic approach; Intervention-focused
Conflict Resolution	Intermediaries; Hostility reduction and compromise	Legal confrontations; Right or wrong and principle of justice
Rhetoric Structure	Roundabout	Linear
Religion	Both/And Orientation; Pantheism; Cycles and recurrences	Right/Wrong mentality; Monotheism

of attending to objects and events in a way that objects are taxonomically arranged and categorized. This can be one explanation of research findings by Nisbett and colleagues about Asians' focus on relationships and European Americans' tendency to categorize stimuli (Chua, Boland, & Nisbett, 2005; Ji, Peng, & Nisbett, 2000; Nisbett, 2003; Nisbett, Peng, Choi, & Norenzayan, 2001).

As briefly mentioned earlier, the West has a tradition of syllogism, which is based on deductive reasoning. Westerners are generally in the habit of applying logical rules to ordinary events and are likely to forego the plausibility of conclusions. In contrast, East Asians are more likely to set deductive logic aside in favor of the desirability and plausibility of conclusions. Each case is understood within context, which allows inductive reasoning to set in. Conclusions tend to be reached by understanding the context first and then subscribing to the general standard and complying with it.

Logic can be seen as a cognitive tool that is developed to understand the principles of natural and social operations and to deal with social matters. A style of

reasoning was developed as a Chinese way of logic, which is called dialecticism, that focuses not only on contradictions, but also on how to resolve them, transcend them, or find the truth in both (Nisbett, 2003). This is different from the Hegelian dialectic because the Chinese dialectic deals with contradictions to understand relationships among objects or events in order to transcend oppositions (Nisbett, 2003). The Hegelian dialectic uses the cycle of *thesis-antithesis-synthesis* to obliterate contradictions instead of embracing or transcending them in order to understand objects or events better.

Social practices can influence habitual thinking and the way of conflict resolution. Under the traditions of Confucianism and Taoism, debate is not encouraged and is considered disrespectful in Asian culture; hence, the combative rhetoric was absent in Asian ideology. Whenever conflict arises, Asians tend to be oriented toward a *Middle Way* to reduce animosity between both parties instead of seeking fairness. Asians have the tendency of considering both other people and their own goals in search of the benefit of themselves by not being overly constrained by their relationships with other people (Nisbett, 2003). The difference in the ways of conflict resolution and the priorities placed in the East and the West is observed in the current practice of law in Asia and the U.S. According to Nisbett (2003), not only is the ratio of attorneys to engineers 40 times lower in Japan than in the U.S., but also the expected role of lawyers is different between the U.S. and Asian countries. The U.S. lawyers' emphasis is placed on confrontations and defense as well as on demands for justice in terms of winners versus losers within the legal system. However, lawyers in the Eastern countries serve more as intermediaries or mediators to reach compromises (*Middle Way*) in order to reduce hostilities between both parties involved in the legal system (Nisbett, 2003).

Due to their foci on rules for conducting debate, the principle of non-contradiction, and formal logic, Westerners might have been able to develop scientific modes of inquiry and thus yield modern scientific achievements. It is natural to make an advancement from logic to science, because science can be viewed as an extension of logic and rhetoric. Since the standard logic *hypothesis-evidence-conclusion* that is used for geometric proofs applies to debate and rhetoric, a geometric proof essentially involves rhetoric (Cromer, 1993; Nisbett, 2003). In contrast to their advances in algebra and arithmetic, the Chinese made little advancement in geometry-related realms because formal logic and the principle of contradictions, which were crucial components for geometric proofs, were not considered important for them (Logan, 2004; Nisbett, 2003). Cromer (1993) also argued that ""It [science] originated in the democratic practices of ancient Greece, which replaced private dogma with public debate" (p. 250)

In summary, since the Eastern orientation toward Nature and humanity is concrete, abstract speculation was discouraged. This is different from the abstraction infused in the Greek philosophy. Given the order of existence (i.e., scripts preexisted all philosophical and cultural groundworks), the predated scripts might have influenced the cultural differences between the East and the West because Chinese characters are relatively concrete, compared to the alphabet's arbitrariness and abstraction.

6.3 Interpretations of the difference between the East and the West

6.3.1 Diamond's Guns, Germs, and Steel

Diamond (1999) is a keen observer of the different developmental trajectories of human societies and human history across continents on the globe. Diamond (1999) questions why history has unfolded differently on different continents in the world. This is a fundamental question to understand human history and historical inequalities and to predict a future path. The continents of sub-Saharan Africa, the Americas, Island Southeast Asia, Australia, New Guinea, and the Pacific Islands have shown the various trajectories of civilization and historical inequalities among the continents. Some societies developed literate industrial systems, while other societies developed only non-literate farming systems for a long time. Some societies still remained in a hunter-gathers stage with stone tools (Diamond, 1999). Diamond examines a large set of contrasts of the regions in light of colonial expansions, technical and political differences, different rates of development, linguistic reverberations, mode of civilization, and environmental differences across continents from the lens of anthropology, behavioral ecology, epidemiology, archeology, and linguistics.

In order to identify a chain of courses to explain why human development has proceeded at different modes and different rates of civilizations on the different continents in history, Diamond provides several explanations. First, biological differences in innate abilities among peoples, such as intelligence, can be a factor behind the advancement of modernized societies or the disparate rates that different societies have shown in the course of civilization. Based on his 33 years of work with New Guineans, however, Diamond completely dismisses a genetic factor as a determiner of the mode and rate of civilizations among the continents. He claims that IQ test results are the outcomes of cultural learning based on childhood environments and learned knowledge, which are not a true measure of pure innate intelligence.

Second, the seasonally variable climate can be a cause that explains the process of civilization because it is assumed that human creativity and energy are stimulated by a cold climate but are fended off by a hot, humid, and tropical climate. The assumed stimulatory effects of the cold climate and the inhibitory effects of hot and humid climate might have stemmed from the view that the seasonally variable climate tends to pose more diverse challenges for living than does a seasonally constant tropical climate. The challenges in the cold climate, coupled with the long winter at high latitudes that left people with more time to stay indoors and invented necessities, might have resulted in more technological invention for survival. However, Diamond dismisses this explanation as well because "…the peoples of northern Europe contribute nothing of fundamental importance to Eurasian civilization until the last thousand years…" (p. 22).

Third, irrigation systems in agricultural regions, such as China, India, and Peru, can be another explanation because large-scale irrigation system required centralized bureaucracies, and, in turn, centralized political systems. However, archaeological evidence shows that political centralization arose before controlled complex irrigation systems for other reasons (Diamond, 1999).

The fourth explanation has to do with factors including European guns, infectious diseases, steel tools, and manufactured products, which enabled Europeans to invade other peoples to conquer for imperialism. In short, it boils down to the effects of guns, germs, and steel on the disparate routes taken in different continents. Such an explanation is plausible for explaining the pathways of civilizations in the world. However, Diamond claims that this explanation is still incomplete because it does not offer an ultimate explanation for the identification of responsible causes for the unequal rates and modes of civilization in world history. In other words, this account does not explain *why* Europeans, rather than other groups, were able to make guns, ended up with germs, and were able to use steel. According to Diamond, the query continues until we have a convincing, comprehensive, and agreed-upon explanation to account for the broad pattern of world history.

Diamond (1999) summarizes his book, *Guns, Germs, and Steel: The Fates of Human Societies*, in one sentence as follows: "History followed different courses for different people because of differences among people's environments, not because of biological differences among peoples themselves" (p. 25). He might as well adopt the notion of environmental geography and biogeography in order to explain the lopsided historical and developmental trajectories across societies in world history. The notion of geography is directly linked to the gist of Nisbett's (2003) argument. In the following section, Nisbett's book entitled *The Geography of Thought: How Asians and Westerners Think Differently…and Why* is briefly discussed.

6.3.2 Nisbett's The Geography of Thought

Nisbett (2003) meshes cultural intricacies with a broad concept of geography situated in the East and the West. Nisbett (2003) claims that human behavior is a function of culture and that the difference between the East and the West results from the difference in ecological systems, along with social structures, philosophies, and educational systems. Nisbett (2003) attempts to understand how Asians and Westerners think differently and explains the reason behind the variabilities in his book *The Geography of Thought.* He finds the source of the differences between the East and the West in the geography of Greece and China. Greece is viewed as the cradle of western civilization as well as the birthplace of democracy, Western philosophy, literature and drama, major scientific and mathematical principles, and historiography. Greece is a transcontinental country situated at the crossroads of Europe, Asia, and Africa, comprising a mountainous peninsular mainland and numerous islands. Greece is one of the most mountainous countries in Europe with

about 80% of the land covered with mountains and hills. This ecology made the Greek rely more on hunting, herding, fishing, shipping, and trade than other options.

Nisbett (2003) notes that Greece was uniquely different from all contemporary civilizations in the development of individuality, personal freedom, objective thought, rational argument, and political systems. Greece's geographical ecosystem was suitable to maritime trade, which was lucrative for the Greeks in antiquity. This led to the Greeks' focus on shipping and oceanic industries that have been a key element of Greek economy since ancient times. Activities, such as hunting, fishing, shipping, and trade require a comparatively low level of cooperation with others. The geographical environment made the ancient Greeks develop a strong sense of individual identity as well as a sense of personal agency, which led the Greeks to a firmly individualistic mentality.

The ancient Greeks subscribed to plays, poetry readings, and philosophies by attending gatherings to share knowledge for personal growth at Epidaurus from dawn till dusk for several days in a row as special occasions in the period from the sixth to the third century B.C. (Nisbett, 2003). A theater built into a hillside at Epidaurus, which was known as the birthplace of Apollo's son Asclepius in Greece, held about 14,000 people. With the tradition of attending plays and poetry sharing on special occasions, it is not surprising that the word "school" comes from the Greek word for "leisure" *scholé*. The legacy of Aristotle made the Greeks coalesce the classical ideal for education with Greek philosophy in pursuit of knowledge. Under Greek philosophy, individual freedom and curiosity about the world were encouraged, coupled with a sense of agency. The Greeks' sense of agency and individuality also helped establish the tradition of debate. The logic of debate influenced the approach to law and order. This laid a foundation for democracy in the fifth century B.C. (Nisbett, 2003). Science or the scientific mind was also reinforced by logic, and, in turn, shaped the Greek style of rhetoric.

The geographical ecology in ancient China was different from that of ancient Greece. China was the cradle of Eastern civilization as the birthplace of Eastern philosophical traditions. Ancient China had relatively low mountains compared to Greece, fertile grasslands, and rivers, which encouraged the people to adopt agriculture especially in southern China. Agricultural people need to live and work in harmony in a reasonably cooperative fashion to deal with seasonal labor-intensive agricultural work (Nisbett, 2003). As opposed to the Greeks' attendance at plays and poetry readings as special occasion events, Chinese special-occasion events were primarily visiting and spending time with friends and family (Nisbett, 2003). These activities reinforced a sense of group harmony and the importance of consensus among members. In addition, rice farming required irrigation to be regulated, which resulted in the society's centralized control over irrigation systems. This means that environmental ecology affected Chinese livelihood, modes of living, social structures, and state involvement in people's everyday lives, resulting in central control of irrigation systems. The Chinese's acceptance of the centralized control in antiquity might have to do with their tolerance of top-down governance. This is consistent with the aforementioned Hofstede's cultural scales. Specifically, Chinese people tend to show a higher scale score on Power Distance than that of the

Japanese (80 vs. 40, respectively) on Power Distance (Hofstede et al., 2010). This means that the Chinese are more tolerant of the unequal distribution of power in society than the Japanese.

The implied *homeostasis* is also an important implication of the view of the causes of Greek and Chinese mental differences (Nisbett, 2003). With the agricultural tradition in China, which requires cooperation with others, the Chinese are less concerned with personal goals or self-aggrandizement than are Westerners. As a result, group goals and coordinated actions are more often their concerns than individual gratification and growth.

6.3.3 Logan's The Alphabet Effect

Diamond's analysis of different routes taken for civilizations among the continents in the world as well as Nisbett's geographical and social-psychological interpretation of differences in the East and the West have keen points in their own right. Masuda and Nisbett (2001) claim that cultural systems influence the mode of attention and further the culture-specific patterns of attention. A series of cross-cultural studies converge on Easterners' holistic and Westerners' analytic thinking styles (Miyamoto et al. 2006; Nisbett, 2003; Nisbett & Masuda, 2003; Nisbett et al., 2001). What is still unknown is a more microscopic enabler of perception, cognition, and thought patterns than culture, because culture is still a broad term.

The writing system has played an instrumental role in the development of the styles of information processing in the East and the West. In a study of the evolution of writing systems, Logan (2004) describes how phonetic writing, the alphabet in particular, has molded the development of Western civilizations and intellectual and cultural growth, particularly compared to the Chinese writing system. He claims, in an attempt to understand the making of Western civilization, that the alphabet promotes cognitive skills in the dimensions of abstraction, analysis, coding, and classification. Although Logan meshes Western civilization with the alphabet effect, the influence of written language has already been fermented by Innis (1972) and Ong (1982) in earlier days, who explored the changes in our thought processes and social structures as a result of literacy.

Since the alphabet uses a smaller number of graphs to represent spoken language (i.e., the economy of symbols in alphabetic systems), a greater level of abstraction and analytic skills is required to decode phonemic symbols, than in Chinese characters, which, in turn, contributes to the user's cognitive development in a particular way. Given that the West primarily uses the alphabetic writing system, the alphabet has made a significant impact on Westerners' cognition and thought patterns. Logan (2004) suggests that, due to the use of alphabet, the ancestors of Westerners were able to develop codified law, monotheism, abstract science, deductive logic, and individualism. In contrast, Chinese characters promote holistic, intuitive, polytheistic characteristics of the Chinese due to the logographic characteristics of the Chinese written language.

Logan (2004) has received criticisms by the public and Chinese scholars for the sweeping overgeneralization and for degrading Chinese characters and cultural characteristics based on his claim that Westerners are generally rational and analytic and that the Chinese are mystical and holistic due to the different writing systems. It is worthwhile to reassess the role of the writing system in our cognition and thought because we are bombarded with text and are constantly reading in print or online. According to Logan (2004), reading in alphabetic scripts is under influence of the intellectual by-products of reading or scientific and logical thinking, such as abstraction, rational analysis, and classification, which are predominantly provided by the alphabet. Despite this contentious claim, research findings in social psychology support Logan's claim (see the Attention and Perception as well as Problem-Solving Strategies sections in this chapter). The counterargument from the alternative hypothesis (i.e., the writing system has *no* effect on cognition[6]) is difficult to prove. Since the alphabet effect is covered again in Chapter 7, the Consequences of Reading, further discussions are reserved to the following chapter.

6.4 Toward the New Direction, *Script Relativity*

Although it is not an exaustive review of the differences between the East and the West, this chapter has provided a condensed survey of philosophical underpinnings as well as cultural and behavioral characteristics of the peoples in the two hemispheres of the globe based on empirical research, collective views of scholars, and my anecdotal observations. Masuda (2017) notes that it is time to explain the subcomponents of holistic versus analytic culture as well as the thought patterns of cultural members and to go beyond the dichotomous characterization. She also calls for further research on other dimensions of a society that influence culture and group members' social behaviors.

Diamond (1999) notes that "[a]s of the year A.D. 1500, … Europe's worldwide colonial expansion was just beginning…" (p. 15) and continues to state that "… those technological and political differences as of A.D. 1500 were the immediate cause of the modern world's inequalities. Empires with steel weapons were able to conquer or exterminate tribes with weapons of stone and wood. How, though, did the world get to be the way it was in A.D. 1500?" (p. 16). Diamond answers the question with the identification of the three factors of *guns*, *germs*, and *steel* that contributed to the pathways of civilizations in world history. He also asserts that the "[d]ifferent rates of development on different continents from 11,000 B.C. to A.D. 1500 were what led to the technological and political inequalities of A.D. 1500" (p. 16). Although he does not point it out, it is not coincidental that 11,000 B.C. was about the time writing started to emerge and that A.D. 1500 is around the time when

[6] A reviewer states that that "cognition had an effect on the development of the writing system and not the other way round." This assertion needs to be scientifically backed up. So far, there is no research evidence that supports this claim.

information dissemination was revolutionary more than ever before due to the invention of metal movable printing in the West[7]. The 42-line-per-page Gutenberg Bible was first published in 1455. These two timepoints bear a significant meaning that gives rise to script relativity.

Diamond (1999) also explains the civilization of Australia while dismissing a genetic factor as an explanatory cause of the disparity in the rate and mode of civilizations. European immigrants to Australia built a literate, industrialized, politically centralized, and democratic society within a century, whereas the aborigines remained the same tribal hunter-gatherers stage. Diamond poses a question "What further proof could be wanted to establish that the differences between Aboriginal Australian and European societies arose from differences between the peoples themselves?" (p. 19), after pointing out that "the environment was identical and the sole variable was the people occupying that environment" (p. 19). Diamond elucidates how metal tools and food production allowed the Europeans immigrants to Australia to spearhead the civilizations and conquer the aborigines who did not use metal. Despite the valid point, what is missing in Diamond's argument is the presence and effect of written language. When they occupied the Australian tribes, Europeans had a solid form of written language, while the Australian tribes did not.

Diamond (1999) also notes that China was technologically more advanced and more innovative than Western Eurasia until A.D. 1400. Again, this period coincides well with the explosion of literacy due to movable metal printing in the West. During the dynastic period in China, which ended in 1911, literacy was confined to "a tiny upper crust of males while preventing the spread of functional literacy among the masses" (Taylor & Taylor, 2014, p. 89). The Confucius classics and other books were the main subject of the institutionalized civil-service examination in ancient China, which was the royal ticket for social upward mobility. Since Chinese characters are complex and are not easy to learn, it was easy for the upper class to monopolize literacy. As shown in the following poem written by a Song emperor, "books" were considered a means to "enrich your family" as "houses of gold," which is different from that of industrialized capitalist societies.

> To enrich your family, no need to buy good land:
> Books hold a thousand measures of grain.
> For an easy life, no need to build a mansion:
> In books are found houses of gold….
> A boy who wants to become somebody
> Devotes himself to the classics, faces the window, and reads (Miyazaki, 1963/1981, p. 17, cited in Taylor & Taylor, p 91).

[7] Korea was the first country in the world to invent a movable *metal* type printing machine during the Goryo dynasty in 1377. This was 78 years earlier than the Gutenberg 42-line Bible published in 1455. The first publication that used the movable metal type printing technology was a book of Buddhist teachings, *Jikji*, written by a monk named Baekun (白雲), as mentioned in Chapter 5. This historical feat had been buried for a long time because a French missionary to Korea took *Jikji* to France and the book had been in the Collection of the National Library of France since 1890. The credit for the first movable metal printing in the world was finally granted in 1972 when a Korean scholar found it in the national library in France.

After the dynastic period, China was still able to restrict literacy with the establishment of the communist People's Republic from 1949. However, the West has gone through a different trajectory due to the phonetic writing system which was much easier to learn to read than Chinese characters and due to metal printing that was instrumental for promoting literacy among the masses. In short, the alphabetic writing system contributed to the establishment of democratic information sharing (Logan, 2004; Wolf, 2007). In this line, it is not surprising to find that current information-sharing endeavors and open-access information have begun and been materialized by individuals whose written language is the alphabet.

As indicated in the Prologue and Chapter 1, oral languages that do not have corresponding written languages are more likely to disappear in the world. If there is a truth to Logan's (2004) claim regarding the alphabet effect on promoting more deductive, linear, scientific thought, the recent surge of Chinese economy and technological development may have to do with the supplementary use of Pinyin to their characters and, in turn, recently gained high literacy rates. This phenomenon is not remote from script effects, which is the *script relativity hypothesis*, the main thesis of this book.

In a similar vein, as mentioned in the Prologue, South Korea's economy rapidly boomed into a developed country within less than 50 years from a war-torn developing country after the Korean War (1950–1953), which is dubbed the "miracle on the Han river." Factors, such as strong political leadership, healthy nationalism or patriotism, and hard work of the labor force stemming from Confucius values and ethics, can be attributable to the rapid transformation. However, I truly believe that Hangul was behind the phenomenal socio-economic growth, because the Koreans had already had those characteristics in history but had never achieved such a success before the "miracle on the Han river" in recent decades. With the high literacy rate due to Hangul's great learnability and its effect (i.e., alphabet effects), the Koreans were able to achieve such a success. Notwithstanding the small size of the population (51 million), compared to that of any developed country, the Koreans continue to excel in the many sectors, such as mobile devices, K-pop, K-drama, films, and cosmetics.

The findings of social psychological studies are particularly related to *script relativity*. As reviewed earlier, Easterners have tendencies to rely on context-based and background information in a holistic fashion, while Westerners tend to zero in on particular information presented at the center in an analytic way (Masuda & Nisbett, 2001; Miyamoto, Nisbett, & Masuda, 2006; Nisbett, Peng, Choi, & Norenzayan, 2001). These findings may be attributable to the script characteristics of Chinese and English. Chinese characters are processed holistically and, as a result, Chinese readers process objects and situations more holistically than Westerners. In the same vein, the alphabet is processed serially[8] (Coltheart et al.,

[8] White et al. (2008) indicated that "letters within words are processed serially rather than in parallel, at least for early word processing" (p. 1274). Since reading models, such as the dual-route model (Coltheart et al., 2001), the SERIOL model (Whitney, 2001), or the connectionist model, are beyond the scope of this book, no further discussion is provided here.

2001; White, Johnson, Liversedge, & Rayner, 2008; Whitney, 2001), unless words are orthographically irregular, and, as a result, alphabetic readers process objects and situations more analytically than Chinese. In particular, Ji et al.'s (2004) study shows significant language effects among adults from Mainland China and Taiwan and from the U.S. and Mainland China when they were tested in Chinese compared to when tested in English, but no language effects were found among the bilingual groups from Hong Kong and Singapore. These language effects can be further extended to script effects because all participants in the aforementioned studies are university students who have been literate for about two decades.

From a microscopic view, variations are also found within the three East-Asian cultures. Although some East-Asian culture is shared in general, social values, modes of operating societal norms, and ideological or religious preferences are different among the Chinese, Japanese, and Koreans. Historically, Chinese characters were used in all three nations until the Korean government removed Hanja from the national curriculum in K-12 settings (some Korean parents still make their children Hanja learn through private lessons). The common use of the morphosyllabary might have generated the shared East-Asian culture among the three nations. However, the Koreans' Hangul use might have been reinforcing the aforementioned differences in the East-Asian nations. The existing interpretations of the locus of the differences (i.e., geography and environment), as reviewed earlier, cannot explain those specific differences among the three cultural groups. Script relativity would be an alternative or the best account to explain them.

In the following chapter, the consequence of reading is discussed from an ecosystem perspective. Chapter 8 discusses script effects based on psycholinguistic research findings. Chapter 9 discusses script relativity using the findings of neuroimaging studies.

Chapter 7
The Consequences of Reading: The Reading Brain

> *"Reading can be learned only because of the brain's plastic design, and when reading takes place, that individual brain is forever changed, both physiologically and intellectually. For example, at the neuronal level, a person who learns to read in Chinese uses a very particular set of neuronal connections that differ in significant ways from the pathways used in reading English."*
>
> - Marianne Wolf (2007, p. 5).

Abstract This chapter discusses the consequences of reading in terms of the reading brain. As a holistic view of the mind's software, the ecosystem of reading is used as a theoretical framework, which includes microsystem, mesosystem, exosystem, and macrosystem. The ecological system of reading particularly focuses on the reader's mind as the microsystem and on language and script (i.e., oracy and literacy) as the mesosystem within the interrelated networks of the biological basis, cognitive characteristics, and the sociocultural dimensions of learning and reading. The discussion continues to cover the similarities and differences between oracy and literacy. Finally, the reading brain is discussed with respect to the cognitive impact of reading. The literate brain shows a stable cerebral architecture and neural networks specifically attuned to reading in the left occipito-temporal region.

Keywords ecosystem of reading · microsystem · mesosystem · oracy · literacy · similarities and differences between oracy and literacy · the reading brain

The word *psychology* was derived from the Greek word *psyche* (more specifically the Greek word *psuche*) meaning the "mind" or "soul" and *logos* meaning "study" or "discourse." The word *psychology*, therefore, literally means the *study of the mind*. Since the mind is at the heart of human beings, psychology also refers to the study of people. The mind is likely to be shaped by what we do most of the time. We

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read everyday especially in this digital era in the forms of instant text messages and social media. Text is virtually all-pervasive in our lives. We often read beyond our intention even when we watch television due to the provision of caption or commercials that embed text. Wolf (2007) argues, as shown in the epigraph, how reading is learned changes the brain's neuronal circuits. Given the connection between the brain and the mind, the major question to understand human beings involves how the brain and the mind are shaped and how they function in conjunction with our habitual reading.

The interconnected networks among reading, language, cognition, and culture are related to Bronfenbrenner's (1979) ecosystem, which holistically captures the individual's development within the interrelated systems of mental, cognitive, physical, moral, and social environments. In human development, language and reading skills are foundational and instrumental to the development of other skills. Within this context, this chapter discusses the consequences of reading. It begins with the software of the mind with respect to the ecosystem of the mind, cognition, language and script, culture, and geographical environments. After discussing the ecosystem of reading, the chapter reviews the cognitive impact of reading in light of the reading brain before discussing linguistic and neurolinguistic evidence of *script relativity* in Chapters 8 and 9.

7.1 Ecosystem of Reading

Bronfenbrenner's (1979) ecological theory is related to the framework of the mind's software, as it encompasses multiple components that contribute to our learning. The ecological theory explains the individual's developmental growth with respect to the interconnected networks of biological basis, cognitive characteristics, and the sociocultural dimensions of learning. It views human development as a system of interactions, which comprises four subsystems, comprising the microsystem, mesosystem, exosystem, and macrosystem. The microsystem, the most influential level at the core of the nested system, involves the individual and his/her interactions with immediate and direct agencies, such as caregivers, family members, and peers. All relationships within the ecosystem are bidirectional. The mesosystem refers to the second layer of the nested system involving interconnections and relationships between/among two or more microsystems and between the individual and schools. The exosystem refers to the third layer involving influential but indirect relationships between the individual and other agencies, such as the media, socioeconomic status, poverty, and ethnicity (although these can be categorized as a macrosystem in a different context). The macrosystem concerns the last outermost layer of the system involving the culture of the individual. It also includes cultural and societal beliefs, socioeconomic status, poverty, and ethnicity. All these subsystems commensurate with one another. As the individual's growth is shaped by the individual's interactions with the different layers of surroundings, each system exerts both independent and collective impacts on the individual's growth.

The ecosystem model shows how an individual's cognitive development occurs in the nested and interconnected structures. Given that not only is reading fundamental for information gathering, processing, and sharing, but also involves multifarious components, such as the script being read, the brain, context, prior knowledge molded by a set of educational systems, culture, and geo-environments, this model fits to reading as well. Drawing upon the ecological system, Figure 7.1 displays the framework of the mind-language/script-culture-geography/environment connectivity as a nested system in relation to reading. At the center is the individual's mind (microsystem) which is directly influenced by language and script (mesosystem). The subsystem of language and script (or reading) is nested within another layer of culture (exosystem). Since culture is indispensably connected with language and script, culture can reinforce the linguistic and scriptal characteristics in a given culture. The culture is affected by geographical environments (macrosystem). Although the model is stretched toward reading, this is one way to understand the impact of reading.

The ecosystem framework comprises both quantitative and qualitative development in the subsystems. The quantitative and qualitative components interact together to facilitate new and more efficient learning (primarily through reading) within the developmental organism. Learning that occurs within the ecosystem is affected by a number of factors. Firstly, individuals have varying levels of aptitude and motivation as well as varying amounts of effort they can put in at a given (reading) situation. These differences are dependent upon individual characteristics and intellectual capacities. Secondly, individuals use selective attention or focus on information depending on relevance and necessity in different learning situations at hand. Lastly, individuals have varying degrees of familial and institutional resources that are influential to their learning. Since the geography and culture have been discussed in Chapter 6, this chapter focuses on the interaction between the script being read and the reading brain as the mesosystem and microsystem, respectively.

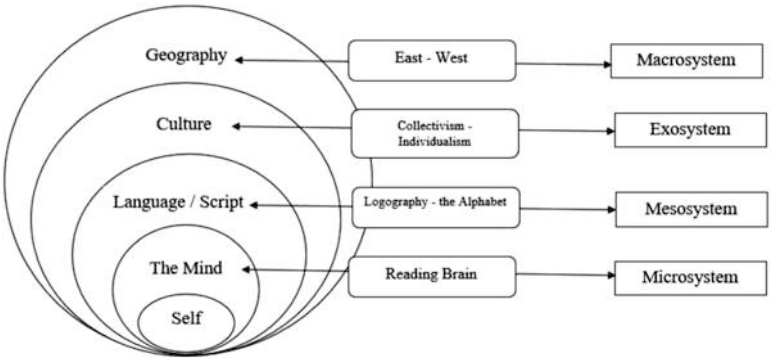

Fig. 7.1 The Ecosystem of Reading

7.1.1 The Reader's Mind (Microsystem)

The mind is a stream of consciousness and a set of mental capacities encompassing consciousness, perception, judgment, thought, memory, recognition, imagination, volition, and language. It closely works with the brain and nervous systems to understand the outer stimulus, and forms the power of awareness, recognition, and imagination. Coupled with the brain, the mind is the engine that drives our attention, attitudes, and actions. Since mental faculties and behaviors are the functions of the mind, of great interest in cognitive psychology is how the mind works in order to understand our abilities, attitudes, and behaviors. The mind regulates the way we make sense of the world, the way we comprehend and respond to the world, and the way we recognize the significance in our lives. Mental processes such as perception, cognition, and emotion, as well as environmental effects such as sociocultural influences and interpersonal relationships, jointly affect our learning, especially when it comes to reading because reading is a complicate cognitive process (Dehaene, 2009; Wolf, 2007).

In reading, the mind processes information available from the script being read, textual contexts, and prior knowledge formed by culture and physical environments. However, the selectivity of attention (e.g., cocktail party syndrome or effect; the tendency to attend to one thing rather than another while filtering out a range of other stimuli) is primarily involved in reading, coupled with selective perception and understanding. Individuals' cognitive abilities inherently vary. However, the function of cognitive systems for reading is largely similar across individuals in the mechanism from initial input (e.g., text), its mental processes (e.g., memory, retrieval, and information storage), and output (e.g., comprehension). This also accords with the notion of the universal grammar of reading posed by Perfetti (2003).

7.1.2 Language and Script: Oracy and Literacy (Mesosystem)

Language is closely related to cognition. Language is essentially involved in every aspect of learning and development. Lenneberg's (1967) summarizes biological criteria for language in his book, *Biological Foundations of Language*, as follows:

- Language is viewed as a species-specific behavior and a human-specific ontogenetic process with universal milestones in language development.
- Although language processing primarily involves the left hemisphere of the brain, language is integrated into the cerebral structure as a whole.
- Language structure is a function of basic processes of categorization through generalization, differentiation through the segmentation of categories into subcategories, and transformation through the identification of similarities between categories.
- The linguistically rich environment is necessary for the actualization of our innate ability of language before puberty.

Although every species has its own communication system, the level of breadth and depth is different. If it is unique to the species, the communication system is part of the genetic makeup of the members of the species (Fernández & Cairns, 2010). The human communication system is the most comprehensive. The sophistication of human language is the defining line between humans and other species. No animal has been able to acquire or learn a creative syntactic system. Some chimpanzees are able to learn more than a hundred individual words, but they fail to organize words in syntactically coherent ways (Fernández & Cairns, 2010). The animal example provides evidence that language is the biologically endowed system only for human beings.

The second criterion involves the universality of language. From the viewpoint of generative linguistics, especially the notion of universal grammar (Chomsky, 1957), the human mind is biologically constructed and programed. According to Chomsky (1957), all humans are hard-wired or biologically predisposed to acquire language using the *language acquisition device* embedded in our brain. Due to this endowed linguistic faculty, we can produce and understand the infinite number of sentences. Universal grammar posits not only the general organization of the system across languages, but also the universal properties of syntactic rules such that all human beings can utter and understand an infinite number of new sentences. General consensus in applied linguistics and psycholinguistics is established on linguistic universals and linguistic particulars.

The third criterion involves the difference between oral language and written language. The acquisition of the native language is a byproduct of a naturally unfolding process with the condition of proper linguistic exposure, a certain period of time, and interaction between and among social members. Due to its natural aspect, the acquisition of the first language cannot be suppressed when these three conditions are provided. This is another manifestation of the biological nature of language. In contrast, written language does not come naturally and needs to be explicitly learned.

The fourth criterion connects to common language-acquisition milestones and acquisition speed, irrespective of the language being acquired, culture, and learning contexts. The critical period hypothesis posits that there is a golden time window for natural language acquisition (Lenneberg, 1967). A critical period of language acquisition is universally acknowledged as a necessary condition for adequate acquisition before puberty to acquire intuitive syntactic skills in the first language and native-like pronunciation in a foreign language or a second language. After puberty, language acquisition becomes more challenging and effortful, and, although it is possible, learners hardly acquire a full command of language, especially in syntax. Evidence for the critical period hypothesis comes from a report of Genie, a California girl who was deprived of linguistic input from being locked in a closet by an abusive father for the first 13 years of her life (Curtiss, 1977). Without natural exposure to language until her early teen years, Genie was never able to master English despite experts' explicit linguistic training. She was able to acquire words, but never gained the full mastery of the grammatical system. This is a piece of evidence that strongly

demonstrates that language acquisition is an enterprise that relies on both nature (innateness) and nurture (learning).

Although oral speech comes naturally to human beings who have no physiological and psychological impairment, reading is not biological. Building upon Lenneberg's (1967) biological foundations and psychological capacities of languages, Table 7.1. juxtaposes similarities and differences between oracy and literacy.

According to Ong (1982), reading connects to a new sensory modality by moving speech from the oral-aural form to the form of vision. Ong (1982) asserts that writing not only transforms societies, but also restructures the way we think about and perceive the outer world. However, oracy and literacy are not in a binary opposition. They rather work as a complementary means to each other. Especially as a functional medium for the message transmission, oracy and literacy work in tandem.

McLuhan's (1964) famous dictum "[t]he medium is the message" underscores a symbiotic relationship between the form of the medium and the effect of the message. It is "the medium that shapes and controls the scale and form of human association and action" (McLuhan, 1964, p. 9). Beyond being a mere channel for the transmission of message, a medium conveys its own implicit message that affects our perception and the understanding of information delivered, irrespective of its content of the message or the intention of the sender. With the awareness of the crucial role of the medium, McLuhan (1964) classified eight media, including speech, pictographs, ideographs, alphabets, print, radio, film, and television. These media represent the evolution of historical advances over time. Of these eight media, four items are related to writing (and reading)—pictographs, ideographs, alphabets, and print. The recent technological advances of hypermedia and digitally mediated text can be added to the list. Among the different ways of understanding the underpinnings of our society and culture, the medium we essentially rely on to obtain information from print is the script in which we read. The script is basically the medium that not only connects abstract ideas permeated in text to our brain for comprehension, but also allows us to communicate with others in a written form.

Table 7.1 Similarity and Differences between Oracy and Literacy

Oracy	Literacy
Similarity	
• Language is human species specific	• Reading is human species specific
Differences	
• Language is universal in humans	• Reading is not universal in humans
• Language needs not be taught, nor can it be suppressed	• Reading needs to be taught
• Children everywhere acquire language on a similar developmental schedule	• Children do not acquire reading on a similar developmental schedule without specific instruction
• Language development is triggered by the [linguistically-rich] environment	• Reading development is shaped by instructional input

Note: The summary in the left panel for Oracy is adapted from Fernández and Cairns (2010, pp. 71–81).

Reading is a cognitively demanding activity that involves a multitude of processes, such as the processing of graphemic and phonological information, access to and retrieval from the mental lexicon, working memory, semantics, and prior knowledge. When systematically coded visual marks were invented and developed into a solid writing system about 3,000 years ago, a unique breakthrough into the new world of knowledge took place (Innis, 1972; Ong, 1982; Wolf, 2007). Writing allows the reader to generate the meaning that the writer has intended to express through written signs. Due to writing, we can travel time longitudinally and space horizontally with no constraints and boundaries.

As writing transforms the word from elusive sounds to visual equivalents in a systematic way, Ong (1982) asserts that there is a fundamental difference between oracy (*orality* in his term) and literacy. In his account of the relationship between the invention of writing and its effect on culture, Ong (1982) stresses writing to be a technology or technological revolution. His view of technology is not a mere exterior aid but an interior agency that transforms our consciousness. He also notes that a technology is artificial, and that, if it is properly interiorized, reading enhances human life. In his view, writing has changed three dimensions drastically: (1) it transforms speech sounds (i.e., oral language) to leave immortal marks in space by assimilating to the form of vision (i.e., written language); (2) it transfers the world of living in the present (i.e., currency) to a long-lasting text (i.e., eternity; longitudinal time travel for which writing allows); and (3) it uses an artificial medium (i.e., arbitrary written signs).

7.2 The Cognitive Impact of Reading

Given the integral part that written language plays in every sphere of our lives, many scholars have contemplated the impact of reading or literacy on cognitive processes and modes of thought. Based on the significance of the medium and written words' sustainability, it is natural to surmise the impact of overarching writing systems or specific scripts on thought and culture over time. Ong (1982, 1986) postulated the consequences of literacy, claiming that the transition from oracy to literacy fundamentally changed the form of thought, consciousness, and culture. Ong (1982) asserts that writing was the most momentous among all technological inventions that have ever been made. Ong (1986) also notes that writing has transformed human consciousness more than any other single invention. He considers writing to be a *technology* that needs to be laboriously learned. Writing has restructured thought patterns by transforming from the *world of sound* to the *world of sight* (Logan, 2004; Ong, 1982).

Innis (1972) is also in the same line, claiming "[w]riting enormously enhanced a capacity for abstract thinking" (p. 10). If writing affects human consciousness and cognition, we can conjecture the differences in cognitive thought patterns between the literate and the illiterate as well as among different societies or cultures that have drastically different writing systems. Goody and Watt (1963) posit the relationship

between writing systems and their social and cultural diffusion. Specifically, they elucidate how different writing systems yield different cultural (re)production and development. Goody and Watts (1963) acknowledge the difference in cultural traditions between nonliterate and literate societies, and underscore the consequences of literacy in the division of cultural diffusion, power, and hegemony between the literate and the nonliterate. They claim that literacy was used as a tool to maintain social power or status quo in the past by reserving written language to the powerful only (e.g., clergies in the Middle Age).

As a neurobiologically demanding activity, reading is one of the most influential fundamentals in the human genetic and intellectual history (Wolf, 2007). If language shapes the way we think, the script in which we read cannot be overlooked. The effect of reading or literacy on human cognition has long been contemplated. The availability of the printing press and the advent of new technologies have reinforced and solidified the effect of scripts. Increased frequencies of exposure to both traditional text and digitally mediated text are likely to galvanize script effects, and its effects will undoubtedly continue.

When reading, we identify 10 or 12 letters per saccade (Dehaene, 2009). However, the visual span is asymmetrical including three or four letters to the left of fixation and seven or eight letters to the right of fixation, on average. Pollatsek, Bolozky, Well, and Rayner (1981) report asymmetries in the perceptual span that Westerners' visual span is much greater toward the right side, while readers of Hebrew, who read the page from right to left, show asymmetry to the left. Similarly, Chinese readers, whose characters are much denser than English, show that their saccades are shorter than those of English readers and that their visual span is reduced. This is a piece of evidence that our physiological characteristics can also be changed by the script we read in for a long period of time. These findings demonstrate that readers of each writing system adapt their visual exploration strategy to the script in which they read (Dehaene, 2009).

7.3 The Reading Brain

Recent scholarship on the relationship between reading and the intricate workings of the brain has grown. Wolf (2007) summarizes the neuronally and intellectually circuitous act as follows:

> [A]ll human *behaviors* are based on multiple *cognitive* processes, which are based on the rapid integration of information from very specific *neurological structures*, which rely on billions of *neurons* capable of trillions of possible connections, which are programmed in large part by *genes*. In order to learn to work together to perform our most basic human functions, neurons need instructions from genes about how to form efficient *circuits* or *pathways* among the neurological structures (p. 10, emphasis in original).

Wolf continues to note that within the biological and cognitive contexts, "the generative capacity of reading parallels the fundamental plasticity in the circuit wiring of our brains" (p. 17). Wolf (2007) underscores the impact of literacy on the

brain in that reading is an unnatural process because we do not have an innate disposition for reading. Wolf (2007) asserts "we were never born to read" (p. 3) because there are no genes innately programmed only for reading. This may explain why it took so long for our ancestors to invent writing systems. As Wolf (2007) explains, "[e]ach major type of writing invented by our ancestors demanded something a little different from the brain, and this may explain why more than 2,000 years elapsed between these earliest known writing systems and the remarkable, almost perfect alphabet developed by the ancient Greeks" (p. 18). Interestingly, it parallels the optimal age to learn to read: "… although it took our species roughly 2,000 years to make the cognitive breakthroughs necessary to learn to read with an alphabet, today our children have to reach those same insights about print in roughly 2,000 days" (Wolf, 2007, p. 19).

As a consequence of many years of practice, the brain is rearranged and rewired for reading due to neuroplasticity. Wolf (2007) asserts that the acquisition of literacy has shaped the development of new brain circuitry, as new wiring has evolved from simple counting to the present sophisticated reading brain. According to Wolf (2018), "[t]he act of learning to read added an entirely new circuit to our hominid brain's repertoire. The long developmental process of learning to read deeply and well changed the very structure of that circuit's connections, which rewired the brain, which transformed the nature of human thought" (p. 2). She continues to argue, based on a literature review and her own studies, that the brain's circuitry rearranges itself to accommodate the linguistic demands of each of the writing systems, causing the repertoire of the brain capacities to change in thought.

Dehaene (2009) joins Wolf's argument of our brain being rewired through the change of the brain's structures, pathways, circuits, and association. He asserts that "our brain [is] not designed for reading, but recycles some of its circuits for this novel cultural activity" which means reading (p. 8). He dubs the reading activity "*neuronal recycling*," meaning that the brain recycles available brain circuits for reading that are already constrained by the genetic architecture because our brain is not inherently designed for reading. To explain his neuronal recycling hypothesis, Dehaene explains how the brain works as follows:

> Far from being a blank slate that absorbs everything in its surroundings, our brain adapts to a given culture by minimally turning its predispositions to a different use. It is not a *tabula rasa* within which cultural constructions are amassed, but a very carefully structured device that manages to convert some of its parts to a new use. When we learn a new skill, we recycle some of our old primate brain circuits—insofar, of course, as those circuits can tolerate the change (p. 7, emphasis in original).

According to the *neuronal recycling hypothesis*, the brain architecture is tightly constrained, but "some circuits have evolved to tolerate a fringe of variability" (p. 7). Dehaene (2009) also notes that, since a part of the visual system is not constrained or hardwired, it provides room for changes as necessary within the parameter of physiological availability. Moreover, brain plasticity allowed for cultural acquisition, of which our ancestors made use for the invention of written signs. Wolf (2018) joins this line of argument: "it [the brain] is able to go beyond its original, biologically endowed functions—like vision and language—to develop totally

unknown capacities such as reading and numeracy" (p. 16) by forming a new set of neuronal networks.

The account of writing systems tells us about the trajectory of linguistic and cognitive development as well as cultural changes over time. It also tells us about how different forms of writing have required different adaptations of the brain's original structures to accommodate the way we think. The invention of writing systems has facilitated our brains to evolve by assimilating or accommodating information differently according to different writing systems. In antiquity, different types of writing systems appeared and disappeared, as discussed in Chapter 2. Currently used writing systems have been time-tested through natural selection and the function of our brain in terms of assimilation and accommodation. In this sense, the notion of the universal nature of writing systems and its fundamental links to spoken language as well as research findings that support script-specific reading secure its ground to point toward the biological commonality and script-dependent diversity (Perfetti, 2003). Results of neuroimaging studies provide behavioral evidence for these claims.

On a general scale, the literate brain shows a stable cerebral architecture and circuitry specifically attuned to reading in the left occipito-temporal region (Dehaene, 2009; Perfetti, Liu, Nelson, Bolger, & Tan, 2007; Pugh et al., 2000). In addition, Dehaene et al. (2010) have shown that literacy profoundly affects the cortical specialization and organization of the brain, regardless of the time of literacy acquisition (i.e., childhood or adulthood). Brain imaging studies show that written words are processed in different scripts, such as English, Chinese, and Japanese, through similar brain networks in the left occipito-temporal visual word form area, despite differences in the surface form of various written languages (Dehaene, 2009; Kim et al., 2016; Perfetti et al., 2007; see Chapter 9 for more in-depth review). This is consistent with the notion of the universality of reading (Perfetti, 2003).

On a narrower scale, differences in brain specialization have been found according to scripts being read, despite the overlap found toward the left hemisphere at the global level. Chinese characters or Japanese Kanji tend to evoke greater activation and specialization in the left middle temporal region which is related to the mental lexicon, while alphabetic reading is likely to recruit activation in the left superior temporal region and the angular gyrus which are related to the auditory processes through letter-sound conversion route (Chen et al., 2002; Fu et al., 2002; Perfetti et al., 2007). Wolf (2007) also claims that the brains of Chinese, Japanese, and English readers are different in terms of the brain's network and capacity for visual specialization and organization in the left and right hemispheres (see Figure 3–1, p. 62). Based on neurolinguistic evidence, Wolf (2007) asserts that Chinese readers use a particular set of neuronal connections that are different from the pathways used in reading English. More evidence of neuroimaging is provided in Chapter 9.

Dehaene (2009) argues that "[i]f the brain did not evolve for reading, the opposite must be true: writing systems must have evolved within our brain's constraints" (p. 8). Based on diversity in spoken languages around the world, this notion may need a further examination. In a sense, this may explain why we have different writing systems across different cultural groups. If the brain was innately designed for

reading, we might have had by and large a shared writing system among all cultural groups in the world. Since the brain "recycles" brain circuitry for reading according to written language which encodes spoken language, different brain networks would be observed across speakers of different languages and readers of different scripts. This is directly related to the thesis of this book, *script relativity*.

Many written signs appeared and disappeared in antiquity. Currently used writing systems have been time-tested and endured, by overcoming inevitable perils encountered over time. Whatever a writing system individuals use within a culture, there should be valid compatibility between the writing system and its users or their culture. Although the invention of writing could be an artificial selection originating thousands of years ago, modifications and reproductions over time might have been governed by natural selection for the best compatibility between writing and its users. Therefore, it is conceivable that the time-tested writing system in each culture has a significant impact on our cognition and perception, which the brain regulates.

In conclusion, the symbolic representation in writing moved our ancestors' cognitive development to a significant level up from the drawings of simple marked lines or images to a novel concept of the sound-symbol correspondence. Through the use of written symbols to express thoughts and ideas, we can free our cognitive resources and make use of memory and effort in reading more economically to the extent that cognitive processes for reading become automatic. This cognitive efficiency related to reading becomes the backbone of information processing in our lives. This capability closely intertwined with the function of the mind as the microsystem in human development. Among other agents that affect the individual's cognitive development, both language and the script being read serve as fundamental agents as the microsystem. Many scholars assert that habitual reading shapes the way we think and, further, rewire our brain circuits and networks to the degree that the brain architecture becomes specialized according to the script we read in (Innis, 1972; Ong, 1982; Shlain, 1998; Dehaene, 2009; Wolf, 2007).

This chapter has provided arguments related to the consequences of reading. In the following two chapters, linguistic evidence and neurolinguistics evidence for the consequences of reading are provided based on empirical research, which extends to *script relativity*.

Chapter 8
Linguistic Evidence for Script Relativity

"The relation between thought and word is a living process; thought is born through words. A word devoid of thought is a dead thing, and a thought unembodied in words remains a shadow."

- Lev S. Vygotsky (1986, p. 255).

"All writing systems represent spoken languages, a universal with consequences for reading processes."

- Charles A. Perfetti (2003, p. 3)

Abstract Using the *universal grammar of reading* and the *system accommodation hypothesis* (Perfetti, 2003) as theoretical frameworks, this chapter reviews a wide range of linguistic evidence that supports *script relativity*. Universality and specificity found according to script features are discussed with respect to the operating principle (alphabet vs. logography), psycholinguistic gran size (phoneme vs. syllable), graph configuration (linearity vs. block), symbolic representation (arbitrariness vs. iconic quality), graph complexity (traditional characters vs. simplified characters), and multi-script representation (phonogram Kana vs. Ideogram Kanji). Linguistic skills associated with reading in terms of orthography, phonology, morphology as well as cross-linguistic and cross-scriptal transfer are reviewed. Next, based on the reviewed literature, each criterion for causality from script to cognition through reading as a multifaceted cognitive activity is checked. Although the existing literature did not aim to directly test script relativity, research findings collectively suggest script effects on readers' thought and cognition.

Keywords universal grammar of reading · system accommodation hypothesis · script universal · script specific · cross-scriptal influences · script relativity

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Vygotsky (1986) stresses the interlocking relationship between language and thought and underscores the fact that thought is dependent on language, as in "thought is born through words" (p. 255). Perfetti (2003) furthermore notes the writing system dovetails with its spoken language. As a collection of Vygotsky's and Perfetti's assertions, the interdependent relationships among thought, spoken language, and written language are conceivable. The role of written language has become significant in our daily lives, especially in the digital era.

Given that reading skills are integral for academic success, reading research has been a mainstay in education, psychology, cognitive science, and applied linguistics for many decades. Research has identified the common precursors of fluent reading among emergent readers, including phonological awareness, working memory, phonological retrieval (e.g., rapid automatized naming, RAN), and an awareness of morphological structures within the word. The National Reading Panel (2000) also identified the five pillars of reading based on studies that used experimental or quasi-experimental designs and studies that met rigorous scientific standards, such as well-defined instructional procedures, verified causality from instruction to student outcomes, and large sample size for adequate statistical power and generalizability, as follows: phonemic awareness, phonics, vocabulary, fluency, and reading comprehension. Of these five pillars, the first two are related to phonological properties. As metalinguistic skills, phonological awareness is considered to be a significant predictor of efficient reading in alphabetic orthographies and even in nonalphabetic orthographies, such as Chinese and Japanese, although the level of phonological units involved in reading and the time of phonological activation (i.e., prelexical or post lexical) during reading vary across orthographies (Cho & McBride-Chang, 2005; Perfetti & Liu, 2005). In addition, beyond the three East-Asian scripts, Desrochers et al. (2018) investigated the early contribution of morphological awareness to reading skills among English-, French-, and Greek-speaking children and found that second graders' morphological skills were a common predictor of reading comprehension and spelling in the three languages, whose magnitude of the contributions was not significantly different among the three languages. The general consensus is that sensitivity to both meta-linguistic phonological properties and morphological structures is script-universal, while orthographic awareness is script-specific (Cho, 2018; Perfetti & Liu, 2005; Wang, Park, & Lee; Yamashita, 2018).

Beyond reading being a critical catalyst for academic success, identifying the significant predictors of reading is important because reading is the complicated activity of information processing. Our habitual reading lays a foundation for our cognitive prototype. Aggregated research results point toward *universality* involved in reading all scripts as well as *specificity* found according to the linguistic characteristics of scripts being read. The *universal grammar of reading* postulates that all writing systems that encode spoken languages capture the universal aspect of reading across scripts (Perfetti, 2003). Relatedly, the *linguistic constraints hypothesis* addresses how reading involves the way in which spoken language is encoded within the writing system, and, as a result, reading engages in script-dependent

reading processes to the extent that the graphic features and orthographic configurations of each script lead to script-specific processes in reading (Perfetti, 2003).

Figure 8.1 shows that commonalities lie in the three East-Asian scripts as well as differences in their own scripts. As explained in Chapter 5, the Chinese script adopts the writing system that has logographic, or morphosyllabic, characteristics, along with Pinyin (a Latin alphabet phonetic system that supplements the morphosyllabic script) as an additional alphabetic system. The Japanese use multi-scripts of logographic Kanji and phonographic Kana including Hiragana and Katakana. The Koreans now officially use alphabetic Hangul only, discouraging Hanja (traditional Chinese characters used in Korea), but a part of the population still learn and use Hanja.

Based on the commonalities and differences of the three East-Asian scripts, this chapter reviews studies of word reading in the three East-Asian scripts of Chinese, Japanese, and Korean, in relation to English. Reading is a multifaceted cognitive skill, involving word decoding, vocabulary, and sentence comprehension at the stimulus level as well as attention, memory, retrieval, and inference at the cognitive level. Since sentence comprehension involves a wide range of skills, including word identification, vocabulary, working memory, prior knowledge, and intrinsic and extrinsic motivation, it is difficult to rule out intervening or spurious factors involved in reading. Hence, this review limits its scope to word reading in order to focus on script effects without uncontrollable variables involved. The theoretical frameworks are first discussed. The extant literature is next reviewed in light of scriptal dimensions, including the operating principle, grain size, graph configuration, symbolic representation, graph complexity, and multi-graph representation. Cross-linguistic influences on reading in a second language (L2), in comparison to English when necessary, are also discussed. Hill's (1965) criteria for causality are examined

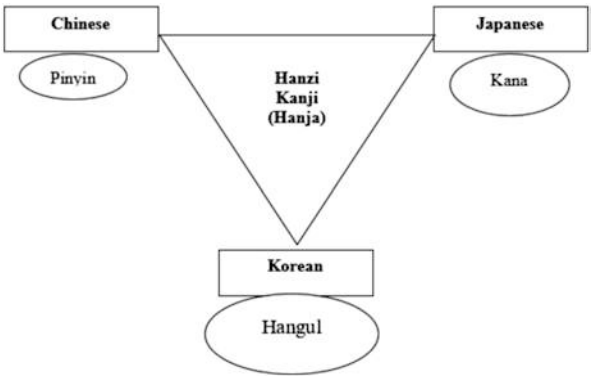

Figure 8.1. Commonalities and Differences among Chinese, Japanese, and Korean scripts
Note: The parenthesis used for Hanja at the center denotes unofficial use of Hanja in Korean. The size of the balloon indicates the degree of usage in the given writing system; that is, a supplementary use of Pinyin in China, the co-use of Kana in Japan, and the sole use of Hangul in Korea.

between independent variables and dependent variables. Finally, based on the results of previous research, the main thesis of this book, *script relativity*, is revisited to substantiate it with empirical corroboration. It should be noted that previous research is reviewed in a way that each study's findings are autonomously reviewed in Chapters 8 and 9 in order to provide the reader with more contexts for each study, compared to other chapters that integrate and synthesize all pertinent information for claims made for specific purposes in the given chapter.

8.1 Theoretical Considerations

Perfetti (2003) claims that "writing systems encode spoken language" (p. 3) such that languages place the constraints of speech on writing systems. The indispensable ties between spoken language and written language are indisputable, because "[t]here are no writing systems currently in use that bypass language to erect an independent system of signs" (Perfetti, 2003, p 5). This claim is consistent with DeFrancis' criterion (1989) for a full-scale writing system. DeFrancis notes that all full systems of writing are grounded in speech and that, if written symbols do not correspond to the sound of any language, it cannot be considered a full-fledged writing system. This is why pictographs and semasiography (e.g., Blissymbols or Blissymbolics, which is an ideogram comprising several hundreds of pure symbols) do not qualify as a script (Sampson, 2015). Daniels' (1996) view of the writing system is also in line with this. The pattern and the extent to which spoken language is related to written language are variable across languages and scripts, however. Perfetti (2003) uses the phrase "universal grammar" to dub the *universal grammar of reading* in order to highlight the universal aspect of reading processes as an overarching framework. He articulates three propositions under the *universal grammar of reading* such that reading is characterized by spoken language and written language. The first proposition is to define reading as an activity that is inextricably interconnected with a language and its corresponding writing system. The second proposition is to delineate the subcomponents of language that characterize spoken and written languages. This proposition implicates the schematic model of subcomponents as follows: Language comprises grammar, phonology, and pragmatics; grammar consists of syntax and morphology; morphology is composed of lexical roots and inflections; and lexical roots comprise syntactic categories and meaning. Among these universal subcomponents of language, phonology and grammar (particularly the morphological aspect of grammar) are most relevant to reading. The third proposition explains two levels of writing systems: (a) a higher level of the mapping principle at the graphic unit and language levels and (b) a lower level of spelling or orthographic constraints that provide mapping details. The higher level implicates language universal, while the lower level of orthographic constraints associates with language specific.

Under the *universal grammar of reading*, Perfetti (2003) proposes two universal principles with respect to reading: (1) the *universal writing system constraint* and

(2) the *universal phonological principle*. The *universal writing system constraint* postulates that writing systems reflect the linguistic properties of spoken language, as all writing systems express spoken language in written signs (Perfetti, 2003; Perfetti & Liu, 2005; Sampson, 2015). The *universal phonological principle* notes that the phonology of the word being read is activated at the smallest unit for which its writing system allows. Even Chinese not only conforms to the principle that graphic units are tied to pronunciation, but also makes use of phonological mapping to access meaning in reading, although Chinese phonology is not activated at the phonemic level. The model of reading universality is augmented by accommodation that spoken language and written language provide. Specifically, Perfetti and Liu (2005) further propose the *system accommodation hypothesis* to explain that both reading processes and neuronal networks and structures[1] that are involved in reading accommodate the specific visual and structural features of the script being read.

Perfetti (2003) provides empirical substantiation for the *system accommodation hypothesis* by looking at the linguistic characteristics of Korean Hangul, given that the Korean writing system offers a unique opportunity for comparisons of Hangul and other alphabetic writing systems due to the characteristics of being an alphabet and, at the same time, of using non-Roman script and structural autonomy of syllabic blocks. As mentioned in the previous chapters, Chapter 5 in particular, Korean Hangul is an alphabetic script, but spoken language represents a syllable largely conforming to the three-sound system of initial sound, middle sound, and final sound, literally referring to the three-sound system, for the CVC syllable which accounts for about 70% of the Korean lexicon. Due to the syllabic requisite, the onset consonant cannot stand alone for all syllables. This syllabic characteristic of spoken language seems to exert an idiosyncratic segmenting or processing unit in naming Korean words and reading Hangul. Specifically, the onset-rime primacy (i.e., tendency to segment the CVC syllable into C-VC units; e.g., *hat* → *h* + *at*) that has been found in European alphabetic scripts is hardly found in processing Hangul, despite being an alphabetic script. For example, Yoon, Bolger, Kwon, and Perfetti (2002) examined Korean children's sensitivity to phonological units using a grapheme substitution task. Their findings indicated that a different phonological unit was preferred by Korean children, showing higher sensitivity to syllable body (i.e., body-coda, CV-C, segmentation) than the onset-rime structure (i.e., onset-rime, C-VC, segmentation) that has been found in English (Treiman, Fowler, Gross, Berch, & Weatherston, 1995). This is consistent with the findings of Kim's (2008) study that shows that Korean monolingual kindergartners and first graders prefer segmenting Korean syllables into the body-coda structure. She also shows that emergent Korean readers' awareness of the body-coda structure is a salient predictor of word decoding and spelling in Korean. She further indicates that the salient subsyllabic body-coda structure involved in reading Korean is attributable to the phonotactic features of Korean (i.e., CV co-articulation). Earlier findings of Yi's

[1] Neuronal structures are discussed in the next chapter of Neurolinguistic Evidence for Script Relativity.

studies (1995, 1998) are also in line with this. These findings are important because this evidence notably indicates that different levels and units of phonological awareness are involved in reading according to the linguistic properties of the given language. Considering this line of evidence, Perfetti and Liu (2005) assert that "languages themselves can be the source of the variability in reading process" (p. 199), as language can impose constraints on the level of mapping between graphemes and phonemes. This provides a foundation for the extension of linguistic relativity to script relativity.

Notably, the segmentation of the word *cat* into the body-coda structure in Korean results in two solid syllables, 캐 /kæ/ and 트 /tə/, with an insertion of an epenthetic vowel "으" /ə/[2] to the coda unit in Korean. The use of vowel epenthesis results from coarticulation of a consonant and a vowel, which is the linguistic mandate of Korean to the extent that a consonant cannot stand alone without a vowel (i.e., the complementary and consummating nature of consonants and vowels within the syllable). This combinatory rule underscores the syllabic feature of the Korean language and Hangul. This is why consonant strings cannot occur in Hangul with an exception of 13 digraph codas in the orthography (i.e., CVCC). However, each two-consonant coda has only one consonant sound value with the other being a silent (i.e., CVC in the phonology). This accords with the three-sound system of the Korean spoken language. This is different from English which allows for consonant strings from two to five consonants in a row (e.g., within, strengths) in which each consonant has a solid sound value. An extreme example in terms of the discrepancy between Korean and English is the fact that the one-syllable word *strike* becomes five syllables when it is transcribed into Korean, *su tu ra i ku*, {스트라이크} with epenthetic vowels added to each consonant and the diphthong split into two sounds. This linguistic phenomenon is an example of the notion that the properties of spoken language constrain written language (i.e., the *writing system constraint hypothesis*, Perfetti, 2003). This is closely related to the *system accommodation hypothesis* that implicates that "[r]eading makes accommodation to the language" (Perfetti & Liu, 2005, p. 199) as well as "[r]eading accommodates the writing system" (Perfetti & Liu, 2005, p. 199). This hypothesis gives rise to an important implication for *script relativity*, which is discussed at the end of this chapter.

8.2 Universality and Specificity According to Script Features

Reading is a cognitive activity. As a sophisticated cognitive function, the magic of reading begins with the automaticity of reading. Although we are never born to read (Wolf, 2007), reading becomes automatic, once it is acquired, to the degree that it is difficult to suppress. The automaticity of reading is evidenced by the Stroop effect

[2] The schwa sound is the closest sound uttered as a vowel epenthesis in Korean because there is no equivalent phonetic symbol that corresponds to the epenthetic sound in the IPA inventory of phonetic symbols.

(Stoop, 1935). The Stroop effect refers to the magnitude of the interference found in response to the incongruent word and color, compared to that in the congruent word and color. For example, when the word "red' is printed in blue ink instead of red ink (i.e., conflict words and colors), naming the color of the word takes longer and is more prone to produce errors than when the ink-color of the word matches the name of the color (i.e., the word "red" is printed in red ink). The implication of the Stroop effect is the difficulty of suppressing our tendency to read words because we are conditioned to read text instantly, automatically, and effortlessly once a reading skill reaches the threshold of fluent reading. One example of the difficult suppression of reading is found when we talk with someone on the phone while the caption on the television is turned on; it is hard to not read the caption because we read it involuntarily. The *acquired* automaticity of reading is to be linked to cognitive functions.

As indicated in earlier chapters, the Chinese, Japanese, and Korean writing systems serve as a practical means to identify and compare research findings with respect to universality and specificity involved in reading, which provides evidence for script diversity and cognitive diversity. In the following section, research findings with respect to the script features, including the operating principle, psycholinguistic grain size, graph configuration, symbolic representation, graph complexity, and multi-script representation, are reviewed, and then research on second language studies in terms of cross-linguistic influences is discussed. Table 8.1. summarizes the script dimensions which are not mutually exclusive as well as attributes within each dimension.

8.2.1 Operating Principle (Alphabet vs. Logography)

The most widely used scripts in the world are alphabets and logographies. Alphabets are composed of letters that represent sounds rather than meaningful components of words. In contrast, logographies comprise characters representing words or morphemes as a whole or the meaningful components of words as a part. English is a representative alphabet given the greatest number of users as the first language (L1) and as a second language (L2), while Chinese characters are a representative of logographies, along with Kanji which is a Chinese-derived script primarily used for content words in Japan. Korean Hangul shares the alphabetic characteristics with

Table 8.1. A Binary Contrast of Script Dimensions

Dimension	Attribute 1		Attribute 2
Operating Principle	Alphabet	⟷	Logography
Psycholinguistic Grain Size	Phoneme	⟷	Syllable
Graph Configuration	Linearity	⟷	Block
Symbolic Representation	Arbitrariness	⟷	Iconic Quality
Graph Complexity	More Complex	⟷	Less Complex
Multi-Script Representation	Phonogram Kana	⟷	Logogram Kanji

English due to conforming to the alphabetic principle. The alphabetic principle refers to operating rules that graphs represent sounds rather than morphemes to the extent that the minimal sound unit corresponds to the phoneme and that multiple phonemes are combined to construct a syllable. In this regard, Hangul is closer to English than to Chinese and Japanese scripts, but uses non-Roman written signs.

Research shows that the operating principle of the writing system affects how readers process written words. Since alphabets rely on phonology for representation, readers of alphabetic scripts are more likely to rely on phonology than other constituents. This explains why phonological awareness skills are the dominant predictor of successful reading in alphabetic orthographies (Brady, 1986; Goswami, 2002; Wagner & Torgesen, 1987). Along with phonological awareness, RAN, which demonstrates the skills of phonological code retrieval and the speed of lexical access as a part of phonological processing, has also been found to be a significant predictor of Korean reading. Pae Sevcik, and Morris (2004) found that one measure of phonological awareness skills (blending words) and verbal working memory (digit span) were significant predictors of L2 Korean reading skills. When phonological awareness and RAN were controlled in the different language order (i.e., L1 vs. L2) within regression models in a subsequent study (Pae, Sevcik, & Morris, 2010), phonological awareness in English as a dominant language (equivalent to L1) was a salient predictor of sequential Korean (equivalent to L2) reading performance. However, RAN became a more robust predictor of sequentially-learned Korean reading for more skilled readers than less skilled counterparts. A more important role of naming skills than phonological awareness in reading Korean was also highlighted in another study. Cho, McBride-Chang, and Park (2008) found that speeded naming was a salient predictor of both regular and irregular Korean word reading across Korean emergent readers.

Due to the use of a logographic orthography, however, it is assumed that Chinese readers make use of semantic information in word recognition more than phonology. Research shows that the awareness of morphological structure, morphemic meaning, and homophone awareness are predictive of Chinese word reading among Chinese native readers (Chen, Hao, Geva, Zhu, & Shu, 2009; Liu & McBride-Chang, 2010; Tong & McBride-Chang, 2010). The awareness of morphological structures is a stronger predictor of Chinese word reading than homophone awareness. Specifically, Liu et al. (2013) have found that both lexical compound awareness and homophone awareness are significant predictors of character reading among 9-year-old Hong Kong children. However, when character reading at the baseline time-point is controlled, only morphological structure awareness becomes a unique predictor.

Chinese characters comprise simple characters that cannot be divided into a smaller component and compound characters that can be divided into smaller components. Compound characters include phonetic radicals and/or semantic radicals. A rule governs the position of the phonetic radical and semantic radical. For example, radicals { 亻 } and { 扌 } appear only in the left of the character, while { 刂 } appears only to the right (Lin, Wang, & Singh, 2018). Research shows that both children and adults rely on radicals and their positions when reading compound

characters (Shu, Anderson, & Wu 2000). Readers segment compound characters into the phonetic radical to use phonological information as well as the semantic radicals and the whole characters to make use of semantic information, when decoding characters. Liu, Shu, and Xuan (2002) asked children and adults to judge whether the cue and target characters were semantically related or not. Specifically, first presented was either the cue that had the same semantic radical as the target (e.g., {始} <begin>) but was a semantically unrelated character or the cue with an unrelated character to the target in terms of the radical and meaning (e.g., {收} <receive>), and then the target {姐} <sister> that had a shared semantic radical {女} <woman> with the cue that was presented before the target. The correct answer for both types of cues was "No" in the semantic judgment test because both types of the cues were semantically unrelated to the target at the whole word level despite the shared radical. Results showed that both children and adults took longer to reject the pair of words sharing the semantic radical due to an interference effect, although the prime {始} <begin> was not morphologically transparent (summarized from Lin, Wang, & Singh, 2018). This suggests that radicals play a significant role in reading Chinese (Ding, Peng, & Taft, 2004; Liu, Shu, & Xuan, 2002; Shu, Anderson, & Wu 2000).

Other than compound characters, compound words are prevalent in the Chinese lexicon. Compound words comprise more than 75% of Chinese (Koh, Chen, & Gottardo, 2018). For example, the word {冰山} /bīngshān/ <iceberg> is composed of a syllable meaning <ice> and a syllable meaning <mountain> to have an independent word <iceberg>. The word for {computer} {电脑} /diànnǎo/ is also a compound word with a syllable meaning <electric> and another syllable meaning <brain>. The converging empirical evidence on the sensitivity to meaning in reading Chinese comes from the nature of a logography as a script in which a graph represents a morpheme rather than a sound, wherein the character <山> /shān/ represents a mountain, not the sound of the character. It is natural that due to the morphology-derived writing system, morphological awareness plays a key role in reading Chinese, as opposed to alphabetic orthographies showing phonological awareness to be important in reading. McBride-Chang et al. (2005) have found that morphological awareness plays a greater role than phonological awareness in the development of reading in Chinese.

Relatedly, research shows that native Japanese readers tend to rely heavily on visual codes and far less on phonological codes in graph processing (Mizuno & Matsui, 2013). Mizuno and Matsui (2013) further explored to identify predominant information involved in the lexical access to Kanji words for native Japanese readers. They aimed to determine whether or not the lexical access to Kanji characters was related to Japanese implausible-word processing. Two lexical decision experiments were conducted in three nonword conditions, including orthographically confusing transposed-letter nonwords, phonologically confusing pseudohomophones, and standard nonwords. The results showed that the participants were disrupted by transposed-letter nonwords, but not by pseudohomophones. This finding confirms that native Japanese speakers are more likely to rely on visual information than phonological information in the lexical access to Kanji words.

The different results of studies of Korean, Chinese, and Japanese readers indicate that the difference resulted from the operating principle of the script as being an alphabet or a logography is the source of the differences found in reading. This is related to script relativity because reading is a cognitive process that adapts to the demand of the stimulus (i.e., the script being read) for optimal information processing.

8.2.2 Psycholinguistic Grain Size (Phoneme vs. Syllable)

The alphabetic principle not only denotes that letters represent sounds rather than meaning, but also signifies that the minimal graphic unit corresponds to the phoneme and that a syllable is formed by combining multiple phonemes. Due to the minimal grain size of phonemes, phonemic awareness has been found to be a robust predictor of skillful reading in alphabetic orthographies. Consequently, phonemic awareness is considered a language-universal metalinguistic skill across Roman alphabetic languages and scripts (Brady, 1986; Goswami, 2002; Wagner & Torgesen, 1987). A question has arisen as to whether or not the same level of phonological awareness (i.e., phonemes, sub-syllables, or syllables) is uniformly related to efficient reading across languages. This question is valid, given that each language has its own grain size as the smallest psycholinguistic processing unit (Ziegler & Goswami, 2005).

The characteristics of being an alphabetic script and showing syllabic autonomy in the orthography of Hangul have propelled research that examines the role of consonants, vowels, and syllables in reading Hangul as a psycholinguistic grain size. Cho (2009) examined Korean kindergarteners' development of sensitivity to consonants, vowels, and open syllables (i.e., CV syllables) and their longitudinal contributions to reading. Results showed that Korean emergent readers identified CV syllables better than individual consonants and vowels. The sensitivity to CV syllables predicted Hangul word recognition cross-sectionally and longitudinally. However, the awareness of consonants and vowels per se did not account for a significant variance in Hangul word reading when syllable awareness was controlled. Moreover, CV syllable awareness facilitated longitudinally the knowledge of consonants and vowels as well as onset and coda awareness. Cho (2009) underscores "the salient roles of syllables in the early literacy development of Korean" (p. 938). Cho (2018) also examined the extent to which orthographic, phonological, and morphological skills in the first language (L1) contribute to Korean fifth graders' reading in Hangul, Hanja, and English as a second language (L2). She found that orthographic awareness of Hangul predicted Hangul word reading. In contrast, phonological awareness and RAN predicted reading skills in English. This within-script prediction led her to conclude that the effect of orthographic awareness would be script-specific.

In a similar vein, the dominant syllabic structure of Korean seems to make a difference in processing words in L1 and L2. Kim (2011) found that L1 syllable awareness among Korean emergent readers was positively associated with their word

reading and spelling skills in L1 after print-related and phonemic awareness were controlled. Cho and McBride-Chang (2005) have also demonstrated that syllable awareness accounted for a greater variance than phonemic awareness in children's reading in Korean as L1. Specifically, Korean native second graders' Korean (L1) syllable deletion skills played a significant role in predicting third-grade Korean reading, whereas phonemic awareness did not account for a significant variance in third-grade Korean word recognition. In contrast, only phonemic awareness predicted English (L2) word recognition one year later (Cho & McBride-Chang, 2005).

Since the unit of Chinese and Japanese writing represents the syllable, the level of phonology involved in reading is likely to be at the syllable level. McBride-Chang and Ho (2005) found that Chinese phonological-processing skills and orthographic knowledge accounted for unique variances in Chinese character recognition among Chinese kindergartners. Of different levels of phonological awareness, syllable awareness was the most salient predictor of reading in Chinese (McBride-Chang & Ho, 2005; McBride-Chang, Bialystok, Chong, & Li, 2004; Shu, Peng, & McBride-Chang, 2008). This finding can be attributable to the fact that the minimal unit of grain size is a morpheme that corresponds to a syllable in the Chinese language. Although these researchers (Cho, 2009, 2018; Kim, 2011; McBride-Chang & Ho, 2005) did not link the results to script relativity, this line of findings aligns well with the notion of linguistic and script relativity because reading is a cognitive function such that the linguistic and scriptal attributes yield different cognitive outcomes. In short, the involvement of different grain sizes depending on the script being read is another evidence of script relativity.

8.2.3 Graph Configuration (Linearity vs. Block)

The graph configuration has not been directly studied, although it has the potential to provide an insight into explaining a mechanism behind reading. Not all scripts have luxury to offer opportunities for addressing this matter. Hangul is a good fit for this inquiry because it is written in blocks as an alphabetic script that can be written in railroad sequence as in English, although it is not conventional. The block format makes Hangul syllables bear structural autonomy such that syllabic boundary is unambiguous (e.g., {한글} <Hangul> rather than {ㅎ ㅏ ㄴ ㄱ ㅡ ㄹ}). In relevance to the block format, graphs are arranged in left-to-right, left-right-down, or top-to-bottom orientation within each syllable, as opposed to the left-to-right linearity in English. This visual configuration makes Hangul look closer to Chinese and Japanese than English in appearance, although the scriptal properties of Hangul point to proximity to English.

Since the mind constitutes interwoven conscious and unconscious strands, perception and behavior in relation to reading that resulted from automatic and unconscious processes are likely to be anchored in thinking and cognition. Based on this idea, a subliminal intervention called *priming* has been used for experiments for several decades. The use of the priming paradigm provides a further

understanding of the way in which unconscious processing influences reading behavior. In priming tests, participants do not notice or recognize primes because the exposure was too brief or because participants disregarded primes in order to better pay attention to the task at hand. Pae, Bae, and Yi (2019a) examined the role of consonants and vowels in both linear format and block format using the priming paradigm in a lexical decision task. As opposed to the consonant primacy found in Roman alphabetic script (i.e., consonants play a more significant role in word recognition than vowels; Bonatti, Pena, Nespor, & Mehler, 2005; Carreiras & Price, 2008; Carreiras, Duñabeitia, & Molinaro, 2009), Pae and colleagues did not find significant priming effects for consonants compared to vowels when primes were presented in a linear way (e.g., {ㅇㄴㅅㅁ – 인삼}; – 인삼}; Experiments 1 and 2). The linear way was first presented in order to rule out the format effect on rapid word recognition as a way of determining whether individual graphs themselves exerted an effect. Since the syllable block is the standard orthographic configuration for Hangul, Experiment 3 used the standard block format to present consonant and vowel primes (e.g., {침슬 – 침술} for consonant prime-target condition; {ㅜㅓ – 불법} for vowel prime-target condition) in order to capture the natural processes with the conventional format. The consonant effect was not significant compared to that of vowel effects in the blocked experiment, either. Note that, due to the use of CVC syllables, the consonant graphemes were twice as many as those of vowels in the prime. Similar results have also been found with a naming test in another study by Pae et al. (Pae, Kim, Mano, & Wang, 2019b). These results suggest that the consonant primacy found in Roman script may not extend to Korean Hangul. Because the stimuli used in these studies are fragments of the Korean syllable block, it is difficult to relate the findings to script relativity per se. What is important is that the findings suggest a possible difference exiting between European alphabets and the Korean alphabet. This is consistent with the finding that the rime primacy found in Roman script does not apply to Korean Hangul, given a more salient effect of the body-coda structure than the onset-rime structure (Kim, 2008; Yi, 1995, 1998; Yoon, Bolger, Kwon, & Perfetti, 2002), as reviewed earlier. Taken together, these results suggest that reading Hangul may require a different mechanism than that found in Roman alphabetic scripts. These findings have implications for script relativity because the format effect (i.e., linearity vs. block) may result in different modes of information processing in reading as a cognitive activity. More research is warranted in this area.

8.2.4 *Symbolic Representation (Arbitrariness vs. Iconic Quality)*

The alphabet is a system of arbitrary symbols whose meaning has been assigned by users. In other words, letters in European alphabetic orthographies do not bear obvious resemblance to the object or concept that is signified because they are arbitrarily named and assigned. In contrast, the graphs of Korean Hangul are rather iconic, indicating that they bear pictorial representations or graphically symbolic meanings. As discussed in Chapter 5, the core Hangul consonants (i.e., {ㅁ}, {ㄱ}, {ㄴ}, {ㅅ}, and {ㅇ}) depict the place and manner of articulation, while the core vowels (i.e., {ㆍ} , {ㅡ}, and {ㅣ}) portray the trinity of the universe <heaven>, <earth>, and <human beings>, respectively. This feature makes Hangul retain iconic qualities, by and large, such that the shapes of consonants and vowels represent the physical attribute or the resemblance of articulation organs and the universe, respectively. Chinese characters and Japanese Kanji are also iconic symbols because the written signs are in principle related to the object, concept, or meaning that is supposed to represent.

There has been little research that particularly investigates the role of symbolic representations in word recognition or reading. It is worthwhile to investigate whether the linguistic property of conicity (i.e., symbols convey meaning about what they represent) plays a role in word recognition or reading across different writing systems, especially between European alphabets and the three East-Asian scripts. This has the potential to address script relativity as well like the other linguistic features covered in this section.

8.2.5 *Graph Complexity (Traditional Characters vs. Simplified Characters or the Number of Strokes)*

The effect of character complexity (i.e., the number of strokes) on reading has been investigated. Li et al. (2019) investigated the effect of character complexity on Chinese reading and visual search using eye movement. They found that visual complexity affected fixation durations and the skipping rates of both English speakers and Chinese native readers. This finding is consistent with the findings of Chang and Perfetti's study (2018). Chang and Perfetti (2018) calculated the number of strokes and the number of radicals of each character in both traditional and simplified characters used in their study, in which the numbers of strokes and radicals showed different distributions. They indicated that reading more complex scripts would require stronger visuo-spatial skills. The findings of McBride-Chang et al.'s study (2011) were also in line with this, which found that Hong Kong children (traditional character readers) performed better on a visuo-spatial task than Spanish-reading counterparts. These findings suggest that reading more complex scripts

facilitates visuo-spatial skills, which might have been strengthened by habitual reading over time.

The effects of visual complexities and frequency of Kanji words on Kanji word recognition were also examined. Tamaoka and Kiyama (2013) investigated the effects of visual complexity on Kanji processing using simple (2–6 strokes), medium (8–12 strokes), and complex (14–20 strokes) Kanji words with high and low frequencies. The results of a lexical decision task (Experiment 1) and a naming task (Experiment 2) showed that visual complexity negatively affected the processing of low-frequency Kanji words, but not high-frequency Kanji words. These findings suggest that reading experience has a significant impact on visual discrimination performance, which is related, if tangentially, to script relativity.

8.2.6 Multi-Script Representations (Phonogram Kana vs. Logogram Kanji)

The Japanese multi-scripts, including morphosyllabic Kanji and phonosyllabic Kana, offer a unique opportunity to examine script effects within the writing system. Although the Japanese writing system employs both Kanji and Kana scripts, Kanji are used for the majority of content words (Yamashita, 2018). Some researchers have investigated malleable factors within the sub-script (i.e., within Kanji or within Kana including Hiragana and Katakana), while others examined between-relationships in Kanji and Kana, as reviewed below.

A handful of studies have examined within-script reading of either Kanji or Kana. Both orthographic awareness and phonological awareness seem to be important skills for reading in Japanese. Sakuma, Sasanuma, Tatsumi, and Masaki (1998) examined orthography and phonology in Kanji word reading using a semantic decision task with homophones among native adult Japanese readers, given the spelling-sound correspondence was complex in Kanji. Based on the significant homophone effects, the researchers concluded that both orthography and phonology played an important role in the judgment of Kanji words. However, the effect of phonology disappeared when the item was presented only for a brief duration. This led Sakuma et al. (1998) to conclude that orthography was the primary source of meaning extraction of Kanji words. Since Kanji was a Chinese-derived script, a similar finding to that of Chinese was not surprising.

A study of the other phonographic script, Kana, would add another piece of evidence to the understanding of orthographic and phonological codes in Japanese. Besner and Hildebrandt (1987) examined reading efficiency of Japanese Kana. They found that words written in Katakana were named faster than nonwords printed in Katakana or words printed in Katakana that were typically written in Kanji. They concluded that lexical access of words written in Katakana could bypass phonological involvement.

Koyama et al. (2008) examined the role of phonological and orthographic skills in Kana reading and writing as well as Kanji reading and writing among Japanese children. The children's Kana reading showed a ceiling effect. The different patterns of prediction were found between Kana and Kanji. Phonological awareness predicted Kana but not Kanji skills. However, orthographic awareness and short-term memory predicted both Kanji and Kana skills. The findings reflected the difference in the scriptal properties of Kana as a phonosyllabary and Kanji as a morphosylabary. Koyama et al. (2008) attributed the lack of phonological effects on Kanji recognition to the absence of tonal characteristics (which is a part of phonology) in the Japanese language unlike the Chinese language.

In light of a difference in color processing between Kanji and Kana, Feldman and Turvey (1980) have found that words written in Kana are named more quickly than the same two- to four-word-syllable color words written in Kanji, although colors are more frequently written in Kanji. Feldman and Turvey have explained the results in terms of the pathway differences that Kana has a closer relationship to phonology than Kanji due to being a phonogram. The sound-referencing phonographic quality that is related to the phonographic principle might have allowed for faster naming. Feldman and Turvey (1980) note that the particular properties of the writing system and the specification of phonology that are intrinsic to its orthographic form are likely to facilitate Kana naming.

8.2.7 Linguistic Components (Orthography, Phonology, and Morphology)

Three key components involved in reading include orthography, phonology, and semantics (morphology). Since reading is about converting written signs (i.e., words and sentences) into their corresponding sounds, the interplay between orthography and phonology is inevitable. Orthographic awareness refers to the ability to use visual orthographic information to identify or recognize words. Yamashita (2018) summarizes two types of orthographic processing based on Conrad, Harris, and Williams' (2013) conception. The first is *word-specific* knowledge, which involves the word's spelling and shape. The second is *general* orthographic knowledge, which involves the conventional patterns of letter combinations within the script. The latter is more abstract in nature than the former. It constitutes letter sequential dependencies (i.e., letter collocations in letter arrangements), structural redundancies (i.e., letter collocations that occur in different words), and letter position frequencies (i.e., the number of occurrences in the position of letters within the word; Conrad, Harris, & Williams, 2013; Yamashita, 2018).

Due to the intersecting relationship between orthography and phonology, both orthographic and phonological skills are crucial for reading. However, their involvement in reading varies depending on the script to be read. Research has shown that phonological awareness is less important and that visual or visuo-spatial skills are

more important in reading logographies than alphabetic orthographies (Huang & Henley, 1995; McBride-Chang et al., 2005). Yamashita (2018) notes that the dominant role of orthographic, phonological, and morphological skills differs depending upon various variables at hand, such as reading tasks, the reader's proficiency level, word frequency, and familiarity of words. Orthographic awareness appears to be a key predictor of fluent reading in Japanese due to its use of Kanji, which requires visual discrimination more than reading other orthographies.

The constituent skills of orthography, phonology, and morphology are significant predictors of skillful reading in Korean. However, the level of phonology involved in reading seems to be different from that in English. Since not only is Korean spoken language syllable-based, but Hangul is also based on the consonant-vowel complementarity in the syllabic unit, syllable awareness is found to be a more salient predictor of reading Korean than phonemic awareness. Overall, phonological awareness seems to play a greater role than vocabulary in reading Korean. In a study that examined the role of speech perception, phonological awareness, and receptive vocabulary in reading and spelling among Korean-speaking first graders, compared to English-speaking counterparts, Chiappe, Glaeser, and Ferko (2007) found that speech perception and phonological awareness explained a significant variance in early literacy skills beyond oral language skills for both groups.

Another line of research regarding phonology has shown a significant relationship between suprasegmental tone sensitivity and visual word reading (Arciuli, Monaghan, & Seva, 2010; Tong, Tong, & McBride). Tone is a suprasegmental feature that is found in Chinese. A large number of Chinese characters have the same onset-rime sound but have different tones (e.g., {峰} /fēng/ <peak or hill> - {逢} /féng/ <encounter>). Research shows that tone sensitivity, along with syllable awareness, is a significant predictor of Chinese character recognition among Chinese kindergarteners (McBride-Chang et al., 2008; Shu et al., 2008). Research also shows that awareness of different lexical tones explained a unique variance in Chinese character reading, after syllable and onset awareness and morphological awareness were controlled for 6-year-old children in Hong Kong (Tong et al., 2015).

A multi-national study is also available. McBride and colleagues (2005) examined the relationships among phonological awareness, morphological awareness, vocabulary, and word recognition of second graders from China (Beijing), Hong Kong, South Korea, and the U.S. They found significant relationships between phonological awareness and morphological awareness and between these two skills and vocabulary knowledge. However, the extent to which both phonological awareness and morphological awareness were significantly related to word recognition skills was different across scripts. Specifically, phonological awareness was more crucial for reading in English and Korean than in Chinese. However, morphological awareness was more important for reading Chinese and Korean than in English. The findings suggest that both phonological and morphological awareness skills are crucial in reading Korean probably due to the universal role of phonology and the dominant morphological feature of the Korean language. Cho (2018) also found that morphological awareness accounted for a significant variance in fifth graders' writing skills in both Hangul and Hanja in South Korea. The salient role of morphology might

have resulted from the significant portion accounted for in the Korean lexicon. Regarding Korean vocabulary, the Korean lexicon is composed of three types of words, according to Kim (1993), including (1) native-Korean words, which cannot be written in Chinese characters (24.4% of Korean vocabulary), (2) Sino-Korean words, which are Chinese-derived but have Korean pronunciation (69.3%), and (3) loan words, which are mostly borrowed from English (6.3%). While Sino-Korean Hanja have a consistent syllable-to-morpheme correspondence, native-Korean words can take more than one syllable to represent a morpheme. For example, the morpheme <love> takes two syllables in the native Korean word (i.e., {사랑} /sɑ rɑŋ/, in which the individual syllable {사} or {랑} alone does not refer to <love>). In contrast, the Sino-Korean word for <love> takes only one syllable referring to one-morpheme (i.e., {愛} /æ/).

Concerning the use of morphological information in word recognition, Bae and Yi (2016) examined the effects of Hangul and Hanja primes on lexical decisions among Korean undergraduate students who were matched with their proficiency levels of Hanja reading. Hanja primes facilitated the recognition of Hanja words printed in Hangul more than Hangul primes for proficient Hanja readers. However, less proficient Hanja readers did not benefit from either Hanja or Hangul primes. What was notable was that proficient Hanja readers recognized Hangul words much faster than their less proficient counterparts. This result suggests that readers who are proficient in Hanja are likely to decode Hangul more efficiently, probably because they are able to utilize extracted morphological information in the resolution of homographic and homophonic representations (e.g., the word {사과} means <apple> and <apology> with the same orthography and phonology in Hangul but is written differently in Hanja, {沙果}, {謝過}, respectively). Likewise, the absence of priming effects for less-proficient Hanja readers may be attributable to the lack of ability to resolve ambiguous Sino-Korean homophones represented in Hangul that do not provide much morphological information.

Table 8.2. summarizes the findings of studies reviewed so far across the scripts in terms of linguistic components. Both orthographic awareness and morphological awareness play important roles in reading all scripts. The results about phonology have implications for the role playing in different scripts. Although phonology is a dominant constituent involved in reading, it is evident that the level of phonology varies according to the properties of spoken language and written language.

Table 8.2. The Role of Orthographic, Phonological, and Morphological Awareness in Reading

		Alphabet		Logography	Mixed Script	
		English	Korean	Chinese	Japanese	
					Kanji	Kana
Orthographic Skills		+	+	+	+	+
Phonological Skills	Phoneme	+	(+)	-	-	-
	Syllable	(+)	+	+	-	+
Morphological Skills		+	+	+	+	+

Note: The parenthesis indicates marginal or secondary effects.

In summary, due to the nature of mixed-scripts in the Japanese writing system, the role of each constituent of orthography, phonology, and morphology involved in reading seems to be variable depending on the script being read and the task to perform. Kanji reading requires orthographic and morphological awareness more than phonology. However, phonological awareness is a significant predictor of Kana reading. As for Chinese, despite its character complexity, readers of Chinese make use of both phonetic and semantic radicals for word identification. Due to being a morphosyllabary, the level of phonology involved in reading is at the syllabic level. Regarding Korean, the spoken Korean syllable requires co-articulation of a consonant and a vowel, which is reflected in Hangul to the extent that consonant-vowel complementarity governs the syllable in the writing system. The findings of studies reviewed above indicate that reading a particular script is sensitive to the nature and the property of a given script being read. This accords with Perfetti's *language constraint hypothesis* (2003) in that the spoken unit places constraints on the writing system. This is directly associated with script relativity because the linguistic characteristic is reflected in the script and it, in turn, puts a constraint on a cognitive function, reading. In other words, it is apparent that readers develop different processing mechanisms in response to the demands of linguistic and scriptal properties. This suggests that our cognition is shaped by habitual reading, which refers to script relativity.

8.3 Cross-Scriptal Influences

The linguistic phenomenon of cross-linguistic influences (i.e., linguistic knowledge or skills of one language affect(s) the acquisition or use of another language) has been of interest "since antiquity and most likely ever since language evolved" (Jarvis & Pavlenko, 2007, p. 1). Recent decades have witnessed a surge of systematic L2 studies in the light of cross-linguistic influences or cross-language transfer. Although scholars have their own preference of terms to refer to the effect of one language skill on another, the terms *cross-linguistic influences* and *cross-language transfer* are used interchangeably in this chapter because of the particular interest in addressing the carryover effect from acquired linguistic skills to another or the effect of one skill on another. Cross-linguistic influences or transfer can occur in the direction from L1 to L2 forward transfer, from L1 to L2 reverse transfer, or from L2 to L3 lateral transfer (Jarvis & Pavlenko, 2007). However, only L1-to-L2 forward transfer is considered in this chapter for two reasons. First, we have stabilized linguistic abilities in L1, which attest to the invariance of linguistic dominance across speakers. Second, L2 skills are variable across learners depending on the age of acquisition, linguistic distance between L1 and L2, and variables related to individual differences such as personality attributes, motivation (both extrinsic and intrinsic), and the goals of L2 learning. It is assumed that the cognitive processes and modes of thought flow from a more dominant skill to a less dominant one, although bidirectional fluidity is possible. In the following section, studies on cross-linguistic influences from Chinese, Japanese,

and Korean as L1 to English as L2 are reviewed with respect to orthography, phonology, and morphology, and then linguistic and scriptal transfer from L1 English to L2 East-Asian scripts is reviewed under the same themes.

8.3.1 From L1 Chinese, Japanese, and Korean to L2 English

As L2 studies have mushroomed in reading science in the last two decades, L1 influences on L2 reading in the direction from L1 Chinese, Japanese, and Korean to L2 English have been well documented in the literature (Akamatsu, 2003; Cho & McBride-Chang, 2005; Jiang & Pae, 2020; Pae, Kwon, & Lee, 2015; Wang, Koda & Perfetti, 2003b; Wang & Koda, 2005). Beyond the findings that phonological awareness is a critical precursor to proficient reading in L1, its importance has been expanded to L2, regardless of the linguistic features and writing systems. A myriad of studies in Korean-English bilinguals have also supported this line of findings (Cho & McBride-Chang, 2005; Pae, Sevcik, & Morris, 2004, 2010; Wang, Park, & Lee and more). Wang, Park, and Lee examined the role of phonology and orthography in the biliteracy development of Korean-English bilingual children with Korean as L1 and English as L2. Results show that phonological skills in L1 and L2 are strongly correlated to each other and that L1 Korean phonological skills account for a significant variance in L2 English pseudoword reading after English phonological and orthographic skills are controlled. However, L1 orthographic skills are not a salient predictor of L2 reading. Wang, Park, and Lee note that the phonological processes are language-universal, while orthographic skills are script-specific.

Akamatsu (1999) examined the effect of L1 orthographic features on L2 English word recognition among Chinese, Japanese, and Iranian participants using a naming test with the stimuli of case-alternated words (e.g., cAsE aLtErNaTiOn). Since case-alternated words preserve spelling patterns but lose word-shape cues, Akamatsu hypothesized that if readers were sensitive to subword coding, the effect of visual disruption at the subword unit would be smaller than others. Chinese and Japanese participants with nonalphabetic L1 scripts showed larger case-alternation effects than Iranian counterparts with an alphabetic Persian L1 script. He concluded that L1 orthographic features affected the word recognition mechanism in L2 English. Similarly, Pae, Kwon, and Lee (2015) reported a different pattern of resolving visual noise (i.e., deviations from the typical orthographic form) in print, using alternated (e.g., eNgLiSh), inverse (e.g., ), and typical fonts (e.g., English), across native speakers of Chinese, Korean, and English. The performance pattern on visually manipulated fonts in the native Korean speakers was more similar to that of English-speaking participants than that of Chinese-speaking counterparts. This suggests that the relatedness in the alphabetic property plays a role in word recognition.

Ben-Yehudah, Hirshorn, Simcox, Perfetti, and Fiez (2019) also reported cross-language transfer from L1 lexical coding to L2 English word recognition among Chinese-English and Korean-English bilinguals. They used regular fonts and inverse

fonts in a word naming test. Korean native speakers named words faster and more accurately, especially inverse stimuli, than Chinese counterparts, even when English proficiency was controlled. Chinese speakers were more sensitive to word frequency, while Korean speakers were more sensitive to orthographic-phonological consistency in the word. These results serve as another piece of evidence for L1 script effects on L2 word recognition.

Chinese children seem to develop phonological awareness more slowly than their English-speaking peers. Research showed that Chinese-English bilingual children outperformed monolingual Chinese children on phonemic awareness and that L2 English learning facilitated L1 Chinese phonological awareness and Pinyin skills (Bialystok, McBride-Chang, & Luk, 2005; Chen, Xu, Nguyen, Hong, & Wang, 2010). This suggests fluid cross-language transfer occurs once a threshold of L2 proficiency is reached.

Although tone is specific to Chinese among the languages under consideration, sensitivity to tone appears to facilitate L2 English word reading as well (Tong, He, & Deacon; Wang, Perfetti, & Liu, 2005). Tong et al. (2017) found that the tone awareness of Cantonese Chinese measured in grade 2 predicted L2 word reading in grade 3. Wang, Yang, and Cheng also showed that L1 Chinese tone awareness of Chinese-English bilingual children predicted a unique variance in L2 English reading above and beyond phonological awareness and reading-related variables. They have interpreted that tone awareness is general auditory processing, as tone awareness is closely related to awareness of the prosodic features of language, such as stress and rhythm, which also contributes to efficient reading.

Wang, Koda, and Perfetti (2003b) examined alphabetic and nonalphabetic L1 effects on L2 English word recognition among native speakers of Chinese and Korean. The two L1 groups showed the different patterns of reliance on phonological and orthographic information in a semantic category judgment task in L2 English. They showed using a categorization judgment task that native Chinese and Korean speakers exhibit differences in making use of phonological or orthographic information for word recognition. They asked the two groups of students to judge whether a noun (e.g., *rose* or *feet*) represents an exemplar of a certain category (e.g., flower or body part). They used homophonic words (e.g., *rows* for *rose*) with varied orthographic similarity (e.g., *rows* was less similar to *rose* than *feat* to *feet*). Results showed that native Korean speakers tended to make more errors on homophonic targets than on control items, but Chinese speakers did not show such homophonic effects. Chinese speakers were affected by orthographic similarity (e.g., *feet* vs. *feat*; *rose* vs. *rows*). The findings suggest that Korean speakers whose L1 is an alphabetic script are likely to rely on phonological information, while Chinese whose L1 is a logographic script tend to rely on orthographic information.

Morphological skills seem to be not as straightforward as phonological awareness in terms of cross-language transfer. Wang, Cheng, and Chen showed reverse transfer in that English compound awareness was a significant predictor of Chinese character reading among Chinese-English bilingual children from grades 1 through 4 in the U.S. Chinese compound awareness did not explain a significant variance in English word reading, however. Similarly, Pasquarella, Chen, Lam, Luo, and

Ramirez (2011) found using structural equation modeling that English compound awareness predicted Chinese reading comprehension in Chinese-English bilingual children of first to fourth graders in Canada. However, the same effect was not found on Chinese word reading, although a bidirectional relationship between English compound awareness and Chinese vocabulary was found. Pasquarella et al. (2011) explained that the structures of the languages and writing systems of the two languages were likely to determine the direction of transfer. However, Cheung et al. (2010) showed in a study of Hong Kong children in kindergarten, grade 2, and grade 4, that Chinese compound awareness accounted for a significant variance in English word reading and that English compound awareness did not account for a significant variance in Chinese character reading. The direction of transfer might also depend on the relative proficiencies of the languages involved and the language-learning context because Chinese is a more dominant language for Hong Kong children, while English is likely to be a more dominant language for Chinese-English bilinguals in the U.S. and Canada. These findings suggest that cross-language transfer occurs from a more dominant language to a weaker language in Chinese and English. A longitudinal study shows more complicated results. Luo et al. (2014) examined both cross-sectional and longitudinal cross-linguistic relationships between morphological awareness and word reading in both Chinese and English among Chinese-English bilinguals. They found that English compound awareness predicted Chinese word reading through a mediator of Chinese compound awareness. However, longitudinal cross-language contributions were significant neither from English morphological awareness to Chinese word reading nor from Chinese morphological awareness to English word reading.

Wang, Ko, and Choi also examined the contribution of morphological awareness to Korean and English reading skills after controlling for phonological awareness among Korean-English bilingual children. Morphological awareness was measured using a derivational morphology task in both Korean and English as parallel measures. Bilingual children completed a sentence based on a prompt provided. For example, when the prompt *farm* was provided, the child was to complete the sentence "My uncle is a _____" (farmer). An equivalent measure was constructed in Korean to assess the comparable skills. Results showed that the morphological awareness of derivational structures in L1 uniquely accounted for a significant variance in reading real words in L2. The significant forward transfer from L1 Korean to L2 English as well as backward transfer from L2 English to L1 Korean suggest that morphological awareness facilitates word reading across alphabetic writing systems even in different scripts.

A further study on the function of morphological awareness in Korean and English was carried out with adult Korean-English readers. Ko, Wang, and Kim (2011) investigated whether adult Korean-English bilingual readers would activate the constituents of compound words of L1 while processing L2 compound words by decomposing the constituents. The results of lexical decision tasks showed that the recognition of L2 English compound words was more accurate than that of compounds translated into Korean. They concluded that morphological decomposition

and cross-language activation occurred concurrently in bilingual reading of compound words.

A study of cross-language priming effects on the processing of derived words was conducted with Korean-English bilingual adults (Kim, Wang, & Ko, 2011). Strong evidence for the cross-language activation of morphological structures was observed such that L1 morphological structures were elicited to process L2 morphological stimuli. Kim and Wang (2014) conducted a follow-up study to further examine the time course involved in the cross-language activation of constituent morphemes in Korean-English bilingual readers, using a similar masked priming experiment with three prime durations (36, 48, and 72ms). Results showed that, when derived real words of Korean were used as primes, participants' response times were significantly faster on the corresponding English L2 translated word stems at all prime durations. However, derived Korean pseudoword primes (i.e., an illegal combination of a stem and a suffix) showed a significant priming effect on English L2 word stems only at longer prime durations (48 and 72 ms). These results suggest that the cross-language activation of constituent morphemes occurs very early in bilingual reading. The lexicality factor plays an important role in the time course of decomposing L1 morphologically complex words. While an analysis of supra-lexical information is involved in early morphological processing in bilingual readers, a sub-lexical analysis is involved in the later cross-language activation of morphemic information.

Overall, the unique features of the Chinese, Japanese, and Korean scripts exert unique effects on L2 English word recognition. Along with the cross-language transfer of script-universal skills in phonological and morphological processing, the transfer of script-dependent skills in orthographic awareness has also been observed. A review of linguistic transfer from L1 English to L2 is in order.

8.3.2 From L1 English to L2 Chinese, Japanese, or Korean

Studies of cross-language transfer from L1 Chinese, Japanese, or Korean to English as L2 have outnumbered those from L1 English to L2 Chinese, Japanese, or Korean. A handful of studies have generally shown similar results regardless of the direction of cross-language transfer. Chikamatsu (1996) examined, focusing on phonological and visual coding involved in word recognition, the effect of L1 orthography on L2 Japanese word recognition among American and Chinese learners of Japanese by controlling for visual familiarity and word length. Participants read words written in Japanese Kana including both Hiragana and Katakana. Results showed that native Chinese speakers relied on visual information for Kana reading more than did native English speakers and that English speakers relied on phonological information more than did Chinese counterparts. These findings suggest the effect of L1 scripts on L2 word recognition. Another study by Chikamatsu (2006) with American adult students who learned Japanese as L2 showed similar results but provided more information about the developmental aspect of word recognition strategies and

orthographic interferences. Results showed that L2 word recognition strategies were developmental and were reconstructed as proficiency improved, as evidenced by the results of two proficiency groups of skilled and less skilled participants. These results suggest that the use of cognitive problem-solving strategies is dependent upon literacy skills.

Similar results were found in Mori's (1998) and Matsumoto's (2013) studies. Specifically, Matsumoto (2013) investigated learners' Kanji recognition to examine whether learners of Japanese as L2 would use different recognition strategies according to their L1 writing systems and whether L2 exposure would affect L2 Kanji recognition, using a lexical judgment task with three types of Kanji characters including pseudo-homophones, pseudo-homographs, and real words. Three groups of learners participated in the study: (1) beginning-level learners of Japanese whose L1 was English, (2) intermediate-level learners of Japanese whose L1 was English, and (3) beginning-level learners of Japanese whose L1 was Chinese. Results demonstrated that learners with both proficiency levels whose L1 was English showed poorer performance on the lexical judgment on L2 Kanji words, possibly due to relatively lower L2 orthographic relatedness to their L1 than that of Chinese speakers whose L1 script was similar to L2 Kanji. Matsumoto (2013) concluded that different reading strategies tended to be used by learners of different L1 backgrounds and that L2 exposure did affect L2 reading.

Lin and Collins (2012) examined the effects of L1 as well as the effects of orthographic regularity and consistency on naming Chinese characters among speakers of English and Japanese speakers who learned Chinese as L2. Their participants read Chinese characters that varied in the dimensions of regularity, consistency, the number of strokes, and familiarity (i.e., frequency appeared in instructional texts). The two groups showed a difference in reading L2 Chinese according to lexical and sublexical features, such as regularity and consistency. Lin and Collins (2012) attributed the group differences to differences in L1 phonology and the writing system. L2 proficiency also influenced performance on naming Chinese characters. However, the two L1 groups seemed to follow the trajectory of developing orthography-to-phonology knowledge (i.e., exposure to orthography occurs first and then sound is learned afterward), which was consistent with the findings with native Chinese-speaking children (Shu & Wu 2006).

Pae, Sevcik, and Morris (2010) examined reading performance of children of Korean immigrants residing in the U.S. Consistent with the performance of heritage language learners, their English skills were more dominant than Korean skills. Although Korean was the language to which they were first exposed in the home setting, English was the language they first learned to read in mainstream schools and Korean was sequentially learned to read at heritage language schools on weekends. Therefore, Pae et al. dubbed English as a dominant language and Korean as a sequential language in reading that was weaker in skills. Results showed that RAN in Korean as a sequential language (equivalent to L2) played a more dominant role than PA in the Korean within-language relationship. However, in reading English as a dominant language (equivalent to L1), phonological awareness accounted for greater variance than RAN in the within-language relationship. With respect to the

Table 8.3. Cross-Language Transfer of Orthographic, Phonological, and Morphological Skills

	Korean	Chinese	Japanese
Orthographic Skills	-	-	-
Phonological Skills	+	+	+
Morphological Skills	+	+	+

cross-language associations, phonological awareness was more important than RAN skills. Again, these findings suggest that cognitive mechanisms accommodate the reader to the script specificity as a result of reading experience.

Based on the review of the literature on cross-language influences in relevance to Chinese, Japanese, and Korean, Table 8.2 summarizes significant cross-language transfer from L1 and L2 in terms of the three constituents of orthography, phonology, and morphology. Although significant cross-language transfer has been found in phonological and morphological skills, the absence of orthographic-skill transfer has been consistently observed. This suggests that phonological awareness and morphological awareness are language universal as malleable skills to transfer, while orthographic awareness is script specific due to each script's unique visual structure and configuration (Table 8.3).

8.4 Meeting Criteria for Causality

Since script relativity builds on the capacity of written language to influence the reader's thinking and cognition, of interest is the causal relationship from habitual reading to cognitive change. As discussed in Chapter 1, causation runs from habitual reading to the reader's cognition, not the other way around. This is evidenced by the fact that our thinking can change as a result of reading; that is, thinking can be restructured by habitual reading. However, language does not change as a result of thinking per se, although new words are coined when necessary to meet the needs of the outcomes of new discoveries, new social movements, popular culture, and new technology.

The linguistic dimensions discussed above can be viewed as independent variables and the cognitive function as dependent variables. These relationships can also be substantiated through the prism of Hill's (1965) nine criteria for a causal relationship. The nine criteria include strength (effect size), consistency (reproducibility), specificity (no spurious variables involved), temporality (no delays), biological gradient (exposure-incidence relationship), plausibility, coherence, experimental evidence, and analogy (similarities between the observed relationship and any other relationships). Another criterion of conditionality (if the cause disappears, the effect should disappear) is added to the batch. For example, if reading is removed, the difference between literate and illiterate people's cognitive functions

would be removed, which is solid evidence for script relativity (Bramão, et al., 2007; Petersson, Reis, Askelö, Castro-Caldas, & Ingvar, 2000; Petersson, Reis, & Ingvar, 2001). Duñabeitia, Orihuela, and Carreiras (2014) showed how literacy could change a visual mechanism of flexible position coding, which is essential for

Table 8.4. Criteria for Causality

Dimension\Criteria	1	2	3	4	5	6	7	8	9	10
Operating Principle (Alphabet vs. Logography)	✓	✓	✓	✓	✓	✓	✓	✓	(✓)	✓
Psycholinguistic Grain Size (Phoneme vs. Syllable)	✓	✓	✓	(✓)	✓	✓	✓	✓	✓	✓
Graph Configuration (Linearity vs. Block)	✓	✓	(✓)	✓	✓	✓	✓	(✓)	✓	✓
Symbolic Representation (Arbitrariness vs. Iconic Quality)		(✓)	(✓)	(✓)	(✓)	✓	✓			(✓)
Graph Complexity (Chinese Traditional vs. Simplified Characters)	✓	✓	(✓)	(✓)	✓	✓	✓	✓	(✓)	✓
Multi-Script Representation (Phonogram Kana vs. Logogram Kanji)	✓	✓	(✓)	✓	✓	✓	✓	✓	(✓)	✓
Linguistic Components (Orthography, Phonology, Morphology)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cross-Language Transfer	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note: 1 = strength (effect size)
2 = consistency (reproducibility)
3 = specificity (no spurious variables involved)
4 = temporality (no delays)
5 = biological gradient (exposure-incidence relationship)
6 = plausibility
7 = coherence
8 = experimental evidence
9 = analogy (similarities between the observed relationship and any other relationships)
10 = conditionality (if the cause disappears, the effect should disappear as well)

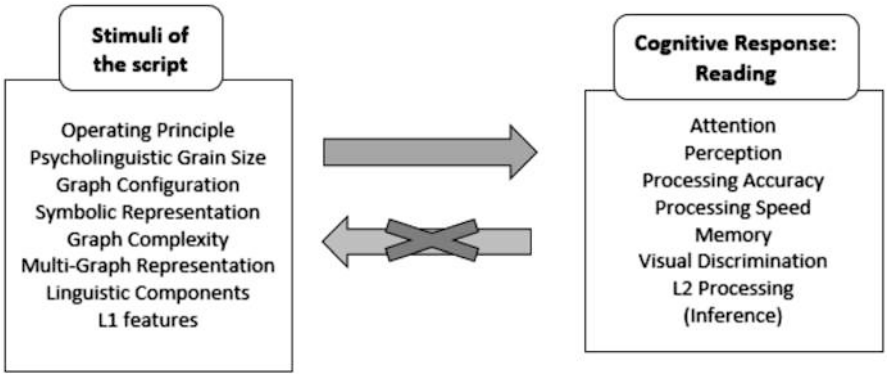

Figure 8.2. Relationships between Scriptal Dimensions and Reading as Cognitive Responses

efficient reading. Table 8.4 shows the capacity to meet each criterion based on empirical evidence reviewed in this chapter. As an extension, Figure 8.2 depicts the causal relationship that runs from the scriptal dimensions to cognitive response (i.e., reading). However, it is hard to prove the causal relationship that travel from cognitive response to scriptal dimensions.

8.5 Toward the Script Relativity Hypothesis

This chapter has reviewed the role of linguistic dimensions, including the operating principle, psycholinguistic grain size, graph configuration, symbolic representation, graph complexity, and multi-graph representation, in skillful reading in Chinese, Japanese, and Korean. Also reviewed are cross-linguistic influences of linguistic skills on reading in these three scripts as L1 and L2 in relation to English. Although minor inconsistencies exist in the findings of studies depending on scripts being reviewed, tasks and measures used in studies, participant characteristics, and the foci of studies, research findings generally and consistently come together on the notion that phonological and morphological processing is script-universal, while orthographic processing is script-specific.

Reading begins with word identification, and word identities are characterized by the three interlinking constituents of orthography, phonology, and morphology. The universal features of reading center around the role of these three constituents involved in word recognition, although the degree to which they involve varies according to the script being read because reading is built upon the language system. This view points to the *language constraint on writing systems* that claims that writing systems encode spoken language (Perfetti, 2003). One example of spoken language constraints on reading comes from Korean speakers' tendency of the subsyllabic segmentation into body-coda units with the insertion of an epenthetic vowel to the coda unit, which is different from English speakers' tendency to segment syllables into onset-rime structures. This illustrates how linguistic features affect reading. The example also demonstrates that "… word reading activates phonology at the lowest level of language allowed by the writing system", which implicates the *universal phonological principle* (Perfetti & Liu, 2005, p. 194).

Reading is also dependent upon the visual orthographic configuration (i.e., script). Within the constraints of reading universality, differences occur as a function of graphic codes illustrated under the graphotactic rules within the writing system. Although Chinese, Japanese, and Korean scripts share visual similarities that are closer to one another than to English, research results show differences in reading among these three scripts especially for the orthographic processing of Korean Hangul. This suggests that the functionality of orthographic features is script specific. This also suggests that script can be the source of the differences found in reading processes and behaviors.

In essence, since writing systems reflect and fulfill the linguistic demands of spoken languages, reading accommodates the demand of both spoken language and

written language. Evidence of psycholinguistic research reviewed in this chapter accords with the concepts of the *universal grammar of reading*, comprising the *linguistic constraint hypothesis* and the *universal phonological principle*, as well as the *system accommodation hypothesis* (Perfetti, 2003; Perfetti & Liu, 2005). All these models and hypotheses are closely related to *script relativity* in that the main findings of dominant precursors of fluent reading and cross-linguistic influences point toward both unity and variability of information processing depending on script differences.

In a similar vein, Wolf (2007) asserts that readers develop different cognitive structures and mechanisms in response to the script in which they read over time. As discussed in Chapter 1, Logan (2004) also claim that alphabetic reading and Chinese character reading result in significant differences in readers' thought patterns, reasoning, values, and problem solving. Given the differences among the four writing systems, it can be surmised that readers of Chinese, Japanese, Korean, and English demonstrate different cognitive mechanisms, which, in turn, escalate the difference between the East and the West on the global level.

Relatedly, as discussed in Chapter 6, a series of studies in social psychology have shown differences in attention and reasoning styles between Asians and Americans. According to Masuda and Nisbett (2001), Asian students tend to describe an animated underwater scene in a relational way by focusing on the background environment of the scene, whereas American students are likely to zero in on a big fish (i.e., focal object) in the background of small fish swimming around. Similarly, Ji, Zhang, and Nisbett (2004) found using word triplets (e.g., panda, monkey, and banana) that Asian bilinguals are more apt to pay attention to and describe objects focusing on relations (i.e., monkeys eat bananas) rather than categories (i.e., monkeys and pandas are both animals). In short, Asians show a tendency of understanding objects or concepts based on thematic relations. However, Americans are likely to attend to categorization or classification of objects based on the similarity of attributes or taxonomic categories. These patterns have been consistently observed in many other studies (see Chapter 6 for detail).

Nisbett (2003) attributed the differences in attention and reasoning styles between Americans and Asians to broader factors, such as differing geographies, ecologies, social structures, philosophies, and educational systems. These factors, except for philosophies, do not belong to the microsystem that is directly connected to the individual in light of Bronfenbrenner's ecosystem, which is discussed in Chapter 7. Instead, it makes more sense to attribute the differences in attentional focus and reasoning between Americans and Asians to the cognitive differences within the microsystem—that is, reading or written language. In other words, Asian students' relationship-grounded attention might have resulted from the spatial relationships embedded within the character of the script. Specifically, most characters of Chinese Hanzi, Japanese Kanji, and Korean Hanja not only comprise multiple subcomponents, such as semantic radicals and phonetic radicals, but also are written in top-down orientation (e.g., {氣}, {炎}), left-to-right orientation (e.g., {明}, {信}), or a mixture of both orientations within the word. Due to the flexibility in the subcomponents of semantic and phonetic radicals as well as in the orientation of the

character, Asians might have developed the sensitivity to the relationships among the multiple attributes of the subcomponents in terms of the spatial characteristics of structure and orientation. Korean Hangul, despite being an alphabet, is not far from having these intrinsic characteristics of the graph. As consequences of literacy, attention to relations might have been inscribed in Asian readers' minds. It is reasonable to assume that this *acquired* sensitivity through habitual reading becomes the default or template for information processing in general. If the script or habitual reading does not affect our cognition, script-specific effects and cross-scriptal influences (Akamatsu, 1999, 2003; Ben-Yehudah et al., 2019; Chikamatsu, 1996, 2008; Pae, Kwon, & Lee, 2015) would hardly be observed because reading is a very cognitive function of the mind. When the empirical findings were viewed through the prism of the causality criteria, the causal relationships from the script to thinking as cognitive responses are tenable.

It should be noted that the studies that I have reviewed in this chapter have been conducted without aiming at specifically testing script relativity. However, it is apparent that the implications of these studies, especially reading Chinese characters, and cross-scriptal influences converge on the fact that our thinking and cognition can be restructured by habitual reading. This suggests that script influences go beyond the absorptions of linguistic influence.

From methodological perspective, as Lucy (1997) pointed out, research on script relativity inherently bears challenges, just like testing the linguistic relativity hypothesis, due mostly to the interlocking relationships among spoken language, written language, and culture. However, it is still possible to tease apart the script effects from intervening or spurious variables with advanced research techniques. Since *script relativity* is newly proposed to overarchingly interpret research findings, more research that specifically tests this hypothesis by other scientists is needed.

With affirmative research evidence for script relativity presened in this chapter, the functions of the brain upon reading the three East-Asian scripts in relevance to reading English are reviewed in the following chapter. The next chapter also expands on the system accommodation hypothesis that is used as one of theoretical frameworks in this chapter because it supports neural structures that accommodate specific visual and structural characteristics of a given script.

Chapter 9
Neurolinguistic Evidence for Script Relativity

"There is evidence that we have been split-brained and split-handed since ancient times. Prehistoric artists painted outlines of their left hands in eighty percent of examples studies, suggesting that the same percentage were right-handed. Presently, the ratio is ninety-two percent right-handed people to eight percent left-handed. Some factor changed in culture to skew these ratios. I believe it was literacy."

- Leonard Shlain (1998, A Conversation, p. 5)

"What we read, how we read, and why we read change how we think."

- Marianne Wolf (2018, p. 2)

Abstract This chapter reviews a vast amount of neuroimaging studies of Chinese, Japanese, and Korean in comparison to L2 English, using the *neuonral recycling hypothesis* (Dehaene, 2009) and the *(writing) system accommodation hypothesis* (Perfetti & Liu, 2005) as theoretical frameworks. In order to understand the basic brain network associated with reading, the major reading circuits found among typical readers are first reviewed. The findings of neuroimaging studies of reading in alphabetic scripts are reviewed and then moved on to the nonalphabetic Chinese and Japanese scripts, compared to L2 English. Although reviewed studies were not carried out to directly test script relativity, evidence converges on biological unity, script diversity, and cognitive diversity, which points toward *script relativity*.

Keywords neuronal recycling hypothesis · system accommodation hypothesis · major reading circuitry · biological unity · script diversity · cognitive diversity

Due to technological advances, imaging methodology, such as functional magnetic resonance imaging (fMRI), positron emission tomography (PET), magnetoencephalography (MEG), Transcranial Magnetic Stimulation (TMS), and Diffusion Tensor

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Imaging (DTI), has been utilized recently in reading science. Neuroimaging research allows us to identify brain regions that become active upon reading. One important contribution of neuroimaging research to reading science is that it provides a useful tool for our understanding of neuronal processing and the brain mechanisms of human cognition and learning. It also offers insights into how efficient reading is accomplished. Evidence converges on the localization of neuronal networks in the left fusiform gyrus or the visual word form areas by going through a genetically constrained circuit (Perfetti, Liu, Fiez, Nelson, Bolger, & Tan, 2007). Perfetti et al. (2007) summarize the brain regions that are generally active for the three constituents of reading (i.e., orthography, phonology, and meaning) as follows:

> The reading network includes posterior visual regions (occipital areas and the left mid-fusiform gyrus) for orthographic processes, temporal/parietal and anterior areas (superior temporal sulcus and inferior frontal sulcus/insula) for phonology, and both posterior (anterior fusiform) and anterior regions (inferior frontal gyrus) for meaning (p. 133).

Building upon research findings that both writing systems and readers' proficiency are likely to yield different activations in brain areas, Perfetti and Liu (2005) propose the *(writing) system accommodation hypothesis*. The hypothesis posits that reading processes as well as the neural architecture and networks accommodate the specific visual and structural features of a given writing system for reading. As in Chapter 8, this theory is used as a theoretical framework for this chapter with a focus on neuronal networks and circuits, along with Dehaene's (2009) *neuronal recycling hypothesis*. Since different brain activities can be explained within and between languages, this chapter reviews the extant literature within each language of Korean, Chinese, and Japanese as well as between languages as the first language (L1) and a second language (L2). This chapter begins with a brief discussion of theoretical considerations. The major brain circuits involved in reading among typical readers are reviewed. Next, empirical brain imaging studies in alphabetic Korean as well as in nonalphabetic Chinese and Japanese are reviewed. Finally, this chapter concludes with a discussion of how this line of empirical evidence extends to *script relativity*.

9.1 Theoretical Considerations

Dehaene (2009) notes that reading requires an activation of a universally involving area in the left hemisphere ventral occipito-temporal cortex known as the visual word form area, which processes orthographic stimuli independent of writing systems. He proposes the *neuronal recycling hypothesis*, positing that certain brain circuits evolve to adapt to variability within strong genetic constraints. Since writing was invented only about 5,000 years ago, there has not been sufficient time for the brain to evolve to form a brain circuitry reserved for visual word recognition. Therefore, the brain adapts to recycle the existing neuronal network in the brain. Accordingly, learning to read is constrained by the mechanism that is specified by

the brain architecture (Dehaene, 2009). Dehaene (2009) also asserts that a different circuit of neurons is involved in our culture-specific activities, depending on the way in which our brain networks are connected to and support these activities. Reading behaviors are shaped by the fundamental workings of our nervous system. He notes that the brain not only governs a direct connection between our native neural structure and our acquired abilities, but also recruits different neuronal circuits according to different writing systems, although there is, in general, a biological unity that the same specialized cortical mechanism works for reading in the same brain regions. Reading is a useful vehicle for demonstrating how our brain organization and our learning are inextricably linked to each other and for testing the neural architecture and networks of the brain to understand the mechanism of cognitive functions.

Drawing upon the notions of universal principles and writing system variations that word identification occurs upon the activation of phonology at the moment of orthographic input, Perfetti, Liu, and Tan (2005) propose the *lexical constituency model* as a general theory of reading across writing systems (in relation to reading Chinese characters). Irrespective of writing systems, word identities are defined by the three interrelated consituents of orthography, phonology, and morphology. Based on the simulations of these three constituents' priming effects, Perfetti et al. (2005) point out both universal reading processes and writing system constraints involved in reading. They indicate that lexical thresholds determine phonological and semantic effects, but not graphic (orthographic) effects. According to Perfetti et al. (2005), despite the universal phonological involvement in reading, the activation process of phonology is dependent upon the way in which the writing system structures its graphic units.

Perfetti et al. (2007) reviewed ERP and fMRI studies of Chinese-English bilinguals and learners of Chinese as a foreign language to elucidate the reading networks of the brain involved in reading in L1 and L2 in terms of the brain's accommodation and assimilation. According to the *system accommodation hypothesis* (Perfetti & Liu, 2005), the neural circuits and networks of reading acquired in L1 become modified to accommodate and adapt to the linguistic demands of L2 script in reading. The brain's assimilation occurs when using the existing L1 networks to process L2, while accommodation is involved when recruiting an additional network for L2 (Perfetti et al., 2007). fMRI studies show that learners of Chinese activate bilateral occipital-temporal and middle frontal areas when reading Chinese (e.g., Liu, Dunlap, Fiez, & Perfetti, 2007; Nelson, Liu, Fiez, & Perfetti, 2009). This is similar to the pattern of native speakers of Chinese but is different from the patterns of alphabetic reading. There seems to be an asymmetry between alphabetic readers and Chinese readers when they read in L2 Chinese and L2 English, respectively. Specifically, alphabetic readers tend to have neural circuits that accommodate the demands of L2 Chinese by engaging in neural networks that are not likely to be utilized for alphabetic reading. In contrast, Chinese natives tend to have neural circuits that assimilate L2 English into the Chinese writing system by recruiting neural networks that are used for reading Chinese characters (e.g., Cao, Tao, Liu, Perfetti, & Booth, 2013; Cao et al.).

9.2 Major Reading Circuits among Typical Readers

Studies using various imaging technologies, such as fMRI, PET, or MEG, show that word and pseudoword reading activates the left hemisphere posterior region that is associated with both the ventral circuit and dorsal circuit (Pugh et al., 2000). The left ventral occipito-temporal cortex (the junction of the occipital and temporal lobes) associates lateral extra-striate areas and a left inferior occipito-temporal area that are activated upon reading. The dorsal circuit (temporo-parietal region) includes the angular gyrus and supramarginal gyrus in the inferior parietal lobule as well as the posterior area of the superior temporal gyrus called Wernicke's Area (Pugh et al., 2000). The region of the angular gyrus is associated with the mapping of orthography and phonology. Silent reading and naming are carried out in the anterior circuit that centers around Broca's area in the inferior frontal gyrus (Pugh et al., 2000).

Converging evidence shows that the left ventral occipito-temporal cortex and nearby white matter tracts are the brain regions that are essential for reading. Yeatman, Rauschecker and Wandell (2013), using a combination of fMRI and white matter tractography, have found that three different pathways of white matter tracts are engaged in reading: (1) the inferior longitudinal fasciculus is connected to the occipital cortex in the anterior and medial temporal lobes; (2) the inferior fronto-occipital fasciculus is connected to the occipital cortex in the ventrolateral prefrontal cortex; and (3) the vertical occipital fasciculus is connected to the dorsal circuit in the lateral occipital parietal junction with the posterior angular gyrus and lateral superior occipital lobe.

Although there are major reading circuits commonly involved in reading, a mapping process from orthography to phonology can vary across writing systems as well as the characteristics of spoken languages. Bolger, Perfetti, and Schneider (2005) conducted a meta-analysis, including studies on English and European alphabetic languages, Chinese, and Japanese. Results showed that word recognition involved a common network of gross cortical regions in the brain regardless of script differences. However, some levels of localization or variation within those regions were observed depending on the script being read, suggesting that localizations might differ according to writing systems. The visual word form area showed consistent localization across tasks involved in reading and across writing systems. Bolger et al. (2005) concluded that the visual word form area in the left mid-fusiform gyrus was essential to word recognition across writing systems.

Of interest is to understand how the brain regions involved in reading vary within and across individuals as a result of reading experience, strategies used, and readers' proficiency. Developmental variations in reading activation are observed in children and adults (Olulade, Flowers, Napoliello, & Eden, 2013). The effect of experience seems to be consistent with an inverted U-shaped function (Price & Devlin, 2011) given that an increased activation in the mid-regions of the left ventral occipito-temporal cortex is observed in emergent readers' learning to read. A robust activation in the region is consistent with adults' learning to read a new script

regardless of the use of lexical or sublexical strategies (Mei et al., 2013). The low part of the inverted U shaped function is associated with reading familiar words, as decreased activation in the middle part of the left ventral occipito-temporal cortex is observed with familiar words (Twomey et al., 2013) among skilled adult readers (Olulade et al., 2013). Adults' efficient reading appears to require less activation but increased anatomical connectivity within the reading network (Lebel et al., 2013). This seems to be related to the automaticity of reading, which is the foundation of script relativity.

Research shows that the brain's blood oxygenation varies in regions according to the proficiency level of linguistic skills. In an fMRI study examining the neural correlates of learning to use pitch patterns of words by English-speaking adults with no previous exposure to the pitches, Wong, Perrachione, and Parrish (2007) measured blood oxygenation levels while participants discriminated pitch patterns of words before and after training. Participants who had mastered the learning program showed increased activation in the left posterior superior temporal region. Participants who had not mastered the pitch discrimination showed increased activation in the right superior temporal region and right inferior frontal gyrus (which were associated with nonlinguistic pitch processing) as well as prefrontal and medial frontal areas (which were associated with increased working memory and attentional efforts). These results indicated a relationship between the range of neural changes and language proficiency, suggesting the physiological contribution of the left dorsal auditory cortex to successful speech and word learning among adults.

9.3 Neuroimaging Studies of Reading Alphabetic Hangul in Relation to L2 English Reading

This section begins with a review of alphabetic Hangul reading because reading models and theories have originated from alphabetic orthographies. Since South Koreans unofficially use Chinese-derived characters (i.e., Hanja—traditional Chinese characters used in Korea), reading Hangul and Hanja is reviewed, and then the review moves on to L2 or L3 English reading in conjunction with L1 Korean.

9.3.1 Reading in Hangul and Hanja

Wolf (2018) makes a claim that "with no genetic bluerint for reading, *there is no one ideal reading circuit*" (p. 18, emphasis in original). Due to the lack of the optimal rading circuit, neural specialization and neural adaptation occur differently depending on the script being read, which is the tenet of the *system accommodation hypothesis*. The hypothesis is useful for Hangul reading because neuroimaging data allow us to better understand biological unity, script diversity, and brain network diversity,

due to Hangul's alphabetic nature and the use of non-Roman script in character-like syllabic blocks.

Based on the fact that the appearance of the Hangul script resembles Chinese characters, Yoon, Cho, and Park examined the brain activation of reading Korean words and recognizing pictures among native Korean speakers. They used 120 items consisting of 60 two- or three-syllable nouns in Hangul and 60 corresponding images that shared the same semantics (e.g., {고양이} <cat> vs. the image of a cat). Results showed that both reading Hangul and recognizing images activated the areas of the occipito-temporal region bilaterally. However, reading Hangul activated the frontal and temporal region as well, which was not activated with image stimuli. Reading Hangul also activated other areas, including the left middle frontal region (related to phonological and semantic processing), the right anterior cingulate (BA 32; related to language and sound organization), the superior temporal area (BA 29; related to phonological system), and the right medial frontal area (BA 8). Based on the activation of the right medial frontal region, the researchers indicated that reading Hangul involved nonverbal visual higher order control or the visuospatial analysis of the Hangul script due to the unique syllabic structure (Yoon, Cho, & Park). This finding suggests that Hangul's square-block format might be the source of the departure point from European alphabets; that is, the unique visual configuration of Hangul seems to yield a unique processing pattern found in brain imaging studies.

Due to the use of both Hangul and Hanja in Korea, researchers have taken advantage of the biscript use in the reading science of Korean Hangul. Lee (2004) compared, using fMRI, brain activation in the reading of Hangul and Hanja among native Korean readers, along with a comparison group that read Hangul and English. An interaction analysis between the two groups showed that the right fusiform gyrus and the adjacent temporo-occipital region were more involved in reading Hanja than Hangul. In contrast, the regions in the bilateral inferior parietal lobules were more active in reading Hangul than Hanja. Lee (2004) indicated that both assembled phonological route and addressed lexical route seemed to be involved in reading Hangul, whereas reading Hanja might not require the assembled phonology route.

An fMRI study showed that, while L1 Korean word reading activated a different part of the brain from the area that was activated when Chinese characters were read, the activation pattern in reading Korean words was similar to that in reading L2 English words on the global level (Yoon, Cho, Chung, & Park). This result suggests that Korean is closer to English than Chinese in terms of orthographic distance. However, the strong activations of the posterior part of the right dorsolateral prefrontal cortex and the right hemispheric dominance of the occipital lobe were particularly observed in reading Korean words, compared to reading English, suggesting that reading Korean might be slightly different from reading English, based on the visuospatial analysis involved in reading Korean. Yoon, Cho, Chung, and Park also examined the neural mechanism of brain activation patterns of reading Korean words in Hangul and Hanja using fMRI. The brain localization of native Korean speakers' reading Chinese characters was similar to that of native Chinese speakers' reading their own L1 characters such that the left-lateralized middle

frontal cortex was strongly activated. Reading in Hangul showed activation in the areas of the bilateral fusiform gyrus, left middle frontal gyrus, left superior temporal gyrus, right mid-temporal gyrus, precentral gyrus, and insula. These results corroborated the collective findings that different activation patterns were observed in reading alphabetic scripts and the Chinese logographic script. Given the strong activation of the posterior part of the right dorsolateral prefrontal cortex in reading, which belonged to the visual higher order control area, the researchers argued that the area of the right dorsolateral prefrontal cortex was responsible for the processing of visuospatial information of Korean words, because the surface form of Hangul was associated with architectural balance in the syllabic unit.

Similarly, Cho et al. (2014) carried out two studies to examine native Korean speakers' word reading of two different scripts of Hangul and Hanja using fMRI. Their first study compared the pattern of cortical activation in reading Hangul and Hanja to find that Hanja reading would cause more activation in the larger areas of the brain than Hangul reading. The second study used Koreans' popular Hangul and Hanja names[1] to assess recognition memory in light of *morphemic clarity* in each character of the two-syllable name (i.e., the degree to which each character of the name preserves clear morphemic information; e.g., in Hangul {현자} <wise + offspring> vs. {동은}---vague meaning) and *semantic transparency* of the two-syllable name as a whole (i.e., the degree to which the combination of two characters in the name delivers a clear meaning; e.g., in Hanja {美玉} <beautiful jade> vs. {貞玉}--vague meaning). The results showed that high morphemic clarity in each letter of the two-syllable name yielded larger effects than those of high semantic transparency as a whole in recognition memory. In terms of the particular areas activated (Lee, 2004; Yoon, Cho, Chung, & Park), the brain activation seems to be different in reading Hangul and Hanja.

Kim and colleagues (Kim, Kim, Kang, Park, Lim, Kim, & Bak) investigated brain mapping and the neurolinguistic circuitry of visual script familiarity for cortical representation in reading Hangul and Hanja among adult native Korean readers with two groups of Hanja proficiency levels. Based on previous findings of different neural pathways engaged in reading according to a given script's orthographic regularity, these researchers also examined, using an implicit word reading task for fMRI, the effect of script familiarity according to different orthographic regularity in Hangul (more familiar script) and Hanja (less familiar script). The fMRI blood-oxygen level showed that reading Hanja involved the ventral pathway, whereas reading Hangul was associated with the dorsal pathway. Both the right superior parietal lobule area and the left supplementary motor area were more stimulated in reading Hanja and Hangul for the lower-proficiency group than the high proficiency counterpart.

[1] In general, Korean family names consist of one-syllable characters, while given names comprise two-syllable characters. Some Koreans' names can be written in both Hangul and Hanja, while others are written in Hangul only because the syllables used in the name are Korean native syllables with no equivalent characters available in Hanja.

9.3.2 Reading in L1 Hangul and L2 or L3 English

Kim et al. (2016) investigated how linguistic distance between L1 and L2 affected the pattern of brain activation among Korean–Chinese–English trilinguals. Linguistic distance is defined as the degree to which two languages are different according to the nature of writing systems of the given languages. Since English and Korean are alphabetic scripts, their linguistic distance is closer than that between English and Chinese or between Korean and Chinese. Using a visual rhyming judgment task, Kim et al. (2016) examined fMRI of Korean trilinguals' reading in Korean (KK), Chinese (KC), and English (KE), along with two control groups of native Chinese (CC) and English (EE) speakers. The results of fMRI showed that the pattern of brain activation of KC was more akin to that of CC than KK. This suggests the brain's neural accommodation. The KC group showed higher accuracy rates with decreased activation in the regions of the KK network. This suggests a reduced assimilation. On the contrary, the brain activation pattern of KE was more similar to that of KK than EE. This suggests neuronal assimilation. The KE group showed higher accuracy with decreased activation in the regions of the EE network. This suggests reduced neuronal accommodation. An analysis of brain regions of interest in the left middle frontal gyrus showed greater activation for the KC group than the KE group. This suggests selective involvement in L2 reading depending on the script being read. Kim et al. (2016) indicated that the brain network involved in L2 reading made use of brain networks established in L1 through an assimilation process when linguistic distance between L1 and L2 was narrow. When linguistic distance is huge between L1 and L2, a significant modification of the neural network seems to take place.

Another study by Kim, Liu, and Cao examined L1 influences on L2 reading among Korean-English and Chinese-English bilinguals, along with control groups of Korean monolinguals and Chinese monolinguals, using a visual word rhyming judgment task in L2 English. Results showed that brain activation upon L2 processing was similar to that of L1 processing for both Korean and Chinese bilinguals. Both Korean monolinguals and bilinguals showed more activation in the right inferior frontal gyrus and medial frontal gyrus regions than Chinese monolinguals and bilinguals, suggesting that the processing of Korean and Chinese might be different from each other. For bilinguals, Chinese bilinguals showed greater activation in the left middle frontal gyrus area than Korean counterparts. Overall, similar brain networks were recruited for L1 and L2 activation within each language group. However, the language difference between Chinese and Korean seemed to remain the same in L2 processing, indicating solid L1 influences on L2 processing.

9.4 Neuroimaging Studies of Reading Non-Alphabetic Chinese and Japanese Scripts

Chinese characters and Japanese Kanji as well as the co-use of Pinyin for Chinese and Kana for Japanese offer a useful means to investigate commonalities and differences in reading due to the use of different scripts than European alphabetic scripts. Research findings of these languages and scripts undoutedly facilitate our understanding of the reading mechanism as well as brain activation and circuitry involved in reading.

9.4.1 Word Reading in Chinese

As the visual word form area within the left hemisphere ventral occipito-temporal cortex is known to be dominantly engaged in reading across scripts, script invariance has been assumed (Krafnick et al., 2016). Using fMRI, Krafnick et al. (2016) found that both English-speaking and Chinese-speaking monolingual first graders in the U.S. and China, respectively, showed activation in the left ventral occipito-temporal cortex when reading, with a significant overlap in the visual word form area, which suggests script invariance. Krafnick et al. (2016) further examined the left ventral occipito-temporal cortex region to find that Chinese children responded to object stimuli (line drawings) in the same way as that of reading Chinese characters. In contrast, English-reading children showed that the left ventral occipito-temporal cortex was more activated when objects were shown rather than English words. Collectively, these results endorsed script invariance in the visual word form area and indicated that the left hemisphere ventral occipito-temporal cortex was the area involved in character or word processing.

Based on the findings of recent fMRI studies showing that lexical processing in alphabetic languages took place in both ventral and dorsal neural pathways originating from the visual cortex, an fMRI study was conducted to identify the effective connectivity of brain regions in reading Chinese (Xu, Wang, Chen, Fox, & Tan, 2015). Xu et al. (2015) examined how the neural systems interacted with one another in reading Chinese by testing the multiple pathways model. Dynamic causal modeling showed that visual word recognition in Chinese involved the ventral pathway from the visual cortex to the left ventral occipito-temporal cortex. However, the activation of the dorsal pathway from the visual cortex to the left parietal region was not observed. The ventral pathway was linked to the superior parietal lobule and the left middle frontal gyrus. A dynamic neural network was formed with information flowing from the visual cortex to the left ventral occipito-temporal cortex to the parietal lobule and then to the left middle frontal gyrus. These findings suggest that the differences in the way in which orthography represents phonology across writing systems are likely to constrain the cortical dynamics connected to the brain regions.

An examination of the co-use of characters and Pinyin allows for a better explanation of brain functions in reading. In order to identify similarities and differences in reading the two scripts, Chen, Fu, Iversen, Smith, and Matthews (2002) tested the dual brain processing routes in reading Chinese characters and Pinyin using an fMRI. They compared the patterns of brain activity to see whether the same or different cognitive mechanisms were engaged in reading the two different scripts, using a block design of phonological and lexical tasks. Common brain areas, including the inferior frontal, middle, and inferior temporal gyri, the inferior and superior parietal lobules, and the extrastriate areas, were activated in reading Chinese characters and Pinyin with some variations across the regions depending on the script difference. Reading Pinyin yielded a greater activation in the inferior parietal cortex bilaterally, the precuneus, and the anterior middle temporal gyrus. Character reading was associated with the activation in the areas of the left fusiform gyrus, the bilateral cuneus, the posterior middle temporal, the right inferior frontal gyrus, and the bilateral superior frontal gyrus. Chen et al. (2002) concluded that both alphabetic and nonalphabetic scripts activated a common brain network for reading with no differences in terms of hemispheric specialization. However, some specialized areas were activated according to the script being read; that is, the inferior parietal cortex was involved for Pinyin via predominantly assembled processes, while the fusiform gyrus was engaged for Chinese characters via predominantly addressed processes.

Cao, Vu, Chan, Lawrence, Harris, Guan, Xu, and Perfetti examined the effect of instructional methods on brain activation. They have trained college students in a character-writing class (more focus on visual-spatial structure) and a Pinyin-writing class with a control group of English readers. fMRI showed that different networks were engaged in reading Chinese characters and English words, supporting the view that the brain's accommodation occurred according to the script being read. The instructional effects were robust such that the character-writing condition yielded greater activation in the bilateral superior parietal lobules and bilateral lingual gyrus than the Pinyin-writing condition in both lexical decision and implicit writing tasks. A greater involvement of bilateral sensorimotor cortex was found for character-writing than Pinyin-writing in the lexical decision task. The recognition accuracy was related to the activation in right superior parietal lobule, right lingual gyrus, and left sensorimotor cortex. Consistent with previous behavioral studies, these researchers found that character-writing training facilitated connections with semantics through producing greater activation in bilateral middle temporal gyri, whereas Pinyin-writing training facilitated connections with phonology through producing greater activation in the right inferior frontal gyrus. The fact that the short-term training resulted in different connections in the brain has a significant implication for script relativity.

Similarly, research on the neural correlates of reading shows that the left middle frontal gyrus, which is typically involved in writing, is more active in reading Chinese than English. Cao and Perfetti (2016) assumed that the writing region would be more activated in Chinese reading due to the learning-to-read practices of copying characters. To test this hypothesis, they tested English speakers who had

learned Chinese as a foreign language. Participants performed both reading and writing tasks in English and Chinese with one group learning Chinese characters by writing/copying characters and the other group by learning phonological properties to examine the effect of writing (copying characters) on reading. Results showed that the left middle frontal gyrus was more activated in writing than in reading regardless of English or Chinese, which confirmed that the left middle frontal gyrus was associated with writing. The left middle frontal gyrus was more activated in Chinese than English regardless of tasks performed. The group that had learned Chinese characters through character-writing showed more activation in the left middle frontal gyrus than the comparison group who had learned through phonological learning. The same results were found with native Chinese speakers, which ruled out the possibility that the above findings stemmed from language proficiency. These findings suggest that the reading-writing connection is modulated by learning experience.

Word recognition research in alphabetic scripts has revealed a possible facilitatory neighborhood size effect (i.e., facilitatory neighborhood size effects mean that the recognition of words with more orthographic neighbors is faster than that of words with fewer neighbors, whereas an inhibitory neighborhood size effects mean slower responses) in low frequency words. Li, Bi, and Zhang (2010) examined neural correlates of the orthographic neighborhood size effect in Chinese. Previous studies showed that reading Chinese characters invoked both facilitatory and inhibitory neighborhood size effects, depending on the frequency of neighbors. Li et al. (2010) also found, using fMRI, the facilitatory contributions of neighborhood size to orthographic activation in silent naming depending on the frequency of neighbors. Results identified greater activation in the left middle frontal gyrus for smaller neighborhood size than larger neighborhood size and activations in the bilateral inferior frontal region for high-frequency neighbors. Greater activation was found in the right middle occipital gyrus for larger neighborhood size than smaller neighborhood size when high frequency neighbors were absent; however, null neighborhood size effects were found in the presence of high frequency neighbors. These results suggest that different neural correlates are involved in reading according to neighborhood size.

Since multi-character words or compound words are prevalent in the Chinese lexicon, studies of multi-characers add new insights into reading mechanisms. Lin, Yu, Zhao, and Zhang (2016) examined the functional anatomy of the recognition of Chinese multi-character words in light of the effects of nonwords, lexicality, and word frequency. In order to rule out possible confounding effects (e.g., effects that are modulated by an interaction effect between different tasks) of reaction time, Lin et al. (2016) used transposable nonwords, regular nontransposable nonwords, and real words. They performed a conjuction analysis on contrasts beween transposable nonwords and regular nonwords and between words and regular nonwords in order to determine whether these different tasks activated the same areas of the brain. Both significant conjunctional effects and positive word-frequency effects were observed in the bilateral inferior parietal lobules and posterior cingulate cortex regions. Conjunctional effects were found in the anterior cingulate cortex area only.

Another study was conducted using multiple scripts. Xue, Jiang, Chen, and Dong (2008) examined how the writing system, stimulus length, and presentation duration affected visual word recognition using event-related potentials (ERPs). They compared early electrophysiological responses (i.e., the first negative peak; N1) to familiar and unfamiliar writings under different conditions in terms of lexicality (words vs. nonwords for familiar writings only), length (characters/letters vs. words), and presentation duration (100 ms vs. 750 ms). Native Chinese speakers with English as L2 participated in reading four types of scripts, including Chinese, English, Korean Hangul, and Tibetan. Results showed no significant differences found between words and nonwords. The language experience (familiar vs. unfamiliar) was significantly affected by stimulus length and writing systems and was affected by presentation duration to a smaller degree. Specifically, the language experience effect (i.e., a stronger N1 response to familiar writings than to unfamiliar writings) was significant for alphabetic letters only, but not for alphabetic words. The difference between Chinese characters and Hangul was significant in the condition of short presentation duration only, but not in the long presentation condition. Long stimuli elicited a stronger N1 response than did short stimuli in the familiar writings, suggesting that N1 response might not reliably differentiate the familiar script from the unfamiliar script being read. Overall, Xue et al. (2008) indicated that N1 was modulated by visual, linguistic, and task factors.

In summary, when reading Chinese characters, Pinyin, and English, common brain networks were involved in the left hemisphere ventral occipito-temporal cortex. This indicated a script invariance. However, specialized regions varied to the extent that scripts being read yielded different brain circuits that were recruited according to instructional methods (character-copying or phonological-learning), readers' language and reading proficiency, neighborhood size, word frequency, and tasks to perform. The dorsal pathway from the visual cortex to the left parietal region was less likely to be active in Chinese reading than in English reading.

9.4.2 Word Reading in Japanese Kanji and Kana

Given that the Japanese use both Kanji (morphograms) and Kana (syllabograms) within one sentence, its complexities have drawn scientific interests in reading science. Research has demonstrated that Kanji and Kana are processed differently due to the difference in the nature of these two scripts. Kana are processed in a way similar to other phonetic languages such as English, while Kanji are processed in a similar way to Chinese characters (Nakamura, Dehaene, Jobert, Bihan, & Kouider, 2005; Sakurai et al., 2000; Thuy et al., 2004). Sakurai et al. (2000) found different cortical activities evoked upon reading of Kanji and Kana in a positron emission tomography study. Reading Kanji activated the lateral fusiform gyrus (BA 37), while reading Kana activated the middle and inferior occipital gyri (BAs 18 and 19) and the deep perisylvian temporo-parietal area (BAs 40/22 and 22/21). Nakamura, Dehaene, Jobert, Bihan, and Kouider (2005) also examined the functional

architecture of visual word recognition in Kana and Kanji, using a subliminal priming method with fMRI. Participants were asked to perform semantic judgment of words, in which a subliminal presentation of either the same or a different word and in the same or a different script was followed by each target word. Word repetition (i.e., same word subliminal presentation) yielded a significant priming effect regardless of script presentation (i.e., Kanji or Kana). Results showed a shared visual occipito-temporal activation for words in Kanji and Kana. However, Kanji reading recruited slightly more mesial and right-predominant activation, while Kana reading was associated with greater occipital activation. These findings indicated that script-dependent and script-independent regions were engaged subliminally in the posterior temporal lobe for the different scripts of Kanji and Kana.

Coderre, Filippi, Newhouse, and Dumas (2008) examined the Stroop effects of color naming using fMRI to identify similarities and differences in brain processing in Kana and Kanji. Significant Stroop effects in reaction time were found within the Kana script and within the Kanji script, but there was no significant difference in reaction time between Kana and Kanji. The brain imaging data showed that the anterior cingulate gyrus, which was the area involved in inhibiting automatic processing, was activated for both Kana and Kanji. Although the Stroop effect was not significant in reaction time between Kana and Kanji, the two scripts showed the different areas of activation in fMRI. Specifically, the left inferior parietal lobule area was activated for the Stroop task in Kana, while the left inferior frontal gyrus region was activated for the Stroop task in Kanji. These results indicated that conflict detection and resolution occurred in the different brain regions according to script input, as evidenced by the activation of different brain areas depending on whether phonographic Kana or morphosyllabic Kanji were used.

A different activation in the brain regions according to varied scripts in size and scrambled-characters has also been investigated using fMRI. For example, Thuy et al. (2004) investigated the implicit and explicit processing of two-syllable Kanji and two-syllable Kana words (i.e., Kanji words were transcribed in Hiragana) and nonwords. In a task, rest (0), task 1 (Kanji), and task 2 (Kana) were alternately repeated as in 0102010201020102 in a time course block design. Each item was shown for 500 ms with a 500 ms inter-stimuli interval. The subject was asked to respond by judging which character was bigger between the first and the second. One of the two characters presented was 25% bigger than the other. The researchers operationally defined size judgment for character stimuli as an implicit language task for linguistic stimuli; operationally defined size judgment for scrambled-character stimuli as an implicit language task for non-linguistic stimuli; and operationally defined lexical decision as an explicit language task. The results of the fMRI study showed that the size judgment for scrambled-Kanji stimuli and scrambled-Kana stimuli led to activation in the bilateral lingual gyrus (BA 18), the bilateral occipito-temporal regions (BA 19/37), and the bilateral superior and inferior parietal cortices (BA 7/40). In addition to these areas, the left inferior frontal region (Broca's area, BA 44/45) and the left posterior inferior temporal cortex (BA 37), which have been considered language areas, were also activated during size judgment for Kanji character stimuli (i.e., implicit language task). Size judgment

for Kana character stimuli (i.e., implicit language task) also activated Broca's area, the left posterior inferior temporal cortex, and the left supramarginal gyrus (BA 40). The lexical decisions for both Kanji and Kana (i.e., explicit language task) yielded activation in these language areas as well. These findings indicated that both implicit and explicit language processing was obligatory for both Kanji and Kana scripts. However, a comparison between the scrambled Kanji condition and the scrambled Kana condition showed no activation in the language areas. A comparison between Kanji and Kana scripts during size judgment and lexical decision showed a greater activation in the bilateral fusiform gyrus (dominant in the left). Thuy et al. (2004) used the common subtraction analysis, which is a method where the summed activation maps of all stimulation conditions are first rescaled based on average images and then the baseline activation maps are subtracted from the stimulation activation maps in order to specify the activation locations in the brain. A Kana-minus-Kanji analysis showed activation in the left supramarginal gyrus during size judgment. The Broca area and left middle/superior temporal junction were active during lexical decision. These results indicated that, despite largely overlapping cortical regions, implicit and explicit reading was different across Kanji and Kana. Thuy et al. (2004) concluded that Kanji reading seemed to be involved in more visual orthographic retrieval and the lexical–semantic system through the ventral route, whereas Kana reading required phonological recoding to access semantic information through the dorsal route. These findings are consistent with the concept of script relativity.

Differet tasks were also used in the comparison of the two scripts in the brain functions. Ino, Nakai, Azuma, Kimura, and Fukuyama (2009) conducted an fMRI study of Kanji and Kana to examine brain activation for processing words written in the two scriptal types using word recognition (pressing a button for the real word) and reading aloud. Brain activation was similar to each other for Kanji and Kana words in reading aloud tasks. However, the regions of bilateral frontal, parietal and occipito-temporal cortices (all of which are related primarily to visual word-form analysis and visuospatial attention) were activated in the word recognition task. Concerning the difference of brain activity between the two tasks, a differential activation was found only in the regions associated with task-specific sensorimotor processing for Kana. Greater activation was found for Kanji in the visuospatial attention network in the word recognition task than the reading aloud task. Ino et al. (2009) concluded that the differences in brain activation between Kanji and Kana were dependent upon the interaction between the script characteristics and the task demands.

In a similar vein, research showed that different neural circuits were activated in reading Kana and Kanji. Higuchi et al. (2015) examined the neural basis for the processing of the hierarchical visual form of Kanji characters using gradient stimuli from fragments of the character to real Kanji characters. Their stimuli included (1) real Kanji characters, (2) pseudo Kanji characters (subcomponents with partial characters), (3) artificial characters (character fragments), and (4) checkerboard (simple photic stimuli). Robust activation according to different stimulus types was found in the left occipito-temporal visual region along the posterior–anterior axis in the order of the structural complexity of the stimuli (i.e., from fragments to

complete characters). Only Kanji characters produced functional connectivity between the left inferior temporal area and the language area (left inferior frontal triangulary). Pseudo Kanji characters produced connectivity between the left inferior temporal area and the bilateral cerebellum and left putamen. Higuchi et al. (2015) concluded that the visual processing of Japanese Kanji involved the left occipito-temporal cortex in a hierarchical structure within the region to the extent that the neural activation was sensitive to the hierarchical coding of the character from the fragment of the character to the full set of the character.

The different role of spatial frequency involved in reading Kanji and Kana has also been investigated. Using high-density ERP, Horie et al. (2012a) reported that the source of different reading in Kanji and Kana could be attributable to spatial frequency information, indicating that low spatial frequency information was associated with Kana, while high spatial frequency information was related to Kanji. In order to identify which brain areas were related to the difference between Kanji and Kana, Horie et al. (2012b) performed fMRI among native Japanese readers, presenting unfiltered and spatially filtered Kanji and Kana words. When either Kanji or Kana unfiltered stimuli were presented, the bilateral inferior temporal (BA 37) regions were activated, compared to the resting condition. Kana reading activated the bilateral inferior parietal lobules (BA 40), but Kanji reading did not activate this area. When Kanji and Kana reading was directly compared, Kanji reading yielded activation in the left inferior temporal region, while Kana reading activated the left inferior parietal lobules. For filtered high spatial frequency stimuli, the Kanji reading minus Kana reading comparison showed a significant activation of the left inferior temporal region only without activation in the inferior parietal lobules area. In contrast, for filtered low spatial frequency stimuli, the Kana reading minus Kanji reading comparison showed a significant activation of the left inferior parietal lobules only without activation in the left inferior temporal region. These results indicated that Kanji and Kana engaged in the relatively overlapping network, with more involvement of the left inferior temporal region for Kanji processing and with more involvement of the left inferior parietal lobules for Kana processing. Consistent with the results of Horie et al.' (2012a) study with ERP, Horie et al.'s (2012b) fMRI results demonstrated that spatial frequency was the source of the dissociation found in reading Kanji and Kana (i.e., high spatial frequency in Kanji and low spatial frequency in Kana).

Koyama, Kakigi, Hoshiyama, and Kitamura (1998) conducted a magnetoencephalographic study to examine areas recruited for reading Kanji and Kana. Participant were asked to read 44 Kanji, 44 Kana, and 20 alphabet letters and to count the number of letters. The magnetic responses were recorded with dual 37-channel Superconducting Quantum Interference Device gradiometers from the temporal, parietal, and occipital areas of the brain. Similar magnetic responses were found for Kanji and Kana in the locations of equivalent current dipoles. The equivalent current dipoles in the posterior-inferior temporal areas were found, approximately corresponding to Brodmann area 37 in the latency range of 150-300 milliseconds. These activities were shown in both hemispheres without consistent laterality. As response time increases, the location of the equivalent current dipoles moved forward from posterior to anterior in the posterior-inferior temporal area.

Given that activities in posterior-inferior temporal areas were also found in alphabet letters, the bilateral posterior-inferior temporal areas were considered to play an essential role in reading.

Since the Japanese multi-scripts allow for writing the same word in either Kanji and Kana, it is possible to differentiate a word's lexical frequency from the visual form frequency. Making use of the Japanese scripts' uniqueness, Twomey et al. (2013) examined the dissociation of visual forms of Kanji and Hiragana. Results showed faster responses to high frequency words than low frequency words and faster responses to visually familiar words than less familiar words in both Kanji and Hiragana. The brain imaging results showed that visual familiarity had a stronger effect on activation in the ventral occipito-temporal cortex than lexical frequency. Activation in the ventral occipito-temporal cortex was also greater for Kanji than Hiragana words, which was not due to their inherent differences in visual complexity. Twomey et al. (2013) explained these findings within a predictive coding framework in which the left ventral occipito-temporal cortex received the bottom-up encoding of complex visual forms and top-down predictions from regions encoding the non-visual attributes of the stimulus.

Ischebeck et al. (2004) examined the role of visual familiarity in brain function within the regular orthography of Japanese Kana using fMRI. They used two phonologically equivalent but visually dissimilar syllabaries, which allowed the writing of foreign loanwords to be written in two ways but only one of which was visually familiar. Three forms of Kana syllabaries included familiarly written words, unfamiliarly written words, and pseudowords (6 conditions in total: 2 types of foreign words x 3 forms of stimuli written in Kana) in a silent articulation task (Experiment 1) and a phonological lexical decision task (Experiment 2). In both experimental tasks, different brain regions were activated according to the three different stimulus types (familiar, unfamiliar, and pseudoword) especially surrounding the areas previously known for phonological encoding and word retrieval for meaning. Pseudowords and visually unfamiliar words, which were known to use phonological assembly, led to an increased brain activity in the left inferior frontal regions (BA 44/47), compared to visually familiar words. The two types of words (i.e., visually familiar words and unfamiliar words) activated the areas associated with lexico-semantic processing more than pseudowords, including the left and right temporo-parietal regions (BA 39/40), the left middle/inferior temporal gyri (BA 20/21), and the posterior cingulate (BA 31).

9.4.3 Word Reading in Chinese or Japanese in Relation to L2 English

Liu and Perfetti (2003) examined the time course of brain activity in reading both English and Chinese among Chinese-English bilinguals performing a delayed naming task. A principal component analysis of ERP from the onset of the stimulus

indicated a different pattern of a temporal unfolding of graphic, phonological, and semantic processing depending on the script being read. Specifically, reading Chinese produced an earlier and higher amplitude shift (negativity 150 milliseconds; N150) than English at 150 milliseconds. Frequency effects were robust at 250 milliseconds for both Chinese and English. However, only the English frequency effect was reliable at 450 milliseconds. A source localization analysis by the Low Resolution Electromagnetic Topography showed that the visual recognition of Chinese characters involved the bilateral occipital regions (left BA 17, right BA 18). High-frequency English word recognition was involved in the left occipital region only (left BA 17), while low-frequency English words activated bilaterally in more diffused and extended temporal patterns. The right prefrontal area (BA 10) was strongly activated in the mid latency between 300 and 400 milliseconds periods of Chinese character naming, whereas English word naming showed more medial frontal (BA 8, and 10) activation. A post 450-milliseconds visual verification was general for both Chinese and English.

The neural strategies employed for the character-decoding and morphosyntax of Japanese and Chinese were also investigated using fMRI. Huang, Itoh, Kwee, and Nakada (2012) examined brain strategies for sentence reading among Japanese speakers who were literate in Mandarin and Mandarin speakers who were literate in Japanese. The activation pattern in the brain was distinctly different across the two groups. Irrespective of the participants' native languages, Chinese reading activated more areas than Japanese reading, suggesting that Chinese reading was much more complex than Japanese reading. Chinese reading additionally activated the cortical areas in the right hemisphere. The activation pattern shown in Japanese reading by native Japanese speakers was highly consistent with previous reports, including the left inferior frontal gyrus, left posterior temporal lobe, and left ventral premotor cortex. The activation pattern associated with Chinese reading by native Chinese speakers was also highly consistent with previous reports, including the left inferior frontal gyrus, left posterior temporal lobe, left ventral premotor cortex, left anterior temporal lobe, and bilateral parieto-occipital lobes. The activation pattern shown in native Japanese speakers' Chinese reading was identical to that shown by native Chinese speakers. However, native Chinese speakers' reading Japanese yielded additional activation in the bilateral parieto-occipital lobes compared to native Japanese speakers. Huang et al. (2012) called the bilateral parieto-occipital lobes the "Chinese language area," while the ventral premotor cortex was the "Japanese Kanji area." This study suggests that the inferior frontal gyrus and posterior temporal lobe are universally involved as the language areas. The anterior temporal lobe seems to be essential for processing analytic morphosyntax in Japanese and Chinese.

The age of acquisition seems to be a contributing factor to brain networks as well. Kim, Relkin, Lee, and Hirsch (1997) examined how L1 and L2 were represented in the cortical areas by identifying the spatial relationship between L1 and L2 in the brain cortex. Neuroimaging results showed that L2 was processed spatially in separated regions from L1 within the frontal-lobe language regions (i.e., Broca's area) for late bilinguals who had learned an L2 in adulthood. In contrast, L1 and L2 were processed in the common frontal cortical areas for early bilinguals who

had learned an L2 at an early age. However, little or no difference was found in activation in the temporal-lobe language regions (i.e., Wernicke's area) for both late and early bilinguals. These results suggest that L1 and L2 are processed in different cortical areas depending on the age of acquisition of an additional language.

In summary, there are common language areas involved in the brain for reading Japanese, such as the left inferior frontal gyrus, left posterior temporal lobe, and left ventral premotor cortex. Research shows that different scripts recruit slightly different brain regions. Kanji are processed through the ventral route which is more related to lexico-semantic processing as well as the areas of bilateral frontal, parietal and occipito-temporal cortices which are related to visuospatial attention. In contrast, Kana reading requires the dorsal route which is more related to phonological recoding as well as the left inferior parietal lobule area. In general, reading Japanese seems to be less complex than reading Chinese characters, as reading Japanese Kanji does not activate the cortical areas in the right hemisphere, which activates for reading Chinese characters.

Table 9.1 compares the brain regions activated when reading across the three East-Asian scripts, along with the areas that are generally activated in reading. Note that the table is not based on an exhaustive review of brain-imaging studies, however, due to space constraints.

9.5 Toward the Script Relativity Hypothesis: Biological Unity, Scriptal Diversity, and Cognitive Diversity

Neuroimaging research has identified the visual word form area that is specialized for reading in the neuronal networks on the left fusiform gyrus in the left hemisphere. This common area engaged in reading across different scripts indicates a biological unity. However, differences in the localization of brain regions have also been found according to the script being read.

In short, reading is affected by spoken language, the writing system, and its orthographic characteristics. Neuroimaging studies reviewed so far point toward not only different circuits and networks specialized depending on the nature of the script being processed (i.e., alphabetic or nonalphabetic and logographic or phonographic), but also robust L1 effects on L2 processing. Depending on tasks, languages, and reader or learner characteristics, such as proficiency and the age of acquisition, neuroimaging results vary. Although the identification of precisely specialized regions activated in the brain is still an open question, converging evidence provides a largely consistent picture. Research collectively shows that brain specialization and networks are associated differently for alphabetic scripts and non-alphabetic scripts (Cao, 2018; Kim, Liu, & Cao; Perfetti et al., 2007). As Cao (2018) asserts, the brain networks and circuits involved in word reading are significantly different across languages. Cao (2018) further notes that the cross-language differences in brain activation get larger as language and reading skills improve, given that reduced neural specialization has been found in children with low reading

Table 9.1. Representative Brain Areas Associated with Each Script

Language	Script	Brain Area Involved When Reading	Study
Universal Reading		*visual word form area* in the left mid-fusiform gyrus	Bolger et al. (2005); Perfetti et al. (2007)
		the left hemisphere posterior region associated with both the ventral circuit and dorsal circuit	Pugh et al. (2000)
		the left hemisphere ventral occipito-temporal cortex	Dehaene (2009)
Chinese	Characters + Pinyin	the inferior frontal, middle, and inferior temporal gyri, the inferior and superior parietal lobules, and the extrastriate areas	Chen et al. (2002)
		bilateral occipital-temporal and middle frontal areas	Liu et al. (2007); Nelson et al. (2009)
	Characters	the left fusiform gyrus, the bilateral cuneus, the posterior middle temporal, the right inferior frontal gyrus, and the bilateral superior frontal gyrus	Chen, et al. (2002)
		the left ventral occipito-temporal cortex	Krafnick et al. (2016)
		the ventral pathway from the visual cortex to the left ventral occipito-temporal cortex	Xu et al. (2015)
	Pinyin	greater activation in the inferior parietal cortex bilaterally, the precuneus, and the anterior middle temporal gyrus	Chen et al. (2002)
Japanese	Kanji + Kana	visual occipito-temporal activation	Nakamura et al. (2005)
		the inferior frontal gyrus and posterior temporal lobe	
		the left inferior frontal gyrus, left posterior temporal lobe, and left ventral premotor cortex	Huang et al. (2012)
	Kanji	the lateral fusiform gyrus (BA 37)	Sakurai et al. (2000)
		slightly more mesial and right-predominant activation	Nakamura et al. (2005)
		the left inferior temporal region	Horie et al. (2012b)
		the ventral pathway, bilateral frontal, parietal and occipito-temporal cortices	Ino et al. (2009)
	Kana	the middle and inferior occipital gyri (BAs 18 and 19) and the deep perisylvian temporo-parietal area (BAs 40/22 and 22/21)	Sakurai et al. (2000) Horie et al. (2012b)
		greater occipital activation	Nakamura et al. (2005)
		the left inferior parietal lobules	Horie et al. (2012b)

(continued)

Table 9.1. (continued)

Language	Script	Brain Area Involved When Reading	Study
Korean	Hanja + Hangul	the occipito-temporal region	Yoon, Cho, Chung, & Park
	Hanja	the dorsal pathway	Kim, Kim, Kang et al.
		temporo-occipital region were more involved in reading Hanja than Hangul	Lee (2004)
		the left-lateralized middle frontal cortex	Yoon et al.
	Hangul	the ventral pathway	Kim, Kim, Kang, et al.
		the bilateral inferior parietal lobules were more active in reading Hangul than Hanja	Lee (2004)
		the bilateral fusiform gyrus, left middle frontal gyrus, left superior temporal gyrus, right mid-temporal gyrus, precentral gyrus, and insula	Yoon, Cho, Chung, & Park

proficiency. Although the brain's assimilation and accommodation are engaged in L2 processing, the degree of each mode involved in reading L2 seems to be variable according to the linguistic characteristics of L2. Evidence shows that late unbalanced bilinguals tend to use specialized brain networks established for L1 when processing L2, indicating L1 effects on L2 processing (Cao, 2018; Kim, Liu, & Cao). In contrast, early balanced bilinguals tend to show an overlap in brain activation in both L1 and L2. These findings suggest that the brain can accommodate the linguistic properties of an additional language by recruiting required brain regions as necessary. This is consistent with the *neuronal recycling hypothesis* posed by Dehaene (2009).

A series of studies show that native English speakers tend to accommodate the demand of L2 characteristics, while native Chinese speakers tend to assimilate L2 into L1 (Cao, 2018; Perfetti et al., 2007). Kim and Wang (2018) note that the difference between accommodation and assimilation in the brain network can be attributable to the linguistic distance between L1 and L2. Specifically, when the two orthographies of L1 and L2 are similar to each other, the brain is likely to assimilate L2 processing to the brain's acquired L1 mechanism. However, when the two orthographies are different from each other, the brain is likely to accommodate the linguistic demands of L2. Regardless of the mode of involvement (i.e., assimilation or modification), L2 lexical processing requires more cognitive and brain resources than L1 lexical processing (Ma, Ai, & Guo, 2018).

The different neural specialization and adaptation according to language input can be explained through the theory of the *universal language constraints* which implicates the universal reliance of reading upon spoken language to the extent that writing systems encode spoken language (Perfetti, 2003). This also extends to the *system accommodation hypothesis* which links the accommodation of the universal dependency to the intricacies of the writing system. Neuroimaging evidence

indicates that neural specialization occurs according to the linguistic features of a given language, as the brain adapts to the linguistic demands of an additional script to be read. Why would this different specialization occur according to the script being read? Since reading is a cognitive process, reading activities are orchestrated by our cognition, attention, and brain activity, and, in return, habitual reading influences what we pay attention to, how to process incoming information, and how to form new knowledge. At the center of this process is the script. This is a manifestation that the script in which we read can change our reading and further our thinking and cognition. Since different cultures have different scripts and different thought patterns, the fact that the script in which we read can change the way we think is closely related to *script relativity*. In fact, it would be difficult to explain the unique specializations in the brain regions found in Chinese, Japanese, and Korean without taking the lens of *script relativity*. Likewise, it would also be difficult to explain L1 scriptal influences on L2 script processing without looking through the prism of *script relativity*, given that L1 scriptal properties and skills constrain neuronal circuits and networks for processing L2.

It should be noted that *script relativity* is a new hypothesis. For this reason, we cannot readily find research in the extant literature that has *directly* tackled the matter of script relativity. All I can do at this point is to connect dots among the findings of previous studies from the angle of script influences on our thinking. However, an interpretation from the angle of script relativity has been missing in the existing literature that has specifically addressed L1 scriptal influences on L2 script processing. Script relativity is one explanation that can collectively construe the scriptal influences found in a multitude of studies of cross-scriptal transfer.

It has taken more than a half a century going through the ebb and the flow for linguistic relativity to gain a solid ground in recent decades with supporting evidence. There are still some scholars who are not in favor of linguistic relativity in the face of the vast amount of research that endorses the hypothesis. Considering the history of linguistic relativity, it may take a long time, if not as long as linguistic relativity's trajectory, to accept or dismiss script relativity. Despite the possible controversy, what is meaningful is that I am opening the door to a new debate of script relativity. With improved research methodology and statistical advances, it is possible to efficiently covary potential intervening or spurious variables to single out script influences on our cognition. As I indicated in Chapter 1, I intentionally leave out South-Asian alphasyllabaries and abjads of Arabic and Hebrew from this book because the contrast between English and the three East-Asian scripts serves its purpose well and because I personally do not know those scripts. Well-designed research by scientists who are well versed in those alphasyllabaries of South Asia and abjads of Arabic and Hebrew scripts to test script relativity is expected to be carried out in reading science in the very near future.

With the unprecedented use of digital text in the current digital era, the influence of scripts can take a different mode than traditional reading. In consideration of the recent vicissitudes, Part III covers the impact of online reading and the future directions of script relativity.

Part III
The Digital Era and Reading

Part III shifts to the impact of digital reading on our cognition in response to the current trend of digital text use. Since digitally-mediated text uses more images than traditional text, the different processing of images and texts is first reviewed to hint at implications for *script relativity*. Next, the discussion centers on the impact of digital reading on our cognition. Finally, discussed is how the gap between the bipolar contrast of reading between European alphabets and Chinese characters gradually diminishes and, in turn, how the gap between the East and the West is continuously getting narrower, resulting largely from the increasing co-use of text and image and the growing use of bi-scripts or multi-scripts in many cultures. Due to the gradually closing the gap, testing script relativity will become more challenging than before. To make matters better, however, it is possible that we become more similarly-thinking global citizens rather than increasing divergence in the world.

Chapter 10
The New Trend: The Word Plus the Image

"Needing to have reality confirmed and experience enhanced by photographs is an aesthetic consumerism to which everyone is now addicted. Industrial societies turn their citizens into image-junkies; it is the most irresistible form of mental pollution."

- Susan Sontag, On Photography (1977)

"Imagery is not past but present. It rests with what we call our mental processes to place these images in a temporal order"

- George Herbert Mead (1863–1931)

"Long before there was Hammurabi's stela or the Rosetta stone, there were the images of Lascaux and Altamira. In the beginning was the image."

- Leonard Shlain (1998, p. 432)

"… written words and images are entirely different 'creatures.' Each calls forth a complementary but opposing perceptual strategy."

- Leonard Shlain (1998, p. 4)

Abstract This chapter discusses the new trend of co-use of words and images in digitally-mediated text as well as its impact on our cognition. The function of the left and right hemispheres of the brain is first reviewed. Next, how images are processed, compared to words, is reviewed. Reading words recruits different neural networks than those of "reading" images. Literacy acquisition changes neuronal pathways in the brain, as evidenced by the research findings of pre-literate and literate subjects. Based on the suggestive evidence, script relativity is revisited and highlighted. Research evidence from the comparison of image processing and word processing as well as the comparison of how literate and illiterate subjects process objects and faces indirectly support *script relativity*.

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Keywords words · images · right brain · left brain · processing differences · script relativity

As shown in one of the epigraphs above, images were around long before text emerged (Shlain, 1998). Moreover, we currently live in a world where we are inundated with visual images, along with texts, in every sector of our lives. Images express our surface and inner thoughts as the physical manifestations of streams of consciousness and unconsciousness. With stimuli so abundantly available around us, we seek the most efficient way of acquiring and learning new information. Within the visual modality, images and texts are the most dominant means of information transmission. Although we have achieved the automaticity of reading from years of literacy experience, it takes longer for us to read a text than to perceive an image. We co-use images and words in written communication more than ever before through the use of various forms of emoticons and emoji. Images extend texts. Images are more appealing than texts. Images add features that texts cannot provide, such as color, shade, shape, hue gradation, and orientation.

Text on screen and digitally mediated texts, such as interactive text or hypertext that has hyperlinks to other texts readers can immediately access, are likely to have more images than traditional text, as the digital text tends to imbed image-based visual aids and advertisements. In this context, this chapter briefly compares the image to the text as well as contrasts the functions of the right and left hemispheres of the brain, and then reviews how images are processed compared to texts. Finally discussed are the implications of image and text processing for *script relativity*.

10.1 Images: How They Are Different from Words

Is there a truth to the old saying "A picture is worth a thousand words"? If so, what exactly is the distinction between the image and the text? At least four differences between images and words can be found at the surface level. First, images and pictures convey meaning by simulating the appearance of the world, as images are a display of the mental reproduction of the physical world. In contrast, written words convey meaning by using arbitrary symbols (though Chinese characters are much less arbitrary). Second, images are concrete mainly because they approximate reality, while written words are abstract especially in the alphabet because an alphabet, in general, consists of fewer than thirty graphs that do not represent the images, but represent the sounds of a spoken language. Third, images are perceived in a holistic and simultaneous manner (Shlain, 1998; Smith, 1988), while words are decoded in a one-at-a-time fashion as the eye moves linearly, particularly in Western alphabetic orthographies. Logan (2004) claims that the alphabet is processed in a linear, sequential, and abstract manner. This is consistent with one of models of reading that explains orthographic processing in visual word recognition. The SERIOL

model of letter-position encoding posits that letters within the word fire sequentially upon reading (Whitney, 2001).

Nature provides raw materials. The brain performs the inner workings to comprehend the raw materials that Nature provides. In order to perceive the world through images, the brain relies on the processes of wholeness, simultaneity, and synthesis. The brain perceives the whole by integrating all parts holistically into a gestalt entirety (Shlain, 1998). Last, explicit training on how to "read" images is unnecessary. As we are endowed with the ability to process images, we make direct and automatic connections between images and reality. In contrast, reading needs to be explicitly taught. Automaticity is never gained without years of continuous reading.

Irrespective of the possibility that photographs can be used in other ways than *aesthetic consumerism*, as one of the epigraphs indicates, beautifully-shot photographs and well-drawn or well-painted images not only evoke strong emotional or intellectual responses instantaneously in the viewer's mind, but also help engage and educate the viewer. They also add depth and context to the description of objects and scenes. Hence, images indirectly contribute to the storytelling process, and their impact is vast.

Reading words requires a different process than that of images. Words in alphabetic writing systems are composed of multiple graphs arranged in a linear sequence as in Roman alphabets or in a block as in Korean Hangul. The eye scans a series of graphs to ferret out meaning. An analysis of letter chunks (i.e., words) instantaneously occurs based on graphotactic rules that dictate the plausible combinations and collocational occurrences of graphs within the word because meaning is anchored to the plausible sequence of graphs within the word. To extract the meaning of a word, the brain relies on the sequential, analytic, and abstract processes to discern the orthographic and phonological components of the word.

10.2 Right Brain versus Left Brain

All vertebrates have bi-lobed brains with mirror-image hemispheres which perform the same type of task in the two hemispheres (Shlain, 1998). However, the bi-lobed human brains function differently with different strengths for each hemisphere. Ornstein (1997) asserts that the left hemisphere perceives the world in a bottom-up process, while the right hemisphere assesses the world in a top-down manner. The corpus callosum connects and integrates the two cortical hemispheres as the bridge of neuronal fibers. Shlain (1998) asserts that, in utero, the right hemisphere of the brain first develops before the left hemisphere starts its way of maturation. The right hemisphere is more sensitive to biological needs and integrates feelings, recognizes images, and appreciates music. It synthesizes multiple converging determinants to help the mind to process the sense organ's input all at once. It is the right brain that can listen to the sounds of a seventy-piece orchestra holistically and appreciate the harmony (Shlain, 1998). It is also the right brain that can perceive objects concretely. It processes nonverbal information to the extent that a facial expression can

be "read" without any attempt to translate it into words. The right brain is also attuned with the animal modes of communication. It generates sensational feelings, including love, humor, or aesthetic appreciation, which are distant from logic and rules of conventional reasoning. As they do not progress in a linear fashion, feelings are experienced in an all-at-once gestalt manner or in a flash like lightning (Shlain, 1998). In short, the right brain cognizes images by simultaneously integrating the componential parts in the visual field, gauging dimensions and distances, and synchronizing seemingly unrelated elements instantly (Brincat & Connor, 2006; Dehaene, 2009; Shlain, 1998). The right brain is good at perceiving space and making aesthetic distinctions in terms of balance, harmony, and the composition of the object in a swift and instantaneous manner. The right brain is associated with "*being, images, holism,* and *music*" (Shlain, 1998, p. 21; emphasis in original).

The left hemisphere functions differently from the right counterpart and harmonizes with the right lobe. The left lobe is largely associated with speech and action. Since words are tools for the abstraction, discrimination, and analysis of objects and categories as well as the implements of thought, the left brain tend to engage linear progression or processing. Unlike the right brain, the left brain relies on the duality between *me-in-here* and *the world-out-there* (Shlain, 1998). This dualism promotes objective thinking and enhances reasoning skills, which eventually leads to logic. Logic takes linear progression instead of a holistic gestalt processing. In essence, the left brain involves *doing*, *speech*, *abstraction*, and *numeracy*, which all take linear progression, unlike the right brain's primary association with *being*, *images*, *holism*, and *music* (Shlain, 1998). Shlain (1998) further notes "the left hemisphere is actually a new sense organ designed by evolution to perceive time" (p. 23). If this remark can be extended to reading that primarily takes place in the left hemisphere, it would be reasonable to connect it to Dehaene's (2009) *neuronal recycling hypothesis*. This hypothesis postulates that reading is a cultural invention to the extent in which the brain utilizes and recycles existing brain networks and circuits in order to be able to read because the neural pathways are not prewired or programmed to reading (Dehaene, 2009; Szwed, Cohen, Qiao, & Dehaene, 2009). Due to neuroplasticity which allows for the brain's cortical architecture to reorganize and reconfigure for reading, the neurons and the cortex can adapt to the novel function of reading through accommodation (Perfetti & Liu, 2005).

Although the two hemispheres work in tandem with each other, each hemisphere of the brain controls the muscles in the opposite side of the body. The hemispheric specialization or lateralization is asymmetrical. Although the brain lateralization varies across individuals, the general symptoms of the brain dysfunction manifest the stark difference in the functions of the two hemispheres. Shlain (1998) summarizes the difference, based on his own medical practice, as follows: "If a right-handed person has a major stroke in the controlling left hemisphere, with few exceptions, a catastrophic *deficit of speech, right-sided muscle paralysis and/or dysfunction in abstract thinking* will occur. Conversely, damage to the right brain will impair the afflicted person's ability to *solve spatial problems, recognize faces, appreciate music,* besides *paralyzing the left side of the body*" (Shlain, 1998, p. 18; emphasis in original). This description is consistent with the findings of patients

with impaired facial and word recognition (Behrmann & Plaut, 2014). Data from patients and individuals with particular deficits provide valuable information regarding the optimal function of the given hemisphere of the brain because the data allow for comparisons between those with and without particular skills. These data attest to the different roles of each lobe of the brain.

10.3 How Images Are Processed Compared to Words

Seeing is automatic. According to gestalt psychology, objects and scenes are observed as a whole, which is the simplest form of perception (Smith, 1988). The whole of an object or scene is more important than the sum of its individual parts because observing the whole helps us find the order and unity among seemingly unrelated parts and pieces of information. For example, perceiving multiple flashing lights as a moving image is a result of the brain's holistic information processing through filling in missing pieces for a whole configuration. Gestalt psychologists postulated that visual information is processed automatically, and that the automatic visual perception organizes the whole scene or the whole object (Smith, 1988). The automatic processing of images is a sophisticated system that not only selects and processes relevant information at a given moment, but also allows the attention mechanism to work efficiently. The ability to discriminate or identify a specific object, image, or word is dependent on individual differences. Images promote our aesthetic appreciation beyond what text can provide.

How the brain sees, perceives, and recognizes objects is one of the most intriguing topics in neuroscience. When we look at numbers, letters, or other shapes, neurons in the brain's visual center instantly respond to the different characteristics and components of the shape of the stimuli to create an image that we see and understand (Brincat & Connor, 2006). The brain perceives an object in its entirety. This process is complex but swift. Unlike reading, people from different cultures process images in the same way because not only are our brains biologically hard-wired in the same way (with regard to image processing), but also the brain architecture is similar among all human beings to such a degree in which images are automatically processed in the right hemisphere without specific training (Dehaene, 2009; Shlain, 1998). The brain region V1, which is the brain's earliest visual processing center located at the central posterior of our brains, identifies the simplest forms of images, such as lines and edges of contrasting intensities (Brincat & Connor, 2006). The downstream visual areas (i.e., V2, V3, and V4) work together to process basic visual forms in a goal-directed way or a stimulus-driven way, depending on the viewer's intention and the task at hand.

Special neuronal pathways in the brain's visual area integrate an object's parts into a whole in a fraction of a second upon seeing one part of an object. According to Brincat and Connor (2006), visual processing does not happen in the eye, but happens at multiple stages in the brain, which engages at higher-level stages throughout object-image processing. Once a visual stimulus is presented, neurons in

the higher-level visual cortex respond indiscriminately at first, signaling all the individual features within the object. Within milliseconds, the brain begins a rough categorization by putting the slices of information together to construct a whole picture and by exclusively responding to *combinations* of object-image fragments, rather than individual fragments. Brincat and Connor (2006) have not found a conflict between component perception and pattern perception, suggesting that persistent component regulation occurs in the posterior infero-temporal cortex cells. Responses to shape patterns seem to support the global perceptions of components. However, persistent responses to parts or simpler components could serve to make local structural information available throughout the pertinent process.

The cortex and subcortex in the brain consist of many different structures that deal with complex cognitive demands, such as memory, language, and spatial awareness. Since the brain makes sense of images rapidly, the visual system delicately functions to extract conceptual information from visual input in a fraction of a second. It seems that less than 20 milliseconds are enough to identify and discriminate complex visual input. Potter, Wyble, Hagmann, and McCourt (2014) measured the minimum viewing time required for visual comprehension using rapid serial visual presentation. They presented a set of six or 12 pictures for 80, 53, 40, 27, and 13 milliseconds per picture without an inter-stimulus interval. Results showed that the detection of pictures (e.g., smiling couple, picnic) improved as the exposure duration increased, but participants could accurately detect the stimulus beyond the chance level even at 13 milliseconds. These results suggest that the conscious detection of rapidly presented complex images occurs very quickly and is faster than word recognition. This also suggests that reading a word requires a different process from "reading" an image and that there are more steps involved in reading text.

Multiple strategies seem to be involved in object processing. Qiu and von der Heydt (2005) have examined figure and ground processing to find that figure-ground organization, which refers to a process by which the visual system distinguishes the foreground from background of the image, is encoded using two strategies of computation. One strategy exploits local information, while the other uses the global configuration of contours. Brain region V2 seems to combine microscopic cues for local information with gestalt factors for the global configuration of contours, which influences the response. These two encoding strategies are combined into a single neuron so that brain area V2 processes two dimensional figures as if the objects were presented in a three dimensional context.

Object recognition relies on visual features such as the juncture of two lines meeting at vertices (e.g. T, L). Since written language is a relatively recent invention, compared to spoken language, to the extent that it has not been around long enough to exert evolutionary pressure on our brains, according to Dehaene (2009), visual word recognition makes use of pre-existing mechanisms that have been commonly used for the visual recognition of objects and scenes. Szwed, Cohen, Qiao, and Dehaene (2009) examined the visual recognition of objects and words using invariant visual features to identify whether or not the visual characteristics of letters contribute to the reader's or viewer's swift recognition. Szwed et al. (2009)

employed a naming task to present the partial pictures of objects and printed words in which either the vertices or the mid-segment line were retained while the other parts were missing. There was no significant difference in the pattern of recognition between objects and words. However, participants were more efficient when vertices were preserved, making fewer errors and responding faster than when the other part of the stimulus was preserved. Overall, the results suggest that vertex invariants are more important for object recognition and that the evolutionarily ancient mechanism that is hard-wired to process objects is being recycled for reading.

Inquiries into the whole versus its parts have been addressed by comparing the visual recognition of faces and words. Martelli, Majaj, and Pelli (2005) have examined whether objects are identified as a whole or by its parts and further whether faces are processed like words, given that words are different from faces qualitatively and that faces are different from words parametrically. As opposed to previous research suggesting that faces are processed as a whole, while words are recognized by parts sequentially, Mertelli et al.'s (2005) findings show that both words and faces tend to be recognized by parts. It seems that faces are recognized differently from objects due to the delicacy of individual facial features. One way to disentangle the intricacy of visual recognition would be to employ visual noise or visual alteration in stimuli. Albonico, Furubacke, Barton, and Oruc (2018) have examined perceptual efficiency and the inversion effect (i.e., difference in the recognition of stimuli between upright and inverted orientations) for faces, words, and houses, given that an inversion effect has been considered to be an index or marker of expert processing. The orientation manipulation yields different effects across faces and words. Results show that the recognition of inverted faces is significantly disrupted and that the recognition of inverted words and houses is minimally affected. Recognizing individual faces seems to take longer than objects because the brain needs to construct an internal representation of a face based on emerging signals for the combinations of face fragments.

Although the brain is built upon the genetic blueprint, the impact of literacy on facial recognition is also noted. Ventura (2014) argues based on a plethora of previous studies that different neuronal specificities for words and faces are involved and that reading acquisition changes face processing because reading competes with the cortical representation and the neuronal coding of faces. Similarly, Dehaene et al. (2010) show that, as literacy skills increase, cortical responses to faces decrease slightly in the left fusiform area, but increase significantly in the right fusiform area. The literate's and illiterate's brains seem to be different given the increased lateralization for faces in the right hemisphere among literate individuals. A greater left lateralization for reading and a stronger right lateralization for faces are also found in 9-year-old typical readers and dyslexic children (see Ventura, 2014, for review). Ventura et al. (2013) examine the relationship between literacy acquisition and the processing of faces and houses to explain the brain reorganization pattern. They found by using a face composite task that literate individuals are less holistic than illiterate counterparts in processing faces and houses. They indicate that, due to the brain reorganization resulting from literacy, literates tend to use analytic visual strategies in face processing in a task that requires selective attention to the parts of

an object, while illiterates are consistently more holistic in processing faces and houses.

Li and colleagues (2013) have also examined, using an ERP, the effect of literacy on early neural development for word processing and its collateral effects on the neural development in face processing among preschool children. Their findings point toward a significant role of reading experience in the neural specialization for the processing of words and faces beyond the effect of children's typical maturation. The neural development of visual word processing competes with that of face processing to the extent that the neural specialization for word processing delays the neural development of face processing before the neuronal circuitry is specialized (Li et al., 2013; Shlain, 1998).

More research has also been conducted in this line. Behrmann and Plaut (2014) investigated the hemispheric processing of words and faces in prosopagnosia (impaired face recognition resulted from right hemisphere ventral lesions) and face impairments in pure alexia (impaired word recognition resulted from left hemisphere ventral lesions). Prosopagnosic patients show mild but reliable word recognition deficits, while alexic patients reveal mild but reliable face recognition deficits. The mechanisms of face and word processing seem to be a consequence of interactive learning, which is the result of optimizing a procedure for specific computational principles and constraints upon the processing of faces or words.

Dehaene et al. (2010) monitored brain responses to spoken language, words or sentences, visual faces, houses, tools, and checkerboards in illiterate individuals, adults who became literate in adulthood, and adults who became literate in childhood. Regardless of when literacy was acquired (childhood or adulthood), similar brain organization was found among literate adult participants. As literacy skills advances, the left fusiform is engaged in reading. The left fusiform evoked a small competition with faces, and extended to the occipital cortex and area V1. Interestingly, a significantly reduced activation was observed for checkerboards and faces in the visual word form area. This suggests that words and images are processed in different regions in the brain.

In adults' brains, faces and words elicit divergent activation in the ventral temporal cortex with faces being selectively activated in the mid-fusiform gyrus and words being activated in the lateral mid-fusiform/inferior temporal gyrus (Cantlon, Pinel, Dehaene, & Pelphrey, 2011). Based on adults' category-based specializations manifested in the visual regions of the brain (e.g., fusiform gyrus), Cantlon et al. (2011) have investigated cortical representations in children to identify whether these specializations in the brain are driven by "building up or pruning back representations" (p. 191). Four-year-old children were tested on the four categories of faces, letters, numbers, and shoes, using fMRI. The researchers found that the specialization of visual categories in the brain varies depending on the characteristics of the stimulus. Specifically, faces and symbols are doubly dissociated in the fusiform gyrus before children learn to read. In addition, young children's category-specific visual specialization is sensitive to the degree to which the knowledge of preferred categories increases, while the knowledge of non-preferred categories decreases. This study also indicates that the specializations of different categories, such as faces and

symbols, take shape at the age of four when children typically begin to learn to read. Dehaene (2009) summarizes imaging studies that high-amplitude waveforms appear in the left hemisphere for word processing and in the right hemisphere for face processing. He continues to note that "[w]hen the data from multiple [epileptic] patients are placed in a standard anatomical space, faces appear to preferentially engage the right hemisphere, while word responses predominate in the left" (p. 81).

10.4 (Indirect) Support for Script Relativity

Technical advances in neuroscience over the last two decades have allowed us to unravel the brain's networks and circuits. Both right and left hemispheres of the brain regulate our perception and understanding through complementary cooperation with each other (Shlain, 1998). When we see an object or scene, both hemispheres engage but the right hemisphere is largely active to process the image of an object or a scene. People with different cultural backgrounds process images largely in the same way, because our brains are hard-wired to process images automatically without any particular training (Dehaene, 2009; Shlain, 1998; Wolf, 2007). The unity of image processing in the right hemisphere across individuals with different cultural backgrounds indicates that all human beings have commonalities in perceiving objects and scenes. This may have to do with the notions that the right hemisphere develops before the left lobe starts to develop in utero, that image processing is an innate competence, and that images are processed in a top-down manner bypassing delicate bottom-up analysis (Shlain, 1998).

In contrast, when we read, the left hemisphere is primarily responsible for the recognition of words. The relative level of involvement depends on the importance and relevance of the stimulus to the viewer or the reader. These processes are a part of universality across both individuals and cultures. Research shows that spoken language and reading are predominantly processed in the province of the left hemisphere (Dehaene, 2009; Ventura, 2014; Wolf, 2007), as reviewed in Chapter 9. Interestingly, the subtleties of language that make it rich are "painted" by the right hemisphere through metaphors. According to Shlain (1998), metaphors are "the right brain's unique contribution to the left brain's language capability" and "the synergy between the right brain's concrete images and the left brain's abstract words" (p. 20).

Dehaene et al. (2010) also claim that words and images are processed in different areas of the brain with the left hemisphere involved in word recognition and the right associated with image perception. Dehaene (2009) asserts "[o]n the cortical surface, places and faces occupy extended and well-separated areas, but both are very far from the letterbox area in the left hemisphere. The place area, present in both hemispheres, lies close to the brain's midline, while the face area is principally found in the right hemisphere" (p. 184). Importantly, Dehaene et al. (2010) also note that literacy acquisition changes the neuronal pathways or circuits of processing images. As a consequence of brain reorganization due to literacy, literate individuals

use analytic visual strategies for face recognition because it requires selective attention to the parts of a face, whereas illiterates are likely to use holistic processing for both faces and other objects. It appears that faces are processed more like words than images (Martelli, Majaj, & Pelli, 2005). In fact, human faces are the most compound image with the infinite variety of faces and flexible facial expressions.

In particular, the results of literate and illiterate brain functions as well as brain liability collectively offer credence to *script relativity*. According to Dehaene (2009), due to the genetically constrained circuits of the brain, our learning is intensely constrained by the brain networks and the mechanism is strictly specified by our genes. Dehaene's (2009) *neuronal recycling hypothesis* can explain the parameter of the brain's constraints and its reconfiguration. It postulates that the brain is organized by neural maps that are biologically hard-wired to respond to the outer world and that the brain circuits for cultural tools, such as reading and writing, are not present at birth; as a result, neuronal circuits reorient themselves to accommodate the demands of the evolved cultural activities of reading and writing. Furthermore, the original organization of the brain constrains what can be learned to such a degree that cultural variabilities are limited due to neural constraints. This is consistent with Perfetti's (2003) *universal grammar of reading* that explains universality as well as script specificity. This is also related to the *system accommodation hypothesis* (Perfetti & Liu, 2005). We are able to decode words, regardless of their size, shape, or case (i.e., uppercase or lowercase), as a result of rewiring (i.e., recycling) of the cortical architecture whose original functions have been strengthened for object recognition.

The aforementioned studies have not been carried out to directly test script relativity in comparison to object processing, because script relativity is a new hypothesis that I propose in this book. Experimental research along the lines of the comparisons of image processing and word processing as well as literate and illiterate people will shed light on script relativity. One potential challenge for testing this hypothesis comes with the current trend of digital text that is coalesced with images, especially with social media that are filled with emoticons or emoji. This trend adds huddles for teasing apart true text effects from intertwining effects with images. With this in mind, the next chapter reviews how digital texts are read and processed.

Chapter 11
The Impact of Digital Text

"Our writing equipment takes part in the forming of our thoughts."

- Friedrich Nietzsche (1844–1900)

Abstract This chapter discusses reading on screen and in print, as the emergence of digital age has transformed our reading and attention. Digital reading reshapes the concept of reading with the use of various forms of social media that are full of acronyms and emoticons or emoji. Advantages and disadvantages of reading on screen and in print are reviewed. The effects of digitally-mediated text on information processing and reading comprehension are also discussed. Although reading online has merits, such as convenience, low cost, and easy accessibility, readers are likely to scan through an F-shaped gaze pattern. The use of digital media may have a significant influence on brain networks due to the brain's adaptability and accommodating abilities. Digital text that includes more images and visual aids than hard-copy text may lead to more balanced brain functions. This may have implications for reduced script relativity in the future.

Keywords reading on screen · reading in print · emoji · information processing · (reduced) script relativity

Never fully recovered from eye injuries gotten from serving in an artillery unit in the Prussian army, Nietzsche's vision hindered his writing. As a remedy, he ordered a typewriter in 1882. The writing equipment allowed Nietzsche to resume his writing because he could write with his eyes closed once he was accustomed to it. This had an impact on his prose. His writing had become tighter, more telegraphic, and more

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powerful than writing on paper (Carr, 2010). As the epigraph shows, Nietzsche had a keen observation on the impact of the writing tool on thought. If he was right about the function of writing tools, the medium through which we read may also have an impact on our thoughts.

Given that digital text and technology-mediated text have become more prevalent than ever before, how reading on screen differentiates from traditional reading on paper and how the brain responds to on-screen text are crucial questions to ask these days. As a consequence of habitual use, the digital revolution reshapes the way we read, write, and process new information. Wolf (2018) asserts "[w] hat we read, how we read, and why we read change how we think" (p. 2) and that "[i] n our almost complete transition to a digital culture [the fact that] we are changing in ways we never realized would be the unintended collateral consequences of the greatest explosion of creativity, invention, and discovery in our history" (p. 3). This kind of change will be intensified with a constant engagement in digital text. According to a Pew Research Center survey conducted in 2018, about 26% of American adults go online 'almost constantly,' and the percentage increases to 39% of those aged 18–29. Those who are connected daily to the Internet account for 77% of the American public (Pew Research Center, 2019). It also shows that nearly all (98%) of children below eight years of age in the U.S. have access to mobile devices. It is expected that not only will these numbers continuously increase for younger children, but this trend is also consistent globally. In these contexts, this chapter discusses the impact of digital text on our information processing and literacy behavior. It first surveys the phenomenon of the digital age, and compares reading on digital screens to reading in hard copy. It next discusses the possible effect of digitally-mediated text on our cognition in light of *script relativity*.

11.1 Reading and Writing in the Digital Age

The emergence of digital platforms has transformed the traditional function of the media. The phone is no longer a means of oral communication only, but it has morphed into an omnibus device for a semi-computer and camera with multiple functions. The digital world has also transformed the mode of reading and writing. Social media platforms, such as Twitter, Instagram, Facebook, and more, have emerged into the forefront of the digital world, which has become the new environment for reading and writing. With the demand of immediacy and instantaneity in this digital age, we tend to compose short to-the-point messages, often with the use of emoji or emoticons and acronyms (e.g., YW for *you are welcome*, DK for *don't know*, TL for *too long*, etc.). Various resources, such as websites, blogs, forums, chat rooms, and other social platforms, are available literally at the fingertips. The zenith of social media is that, when a short-form verbal phrase transcribed in the social media text goes viral, it shapes language. Social media have even become an intermediary hybrid between spoken and written languages. Twitter is where people who rarely read can argue in a vernacular form of language with people who write

books, which means that the boundary between specialists and lean subscribers of written language gets blurry.

In the face of this change in the digital world, Baron (2015) claims that digital reading reshapes the realm of reading and that there is a division between digital reading and traditional reading. According to her, digital reading works for short pieces and light content that do not require a focused analysis or rereading. E-reading is less well suited for long essays that require serious thought or deep reflections because the interactive features of the digital text tend to distract readers from the content.

When the reader's reading habit changes, the author's writing style changes accordingly. Since on-screen readers are more likely to skim rather than read in depth, writers of e-essays place to-the-point statements upfront and/or use bullet points instead of running texts of full sentences.

11.2 Ink versus Pixels: Reading on the Two Media

Reading is a multi-sensory cognitive activity. In a traditional sense, reading involves optical gaze and the tactile act of holding a physical book or pages beyond the invisible brain activity. Baron (2015) summarizes the advantages of print over digital text. Print "enables us to stumble upon works, reminding us of things we've read before or have meant to read; gives us a tangible sense of ownership (of both the physical book and its contents); offers a sensory experience—of smell, of sight, of touch; is conducive to generating emotional engagement; affords us personal space for recording responses to what we read (though, granted, mobile reading affords a different sort of privacy, as for erotica); and encourages us to slow down when we are reading, clearing time for understanding or reflection" (p. 153). With the digital text, we have a similar sensory involvement to some extent. However, the degree of attention, the depth of engagement, and comprehension are variable. The advantages of on-screen materials include convenience, cost efficiency, environmental benefit (although this can be debatable), and accessibility through open education and open access (Baron, 2015).

Although they are more convenient and easier to carry than heavy books, most digital texts on screens, tablets, and smartphones are less likely to provide the reader with the intuitive mapping and navigation of texts than printed books. The impact of technological interfaces on reading comprehension has been investigated, as educational reading materials are increasingly digitized. Mengen, Walgermo, and Brønnick (2013) examined the effect of reading texts in print versus on screen on reading comprehension among Norwegian tenth grade students. Seventy-two students were randomly assigned into two groups, in which the first group read two texts (1400–2000 words in each text) in print, and the other group read the same texts as PDF on a computer screen. Their baseline data were collected on word reading, vocabulary, and reading comprehension to examine the extent to which the two reading media (i.e., print or screen) influenced students' reading comprehension.

Results showed that students who read texts in print scored significantly higher on reading comprehension than those who read the texts on computer screens.

Mayes, Sims, and Koonce (2001) examined differences in reading speed, comprehension, and mental workload on computer screens and printed books. Results showed that those who read from computer screens were significantly slower than the counterpart who read in print. Results also showed that comprehension scores were lower for those reading from computer screens than those who read from printed copies. Participants might have comprehended less when they read on a screen because screen-based reading was more physically and mentally demanding (due partly to the eye strain coming from the light that computer screens, smartphones, and tablets emit directly on the reader's eyes) than reading in print.

Noves and Garland (2003) replicated Mayes et al.'s study (2001) and found slightly different results while examining reading speed, the number of correct answers, and memory retrieval. They asked British university students to read study materials for an introductory economics course on a computer screen or printed booklet for 20 minutes. The participants were tested on multiple-choice questions. They found no difference in reading time and comprehension of reading on computer screens and in traditional paper-based materials. Although the participants' scores were not different between the two presentation media, a difference was found in how they *recalled* the information they read. Based on the significant difference in cognitive processing associated with memory in the use of the two media, Noves and Garland (2003) suggest that other variables that go beyond the traditional performance outcomes (e.g., reading speed and reading comprehension) need to be used in research in order to accurately assess the magnitude of the difference in reading performance between the two media.

Some of these variables involved in-print and on-screen reading seem to be *interactive* variables. Porion et al. (2016) examined the effect of computerized versus paper-based texts on reading comprehension and memorization using a one-page text with hierarchical structures among secondary school students. Three types of questions were used to measure reading comprehension skills: surface comprehension, semantic comprehension, and inference. The results showed no difference in comprehension and memory between the two types of presentations. For both comprehension and memory, regardless of the text media, surface comprehension scores were higher than those of semantic comprehension and inference. The authors concluded that, when certain variables, such as text structure, single page presentation, screen size, and types of questions measuring reading comprehension and memory, were controlled, reading performance was not significantly affected.

The effects of reading media and contexts have also been examined. Daniel and Woody (2012) investigated the cost of digital reading by comparing performance on reading electronic and print texts at home and in a laboratory. College students' comprehension was similar across both media (i.e., electronic or print texts) and contexts (i.e., home or lab). However, reading speed was significantly slower in reading on screen than in print and at home than in the laboratory. Students also reported that they tended to be involved in multi-tasking at home, which might have been the cause of slower reading at home. Baron (2017) also reports that students

tend to multi-task more when reading digitally than in print and that about 85% of users in the U.S. are multi-tasking when reading on screen, compared to 26% in print.

Ho, Rashid, and Lee (2017) also examined print and screen reading to identify whether a cognitive map or *medium materiality* was involved in the modality of reading among three groups that used paper books, digitally equivalent texts, and digitally disrupted texts. Results showed that the reading outcomes of reading paper materials were similar to those of digitally equivalent texts and that reading scores obtained from paper and digital texts were better than those from digitally disrupted texts with respect to comprehension, the level of fatigue, and psychological engagement. Ho et al. (2017) concluded that readers' abilities to construct a cognitive map of the entire passage, which was easier for students to create in print than on screen, were the main source that affected reading outcomes, supporting the cognitive map mechanism but not the medium-dependent mechanism (i.e., *medium materiality* in their terms).

Research compilation would provide collective information. Recently, Delgado, Vargas, Ackerman, and Salmerón (2018) carried out a meta-analysis on the effects of paper-based and digital-based reading on comprehension based on studies published during the span between 2000 and 2007. Studies that used between-subjects and within-subjects designs showed the general advantage of paper-based reading over digital-based reading. Three significant moderators were found, including time limit specified for reading tasks, text genre, and publication year. Specifically, reading on paper showed more advantages over digital reading when time constraints were placed in reading; the advantage of reading in print was consistently found across studies that used informational texts or a mixture of informational and narrative texts, compared to narrative texts only; and the advantage of reading in print over reading digitally has increased over the passing years. Kong, Seo, and Zai (2018) also conducted a meta-analysis to compare the effect of print and screen reading on reading performance. They found that, although reading speed was not different in reading in print and on screen, comprehension was better in paper-based reading than digital reading. Another meta-analysis showed that reading medium (on paper or on screen) plays a significant role in comprehension according to text or task conditions and readers (Singer & Alexander, 2017).

Baron, Calixte, and Havewala (2017) conducted a multi-nation survey, including the U.S., Japan, Germany, Slovakia, and India, to examine the use of digital technologies among more than 400 university students. A series of questions were asked as follows: How much time they spent reading in print versus on screen; whether cost was a factor in their choice of reading platform; in which medium they were most likely to reread; whether text length influenced their platform choice; how likely they were to multitask when reading in each medium; in which medium they felt that they concentrated best; and what they liked most and least about reading in each medium. Baron et al. (2017) note that the demand of quick action in the digital era goes hand in hand with a notion that writing is for a here-and-now mentality, which is different from the function of traditional written language as a durable form of communication. This change makes writing more ephemeral than writing in

Table 11.1. A Summary of the Findings of Baron, Calixte, and Havewala (2017)

Dimension	Findings
Time Reading in Print vs. Onscreen	The entire group of participants spent about two-thirds of their reading time in print. Among students in the U.S., Japan, Germany, Slovakia, and India, Japanese students read on screen the most for both schoolwork and pleasure (with variation).
Cost	If costs were the same, most participants (more than 4/5) would choose to read in print rather than on screen, especially for academic reading. Students in Germany preferred print the most (94%).
Rereading	Not everyone in the study reread for either schoolwork or pleasure. Among those who did, six out of ten indicated that they were more likely to reread print.
Text Length	For short texts, participants expressed mixed preferences for both academic work and pleasure. For longer texts, more than 86% preferred print for schoolwork and 78% for pleasure.
Multi-tasking	As for the tendency to multitask when reading on screen, 85% of U.S. participants multitasked when reading digitally, compared to 26% in print.
Concentration	Among platforms (i.e., print, computer, tablet, e-reader, or mobile phone) on which they concentrated best, 92% said that it was better to concentrate when reading in print than on screen.

the analog era. Table 11.1 summarizes the dimensions used in Baron et al.'s study (2017) and their findings, which can serve as a synopsis of the profile of digital reading.

Although reading online has virtues, such as convenience, cost savings, and easy accessibility, readers tend to scan and rarely read word by word. According to a Nielsen report of the average U.S. Internet usage, the duration of a webpage viewed in January 2013 was, on average, 1 minute 12 seconds (Baron, 2015; Neilsen, 2013). Eye-movement research shows among 300 people aged 18 to 64 years that readers on screen scan webpages and phone screens in various patterns and that the dominant gaze pattern is in the shape of the capital letter "F." Readers on screen tend to scan the upper part of text in a horizontal movement and then move down several lines and read across in a second horizontal movement, and finally read the first few words in a vertical way, which makes ultimately an F-shaped gaze pattern (Pernice, 2017). On-screen readers tend to scan in this F-shaped manner when trying to read most efficiently on a page that has little or no formatting (i.e., no bold fonts, bullets, or subheadings).

11.3 The Effects of Digitally-Mediated Text on Information Processing

Genetic blueprints between the human genome and the chimpanzee genome show that both species share 96 percent of each other's DNA. The genetic difference between humans and chimps is ten times smaller than that between mice and rats

(Lovgren, 2005). Despite the similarities in the DNA between humans and chimps, the latter have never learned a sophisticated language system or learned to read. Although reading is a relatively recent cultural invention that is only 5,000 years (or 3,500 years depending on how to view the primitive writings) old, compared to 13,000 years of human civilizations (Dehaene, 2009; Diamond, 1999), human beings have adapted well to the demand of reading, becoming well versed in the skill. Even media for reading have been extended in the digital era with the widespread presence of platforms such as computer screens, tablets, e-readers, or mobile phones.

The use of digital media may have a significant influence on brain circuitry due to the adaptability of our brains to habitual use. The shift from page-based reading to screen-based reading can change the specialization of the neural networks and circuits because the brain is not genetically fixed into rigid modes of thought and behavior, but rather *neuroplasticity* allows for neuronal accommodation to the demands of reading in different scripts (Dehaene, 2009; Perfetti & Liu, 2005; Wolf, 2007). Changes in our habitual thought can (re)shape and (re)fashion our neural pathways and circuits. The continuous use of on-screen materials may weaken higher-order cognitive functions and cognitive depth, such as mindfulness, reflection, critical thinking, inductive analysis, imagination, reflection, and abstract vocabulary, because of shrinking attention, multitasking, distraction, and information overload involved in screen-based reading (Baron, 2015). Baron (2015) asserts that digital reading discourages "reading longer texts, rereading, deep reading, memory of what you have read (which is often aided by handwritten annotation), [as well as] individual (rather than primarily social) encounters with books, stumble-upon possibilities, and strong emotional involvement" (p. 213). However, it is still uncertain how the heavier use of visual aids in digital text affects the overall reading processes and reading outcomes.

Baron (2015) forecasts the digital future based on advances that have already been made or are in the pipeline. First, digital reading devices will continue to get thinner and lighter but the storage capacity and battery life will be extended for greater downloads. Eyestrain resulting from reading on screens will reduce. Second, public access will increase through public digital libraries and open-access journals. Third, the traditional notion of textbooks will change, especially in higher education. Fourth, the concept of reading experience will be redefined. Fifth, the public will acculturate to reading on mobile digital devices, as technological advances continue to progress. Next, battling distraction in digital reading will continue in an effort to more effectively read on screen. Last, the future of publishing will have unifying forces in the mode of "digital plus print" based on the content of the book rather than two separate forces of media. Fictions and light content will go digital, while nonfiction and classics will stay largely print.

11.4 Script Relativity in the Digital Era

As discussed in Chapter 10, the processes of reading texts and images are different in terms of the *modes* of processing and *brain regions* that are dominantly recruited for processing. Texts are more likely to be processed in a one-at-a-time (at the initial level) or bottom-up manner particularly in alphabetic scripts, while images tend to be processed in an all-at-once or top-down fashion (Shlain, 1998). In short, the left hemisphere of the brain is primarily engaged in reading, while the right hemisphere is involved in perceiving images (Dehaene, 2009). Digital texts use more images and visual aids, like photographs, animated images, or embedded video clips, than traditional texts. This suggests that both left and right hemispheres of the brain as well as both sequential progression and holistic processing are likely to be involved in reading digital texts. This has implications for simultaneous and more balanced brain functions in on-screen reading than in hard-copy reading.

The writing systems used in the world boil down to two *conspicuous* written languages--the alphabetic writing system and the Chinese writing system, although alphasyllabaries of South Asia are another type of writing system. As I specified in Chapter 1, South-Asian scripts are excluded from the discussion in this book for contrastive purposes. Alphabetic and Chinese writing systems exhibit differences in appearance as well as in internal structures. Due to these differences, brain imaging studies show that alphabetic scripts and Chinese characters recruit slightly different brain regions for reading, as discussed in Chapter 9.

This digital era reinforces *biscriptal* use. Although the purpose of adopting Pinyin has little to do with the digital era, the Chinese have been using Pinyin as an official supplementary Romanization system since 1958. Because it is virtually impossible to type in tens of thousands of characters using the limited dimensions of a keyboard, the Chinese type in the alphabetic code (i.e., Pinyin) on the keyboard and then select a character of interest out of options that appear upon typing the alphabetic code of a given word. A similar way is used for typing in Japanese Kanji, as the Japanese have used multi-scripts, including Kanji and Kana, since A.D. 794 (Taylor & Taylor, 2014).

In recent decades, the use of bi-scripts has been observed worldwide, adding an additional writing system to an existing writing system. For example, the official script for Hindi is Devanagari, but it has become biscriptal in recent years through the use of the Roman alphabet to write in Hindi (primarily in online contexts, such as social media, text messages, and Internet searches). The term *Romanagari*, which combines *Roman* and *Devanagari*, is used to refer to the addition of Roman script. Similar biscriptal use is also found in Greek with *Greeklish* (the use of the Roman alphabet to write in Greek), in Arabic with *Aralish* (the use of the Roman alphabet to write in Arabic), and in Japanese with *Romaji* (the use of the Roman alphabet to write in Japanese).

Dehaene (2009) notes that mixed writing systems have “the vast advantage of being particularly well suited to the connectivity of the letterbox area” (p. 189), considering “the way our memory is structured, how language is organized, and the

availability of certain brain connections" (p. 189). He continues to argue "a mixed writing system using fragments of both sound and meaning appears to be the best solution" (p. 189). Especially for Chinese characters, our memory is not well equipped to memorize each character of 50,000 words in the lexicon.

Digital text tends to include more visual aids than traditional text. Due to the use of visual images in the digital text along with biscriptal or multiscriptal use in the writing systems of said text, *both* hemispheres of the brain are likely to be engaged in reading on screen. Hence, the increased use of digital text and mixed writing systems may cause the magnitude of script effects to gradually diminish. As a result, the difference between the East and the West[1] will also gradually diminish in the future. This has an implication for the hypothesis of script relativity because the global phenomenon will make testing the hypothesis more difficult than uni-script use in one culture and traditional reading on paper due to the possibilities of more intervening variables involved in the design of research. This also has another implication for positivity. The ongoing phenomenon of reading on dual platforms may lead us to harmonization or co-existence on the globe beyond the bipolar concept of the East and the West.

[1] As noted in Chapter 1, the East refers to Chinese, Japanese, and Koreans, while the West refers to European Americans as a representative group.

Chapter 12
Conclusion: Convergence or Divergence between the East and the West?

> *"Surgery is very yang and a little yin, [while] writing is very yin and a little yang. Being both a writer and a surgeon provides a considerable balance to my life. Also, surgeons are steeped in science and are trained in a very left-brained manner early on. But the actual practice of surgery is very right-brained. It is tactile, intuitive, and very visual-spatial."*
>
> - Leonard Shlain (1998, p. 4)

Abstract This chapter briefly reviews language as a cultural tool and claims written language or script to be the influential force that runs cognition and culture. As an extension of the linguistic relativity hypothesis, *script relativity* is considered to be the engines and underpinnings of our cognition, everyday problem-solving strategies, and overarching culture as the consequence of accommodated brain pathways upon reading. The mixed-script advantage is also discussed. Uni-script use has evolved to the use of bi-scripts or multi-scripts, as in Chinese with Pinyin and Japanese multi-scripts as well as the recent adoptions of Hindi-English bilinguals' Romanagari, Aralish that is used to supplement Arabic, and the Greeks' additional use of Greeklish. As the results of the co-use of words and images, the adoption of bi-scripts or multi-scripts, and a mixture of digital and paper-based texts, more convergence as well as the state of complementarity and harmony between the East and the West are expected. The chapter ends with the notations of limitations of the book and recommendations.

Keywords cultural tool · conversion of the East and the West · complementarity · harmony · (reduced) script relativity

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Beyond spoken language, human history has imparted a myriad of ways by which we have used to express ourselves, from the El Castillo stone cave paintings (39,000 B.C.) which illustrate abstract symbols and hand outlines on rock faces to systematic writing systems, such as the alphabet and logography. It took a long time for systematic writing systems to emerge in human history, compared to other inventions that have appeared throughout the course of civilization. Written language traces back only 5,000 years or so, while other inventions[1] materialized well over 10,000 years ago. It may be because we are not born to read. Because the brain is not biologically hard-wired for reading, unlike the spoken language, our brains need to reconnect and restructure neuronal pathways and networks by recycling the existing circuitry in the brain (Dehaene, 2009). Once it was invented, writing, as a linguistic and cultural tool, has come to the forefront of human communication and has become an integral part of our lives. Especially in the digital epoch, reading is no longer a passive conduit for the transmission of information to the extent that it has become an active force in creating new social interactions and realities within the new channels of communication. In these days, we are at times forced to participate in reading and writing through text messages, emails, or group chats, which have begun to replace face-to-face communication. These new channels that were unprecedented in the pre-mobile era have become a quintessential vehicle of interactions. What is important is that whatever principal medium with which we communicate everyday has a subliminal impact on our brains and can shape the way we view the world. Moreover, the habitual use of the medium plays a crucial role in determining which neuronal pathways and networks of the brain are to be recycled and reinforced to accommodate the demand of the continuous task of reading (Dehaene, 2009; Wolf, 2007).

This book has reviewed, integrated, and synthesized anecdotal and empirical evidence to interpret written language or script as the covert engine or agent that drives our perception and cognition. In order to ground the leitmotif of script relativity in theories and empirical evidence, I have relied on a plethora of books and articles in linguistics, psycholinguistics, cognitive psychology, social psychology, and neurosciences. In a nutshell, I have put the theoretical discussion of the *script relativity hypothesis* on a new footing to augment the *linguistic relativity hypothesis*. By showing how the linguistic relativity hypothesis was inadequately dismissed by a school of thought (e.g., nativists) in the 1960s through the 1980s and by offering new interpretations and findings, especially from second language studies, I have provided a foundation for the new theory of *script relativity*. I have grounded my argument in the theories of the *universal grammar of reading* (Perfetti, 2003) and the *system accommodation hypothesis* (Perfetti & Liu, 2005), which recognize linguistic universality and specificity involved in reading and the interaction between script and word recognition. In short, biological unity (i.e., linguistic universality) and scriptal diversity (i.e., script specificity) co-play a role in reading processes.

[1] Germanic groups invented the flute about 35,000 years ago; human portraits and fish hooks were first used in Italy about 14,000 years ago; rice crop was first harvested in China about 10,000 years ago; and beer was first brewed in China about 10,000 years ago.

However, script effects go above and beyond the absorptions of linguistic influences on our thinking and thought patterns.

12.1 Language as a Cultural Tool

Language is the medium through which we express ourselves and perceive the world. Language is also a system for processing information because, without language, we would have difficulties organizing information and our thoughts. Although the function of language is by and large invariant across languages, every culture has its own language. Even English has been indigenized and has taken on colorations according to the locality in which it is spoken around the world, such as British English, American English, Indian English, and Nigerian Pidgin English (Diamond, 1999). These related but distinct "Englishes" have been incorporated into their respective cultures to the degree that they can be unintelligible to speakers of other "Englishes" in terms of vocabulary, idioms, collocations, and pronunciation. Hence, it seems that having different cultures means having different languages or vice versa.

Attempts to identify the source of cultural differences have been made from various perspectives for a better understanding of people with various backgrounds and cultures. Diamond (1999) explains in *Guns, Germs, and Steel* why the rise and manifestations of human civilizations have emerged differently on the major continents across the globe over the past 13,000 years. He attributes the differences found in the trajectories, modes, and patterns of civilizations around the world to continental, geographic, and environmental factors rather than to human biology. Diamond's explanation is similar to Nisbett's (2003) observations and claims, which find the variations between the East and the West in geographical and cultural dissimilarities. In order to understand how and why Easterners and Westerners think differently, Nisbett and his colleagues have conducted a series of experiments in social psychology, as reviewed in Chapter 6.

The discussions of divergences between the East and the West have reverberated through empirical evidence advanced by the studies of social psychology and applied linguistics. Of interest is a systemic analysis of how ideological undercurrents are formed and how intrinsic characteristics (e.g., philosophy, belief systems, attention, and the mind) coalesce with the extrinsic stimulus (e.g., written language or script we read in) for compatibility or how the extrinsic stimulus defines the intrinsic characteristics for covert causality. This line of analysis helps us understand the way we pay attention and solve problems, and further understand the underlying construct that is responsible for the differences in aspects observed between the East and the West. Although universal characteristics exist among cultures, Nisbett (2003) observes that Westerners tend to categorize things around them, whereas Easterners look for relationships among items surrounding them. East Asians tend to demonstrate a holistic perceptual pattern by paying more attention to the context and interactions between the foreground and background. In

contrast, Westerners are more likely to pay attention to focal objects or main characters rather than backgrounds in a context-independent and analytic way (see Chapter 6 for details).

12.2 Scripts: The Hidden Drive of Cognition and Culture

Although there are multiple ways to look at script effects, the effect can be viewed as (1) an extension of the linguistic relativity hypothesis, (2) the result of accommodated brain networks, and (3) the underpinnings of our cognition, everyday problem-solving strategies, and overall culture. First, as the extension of the linguistic relativity hypothesis, Chapter 3 summarizes how the linguistic relativity hypothesis was misinterpreted about three to five decades ago without sufficient empirical evidence for the dismissal. Research on color, motion, number, time, object, and nonlinguistic representations offers substantial support for the linguistic relativity hypothesis, which provides a valid rationale for the resurrection of the hypothesis. It is difficult to prove that the language we speak does *not* affect our cognition and the perception of the world. The claim that our thinking influences language is a moot point, however (see Chapter 1 for further information). This book goes beyond the linguistic relativity hypothesis to highlight the impact of the script being read. Given that we rely on largely arbitrary symbols to extract meaning, the process of reading requires inner workings of the brain. This is directly related to the second point, the brain circuitry. As Dehaene (2009) proposes the *neuronal recycling hypothesis*, literacy experience reshapes the brain circuits and pathways to accommodate the constraints of the script being read (Kim & Wang, 2018; Perfetti & Liu, 2005; Shlain, 1998; Wolf, 2007). Last, the East and the West in general reveal divergent cultures. The differences between the two cultures have been manifested in ancient architecture, religion, and everyday practices, which are the expressions of cultural members' minds, cognition, and problem-solving strategies. Chapter 6 summarizes the pivotal cultural characteristics in the East and the West based on anecdotal and empirical evidence.

Although Nisbett (2003) and Diamond (1999) have established solid grounds for their all-encompassing theses on the differences between the East and the West and among the different continents on the globe, respectively, their arguments *cannot* explain the microscopic aspects of the brain's networks, a language group's collective mind and cognition, problem-solving strategies, and culture that are in variation across users of different languages. Of importance is the fact that China, Korea, and Japan share geographical proximity and culture to a great extent, but the people of the three countries have different spoken languages and scripts (and therefore different ways of thinking). This suggests that there is something beyond Diamond's (1999) and Nisbett's (2003) claims that geography and environmental factors are the defining cause of the variations. From the viewpoint of *script relativity*, it is the script being read that underpins the differences found among these three groups of people. Spoken language is biological, while written language is not and needs to be

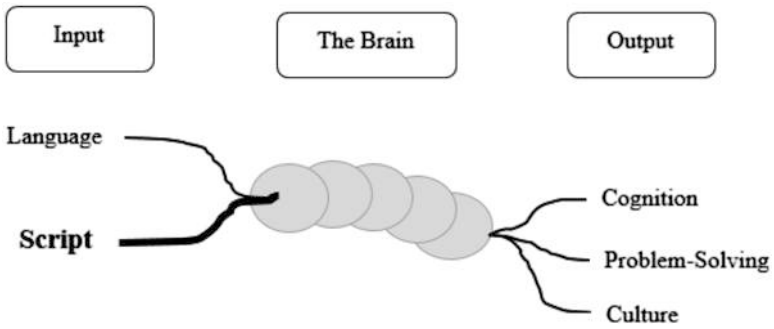

Figure 12.1. A Causal Effect of the Script on Cognition, Problem-Solving, and Culture

explicitly learned. Hence, our conscious effort to combine graphs to form syllables or words (i.e., reading alphabetic scripts) or to make sense of whole characters by extracting meaning out of them (i.e., reading logographic or morphosyllabic Chinese characters) is likely to shape the processes of information processing. It is also written language that restructures and rewires the brain to accommodate the writing system, although our bodies remain the same (Dehaene, 2009; Shlain, 1998; Wolf, 2007).

These interactions are summarized in Figure 12.1. Language and script designate *input*, while cognition, problem-solving strategies, and culture represent *output*. Script effects can be greater than spoken-language effects because reading is an effortful endeavor, while spoken language is acquired naturally with time, exposure, and interaction. To address this notion, script is distinguished with a bolder thread than oral language. The brain is the machine that processes the input to yield the output. Based on the nature of a script as well as the brain's workings to accommodate the script's constraints, the outcomes of cognition, problem-solving strategies that we use, and the overall resulting culture of the scripts' respective readers would be different.

12.3 Conversion or Diversion of Cultures?

More than two decades ago, Huntington (1996) asserted that "[i]n this new world the most pervasive, important, and dangerous conflicts will not be between social classes, rich and poor or other economically defined groups, but between peoples belonging to different cultural entities" (p. 28). This might be true in international relations and world politics and in some aspects of civilizations. A civilization is "the broadest cultural entity … the highest cultural grouping of people and the broadest level of cultural identity people have short of that which distinguishes humans from other species" (Huntington, 1996, p. 43). Since a civilization comprises a wide range of entities, including language, history, religion, customs, and

institutions, the diverse facets of a civilization may take different trajectories and patterns among different cultural groups.

Through recent history, the West or the Western ideas has/have dominated the course of all civilizations as a *universal civilization* in which Western cultural entities have been accepted as "common" values, beliefs, orientations, and practices (Huntington, 1996). This resulted in cultural hegemony and cultural imperialism. Cultural imperialism refers to the maintenance of cultural inequity or dependent relationships between a more politically or economically dominant group and a less powerful group in asserting supremacy over another group. It often marginalizes less powerful groups' cultural values, beliefs, customs, and standards (Huntington, 1996). The cultural hegemony of more economically powerful countries has been exercised in the context of constructing theories of a transnational power structure. Huntington (1996) predicted that differences among nations would continue to grow with the "clash of civilizations," which would escalate a continued divergence. This would also yield variabilities in individuals' perceptual patterns, reasoning styles, and systems of thought among different cultures.

As such, Huntington (1996) predicted that the societal differences would become wider than before (i.e., the world has already diversified into eight groups in the course of civilization based on religion beyond previously two polar opposites), because divergent cultural paths, rather than economic or political matters, would intensify future international conflicts. Despite the truths in this theory, Eastern and Western cultures seem to get more assimilated to each other by overcoming cultural myopia and ethnocentrism. Peng, Nisbett, and Wong (1997) found that Chinese students showed higher scores on Western values, such as valuing equality, imaginativeness, independence, broad-mindedness, and a varied life, than did American students. Similarly, American students reported higher values on being self-disciplined and loyal, having respect for tradition, and honoring parents and elders more than did Chinese students.

Pubic education in the East has a general tendency to implement an American curriculum in their own educational systems. Especially with the English language integrated into the national curriculum of compulsory elementary education in Asia, American instructional methods are predominately adopted in Asian educational curriclua. Another reason for the Americanized curriculum is that key policymakers in Asia obtained their terminal degrees (Ph.D. or EdD) from American institutions and apply what they have learned in the U.S. to their Eastern educational systems.

However, blending social systems and values in the East and West may merely be a trend. Consider the Westernization of Asian business environments and the gradually increasing number of Christians in China in recent years—aside from the already high number of Christians in Korea, as mentioned in the Prologue. The reverse phenomenon has also been observed in recent times. We are witnessing an increased interest in the study of Buddhism in America, an upward trend of Yoga practice in Western countries, and an adoption of holistic medicine including herbal medicine and acupuncture in Western medical practice.

Relatedly, a literacy-related example is also found in China. Although a direct connection has not been identified, the new adoption of a supplementary writing

system, Pinyin, might have contributed to improved literacy rates in China. When the communists took over the People's Republic of China in Mainland China in 1949, the literacy rate in China was below 20%. Using logography, it was easier for Chinese authority to control the literacy rate and maintain the restriction of information because it takes much longer to learn to read than the alphabet (Goody & Watt, 1963; Logan, 2004; Wolf, 2007). China's literacy rate has rapidly increased in recent decades. By 1990, the literacy rate rose to 78% with a gender difference of 19% (87% for men and 68% for women). According to the UNESCO Institute for Statistics, in 2010, the literacy rate was reported as 95.5% with only 5% difference in gender (98% for men and 93 for women). Among China's youth (ages 15 to 24), the literacy rate is almost 100% with no gender gap (99.7% for young men and 99.6% for young women). Although it can be argued that the character simplification in Mainland China was a contributing factor to the literacy surge, it is not completely convincing given that Hong Kong, Macau, and Taiwan still use traditional Chinese characters but report high literacy rates. If there is a truth to Dehaene's (2009) claim of the mixed-script advantage, the use of Pinyin may be the catalyst for the dramatic change in the literacy rate exhibited in China from 1949 to 2010, besides the political and economical changes in recent decades. Dehaene (2009) asserts that "[a] mixed system using fragments of both sound and meaning appears to be the best solution" (p. 189) in consideration of the crossroads among multiple cognitive constraints as to "the way our memory is structured, how language is organized, and the availability of certain brain connections" (p. 189). He continues to note that "[t]he mixed writing system … has the vast advantage of being particularly well suited to the connectivity of the letterbox area" (p. 189).

Users of bi-scripts utilize customized dual keyboards which can switch back and forth between two scripts with a single stroke of the keyboard. Another example is the use of fully convertible functionality from Pinyin to Chinese characters. In this case, Pinyin is typed and the program displays a selection of characters that have the same sound so that users can choose the appropriate one. This method, however, may be a little cumbersome, and hence the next development may be a voice-recognition protocol, such as the Media Resource Control Protocol—a communication protocol used to provide speech recognition and speech synthesis—to eliminate the extra step of switching. Although empirical evidence is unavailable as of today, it is within reason to prognosticate that the swift judgment and instantaneous selection would promote the user's flexibility and efficiency in problem-solving.

12.4 Toward the State of Complementarity and Harmony

In an attempt to address most of the points discussed in this book, Figure 12.2 summarizes ever-evolving script effects as well as *what* we read, *how* we read, and *why* we read in this digital era. With respect to *what* we read, when the writing system was invented, we predominantly used a single script. As needs arise, the uni-script use has evolved to using bi-scripts or multi-scripts. The Japanese were reportedly

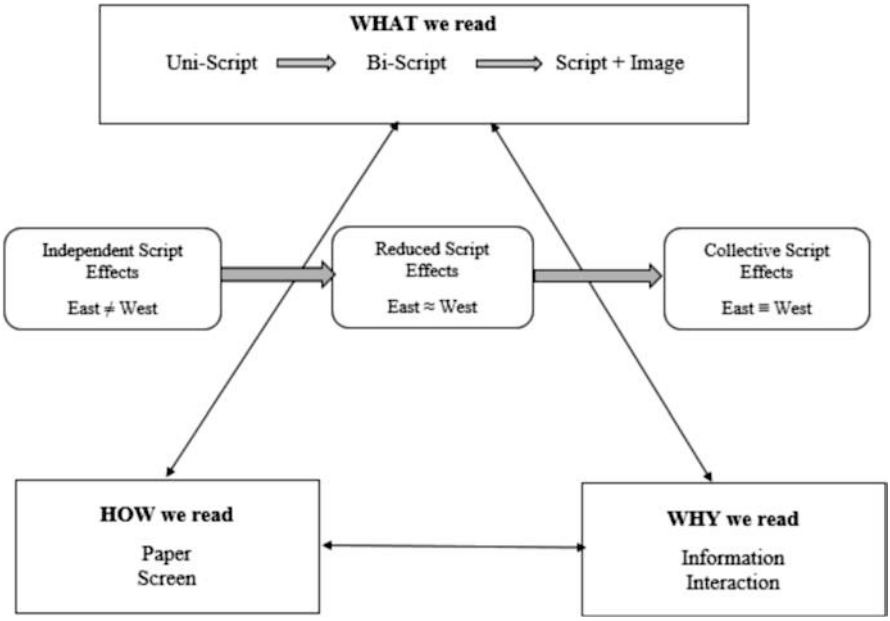

Figure 12.2. The Interaction among What, How, and Why We Read and Script Effects

the first society to have used both Kanji and Kana systems post A.D. 800 or so. The Chinese adopted Pinyin in 1958 with several revisions since then. More recently, Hindi-English bilinguals use *Romanagari* in addition to Devanagari (the official script that represents the Hindi language). The Greeks started using *Greeklish* as a way of using the Roman alphabet to write Greek. There is also *Aralish* that is used to supplement Arabic, as well as *Romaji* that have been used by the Japanese to represent the Roman alphabet. In addition to the increased usage of bi/multi-scripts, text has become even more enhanced in the advent of the digital epoch. Digital text of today makes use of more images and symbols than traditional text, engaging both hemispheres of the brain. These left and right brain regions, believed to be specialized for reading and image processing, respectively, are simultaneously recruited when reading digital text.

The brain's neuroplasticity accommodates the constraints that scripts put on our neural pathways while adapting to the medium through which we read. In addition to the plasticity conducive to *what* we read (i.e., the script and the medium), the quality of reading seems to affect the malleability of the brain. Specifically, Wolf (2018) argues "[t]he quality of our reading is not only an index of the quality of our thought, [but] it is our best-known path to developing whole new pathways in the cerebral evolution of our species." (p. 2).

Regarding *how* we read, technological advances have provided another platform of reading—on-screen reading. As we use electronic devices more than ever before, on-screen reading has dramatically increased. The presence of the digital text

defines *how* we read in terms of the medium and the manner of reading. We have recognized a tendency to scan on-screen text in an F-shaped manner in lieu of reading the text in entirety. Aside from less attention given to digital text, this skimming manner itself may result in the reduced quality of reading on screen, as Wolf (2018) points out.

As for *why* we read, technological advances have also changed the purpose of our reading. In the traditional notion, we read text for information gathering, entertainment, and related utility. Traditional reading takes place independently, and readers have control over their reading. However, in the digital era, we are at times forced into reading on screen. When the other party sends emails or text messages rather than phone calls or in-person meetings, we are bound to engage in on-screen reading and writing. Today, the purpose of reading and writing has not only merged but is now more geared toward interactive communication than traditional purposes.

McLuhan's (1964) dictum "the medium is the message" encompasses all these aspects of reading because the medium is closely tied not only to the content of information, but also to the channel for message transmission as well as our intentions and choices for reading and communication. McLuhan (1964) continued to argue that the medium would shape and control "the scale and form of human association and action" upon message transmission (p. 9). If this is true, Hemingway's shortest "short story" that he has ever written, including only six words, would have different effects on paper and on screen. The shortest story is as follows:

For sale: baby shoes, never worn.[2]

When this is read in a traditional medium, on paper, this six-word "short story" would invoke readers' imagery and imagination as to why the shoes were never worn. The image of a lonely pair of baby shoes captures the reader's multiple layers of emotions based on their background knowledge, inference of a loss, suppressed feelings, and prayer-like wishes. However, it is unsure whether or not reading this story on screen would yield the same effect as reading on paper.

To sum up, with the changes to *what*, *how*, and *why* we read, there is a unifying trend revolving us into a more integrated world. The implication of this trend lies in the understanding of the East and the West as well as its relation to the thesis of this book. Neuroimaging studies show that brain networks and circuits are different in reading Chinese characters and English as a result of accommodating the linguistic needs of the given writing system. With the use of biscriptal scripts and digital text, the differences in reading between Chinese and English are expected to be diminished, and, in turn, the differences in cognition and thought are also to be diminished.

Two decades ago, Shlain (1998) predicted balance that would come into human behavior, technology, and communication with his optimism for the future of mankind as follows:

> The computer and the Internet will once again reconfigure the brains of those that use them. Typing is a two-handed activity that requires input from both sides of the brain. Writing requires only the dominant hand. The use of a mouse … necessitates the activation of right-

[2] This is cited in Wolf (2018, p. 41).

> hemispheric visual-spatial skills. The World Wide Web and the Internet are not linear, they are holistic. (Shlain, 1998, A Conversation, p. 8).

These complementary modes of understanding reality and communicating amongst one another are analogous to the integration, balance, and symmetry of yin and yang. The yin and yang indicate that one side without the other is incomplete. They form a unified completeness only when they are together, which is stronger than either half or both halves combined. This is consistent with the way Shlain finds the integration and harmony in his profession (surgeon), as shown in the epigraph. This also echoes what Shlain mentioned: "The human community should strive for a state of complementarity and harmony" (p. 431).

12.5 Limitations of This Book and Recommendations

In closing, I should make note of the (possible) limitations of this book. First, as I noted in Chapter 1, I have used representative concepts and terms. By East Asians, I mean Chinese, Japanese, and Korean people. By Americans, I mean European-heritage Americans. The East refers to Chinese, Japanese, and Koreans in light of their languages and cultures because China exerted its influence on all Asian regions in history and because Chinese, Japanese, and Koreans are all East Asians but have different languages and scripts, which provides a unique discussion point. The West refers to European Americans in relation to their language and culture, as the modern U.S. is a European-molded society (Diamond, 1999). Some may find this representation overly simplified. As I mentioned elsewhere, however, I chose the binary contrast because the Chinese writing system is rich enough to discuss within and between scripts and, at the same time, the three East-Asian scripts have enough variations to differentiate among themselves. This has served its purpose well to make my argument in this book. Another reason why I do not cover other scripts, such as South-Asian alphasyllabaries, Arabic, and Hebrew, is that I am not qualified to deal with those languages and scripts in a scientific way. It is my hope that the merit of this book outweighs the risk of (potential) over-simplification.

Second, using *script relativity* as an all-encompassing thesis may also be considered an over-simplification by some scholars, especially given the early (unjust) dismissal of the linguistic relativity hypothesis. In comparison to the explanations of geographical and environmental factors by Diamond (1999) and Nisbett (2003), *script relativity* may gain more competitive plausibility in explaining the covert script influences on our cognition and our mind.

Third, although this is not a limitation but a stance, some scholars may criticize my relativistic view, although I have tried to suspend my own cultural bias while providing circumstantial or anecdotal evidence. I acknowledge that my viewpoint is based on epistemology rather than ontology. At the same time, I have taken the *emic* view of my insider account as a Korean native as well as *etic* view of an outsider or

observer account as a psycholinguistic researcher to provide a fuller, richer, and deeper description of *script relativity*.

Because I personally do not see the above as halting limitations, I believe that this line of inquiry and dialogue needs to continue. Not only has the linguistic relativity hypothesis been revisited and reinterpreted by enlightened psychologists, linguists, and anthropologists, but empirical research also picks up for the resurrection of the hypothesis especially in second language studies. The same applies to script relativity.

Since I have left out alphasyllabaries of South Asia and abjads of Arabic and Hebrew from this book, the discussion of *script relativity* needs to be broadened and intensified by other researchers who know the languages and scripts well. Notably, the genesis of my claim, linguistic relativity, has taken several decades to gain fair treatment and interpretation with a vast amount of research. It is now the time to think about and test script relativity as an extension. My thesis sets the stage for studies for other languages, regions, and groups of people.

As I briefly indicated in earlier chapters, both the new trend of digital text and the increasing use of bi-scripts and multi-scripts within a culture make testing script relativity difficult. In addition, testing illiterate people in comparison to literate counterparts is a useful way to address script relativity. However, the growing number of literacy rates in the world will keep us from teasing apart script influences on thinking in research. Another inherent challenge has to do with the difficulty of separating cognition from reading or reading from cognition because reading itself is a multifaceted cognitive activity. Nevertheless, the script relativity hypothesis meets the requisite for a theory, which includes generalizability, testability, falsifiability, predictability, and the principle of parsimony. My attempt ends here by providing a new footing for scientific dialogue that goes beyond linguistic relativity. The fate of script relativity depends on the reader's judgment of competitive plausibility among many possible explanations of the given phenomenon.

Epilogue

"I am convinced we are entering a new Golden Age—one in which the right-hemispheric values of tolerance, caring, and respect for nature will begin to ameliorate the conditions that have prevailed for the too-long period during which left-hemispheric values were dominant. Images, of any kind, are the balm bringing about this worldwide healing. It will take more time for change to permeate and alter world cultures but there can be no doubt that the wondrous permutations of photography and electromagnetism are transforming the world both physically and psychically. The shift to right-hemispheric values through the perception of images can be expected to increase the sum total awareness of beauty."

- Leonard Shlain (1998, p. 432)

As the epigraph indicates, Shlain (1998) forecasted more than two decades ago a converging force in our lives through the increasing use of images in the digital epoch. With the new technology and new platforms for human interactions, the late Shlain's prediction has proved its legitimacy. To understand cognitive variations across cultures, I have tried to deliver my new claim, *script relativity*, from both insider's view as a Korean native and outsider's view as a psycholinguist in order to have a full description of *script relativity*. I have also tried to avoid simplified universalism or radical cultural relativism by relying on numerous research findings by other scholars who specialize in social psychology, cognitive psychology, psycholinguistics, and second language studies. I have tried to avoid an overstatement glossing over subtleties or a lopsided assertion on script influences without evidence.

Before beginning to write this book, I spent a year and a half gauging the degree of the (potential) side-effects of my thesis because I expected there to be more controversy than agreement on script relativity, especially given the unjust dismissal of the linguistic relativity hypothesis for about five decades. It might have seemed as if I was trying to grow a new branch from a dead tree. Why is it nevertheless illuminating to interpret the differences through the lens of script relativity?

After the long incubatory or gestation period, it took about seven months for me to write the 12 chapters. Writing this book has been a great pleasure as I have truly enjoyed writing it. The more I delved into the chapters, the more I was convinced that we should not remain in the complacency of anti-Whorfianism (because this

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inhibits us to advance reading science) and that we cannot ignore the mounting evidence of the effects of both language and script (because there is no other way to interpret the evidence of cross-scriptal transfer).

When I wrote "[d]ue to its on-going nature, the thrust of this book is a working hypothesis" in the Prologue at the onset of writing this book, I was humble and worried about the (potential) criticism for sweeping generalizations. However, after completing all the chapters, I have more confidence in this theory. It is because I have gathered and synthesized vast evidence that supports *script relativity* (even if indirectly because it has never been directly tested so far). Especially, it is difficult to interpret all results of second language studies that show robust cross-scriptal transfer without considering L1 script effects, which funnels down to *script relativity*.

In short, since the script in which we read affects how we read, how we read affects the brain's specialization, and the brain's specialization further affects how we process incoming information, we can logically infer the impact of script we read in on our cognition and perception. Habits maximize the effect, and we read everyday. Hence, script effects on our cognition and perception *cannot* be overlooked.

Notably, *script relativity* meets the criteria for scientific theory, as summarized in Cramer (2013): (1) comprehensiveness, (2) precision and testability, (3) parsimony, (4) empirical validity, (5) heuristic value (i.e., "its ability to generate unique thoughts and perspectives and directions in other fields" p. 11), and (6) applied value. I do not explain each criterion here because the criteria are self-explanatory to a great extent.

The theory of *script relativity* is now in your hands. It is your turn whether to accept or dismiss (or to remain undecided about) *script relativity*. I ask you to consider competitive plausibility among all possible explanations of cross-scriptal influences that have been found in second language studies. What would be the most plausible explanation other than *script relativity*? I end this book by echoing Shlain's (1998) remark as follows: "My hope is that this book will initiate a conversation about the issues I have raised and inspire others to examine the thesis further" (p. 432).

References

Adams, M. J. (1990). *Beginning to read: Thinking and learning about print*. Cambridge, MA: The MIT Press.

Agrillo, C., & Roberson, D. (2009). Colour language and colour cognition: Brown and Lenneberg revisited. *Visual Cognition, 17*(3), 412–430.

Akamatsu, N. (1999). The effects of first language orthographic features on word recognition processing in English as a second language. *Reading and Writing, 11*(4), 381–403.

Akamatsu, N. (2003). The effects of first language orthographic features on second language reading in text. *Language Learning, 53*(2), 207–231.

Albonico, A., Furubacke, A., Barton, J. J. S., & Oruc, I. (2018). Perceptual efficiency and the inversion effect for faces, words and houses. *Vision Research, 153*, 91–97.

Arciuli, J., Monaghan, P., & Seva, N. (2010). Learning to assign lexical stress during reading aloud: Corpus, behavioral, and computational investigations. *Journal of Memory and Language, 63*(2), 180–196.

Athanasopoulosa, P., & Albright, D. (2016). A perceptual learning approach to the Whorfian hypothesis: Supervised classification of motion. *Language Learning, 66*(3), 666–689.

Backwell, L., d'Errico, F., & Wadley, L. (2008). Middle stone age bone tools from the Howiesons Poort layers, Sibudu cave, South Africa. *Journal of Archaeological Science, 35*, 1566–1580.

Bae, S., & Yi, K. (2016). The effects of Hanja primes on the recognition of Hanja words printed in Hangul. *The Journal of Linguistic Science, 79*, 139–156.

Bagley, R. W. (2004). Anyang writing and the origin of the Chinese writing system. In S. D. Houston (Ed.), *The first writing: script invention as history and process* (pp. 190–249). New York, NY: Cambridge University Press.

Baron, N. S. (2015). *Words onscreen: The fate of reading in a digital world*. New York, NY: Oxford University Press.

Baron, N. S. (2017). Reading in a digital age. *Phi Delta Kappan*, 99(2), 15–20.

Baron, N.S., Calixte, R.M., & Havewala, M. (2017). The persistence of print among university students: An exploratory study. *Telematics & Informatics,* 34, 590–604.

Behrmann, M., & Plaut, D. C. (2014). Bilateral hemispheric processing of words and faces: evidence from word impairments in prosopagnosia and face impairments in pure alexia. *Cerebral Cortex*, *24*(4), 1102–1118.

Ben-Yehudah, G., Hirshorn, E. A., Simcox, T., Perfetti, C. A., & Fiez, J. A. (2019). Chinese-English bilinguals transfer L1 lexical reading procedures and holistic orthographic coding to L2 English. *Journal of Neurolinguistics, 50*, 136–148.

Berlin, B., & Kay, P. (1969). *Basic color terms; their universality and evolution*. Berkeley, CA: University of California Press.

H. K. Pae, *Script Effects as the Hidden Drive of the Mind, Cognition, and Culture*, Literacy Studies 21, https://doi.org/10.1007/978-3-030-55152-0

Besner, D. & Hildebrandt, N. (1987). Orthographic and phonological codes in the oral reading of Japanese Kana. *Journal of Experimental Psychology: Learning, Memory and Cognition, 13(2)*, 335–343.

Bialystok, E., McBride-Chang, C., & Luk, G. (2005). Bilingualism, language proficiency, and learning to read in two writing systems. *Journal of Educational Psychology, 97*(4), 580–590.

Bloomfield, L. (1933). *Language*. New York: Holt, Rinehart and Winston.

Bolger, D. J., Perfetti, C. A., & Schneider, W. (2005). Cross-cultural effect on the brain revisited: universal structures plus writing system variation. *Human Brain Mapping, 25*(1), 92–104.

Bonatti, L. L., Peña, M., Nespor, M., & Mehler, J. (2005). Linguistic constraints on statistical computations: The role of consonants and vowels in continuous speech processing. *Psychological Science, 16*(6), 451–459.

Boroditsky, L. (2001). Does language shape thought? Mandarin and English speakers' conceptions of time. *Cognitive Psychology, 43*(1), 1–22.

Bowerman, M., & Levinson, S. C. (Eds.). (2001). *Language acquisition and conceptual development*. Cambridge: Cambridge University Press.

Brady, S. (1986). Short-term memory, phonological processing, and reading ability. *Annals of Dyslexia,* 36(1), 138–153.

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Cambridge, MA: Harvard University Press.

Bramão, I., Mendonça, A., Faísca, L., Ingvar, M., Petersson, K. M., & Reis, A. (2007). The impact of reading and writing skills on a visuo-motor integration task: A comparison between illiterate and literate subjects. *Journal of the International Neuropsychological Society*, 13, 359–364.

Brincat, S. L., & Connor, C. E. (2006). Dynamic shape synthesis in posterior inferotemporal cortex. *Neuron, 49*, 17–24.

Brown, R., & Lenneberg, E. (1954). A study in language and cognition. *Journal of Abnormal and Social Psychology, 49*(3), 454–462.

Brysbaert, M., Fias, W., & Noël, M.-P. (1998). The Whorfian hypothesis and numerical cognition: Is 'twenty-four' processed in the same way as 'four-and-twenty'? *Cognition, 66*, 51–77.

Bylund, E., & Athanasopoulos, P. (2014). Linguistic relativity in SLA: Toward a new research program. *Language Learning, 64*(4), 952–985.

Bylund, E., & Athanasopoulos, P. (2017). The Whorfian time warp: Representing duration through the language hourglass. *Journal of Experimental Psychology: General, 146*(7), 911–916.

Cantlon, J. F., Pinel, P., Dehaene, S., & Pelphrey, K. A. (2011). Cortical representations of symbols, objects, and faces are pruned back during early childhood. *Cerebral Cortex, 21*, 191–199.

Cao, F. (2018). Brain mechanisms of Chinese word reading. In H. K. Pae (Ed.), *Writing systems, reading processes, and cross-linguistic Influences* (pp. 137–162). Amsterdam, Netherlands: John Benjamins.

Cao, F., & Perfetti, C. A. (2016). Neural signatures of the reading-writing connection: Greater involvement of writing in Chinese reading than English reading. *PLoS ONE, 11*(12), e0168414.

Cao, F., Tao, R., Liu, L., Perfetti, C.A., Booth, J.R. (2013). High proficiency in a second language is characterized by greater involvement of the first language network: evidence from Chinese learners of English. *Journal of Cognitive Neuroscience. 25*, 1649–1663.

Cao, F., Vu, M., Chan, D. H., Lawrence, J. M., Harris, L. N., Guan, Q., Xu, Y., & Perfetti, C. A. (2013). Writing affects the brain network of reading in Chinese: a functional magnetic resonance imaging study. *Human Brain Mapping, 34*(7), 1670–1684.

Carr, N. (2010). *The shallows: What the Internet is doing to our brains*. New York, NY: W. W. Norton.

Carnes, R. L. (1970). A perceptual model of the Whorfian thesis. *ETC: A Review of General Semantics, 27*(1), 55–65.

Carnes, R. L. (2014). A perceptual model of the Whorfian thesis: A review of general semantics. *et Cetera, 71*(3), 263–271.

Carreiras, M. & Price, C. J. (2008). Brain activation for consonants and vowels. *Cerebral Cortex, 18*, 1727–1735.

Carreiras, M., Duñabeitia, J. A., & Molinaro, A. (2009). Consonants and vowels contribute differently to visual word recognition: ERPs of relative position priming. *Cerebral Cortex, 19*, 2659–2670.

Carroll, J. B. (Ed.). (1956). *Language, thought, and reality: Selected writings of Benjamin Lee Whorf*. Cambridge, MA: MIT Press.

Carruthers, P. (2002). The cognitive function of language. *Behavioral and Brain Sciences, 25,* 657–725.

Casasanto, D. (2008). Who's afraid of the Big Bad Whorf? Crosslinguistic differences in temporal language and thought. *Language and Learning, 58 (Suppl.),* 63–79.

Chang, L.-Y., & Perfetti, C. A. (2018). Visual factors in writing system variation: Measurement and implications for reading. In H. K. Pae (Ed.), *Writing systems, reading processes, and cross-linguistic influences: Reflections from the Chinese, Japanese and Korean languages* (pp. 49–71). Amsterdam: John Benjamins.

Chen, X., Hao, M., Geva, E., Zhu, J., & Shu, H. (2009). The role of compound awareness in Chinese children's vocabulary acquisition and character reading. *Reading and Writing: An Interdisciplinary Journal, 22*(5), 615–631.

Chen, X., Xu, F., Nguyen, T.-K., Hong, G., & Wang, Y. (2010). Effects of cross-language transfer on first-language phonological awareness and literacy skills in Chinese children receiving English instruction. *Journal of Educational Psychology, 102*(3), 712–728.

Chen, Y., Fu, S., Iversen, S. D., Smith, S. M., & Matthews, P. M. (2002). Testing for dual brain processing routes in reading: a direct contrast of chinese character and pinyin reading using FMRI. *Journal of Cognitive Neuroscience, 14*(7), 1088–1098.

Chen, S. X., Benet-Martinez, V., & Ng, J. C. K. (2014). Does language affect personality perception? A functional approach to testing the Whorfian hypothesis. *Journal of Personality, 82*(2), 130–143.

Cheung, H., Chung, K. K. H., Wong, S. W. L., McBride-Chang, C., Penney, T. B., & Ho, C. S.-H. (2010). Speech perception, metalinguistic awareness, reading, and vocabulary in Chinese–English bilingual children. *Journal of Educational Psychology, 102*(2), 367–380.

Chiappe, P., Glaeser, B., & Ferko, D. (2007). Speech perception, vocabulary, and the development of reading skills in English among Korean- and English-speaking children. *Journal of Educational Psychology, 99*, 154–166.

Chikamatsu, N. (1996). The effects of L1 orthography on L2 Japanese word recognition. *Studies in Second Language Acquisition*, *18*, 403–432.

Chikamatsu, N. (2006). Developmental word recognition: A study of L1 English readers of L2 Japanese. *The Modern Language Journal, 90*(1), 67–85.

Chikamatsu, N. (2008). The effects of L1 orthography on L2 word recognition: A study of American and Chinese learners of Japanese. *Studies in Second Language Acquisition, 18*(04), 403.

Chikamatsu, N., Yokoyama, S., Nozaki, H., Long, E., & Fukuda, S. (2000). A Japanese logographic character frequency list for cognitive science research. *Behavior Research Methods, Instruments, & Computers, 32*(3), 482–500.

Cho, J.-R. (2009). Syllable and letter knowledge in early Korean Hangul reading. *Journal of Educational Psychology, 101*, 938–947.

Cho, J.-R. (2018). Cognitive-linguistic skills and reading and writing in Korean *Hangul*, Chinese *Hanja*, and English among Korean children. In H. K. Pae (Ed.), *Writing systems, reading processes, and cross-linguistic influences: Reflections from the Chinese, Japanese and Korean languages* (pp. 391–410). Amsterdam: John Benjamins.

Cho, J.-R., & McBride-Chang, C. (2005). Levels of PA in Korean and English: A 1-year longitudinal study. *Journal of Educational Psychology, 97*, 564–571.

Cho, J., McBride-Chang, C., & Park, S. (2008). Phonological awareness and morphological awareness: Differential associations to regular and irregular word recognition in early Korean Hangul readers. *Reading and Writing, 21*(3), 255–274.

Cho, Z. H., Kim, N., Bae, S., Chi, J. G., Park, C. W., Ogawa, S., & Kim, Y. B. (2014). Neural substrates of Hanja (Logogram) and Hangul (Phonogram) character readings by functional magnetic resonance imaging. *Journal of Korean Medical Science, 29*(10), 1416–1424.

Choi, I., Nisbett, R. E., & Norenzayan, A. (1999). Causal attribution across cultures: Variation and universality. *Psychological Bulletin, 125*(1), 47–63.

Choi, S., & Bowerman, M. (1991). Learning to express motion events in English and Korean: the influence of language-specific lexicalization patterns. *Cognition, 41*(1–3), 83–121.

Chomsky, N. (1957). *Syntactic structures*. The Hague/Paris: Mouton.

Christianity in China. (n.d.). Retrieved April 21, 2019, from https://en.wikipedia.org/wiki/Christianity_in_China#cite_note-CFPS2012-011-012-5.

Chua, H. F., Boland, J. E., & Nisbett, R. E. (2005). Cultural variation in eye movements during scene perception. *Proceedings of the National Academy of Sciences of the United States of America, 102*(35), 12629–12633.

Coderre, E. L., Filippi, C. G., Newhouse, P. A., & Dumas, J. A. (2008). The Stroop effect in kana and kanji scripts in native Japanese speakers: an fMRI study. *Brain and Language, 107*(2), 124–132.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review, 108*, 204–256.

Connor, U. (1996). *Contrastive rhetoric : Cross-cultural aspects of second-language writing*. New York, NY: Cambridge University Press.

Conrad, N. J., Harris, N., & Williams, J. (2013). Individual differences in children's literacy development: the contribution of orthographic knowledge. *Reading and Writing: An Interdisciplinary Journal, 26*(8), 1223–1239.

Cook, V. (2011). Relating language and cognition: The speaker of one language. In V. Cook & B. Bassetti (Eds.), *Language and bilanguage cognition* (pp. 2–22). New York, NY: Psychology Press.

Cook, V., & Bassetti, B. (2005). An introduction to researching second language writing system. In V. Cook & B. Bassetti (Eds.), *Second language writing systems* (pp. 1–67). Clevedon: Multilingual Matters.

Cook, V., & Bassetti, B. (Eds.). (2011). *Language and bilingual cognition*. New York, NY: Psychology Press.

Coulmas, F. (1989). *The writing systems of the world*. Oxford: Basil Blackwell.

Cramer, K. M. (2013). Six criteria of a viable theory: Putting reversal theory to the test. *Journal of Motivation, Emotion, and Personality, 1*, 9–16.

Cromer, A. (1993). *Uncommon sense: The heretical nature of science*. New York: Oxford University Press.

Curtiss, S. (1977). *Genie: A psycholinguistic study of a modern-day "Wild Child."* New York, NY: Academic Press.

Daniels, P. (1996). Part I: Grammatology. In P. T. Daniels & W. Bright (Eds.). *The world's writing systems* (pp. 1–2). New York, NY: Oxford University Press.

Daniels, P. T., & Bright, W. (Eds.). (1996). *The world's writing systems*. New York, NY: Oxford University Press.

Daniel, D., & Woody, W. D. (2012). E-textbooks at what cost? Performance and use of electronic v. print texts. *Computers & Education, 62*, 18–23.

DeFrancis, J. (1984). *The Chinese language: Fact and fantasy*. Honolulu: University of Hawaii Press.

DeFrancis, J. (1989). *Visible speech: The diverse oneness of writing systems*. Honolulu, HI: University of Hawaii Press.

Dehaene, S. (2009). *Reading in the brain: The new science of how we read*. New York, NY: Penguin Books.

Dehaene, S., Pegado, F., Braga, L. W., et al. (2010). How learning to read change the cortical networks for vision and language. *Science, 330*, 1359–1364.

Delgado, P., Vargas, C., Ackerman, R., & Salmerón, L. (2018). Don't throw away your printed books: A meta-analysis on the effects of reading media on reading comprehension. *Educational Research Review, 25*, 23–38.

Demattè, P. (2010). The origins of Chinese writing: the neolithic evidence. *Cambridge Archaeological Journal, 20*(02), 211–228.

Deringer, D. (1996). *The alphabet: A key to the history of mankind*. New Delhi, India: Munshiram Manoharlal Publishers.

Desrochers, A., Manolitsis, G., Gaudreau, P., & Georgiou, G. (2018). Early contribution of morphological awareness to literacy skills across languages varying in orthographic consistency. *Reading and Writing: An Interdisciplinary Journal, 31*(8), 1695–1719.

Devitt, M., & Sterelny, K. (1987). *Language and reality: An introduction to the philosophy of langauge*. Oxford: Blackwell.

Diamond, J. (1997). *Guns, germs, and steel: The fates of human societies*. New York, NY: W. W. Norton & Co.

Diamond, J. (1999). *Guns, germs, and steel: The fates of human societies*. New York, NY: W. W. Norton & Company.

Ding, G., Peng, D., & Taft, M. (2004). The nature of the mental representation of radicals in Chinese: A priming study. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*(2), 530–539.

Diringer, D. (1968). *The alphabet : a key to the history of mankind*. New York, NY: Philosophical Library.

Dolscheid, S., Shayan, S., Majid, A., & Casasanto, D. (2013). The thickness of musical pitch: psychophysical evidence for linguistic relativity. *Psychological Science, 24*(5), 613–621.

Duñabeitia, J. A., Orihuela, K., & Carreiras, M. (2014). Orthographic coding in illiterates and literates. *Psychological Science, 25(6)*, 1275–1280.

Ethnologue. (2005). Languages of the world. Retrieved August 15, 2020. https://www.ethnologue.com/

Ethnologue Languages of the World: Summary by Language Size. (n.d.). Retrieved Feburary 15, 2019, from https://www.ethnologue.com/statistics/size.

Eupedia: What languages in Europe have the most or least phonemes? (n.d.). Retrieved February 15, 2019, from https://www.eupedia.com/linguistics/number_of_phonemes_in_european_languages.shtml.

Everett, D. L. (2005). Cultural constraints on grammar and cognition in Pirahã. *Current Anthropology, 46*(4), 621–646.

Federman, M. (2004). *What is the meaning of the medium is the message?* Retrieved October 21, 2019 from http://individual.utoronto.ca/markfederman/MeaningTheMediumistheMessage.pdf.

Feldman, L. B., & Turvey, M. T. (1980). Words written in Kana are named faster than the same words written in Kanji. *Language and Speech, 23*(2), 141–147.

Fernández, E. M., Cairns, H. S. (2010). *Fundamentals of psycholinguistics*. Malden, MA: Wiley-Blackwell.

Fischer, S. R. (2001). *A history of writing*. London: Reaktion Books.

Fishman, J. A. (1982). Whorfianism of the third kind: Ethnolinguistic diversity as a worldwide societal asset (The Whorfian Hypothesis: Varieties of validation, confirmation, and disconfirmation II). *Language in Society, 11(1)*, 1–14.

Frank, M. C., Everett, D. L., Fedorenko, E., & Gibson, E. (2008). Number as a cognitive technology: evidence from Piraha language and cognition. *Cognition, 108*(3), 819–824.

Frellesvig, B. (2010). *A history of the Japanese language*. New York, NY: Cambridge University Press.

Fromkin, V., Rodman, R., & Hyams, N. M. (2007). *An introduction to language* (8th ed.). Boston, MA: Thomson Wadsworth.

Fu, S., Chen, Y., Smith, S., Iversen, S., & Matthews, P. M. (2002). Effects of word form on brain processing of written Chinese. *NeuroImage, 17*(3), 1538–1548.

Gelb, I. J. (1952). *A study of writing*. Chicago, IL: University of Chicago Press.

Gentner, D., & Goldin-Meadow, S. (2003). Whither Whorf. In D. Gentner & S. Goldin-Meadow (Eds.). *Language in mind: Advances in the study of language and thought* (pp. 3–14). Cambridge, MA: MIT Press.

Gennari, S. P., Sloman, S. A., Malt, B. C., & Fitch, T. (2002). Motion events in language and cognition. *Cognition, 83*, 49–79.

Gibson E., Futrell, R., Jara-Ettinger, J., Mahowald, K., Bergen, L., Ratnasingam, S., Gibson, M,, Piantadosi, S. T., & Conway, B. R. (2017). Color naming across languages reflects color use. *PNAS, 114*(40), 10785–10790.

Goody, J. (1987). *The interface between the written and the oral*. New York, NY: Cambridge University Press.

Goody, J., & Watt, I. (1963). The consequences of literacy. *Comparative studies in society and history, 5*, 304–345.

Gopnik, A., & Choi, S. (1990). Do linguistic differences lead to cognitive differences? A crosslinguistic study of semantic and cognitive development. *First Language, 10*, 199–215.

Gopnik, A., & Choi, S. (2016). Do linguistic differences lead to cognitive differences? A cross-linguistic study of semantic and cognitive development. *First Language, 10*(30), 199–215.

Gopnik, A., Choi, S., & Baumberger, T. (1996). Cross-linguistic differences in early semantic and cognitive development. *Cognitive Development, 11*(2), 197–225.

Goswami, U. (2002). Phonology, reading development and dyslexia: A cross-linguistic perspective. *Annals of Dyslexia, 52*, 141–163

Goto, S. G., Ando, Y., Huang, C., Yee, A., & Lewis, R. S. (2010). Cultural differences in the visual processing of meaning: detecting incongruities between background and foreground objects using the N400. *Social Cognitive and Affective Neuroscience, 5*(2–3), 242–253.

Gumperz, J. J., & Levinson, S. C. (Eds.). (1996). *Rethinking linguistic relativity*. Cambridge: Cambridge University Press.

Hacking, I. (2012). Introductory essay. T. S. Kuhn, *The structure of scientific revolutions* (3rd ed.) (pp. vii – xxxvii). Chicago, IL: University of Chicago Press.

Hall, E. T. (1987). *Beyond culture*. New York: Anchor Books.

Hall, E. T., & Hall, M. R. (1987). *Hidden differences : Doing business with the Japanese* (1st ed.). Garden City, NY: Anchor Press/Doubleday.

Hamada, M., & Koda, K. (2008). Influence of first language orthographic experience on second language decoding and word learning. *Language Learning, 58*(1), 1–31.

Hannas, W. C. (1997). *Asia's orthographic dilemma*. Honolulu, HI: University of Hawaii Press.

Hannas, W. C. (2003). *The writing on the wal: How Asian orthography curbs creativity*. Philadelphia, PA: University of Pennsylvania Press.

Harris, R. (2009). Speech and writing. In D. R. Olsen & N. Torrance (Eds.), *The Cambridge handbook of literacy* (pp. 46–58). New York, NY: Cambridge University Press.

Havelock, E. (1976). *Origins of Western literacy*. Ontario, Canada: Ontario Institute for Studies in Education.

Havelock, E. (1986). *The muse learns to write: reflections on orality and literacy from antiquity to the present*. New Haven, CT: Yale University Press.

Higuchi, H., Moriguchi, Y., Murakami, H., Katsunuma, R., Mishima, K., & Uno, A. (2015). Neural basis of hierarchical visual form processing of Japanese Kanji characters. *Brain and Behavior, 5*(12), e00413.

Hill, A. B. (1965). The environment and disease: Association or causation. *Proceedings of the Royal Society of Medicine, 58(5)*, 295–300.

Ho, J., Rashid, J., & Lee, K. M. (2017). Cognitive map or medium materiality? Reading on paper and screen. *Computers in Human Behavior, 67*, 84–94.

Hofstede, G. H. (1980). *Culture's consequences : international differences in work-related values*. Beverly Hills, CA: Sage Publications.

Hofstede, G. H. (2019). The scales of cultural dimension of international countries. Retrieved February 15, 2019, from https://www.hofstede-insights.com/product/compare-countries/

Hofstede, G., Hofstede, G. J. & Minkov, M. (2010) *Cultures and organizations: Software of the mind* (3rd ed.). McGraw-Hill.

Hoosain, R., & Salili, F. (1987). Language differences in pronunciation speed for numbers, digit span, and mathematical ability. *Psychologia: An International Journal of Psychology in the Orient* (Vol. 30).

Horie, S., Yamasaki, T., Okamoto, T., Kan, S., Ogata, K., Miyauchi, S., & Tobimatsu, S. (2012a). Distinct role of spatial frequency in dissociative reading of ideograms and phonograms: an fMRI study. *NeuroImage, 63*(2), 979–988.

Horie, S., Yamasaki, T., Okamoto, T., Nakashima, T., Ogata, K., & Tobimatsu, S. (2012b). Differential roles of spatial frequency on reading processes for ideograms and phonograms: a high-density ERP study. *Neuroscience Research, 72*(1), 68–78.

Householder, F. W. (1969). Review of Langacker: Language and its structure. *Language, 45*, 886–897.

Huang, H. S., & Henley, J. R. (1995). Phonological awareness and visual skills in learning to read Chinese and English. *Cognition, 54*(1), 73–98.

Huang, K., Itoh, K., Kwee, I. L., & Nakada, T. (2012). Neural strategies for reading Japanese and Chinese sentences: a cross-linguistic fMRI study of character-decoding and morphosyntax. *Neuropsychologia, 50*(11), 2598–2604.

Hunt, E., & Agnoli, F. (1991). The Whorfian hypothesis: A cognitive psychology perspective. *Psychological Review, 98(3)*, 377–389.

Huntington, S. P. (1996). *The clash of civilizations and the remaking of world order*. Haryana, India: Penguin Random House India.

Huntington, S. P. (2016). *The clash of civilizations and the remaking of world order*. Haryana, India: Penguin Random House India.

Igarashi, Y. (2007). *The changing role of katakana in the Japanese writing system: Processing and pedagogical dimensions for native speakers and foreign learners*. (Unpublished doctoral dissertation). University of Victoria, British Columbia, Canada.

Ino, T., Nakai, R., Azuma, T., Kimura, T., & Fukuyama, H. (2009). Recognition and reading aloud of kana and kanji word: an fMRI study. *Brain Research Bulletin, 78*(4–5), 232–239.

Innis, H. (1972). *Empire and communication* (2nd ed.). Toronto: University of Toronto Press.

Ischebeck, A., Indefrey, P., Usui, N., Nose, I., Hellwig, F., & Taira, M. (2004). Reading in a regular orthography: an FMRI study investigating the role of visual familiarity. *Journal of Cognitive Neuroscience, 16*(5), 727–741.

January, D., & Kako, E. (2007). Re-evaluating evidence for linguistic relativity: reply to Boroditsky (2001). *Cognition, 104*(2), 417–426.

Jarvis, S., & Pavlenko, A. (2007). *Crosslinguistic influence in language and cognition*. New York, NY: Routledge.

Ji, L. J., Peng, K., & Nisbett, R. E. (2000). Culture, control, and perception of relationships in the environment. *Journal of Personality and Social Psychology, 78*(5), 943–955.

Ji, L. J., Zhang, Z., & Nisbett, R. E. (2004). Is it culture or is it language? Examination of language effects in cross-cultural research on categorization. *Journal of Personality and Social Psychology, 87*(1), 57–65.

Jiang, N., & Pae, H. K. (Forthcoming). The role of phonology in L2 visual word recognition. In P. Booth & J. Clenton (Eds.). *First* langu*age backgrounds and multilingual lexicons*. New York, NY: Routledge.

Joyce, T. (2016). Writing systems and scripts. In A. Rocci & L. d. Saussure (Eds.), *Verbal communication (Handbooks of Communication Science 3*) (pp. 287–308). Boston, MA: De Gruyter Mouton.

Joyce, T., & Masuda, H. (2018). Introduction to the multi-script Japanese writing system and word processing. In H. K. Pae (Ed.), *Writing systems, reading processes, and cross-linguistic influences: Reflections from the Chinese, Japanese and Korean languages* (pp. 179–199). Amsterdam: John Benjamins.

Kaplan, R. B. (1966). Cultural thought patterns in inter-cultural education. *Language Learning, 16*(1–2), 1–20.

Kaplan, R. B. (1983). Contrastive rhetorics: Some implications for the writing process. In A. Freedman, I. Pringle & J. Yalden (Eds.), *Learning to write?: First language/second language* (pp. 139–161). New York, NY: Routledge.

Karlgren, B. (1923). *Sound and symbol in Chinese*. London: Oxford University Press (also Hong Kong University Press, 1962).

Kay, P., & Kempton, W. (1984). What is the Sapir-Whorf Hypothesis? *American Anthropologist, 86*(1), 65–79.

Kay, P., & Regier, T. (2006). Language, thought and color: recent developments. *Trends in Cognitive Sciences, 10*(2), 51–54.

Kettunen, H., & Helmke, C. (2006). *Introduction to Maya Hieroglyphs*. Retrieved June 1, 2019. https://www.wayeb.org/download/resources/wh2006english.pdf

Khosroshahi, F. (1989). Penguins don't care, but women do: A social identity analysis of a Whorfian problem. *Language in Society, 18*(4), 505–525.

Kim, K. H. (1993). *A discourse on the Korean lexicon*. Seoul, South Korea: Jibmoondang.

Kim, Y.-S. (2008). Cat in a hat or cat in a cap? An investigation of developmental trajectories of phonological awareness for Korean children. *Journal of Research in Reading*, *31*, 359–378.

Kim, Y.-S. (2011). Considering linguistic and orthographic features in early literacy acquisition: Evidence from Korean. *Contemporary Educational Psychology 36(3)*, 177–189.

Kim, S. Y., & Wang, M. (2014). The time-course of cross-language morphological activation in Korean-English bilinguals: Evidence from a masked priming experiment. *Language Research, 50*, 59–75.

Kim, S. Y., & Wang, M. (2018). Neural mechanisms of reading in Korean L1 and related L2 reading. In H. K. Pae (Ed.), *Writing systems, reading processes, and cross-linguistic influences: Reflections from the Chinese, Japanese and Korean languages* (pp. 411–426). Amsterdam, Netherlands: John Benjamins.

Kim, S. Y., Wang, M., & Ko, I. Y. (2011). The processing of derived words in Korean-English bilingual readers. *Bilingualism: Language and Cognition, 14*, 473–488.

Kim, S. Y., Liu, L., & Cao, F. (2017). How does first langauge (L1) influence second language (L2) reading in the brain? Evidence from Korean-English and Chinese-English bilinguals. *Brain & Language, 171*, 1–13.

Kim, K. S. H., Relkin, N. R., Lee, K. M., & Hirsch, J. (1997). Distinct cortical areas associated with native and second languages. *Nature, 388*(6638), 171–174.

Kim, N., Kim, J., Kang, C. K., Park, C. A., Lim, M. R., Kim, Y. B., & Bak, B. G. (2017). Human brain mapping of visual script familiarity between phonological and logographic language: 3 T Functional MRI study. *BioMed Research International, 2017*, 5732642.

Kim, S. Y., Qi, T., Feng, X., Ding, G., Liu, L., & Cao, F. (2016). How does language distance between L1 and L2 affect the L2 brain network? An fMRI study of Korean-Chinese-English trilinguals. *NeuroImage, 129*, 25–39.

Klein, E., Bahnmueller, J., Mann, A., Pixner, S., Kaufmann, L., Nuerk, H.-C., & Moeller, K. (2013). Language influences on numerical development—Inversion effects on multi-digit number processing. *Frontiers in Psychology, 4*, 480.

Ko, I-Y, Wang, M., & Kim, S-Y. (2011). Bilingual reading of compound words. *Journal of Psycholinguistic Research,* 40, 49–73.

Koerner, E.F. K. (1992). The Sapir-Whorf hypothesis: A preliminary history and a bibliographical essay. *Journal of Linguistic Anthropology, 2(2)*, 173–198.

Koh, P. W., Xi, C., & Gottardo, A. (2018). How do phonological awareness, morphological awareness, and vocabulary knowledge relate to word reading within and between English and Chinese? In H. K. Pae (Ed). *Writing systems, reading processes, and cross-linguistic influences: Reflections from the Chinese, Japanese and Korean languages* (pp. 73–98). Amsterdam: John Benjamins.

Kong, Y., Seo, Y. S., & Zai, L. (2018). Comparison of reading performance on screen and on paper: A meta-analysis. *Computers & Education, 123*, 138–149.
Koster, D., & Cadierno, T. (2018). Is perception of placement universal? A mixed methods perspective on linguistic relativity. *Lingua, 207*, 23–37.
Koyama, M. S., Hansen, P. C., & Stein, J. F. (2008). Logographic Kanji versus phonographic Kana in literacy acquisition: how important are visual and phonological skills? *Annals of the New York Academy of Sciences,* 1145(1), 41–55.
Koyama, S., Kakigi, R., Hoshiyama, M., & Kitamura, Y. (1998). Reading of Japanese Kanji (morphograms) and Kana (syllabograms): a magnetoencephalographic study. *Neuropsychologia, 36*(1), 83–98.
Krafnick, A. J., Tan, L. H., Flowers, D. L., Luetje, M. M., Napoliello, E. M., Siok, W. T., . . . Eden, G. F. (2016). Chinese character and English word processing in children's ventral occipitotemporal cortex: fMRI evidence for script invariance. *NeuroImage, 133*, 302–312.
Kubota, R., & Lehner, A. (2004). Toward critical contrastive rhetoric. *Journal of Second Language Writing, 13*(1), 7–27.
Kuhn, T. S. (2012). *The structure of scientific revolutions with an introductory essay by Ian Hacking*. Chicago, IL: University of Chicago Press.
Kuo, L., & Anderson, R. C. (2006). Morphological awareness and learning to read: A cross-language perspective. *Educational Psychologist, 41,* 161–180.
Kwon, M., Kim, J. S., Lee, J. H., Sim, H., Nam, K., & Park, H. (2005). Double dissociation of Hangul and Hanja reading in Korean patients with stroke. *European Neurology, 54*(4), 199–203.
Lakoff, G. (1987). *Women, fire, and dangerous things : what categories reveal about the mind*. Chicago, IL: University of Chicago Press.
Lao Tzu: Tao Te Ching. (n.d.). Retrieved from http://www.bopsecrets.org/gateway/passages/tao-te-ching.htm
Lebel, C., Shaywitz, B., Holahan, J., Shaywitz, S., Marchione, K., & Beaulieu, C. (2013). Diffusion tensor imaging correlates of reading ability in dysfluent and non-impaired readers. *Brain and Language, 125*(2), 215–222.
Lee, P. (1991). Whorf's Hopi tensors: Subtle articulators in the language/thought nexus? *Cognitive Linguistics, 2*(2), 123–148.
Lee, K. M. (2004). Functional MRI comparison between reading ideographic and phonographic scripts of one language. *Brain and Language, 91*(2), 245–251.
Lee, P. (1997). Language in thinking and learning: Pedagogy and the new Whorfian framework. *Harvard Educational Review, 67(3),* 430–471.
Lee, S. (2015). Old Korean writing on wooden tablets and its implications for old Japanese writing. *Seoul Journal of Korean Studies, 27*(2), 151–185.
Lemire, B., & Riello, G. (2008). East & West: Textiles and fashion in early modern Europe. *Journal of Social History, 41*(4), 887–916.
Lenneberg, E. H. (1967). *Biological foundations of language*. New York, NY: Wiley.
Leong, C. K. (1997). Paradigmatic analysis of Chinese word reading: Research findings and classroom practices. In *Cross-language studies of learning to read and spell* (pp. 379–417). Dordrecht: Springer.
Levinson, S. C. (2003). Language and mind: Let's get the issues straight! In D. Gentner & S. Goldin-Meadow (Eds.), *Language in mind: Advances in the study of language and thought* (pp. 25–46). Cambridge, MA: MIT Press.
Li, C. N., & Thompson, S. A. (1976). *Subject and topic: A new typology of language* (pp. 457). Cambridge, MA: Academic Press.
Li, G., Cheung, R. T. F., Gao, J. H., Lee, T. M. C., Tan, L. H., Fox, P. T., Jack, C. R., & Yang, E. S. (2006). Cognitive processing in Chinese literate and illiterate subjects: An fMRI study. *Human Brain Mapping, 27*, 144–152.
Li, Q. L., Bi, H. Y., & Zhang, J. X. (2010). Neural correlates of the orthographic neighborhood size effect in Chinese. *The European Journal of Neuroscience, 32*(5), 866–872.

Li, S., Lee, K., Zhao, J., Yang, Z., He, S., & Weng, X. (2013). Neural competition as a developmental process: Early hemispheric specialization for word processing delays specialization for face processing. *Neuropsychologia, 51*(5), 950–959.

Li, L., Li, S., Xie, F., Chang, M., McGowan, V. A., Wang, J., & Paterson, K. B. (2019). Establishing a role for the visual complexity of linguistic stimuli in age-related reading difficulty:Evidence from eye movements during Chinese reading. *Attention, Perception, & Psychophysics, 81*(8), 2626–2634.

Lin, C.-H., & Collins, P. (2012). The effects of L1 and orthographic regularity and consistency in naming Chinese characters. *Reading and Writing: An Interdisciplinary Journal, 25*(7), 1747–1767.

Lin, N., Yu, X., Zhao, Y., & Zhang, M. (2016). Functional anatomy of recognition of Chinese multi-character words: Convergent evidence from effects of transposable nonwords, lexicality, and word frequency. *PLoS ONE, 11*(2), e0149583.

Lin, Y. C., Wang, M., & Singh, A. (2018). Introductio to script processing in Chinese and cognitive consequences for bilingual reading. In H. K. Pae (Ed.), *Writing systems, reading processes, and cross-linguistic influences* (pp. 25–47). Amsterdam, Netherlands: John Benjamins.

Linell, P. (2005). *The written language bias in linguistics: Its nature, origins and transformations*. New York, NY: Routledge.

Liu, P. D., & McBride-Chang, C. (2010). What is morphological awareness? Tapping lexical compounding awareness in Chinese third graders. *Journal of Educational Psychology, 102*(1), 62–73.

Liu Y., Shu, H., & Xuan, Y. (2002). Developmental research on sublexical processing in Chinese character recognition. *Applied Psychology, 8*, 3–7. (in Chinese).

Liu, P. D., McBride-Chang, C., Wong, T. T. Y., Shu, H. U. A., & Wong, A. M. Y. (2013). Morphological awareness in Chinese: Unique associations of homophone awareness and lexical compounding to word reading and vocabulary knowledge in Chinese children. *Applied Psycholinguistics, 34*(04), 755–775.

Liu, Y., & Perfetti, C. A. (2003). The time course of brain activity in reading English and Chinese: an ERP study of Chinese bilinguals. *Human Brain Mapping, 18*(3), 167–175.

Liu, Y., Dunlap, S., Fiez, J., Perfetti, C.A., 2007. Evidence for neural accommodation to a writing system following learning. *Human Brain Mapping. 28*, 1223–1234.

Logan, R. K. (2004). *The alphabet effect:a media ecology understanding of the making of Western civilization*. Cresskill, NJ: Hampton Press.

Lovgren, S. (2005). Chimps, humans 96 percent the same, gene study finds. Retrieved April, 21, 2019, from https://news.nationalgeographic.com/news/2005/08/chimps-humans-96-percent-the-same-gene-study-finds/

Lu, W., & Aiken, M. (2004). Origins and evolution of Chinese writing systems and preliminary counting relationships. *Accounting History, 9*(3), 25–51.

Lu, A., Hodges, B. H., Zhang, J., & Wang, X. (2012). A Whorfian speed bump? Effects of Chinese color names on recognition across hemispheres. *Language Sciences, 34*(5), 591–603.

Lucy, J. A. (1992). *Language diversity and thought*. New York, NY: Cambridge University Press.

Lucy, J. A. (1997). Linguistic relativity. *Annual Review of Anthropology, 26(1)*, 291–312.

Lucy, J. A. (2016). Recent advances in the study of linguistic relativity in historical context: A critical assessment. *Language Learning, 66(3)*, 487–515.

Luo, Y. C., Chen, X., & Geva, E. (2014). Concurrent and longitudinal cross-linguistic transfer of phonological awareness and morphological awareness in Chinese-English bilingual children. *Written Language and Literacy, 17*(1), 89.

Ma, F., Ai, H., & Guo, T. (2018). Sematic and lexical processing of words across two languages in Chinese-English bilinguals. In H. K. Pae (Ed). *Writing systems, reading processes, and cross-linguistic influences: Reflections from the Chinese, Japanese and Korean languages* (pp. 163–175). Amsterdam: John Benjamins.

Majid, A., Bowerman, M., Kita, S., Haun, D. B. M., & Levinson, S. C. (2004). Can language restructure cognition? The case for space. *Trends in Cognitive Sciences, 8*(3), 108–114.

Malotki, E. (1983). *Hopi time: A linguistic analysis of temporal concepts in the Hopi language*. Berlin: Mouton.

Man, J. (2000). *Alpha beta: How 26 letters shaped the western world*. New York, NY: John Wiley & Sons.

Martelli M., Majaj, N. J., & Pelli, D. G. (2005). Are faces processed like words? A diagnostic test for recognition by parts. *Journal of Vision, 5*, 58–70.

Masuda, T. (2017). Culture and attention: Recent empirical findings and new directions in cultural psychology. *Social and Personality Psychology Compass, 11*(12), e12363.

Masuda, T., & Nisbett, R. E. (2001). Attending holistically vs. analytically: Comparing the contex sensitivity of Japanese and Americans. *Journal of Persoanlity and Social Psychology, 81*, 922–934.

Masuda, T., & Nisbett, R. E. (2006). Culture and change blindness. *Cognitive Science, 30*, 381–399.

Masuda, T., Russell, M. J., Chen, Y. Y., Hioki, K., & Caplan, J. B. (2014). N400 incongruity effect in an episodic memory task reveals different strategies for handling irrelevant contextual information for Japanese than European Canadians. *Cognitive Neuroscience, 5*, 17–25.

Matsumoto, K. (2013). Kanji recognition by second language learners: Exploring effects of first language writing systems and second language exposure. *The Modern Language Journal, 97*(1), 161–177.

Mattingly, I. G. (1972). Reading, the linguistic process, and linguistic awareness. In J. F. Kavanaugh & I. G. Mattingly (Eds.), *Language by ear and by eye* (pp. 23–34). Cambridge, MA: MIT Press.

Matute, E., Montiel, T., Pinto, N., Rosselli, M., Ardila, A., & Zarabozo, D. (2012). Comparing cognitive performance in illiterate and literate children. *International Review of Education, 58*, 109–127.

Mayes, D. K., Sims, V. K., & Koonce, J. M. (2001). Comprehension and workload differences for VDT and paper-based reading. *International Journal of Industrial Ergonomics, 28(6*), 367–378.

McBride-Chang, C., & Kail, R. V. (2002). Cross-cultural similarities in the predictors of reading acquisition. *Child Development, 73*(5), 1392–1407.

McBride-Chang, C., & Suk-Han Ho, C. (2005). Predictors of beginning reading in Chinese and English: A 2-year longitudinal study of Chinese kindergartners. *Scientific Studies of Reading, 9*(2), 117–144.

McBride-Chang, C., Bialystok, E., Chong, K. K., & Li, Y. (2004). Levels of phonological awareness in three cultures. *Journal of Experimental Child Psychology, 89*(2), 93–111.

McBride-Chang, C., Cho, J.-R.., Liu, H., Wagner, R. K., Shu, H., Zhou, A., Cheuk, C S.-M., & Muse, A. (2005). Changing models across cultures: Associations of phonological awareness and morphological structure awareness with vocabulary and word recognition in second graders from Beijing, Hong Kong, Korea, and the United States. *Journal of Experimental Child Psychology, 92*, 140–160.

McBride-Chang, C., Zhou, Y., Cho, J.-R., Aram, D., Levin, I., & Tolchinsky, L. (2011). Visual spatial skill: A consequence of learning to read? *Journal of Experimental Child Psychology, 109*, 256–262.

McLuhan, M. (1964). *Understanding media : the extensions of man* (1st ed.). New York, NY: McGraw-Hill.

McLuhan, M., & Logan, R. K. (1977). Alphabet, mother of invention. *ETC.: A Review of General Semantics, 34*, 373–83.

Mei, L., Xue, G., Lu, Z. L., He, Q., Zhang, M., Xue, F., Chen, C., & Dong, Q. (2013). Orthographic transparency modulates the functional asymmetry in the fusiform cortex: an artificial language training study. *Brain and Language, 125*(2), 165–172.

Mengen, A., Walgermo, B. R. & Brønnick, K. (2013). Reading linear texts on paper versus computer screen: Effects on reading comprehension. *International Journal of Educational Research, 58*, 61–68.

Miller, K. F., Smith, C. M., Zhu, J., & Zhang, H. (1995). Preschool origins of cross-national differences in mathematical competence: The role of number-naming systems. *Psychological Science, 6*(1), 56–60.

Ministry of Education of the People's Republic of China. (2011). Chinese Curriculum Standards for Compulsory Education. Beijing, China: Beijing Normal University Press. 中华人民共和国教育部 (2011). 义务教育语文课程标准. 中国, 北京:北京师范大学出版社.

Ministry of Education of the People's Republic of China. (2013). 通用规范汉字表 (Table of General Standard Chinese Characters). June 18, 2013. Retrieved August 15, 2020. http://www.gov.cn/gzdt/att/att/site1/20130819/tygfhzb.pdf

Miura, I. T., Kim, C. C., Chang, C.-M., & Okamoto, Y. (1988). Effects of language characteristics on children's cognitive representation of number: Cross-national comparisons. *Child Development, 59*(6), 1445–1450.

Miura, I. T., Okamoto, Y., Kim, C. C., Chang, C.-M., Steere, M., & Fayol, M. (1994). Comparisons of children's cognitive representation of number: China, France, Japan, Korea, Sweden, and the United States. *International Journal of Behavioral Development, 17*(3), 401–411.

Miyamoto, Y., Nisbett, R. E., & Masuda, T. (2006). Culture and the physical environment. Holistic versus analytic perceptual affordances. *Psychological Science, 17*(2), 113–119.

Miyazaki, I. (1963/1981). (Translated from Japanese by Conrad Schirokauer). China's examination hell: The civil service examinations of imperial China. New Haven: Yale University.

Mizuno, R., & Matsui, T. (2013). Orthographic or nhonological?: Exploration of predominant information for native Japanese readers in the lexical access of Kanji words. *Psychologia, 56*(3), 208–221.

Montemayor, C. (2019). Early and late time perception: On the narrow scope of the Whorfian hypothesis. *Review of Philosophy and Psychology, 10*, 133–154.

Mori, Y. (1998). Effects of first language and phonological accessibility on Kanji recognition. *The Modern Language Journal, 82*(1), 69–82.

Mori, Y. (2003). The roles of context and word morphology in learning new Kanji words. *The Modern Language Journal, 87*(3), 404–420.

Nakamura, K., Dehaene, S., Jobert, A., Le Bihan, D., & Kouider, S. (2005). Subliminal convergence of Kanji and Kana words: further evidence for functional parcellation of the posterior temporal cortex in visual word perception. *Journal of Cognitive Neuroscience, 17*(6), 954–968.

National Center for Education Statistics. (2020). Students with reading disabilities. Retrieved August 15, 2020. https://nces.ed.gov/programs/coe/indicator_cgg.asp

National Chinese Curriculum for Public Elementary Schools. (2000). *Year 2000 Teaching Scheme (Curriculum) for Full-time Primary Schools Chinese Language (Trial)*. People's Publication Press. https://old.pep.com.cn/xiaoyu/jiaoshi/tbjx/kbjd/jxdg/201008/t20100818_663520.htm. (In Chinese)

National Reading Panel (2000). Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction. Retrieved February 15, 2019, from https://www.nichd.nih.gov/publications/pubs/nrp/smallbook

National Reading Panel. (2002). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction*. Retrieved August 15, 2020. https://www.nichd.nih.gov/sites/default/files/publications/pubs/nrp/Documents/report.pdf

Nelson, J.R., Liu, Y., Fiez, J., Perfetti, C.A., 2009. Assimilation and accommodation patterns in ventral occipitotemporal cortex in learning a second writing system. *Human Brain Mapping. 30*, 810–820.

Ng, S. S. N., & Rao, N. (2010). Chinese number words, culture, and mathematics learning. *Review of Educational Research, 80*(2), 180–206.

Nielsen (2013). Top U.S. entertainment sites and web brands. Retrieved April 21, 2019, from https://www.nielsen.com/us/en/insights/news/2013/january-2013%2D%2Dtop-u-s%2D%2Dentertainment-sites-and-web-brands.html

Nisbett, R. E. (2003). *The geography of thought : how Asians and Westerners think differently--and why*. New York, NY: Free Press.

Nisbett, R. E., & Masuda, T. (2003). Culture and point of view. *Proceedings of the National Academy of Science, 100*, 11163–11175.

Nisbett, R. E., & Miyamoto, Y. (2005). The influence of culture: holistic versus analytic perception. *Trends in Cognitive Sciences, 9*(10), 467–473.

Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: holistic versus analytic cognition. *Psychological Review, 108*(2), 291–310.

Noves, J. M., & Garland, K. J. (2003). VDT versus paper-based text: reply to Mayes, Sims and Koonce. *International Journal of Industrial Ergonomics, 31(6)*, 411–43.

Odlin, T. (2005). Crosslinguistic influence and conceptual transfer: What are the concepts? *Annual Review of Applied Linguistics,25,* 3–25.

Olson, D. (1977). From utterance to text: The bias of language in speech and writing. *Harvard Educational Review, 47*(3), 257–281.

Olulade, O. A., Flowers, D. L., Napoliello, E. M., & Eden, G. F. (2013). Developmental differences for word processing in the ventral stream. *Brain and Language, 125*(2), 134–145.

Ong, W. (1982). *Orality and literacy: The technologizing of the word*. New York, NY: Methuen.

Ong, W. (1986). Writing is a technology that restructures thought. In G. Baumann (Ed.), *The written word: Literacy in transition* (pp. 23–50). New York, NY: Clarendon Press.

Ornstein, R. (1997). *The right mind: Making sense of the hemispheres*. Orlando, FL: Houghton Mifflin Harcourt.

Özgen, E., & Davies, I. R. (2002). Acquisition of categorical color perception: A perceptual learning approach to the linguistic relativity hypothesis. *Journal of Experimental Psychology: General, 131*, 477–493.

Pae, H. K. (2011). Is Korean a syllabic alphabet or an alphabetic syllabary? *Writing Systems Research, 3(2)*, 103–115.

Pae, H. K. (2018). The Korean writing system, Hangul, and word processing. In H. K. Pae (Ed.), *Writing systems, reading processes, and cross-linguistic influences: Reflections from the Chinese, Japanese and Korean languages* (pp. 335–352). Amsterdam: John Benjamins.

Pae, H. K., Kwon, Y-J., & Lee, Y-W (2015). The resolution of visual noise in word recognition. *Journal of Psycholinguistic Research, 44(3), 337–358.*

Pae, H. K., Bae, S. & Yi, K. (2019). Is the consonant primacy script-universal or script-specific? Evidence from non-Roman script Korean Hangul. *Reading and Writing: An Interdisciplinary Journal, 31*, 1085–1106

Pae, H. K., Kim, S-A., Mano, Q. R., & Wang, M. (2019). Another look at the role of vowel letters in word reading in L2 English among native Korean readers. *Journal of Neurolinguistics, 50*, 82–93.

Pae, H. K., Kim, S-A., Mano, T., & Kwon, Y-J. (2017). Sublexical and lexical processing of English orthography among nonnative speakers of Chinese and Korean. *Reading and Writing: An Interdisciplinary Journal, 30*, 1–24

Pae, H. K., Sevcik, R. A., & Morris, R. D. (2010). Cross-language correlates in phonological process and naming speed: Evidence from deep and shallow orthographies. *The Journal of Research in Reading, 33(4),* 335–436.

Pae, H. K., Sevcik, R., & Morris, R. D. (2004) Cross-language links between English and Korean in the second-language reading acquisition, *Journal of Multilingual Communication Disorders, 2(1),* 68–79.

Pae, H. K., Bae, S., & Yi, K. (2020). More than an alphabet: Linguistic features of Korean and their influences on word recognition of Hangul. *Literacy and Written Languages, 22*, 223–246.

Sun, J., Luo, X., & Pae, H. K. (2020). Culture and spoken narratives: Similarities and differences in describing pictures among native speakers of Chinese, Korean, and English. [working paper]

Pasquarella, A., Chen, X., Lam, K., Luo, Y. C., & Ramirez, G. (2011). Cross-language transfer of morphological awareness in Chinese-English bilinguals. *Journal of Research in Reading, 34*(1), 23–42.

Pavlenko, A. (1999). New approaches to concepts in bilingual memory. *Bilingualism: Language and Cognition, 2*, 209–230.
Pederson, E., Danziger, E., Wilkins, D., Levinson, S., Kita, S., & Senft, G. (1998). Semantic typology and spatial conceptualization. *Language, 74*(3), 557–589.
Pegado, F., Nakamura, K., Braga, L. W., Ventura, P., Filho, G. N., Pallier, C., Jobert, A., Morais, J., Cohen, L., Kolinsky, R., & Dehaene, S. (2014). Literacy breaks mirror invariance for visual stimuli: A behavioral study with adult illiterates. *Journal of Experimental Psychology: General, 143(2)*, 887–894.
Peng, K., Nisbett, R. E., & Wong, N. (1997). Validity problems comparing values across cultures and possible solutions. *Psychological Methods, 2(4)*, 329–344.
Perfetti, C. A. (2003). The Universal grammar of reading. *Scientific Studies of Reading, 7*(1), 3–24.
Perfetti, C. A., & Liu, Y. (2005). Orthography to phonology and meaning: Comparisons across and within writing systems. *Reading and Writing, 18*(3), 193–210.
Perfetti, C. A., Cao, F., & Booth, J. (2013). Specialization and universals in the development of reading skill: How Chinese research informs a universal science of reading. *Scientific Studies of Reading, 17*, 5–21.
Perfetti, C. A., Liu, Y., & Tan, L. H. (2005). The lexical constituency model: some implications of research on Chinese for general theories of reading. *Psychological Review, 112*(1), 43–59.
Perfetti, C. A., Liu, Y., Fiez, J., Nelson, J., Bolger, D. J.., & Tan, L-H. (2007). Reading in two writing systems: Accommodation and assimilation of the brain's reading network. *Bilingualism: Language and Cognition, 10*, 131–146.
Pernice, K. (2017). F-shaped pattern of reading on the web: Misunderstood, but still relevant (even on mobile). Retrieved April 21, 2019, from https://www.nngroup.com/articles/f-shaped-pattern-reading-web-content/
Perszyk, D. R., & Waxman, S. R. (2018). Linking language and cognition in infancy. *Annual Review of Psychology, 69*, 231–250.
Petersson, K. M., Reis, A., Askelö, S., Castro-Caldas, A., & Ingvar, M. (2000). Language processing modulated by literacy: A network analysis of verbal repetition in literate and illiterate subjects. *Journal of Cognitive Neuroscience, 12*, 364–382.
Petersson, K. M., Reis, Al., & Ingvar, M. (2001). Cognitive processing in literate and illiterate subjects: A review of some recent behavioral and functional neuroimaging data. *Scandinavian Journal of Psychology, 42*, 251–267.
Pew Research Center (2019). About a quarter of U.S. adults say they are 'almost constantly' online. Retrieved April 15, 2019, from https://www.pewresearch.org/fact-tank/2018/03/14/about-a-quarter-of-americans-report-going-online-almost-constantly/ft_18-03-15_constantusers_roughlythree/
Pinker, S. (1994). *The language instinct: How the mind creates language*. New York, NY: HarperCollins.
Pinker, S. (2007). *The stuff of thought: Language as a window into human nature*. New York, NY: Penguin.
PISA. (2018). Programme for International Student Assessment. Retrieved December 30, 2018. https://www.oecd.org/pisa/test/
Pollatsek, A., Bolozky, S., Well, A. D., & Rayner, K. (1981). Asymmetries in the perceptual span for Israeli readers. *Brain and Language, 14*(1), 174–180.
Porion, A., Aparicio, X., Megalakaki, O., Robert, A., & Baccino, T. (2016). The impact of paper-based versus computerized presentation on text comprehension and memorization. *Computers in Human Behavior, 54*, 569–576.
Potter, M. C., Wyble, B., Hagmann, C. E., & McCourt, E. S. (2014). Detecting meaning in RSVP at 13 ms per picture. *Attention, Perception, and Psychophysics, 76,* 270–279.
Powell, M. A. (1981). Three problems in the history of Cuneiform writing: origins, direction of script, and literacy. *Visible Language, 15*, 419–440.
Price, C. J., & Devlin, J. T. (2011). The interactive account of ventral occipitotemporal contributions to reading. *Trends in Cognitive Sciences, 15*(6), 246–253.

Pugh, K. R., Mencl, W. E., Jenner, A. R., Katz, L., Frost, S. J., Lee, J. R., Shaywitz, S. E., & Shaywitz, B. A. (2000). Functional neuroimaging studies of reading and reading disability (developmental dyslexia). *Mental Retardation and Developmental Disabilities Research Reviews, 6*(3), 207–213.

Qiu, F. T., & von der Heydt, R. (2005). Figure and ground in the visual cortex: V2 combines stereoscopic cues with gestalt rules. *Neuron, 47*, 155–166.

Reischauer, E. O., & Fairbank, J. K. (1969). *East Asia: The great tradition*. Boston: Houghton Mifflin.

Roberson, D., Davidoff, J., Davies, I. R., & Shapiro, L. R. (2005). Color categories: evidence for the cultural relativity hypothesis. *Cognitive Psychology, 50*(4), 378–411.

Roberson, D., Davies, I., & Davidoff, J. (2000). Color categories are not universal: Replications and new evidence from a stone-age culture. *Journal of Experimental Psychology: General, 129*(3), 369–398.

Robertson, D. (2016). Variability in the use of the English article system by Chinese learners of English. *Second Language Research, 16*(2), 135–172.

Sacks, D. (2003). *Language visible: Unraveling the mystery of the alphabet from A to Z* (1st ed.). New York, NY: Broadway Books.

Saiga, H. (1971). Toyo knajihyo no mondaiten. In M. Kenji (Ed.), *Tadashii nihongo* (Vol. 3). Tokyo, Japan.

Sato, E. (2018). Sociocultural implications of the Japanese multi-scripts: Tranlanguing in translation. In H. K. Pae (Ed.). *Writing systems, reading processes, and cross-linguistic influences: Reflections from the Chinese, Japanese, and Korean languages* (pp. 313–332). Amsterdam: John Benjamins.

Sakuma, N., Sasanuma, S., Tatsumi, I. F., & Masaki, S. (1998). Orthography and phonology in reading Japanese kanji words: evidence from the semantic decision task with homophones. *Memory and Cognition, 26*(1), 75–87.

Sakurai, Y., Momose, T., Iwata, M., Sudo, Y., Ohtomo, K., & Kanazawa, I. (2000). Different cortical activity in reading of Kanji words, Kana words and Kana nonwords. *Cognitive Brain Research, 9*(1), 111–115.

Sampson, G. (2015). *Writing systems* (2nd ed.). Bristol, CT: Equinox.

Schanding, B., & Pae, H. K. (2018). Shell noun use in English argumentative essays by native speakers of Japanese, Turkish, and English. *International Journal of Learner Corpus Research, 4*(1), 54–81.

Schatschneider, C., Fletcher, J. M., Francis, D. J., Carlson, C. D., & Foorman, B. R. (2004). Kindergarten prediction of reading skills: A longitudinal comparative analysis. *Journal of Educational Psychology, 96*(2), 265–282.

Schwanenflugel, P. J., Blount, B. G., & Lin, P-J. (1991). Cross-cultural aspects of word meanings. In P.J. Schwanenflugel (Ed.), *The psychology of word meanings* (pp. 71–90). Hillsdale, NJ: Erlbaum.

Shlain, L. (1998). *The alphabet versus the goddess: the conflict between word and image*. New York, NY: Penguin/Arkana.

Shu, H., & Wu, N. (2006). Growth of orthography-phonology knowledge in the Chinese writing system. In P. Li, L. H. Tan, E. Bates, & O. J. L. Tzeng (Eds.), *The handbook of East Asian psycholinguistics* (Vol. 1, pp. 103–113). New York, NY: Cambridge University Press.

Shu, H., Anderson, R. C., & Wu, N. (2000). Phonetic awareness: Knowledge of orthography-phonology relationships in the character acquisition of Chinese children. *Journal of Educational Psychology, 92*(1), 56–62.

Shu, H., Peng, H., & McBride-Chang, C. (2008). Phonological awareness in young Chinese children. *Developmental Science, 11*(1), 171–181. doi:https://doi.org/10.1111/j.1467-7687.2007.00654.x

Singer, L. M., & Alexander, P. A. (2017). Reading on paper and digitally: What the past decades of empirical research reveal. *Review of Educational Research, 87(6),* 1007–1041,

Siqi, D. (2018). Chinese characters and the spirit of place in China. *Technoetic Arts, 16*(1), 99–111.

Siruk, M. (April 23, 2015). On the three factors of "the miracle on the Han river." Retrieved on September 1, 2019. https://day.kyiv.ua/en/article/economy/three-factors-miracle-han-river.

Slobin, D.I. (1996). From "thought and language" to "thinking for speaking." In J. J. Gumperz & S. C. Levinson (Eds.), *Rethinking linguistic relativity* (pp. 70–96). New York, NY: Cambridge University Press.

Smith, B. (1988). Gestalt theory: An essay in philosophy. In B. Smith (ed.). *Foundations of gestalt theory* (pp. 11–81). Vienna: Philosophia Verlag: Philosophia Resources Library.

Sontag, S. (1977). *On photography*. London: Penguin Books.

Statistics Korea. (2016). Retrieved June 1, 2019. http://kostat.go.kr/wnsearch/search.jsp

Stroop, J. R. (1935). Studies of interference in serial verbal interactions. *Journal of Experimental Psychology. 18(6),* 643–662.

Sproat, R. (2010). *Language, technology, and society*. Oxford: Oxford University Press.

Sun, J. (2020). *The teeter-totter in reading Chinese coordinative compound words: A multi- sage investigation on word recognition by native readers of Chinese and learners of Chinese as a second language (unpublished doctoral dissertation)*. Cincinnati: University of Cincinnati.

Sun, J., Zhao, W., & Pae, H. K. (2020). Inter-character orthographic similarity effects on the recognition of Chinese coordinative compound words. *Journal of Psycholinguistic Research, 49*, 125–145.

Szwed, M., Cohen, L., Qiao, E., & Dehaene, S. (2009). The role of invariant line junctions in object and visual word recognition. *Vision Research, 49(7*), 718–725.

Tamaoka, K., & Kiyama, S. (2013). The effects of visual complexity for Japanese kanji processing with high and low frequencies. *Reading and Writing: An Interdisciplinary Journal, 26(2)*, 205–223.

Tamaoka, K., Kirsner, K., Yanase, Y., Miyaoka, Y., & Kawakami, M. (2002). A web-accessible database of characteristics of the 1,945 Japanese basic kanji. *Behavior Research Methods, Instruments, and Computers, 34*, 260–275.

Tan, L. H., Laird, A., Li, K., & Fox, P. T. (2005). Neuroanatomical correlates of phonological processing of Chinese characters and alphabetic words: A meta-analysis. *Human Brain Mapping, 25*, 83–91.

Tan, L. H., Liu, H. L., Perfetti, C. A., Spinks, J. A., Fox, P. T., & Gao, J. H. (2001). The neural system underlying Chinese logograph reading. *NeuroImage, 13*(5), 836–846.

Tan, L. H., Spinks, J. A., Gao, J. H., Liu, H. L., Perfetti, C. A., Xiong, J., . . . Fox, P. T. (2000). Brain activation in the processing of Chinese characters and words: a functional MRI study. *Human Brain Mapping, 10*(1), 16–27.

Taylor, I. & Taylor, M. M. (2014). *Writing and literacy in Chinese, Korean, and Japanese.* (revised ed.). Amsterdam: John Benjamins.

The Curriculum and Teaching Materials Research Institute. (2009, March 27). Teaching Scheme (Curriculum) for Full-time Primary Schools Chinese Language (Trial). People's Publication Press. https://old.pep.com.cn/xiaoyu/jiaoshi/tbjx/kbjd/jxdg/201008/t20100818_663520.htm. (In Chinese)

The Ministry of Education, People's Republic of China (2011). *Curriculum standard for Chinese in compulsory education*. Beijing, China: Beijing Normal University Press.

PISA: The Program for International Student Assessment: Performance of U.S. 15-Year-Old Students in Science, Reading, and Mathematics Literacy in an International Context. (n.d.). Retrieved February 15, 2019, from https://nces.ed.gov/pubs2017/2017048.pdf

Threatte, L. (1996). The Greek alphabet. In P. T. Daniels & W. Bright (Eds.), *The world's writing systems*. New York, NY: Oxford University Press.

Thuy, D. H., Matsuo, K., Nakamura, K., Toma, K., Oga, T., Nakai, T., Shibasaki, H., & Fukuyama, H. (2004). Implicit and explicit processing of kanji and kana words and non-words studied with fMRI. *NeuroImage, 23*(3), 878–889.

Tong, X., & McBride-Chang, C. (2010). Developmental models of learning to read Chinese words. *Developmental Psychology, 46*(6), 1662–1676.

Tong, X., He, X., & Deacon, S. H. (2017a). Tone matters for Cantonese-English bilingual children's English word reading development: A unified model of phonological transfer. *Memory and Cognition, 45*(2), 320–333.

Tong, X., Tong, X., & McBride-Chang, C. (2015). Tune in to the tone: Lexical tone identification is associated with vocabulary and word recognition abilities in young Chinese children. *Language and Speech, 58*(4), 441–458.

Tong, X., Tong, X., & McBride, C. (2017b). Unpacking the relation between morphological awareness and Chinese word reading: Levels of morphological awareness and vocabulary. *Contemporary Educational Psychology, 48*, 167–178.

Treiman, R., Fowler, C. A., Gross, J., Berch, D., & Weatherston, S. (1995). Syllable structure or word structure: Evidence for onset and rime units with disyllabic and trisyllabic stimuli. *Journal of Memory and Language, 34*, 132–155.

Tse, C.-S., Yap, M. J., Chan, Y.-L., Sze, W. P., Shaoul, C., & Lin, D. (2017). The Chinese lexicon project: A megastudy of lexical decision performance for 25,000+ traditional Chinese twocharactercompound words. *Behavior Research Methods, 49*, 1503–1519.

Tversky, B., Kugelmass, S. K., & Winter, A. (1991). Cross-cultural and developmental trends in graphic productions. *Cognitive Psychology, 23*, 515–557.

Twomey, T., Kawabata Duncan, K. J., Hogan, J. S., Morita, K., Umeda, K., Sakai, K., & Devlin, J. T. (2013). Dissociating visual form from lexical frequency using Japanese. *Brain and Language, 125*(2), 184–193.

Ueda, Y., & Komiya, A. (2012). Cultural adaptation of visual attention: calibration of the oculomotor control system in accordance with cultural scenes. *PLoS ONE, 7*(11), e50282.

UNESCO. (2018). UNESCO survey of world languages launched. Retrieved December 1, 2018. http://uis.unesco.org/en/news/unesco-survey-world-languages-launched

Uno, A., Wydell, T. N., Haruhara, N., Kaneko, M., & Shinya, N. (2009). Relationship between reading/writing skills and cognitive abilities among Japanese primary-school children: Normal readers versus poor readers (dyslexics). *Reading and Writing: An Interdisciplinary Journal, 22*, 755–789.

Vaid, J. (1995). Script directionality affects nonlinguistic performance: Evidence from Hindi and Urdu. In I. Taylor & D. R. Olson (Eds). *Scripts and literacy* (pp. 295–310). New York, NY: Springer.

Vaid, J., & Singh, M. (1989). Asymmetries in the perception of facial afface: Is there an influence of reading habits? *Neurolopsychologia, 27*, 1277–1287.

Venezky, R. L. (2004). In search of the perfect orthography. *Written Language and Literacy, 7*(2), 139.

Ventura, P. (2014). Let's face it: reading acquisition, face and word processing. *Frontiers in Psychology, 5(787)*, 1–4.

Ventura, P., Fernandes, T., Cohen, L., Morais, J., Kolinsky, R., & Dehaene, S. (2013). Literacy acquisition reduces the influence of automatic holistic processing of faces and houses. *Neuroscience Letters, 554*, 105–109.

Vos, F. (1964). Papers on Korean studies. In J. K. Yamagiwa (Ed.), *Papers of the CIF far eastern language institute. Committee on far eastern language instruction of the committee on institutional cooperation*. Ann Arbor: University of Michigan.

Vygotsky, L. S. (1986). *Thought and language*. Cambridge: MIT Press.

Vygotskiĭ, L. S., Kozulin, A., & NetLibrary, I. (1986). *Thought and language* (Translation newly rev. and ed.). Cambridge, MA: MIT Press.

Wagner, R., & Torgesen, J. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101*, 192–212.

Wang, M. & Koda, K. (2005). Commonalities and Differences in word identification skills among learners of English as a second language. *Language Learning, 55*, 71–98.

Wang, M., Perfetti, C. A., & Liu, Y. (2003a). Alphabetic readers quickly acquire orthographic structure in learning to read Chinese. *Scientific Studies of Reading*, *7*(2), 127–154.

Wang, M., Yang, C., & Cheng, C. (2009a). The contributions of phonology, orthography, and morphology in Chinese–English biliteracy acquisition. *Applied Psycholinguistics, 30*(2), 291–314.
Wang, M., Cheng, C., & Chen, S.-W. (2006a). Contribution of morphological awareness to Chinese-English biliteracy acquisition. *Journal of Educational Psychology, 98*(3), 542–553.
Wang, M., Ko, I. Y., & Choi, J. (2009b). Morphological awareness is important in Korean-English biliteracy acquisition. *Contemporary Educational Psychology, 34,* 132–142.
Wang, M., Koda, K., & Perfetti, C. A. (2003b). Alphabetic and nonalphabetic L1 effects in English word identification: a comparison of Korean and Chinese English L2 learners. *Cognition, 87*(2), 129–149.
Wang, M., Park, Y., & Lee, K. R. (2006b). Korean-English biliteracy acquisition: Cross-language phonological and orthographic transfer. *Journal of Educational Psychology, 98*, 148–158.
Wang, M., Perfetti, C. A., & Liu, Y. (2005). Chinese-English biliteracy acquisition: cross-language and writing system transfer. *Cognition, 97*(1), 67–88.
Wästlund, E. (2007). *Experimental studies of human-computer interaction: Working memory and mental workload in complex cognition.* (Unpublished doctoral dissertation). Gothenburg University, Sweden.
White, S. J., Johnson, R. L., Liversedge, S. P., & Rayner, K. (2008). Eye movements when reading transposed text: The importance of word-beginning letters. *Journal of Experimental Psychology, 34*, 1261–1276.
Whitney, C. (2001). How the brain encodes the order of letters in a printed word: The SERIOL model and selective literature review. *Psychonomic Bulletin & Review, 8*, 221–243.
Whorf, B. L. (1940). Science and linguistics. *Technology Review, 42*(2), 212–231.
Whorf, B. L. (1956). *Language, thought, and reality selected writings of Benjamin Lee Whorf Technology Press books in the social sciences* (pp. 1 online resource (xi, 278 p.)).
Wikipedia (2019). Confucianism, Taoism, and Buddhism Are One: A painting in the *Litang* style, Song Dynasty. (n.d.). Retrieved February 15, 2019, from https://en.wikipedia.org/wiki/Taoism
Winawer, J., Witthoft, N., Frank, M. C., Wu, L., Wade, A. R., & Boroditsky, L. (2007). Russian blues reveal effects of language on color discrimination. *Proceedings of the National Academy of Sciences of the United States of America, 104*(19), 7780–7785.
Wolf, M. (2007). *Proust and the squid: The story and science of the reading brain*. New York, NY: Harper.
Wolf, M. (2018). *Reader, come home: The reading brain in a digital world*. New York, NY: Harper Collins.
Wolf, M., & Denckla, M. B. (2005). *RAN/RAS: Rapid automatized naming and rapid alternating stimulus*, Austin, TX: Pro-Ed.
Wong, P. C., Perrachione, T. K., & Parrish, T. B. (2007). Neural characteristics of successful and less successful speech and word learning in adults. *Human Brain Mapping, 28*(10), 995–1006.
Wu, J., Wang, B., Yan, T., Li, X., Bao, X., & Guo, Q. (2012). Different roles of the posterior inferior frontal gyrus in Chinese character form judgment differences between literate and illiterate individuals. *Brain Research, 1431*, 69–76.
Xia, T., Xu, G., & Mo, L. (2019). Bi-lateralized Whorfian effect in color perception: Evidence from Chinese Sign Language. *Journal of Neurolinguistics, 49*, 189–201.
Xu, M., Wang, T., Chen, S., Fox, P. T., & Tan, L. H. (2015). Effective connectivity of brain regions related to visual word recognition: An fMRI study of Chinese reading. *Human Brain Mapping, 36*(7), 2580–2591.
Xue, G., Jiang, T., Chen, C., & Dong, Q. (2008). Language experience shapes early electrophysiological responses to visual stimuli: the effects of writing system, stimulus length, and presentation duration. *NeuroImage, 39*(4), 2025–2037.
Yamashita, J. (2018). Orthographic and phonological processing in L2 English word recognition: Longitudinal observation from grade 9 to 11 in EFL learners in Japan. In H. K. Pae (Ed). *Writing systems, reading processes, and cross-linguistic influences: Reflections from the Chinese, Japanese and Korean languages* (pp. 267–291). Amsterdam: John Benjamins.

Yeatman, J. D., Rauschecker, A. M., & Wandell, B. A. (2013). Anatomy of the visual word form area: adjacent cortical circuits and long-range white matter connections. *Brain and Language, 125*(2), 146–155.

Yeon, J. (2010). Was the Korean alphabet a sole invention of King Sejong? *Journal of Korean Culture*, 14, 183–216.

Yi, K. (1995). The internal structure of Kulja and its relation to syllable in Korean. *Korean Journal of Experimental and Cognitive Psychology, 7*, 57–69. (in Korean).

Yi, K. (1998). The internal structure of Korean syllables: Rhyme or body? *Korean Journal of Experimental and Cognitive Psychology, 10*, 67–83. (in Korean).

Yi, K., Koo, M.-M., Nam, K., Park, K., Park, T., Bae, S., … Cho, J.-R. (2017). *The Korean Journal of Cognitive and Biological Psychology, 29*(4), 395–410. [in Korean].

Yoon, H. K., Bolger, D. J., Kwon, O. S., & Perfetti, C. A. (2002). Subsyllabic units in reading: A difference between Korean and English. In L. Verhoeven, C. Elbro, & P. Reitsma (Eds.). *Precursors of Functional Literacy* (pp.139–163). Amsterdam, Philadelphia: John Benjamins Publishing Co.

Yoon, H. W., Cho, K. D., & Park, H. W. (2005). Brain activation of reading korean words and recognizing pictures by Korean native speakers: a functional magnetic resonance imaging study. *International Journal of Neuroscience, 115*(6), 757–768.

Yoon, H. W., Cho, K. D., Chung, J. Y., & Park, H. (2005). Neural mechanisms of Korean word reading: a functional magnetic resonance imaging study. *Neuroscience Letters, 373*(3), 206–211.

Zhao, Y. R. (1930). Retrieved August 15, 2020. https://en.wikipedia.org/wiki/Lion-Eating_Poet_in_the_Stone_Den

Zhou, Y. (1987). Zhongguo yuci chuli he xiandai hanzixue. *Yuwen Jianshe, 5*, 7–13.

Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin, 131*, 3–29.

Ziegler, J. C., Bertrand, D., Tóth, D., Csépe, V., Reis, A., Faísca, L., Saine, N., Lyytinen, H., Vaessen, A., & Blomert, L. (2010). Orthographic depth and its impact on universal predictors of reading: a cross-language investigation. *Psychological Science, 21*(4), 551–559.

Zipf, G. K. (1935). *The psycho-biology of language: An introduction to dynamic philology*. Boston, MA: Houghton Mifflin.