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# Introduction

Cognitive neuroscience is a relatively young field, beginning only about 50 years ago. The term *cognitive neuroscience* originated on a New York City taxi ride shared by Michael Gazzaniga and George Miller on their way to a meeting of brain scientists (Gazzaniga, 1984; see also Gazzaniga et al., 2013). It combines the term *cognition*, which encompasses all mental processes (e.g., sensory perception, thinking, learning, remembering, using language; see E. B. Goldstein, 2014), with the term *neuroscience*, which is the neural basis of mind and behavior. Gazzaniga and Miller envisioned the new field to be interdisciplinary and include researchers from cognitive psychology and neuroscience as well as medicine, philosophy, linguistics, and computer science (Gazzaniga et al., 2013). The focus of cognitive neuroscience is to understand the functioning of the normal, unimpaired brain (Gazzaniga, 1984). However, case studies of processing that occurs in individuals with atypical brains (i.e., damaged or affected by developmental disorder) provide insight into how such conditions lead to atypical processing.

The aim of this book is to synthesize the numerous cognitive neuroscience studies that have investigated one of the most intriguing and most enjoyable types of cognition: humor. In particular, I summarize research on the cognitive processes involved in humor comprehension. Humor can be defined as any event that leads to an involuntary feeling of amusement (also called "mirth"; R. Martin & Ford, 2018). Consider a popular psychology joke: "How many psychologists does it take to change a lightbulb? Just one, but the lightbulb *really* has to want to change." When did you experience the mirth? Jokes and

https://doi.org/10.1037/0000203-001
*The Cognitive Neuroscience of Humor*, by S. M. Kennison

cartoons provide opportunities for humor, but the most common occurrences of humor are those spontaneous instances that occur during social interactions (R. A. Martin & Kuiper, 1999).

I begin this book with a basic introduction to the study of cognition, humor, and the brain. Most of the cognitive neuroscience studies of humor have utilized jokes or cartoons as stimuli to understand the mental processes involved in the comprehension of humor, because researchers can create nonhumorous statements and images that serve as a control condition to compare with the humorous condition(s). In Chapter 1, I briefly review the history of brain science, focusing on relevant theories of how the brain controls cognitive processing. This review also includes descriptions of the early methodologies that researchers used to establish links between brain activity and specific aspects of humor processing.

The next four chapters examine different aspects of the cognitive neuroscience of humor, specifically exploring how brain regions contribute to humor processing. In Chapter 2, I focus on how humor processing is affected in individuals who have experienced brain damage or brain degeneration. These studies include patients with a wide variety circumstances, including brain changes due to normal aging, brain injury (e.g., stroke, traumatic brain injury) and brain degeneration (e.g., Alzheimer's disease, Parkinson's disease, Huntington's disease, amyotrophic lateral sclerosis, chronic alcohol addiction). I also discuss case studies of pathological laughter, which is commonly observed in individuals with brain injuries, tumors, or diseases that lead to brain degeneration. These studies provide clues about the locations in the brain that may be involved in typical humor processing.

Chapters 3, 4, and 5 examine the research most directly related to the brain activity occurring during humor processing. In Chapter 3, I review studies that have used electroencephalography (EEG), which involves recording electricity from the scalp (Luck & Kappenman, 2012). In experiments using EEG, electricity is recorded as participants comprehend jokes or cartoons (Amenta & Balconi, 2008; Coulson & Kutas, 2001: Coulson & Lovett, 2004; Coulson & Severens, 2007; Coulson & Williams, 2005; Coulson & Wu, 2005; Derks et al., 1997; Mayerhofer & Schacht, 2015; Svebak, 1982). In Chapter 4, I discuss the brain imaging studies using functional magnetic resonance imaging (fMRI), which involves tracking blood flow in the brain as participants carry out cognitive tasks within a strong magnetic field (Gorgolewski & Poldrack, 2016). The results from the EEG and fMRI studies indicate that humor is processed in multiple stages, which involve activity occurring in different brain regions during these different stages. In Chapter 5, I describe an intriguing body of research that shows that specific brain regions, when directly stimulated with electricity, are associated with laughing, smiling, mirth, the interpretation of comic facial expressions, or the appreciation of humor. These studies have participants who are undergoing brain surgery for the treatment of medical conditions (e.g., epilepsy, Parkinson's disease).

Chapters 6 and 7 examine how humor varies across individuals. In Chapter 6, I explain about how humor develops in typically developing children and how changes in humor processing are related to changes in cognitive and/or brain development. I also explore the research on humor deficits in three developmental disorders in which abnormal brain development occurs: (a) agenesis of the corpus callosum, which is detectable before birth (Penny, 2006); (b) autism spectrum disorder, which is typically diagnosed in children between the ages of 4 years old and 7 years old (Altschuler et al., 2018; Baio et al., 2018; Sheldrick et al., 2017); and (c) schizophrenia, which can emerge before the age of 18 years old (Miettunen et al., 2019). In Chapter 7, I discuss the research conducted with healthy adults, showing that different aspects of humor appreciation and production vary. Some of the variables that have been associated with differences include sex/gender, social status, personality traits, and heredity. Most of these variables have not been investigated in studies of brain processing. The intriguing possibility is that many individual differences in humor appreciation and humor production may stem from brain-based differences, stemming from a combination of genetics and environmental experiences occurring early in development.

In Chapter 8, I review the rapidly growing body of research showing that experiencing humor may have positive health benefits. This research indicates that experiencing humor results in physiological changes in the body, which involves hormones and immune system function. Clinicians are testing the effectiveness of humor-related interventions in improving mental and physical health. Only by fully understanding the nature of the cognitive and neural processes involved in humor can we determine the extent to which humor might play an important role in health and longevity. Future research likely will be able to elucidate how brain-based changes during humor processing set in motion the hormonal changes associated with positive health outcomes.

In Chapter 9, I explore the evolutionary roots of humor and the adaptive value that humor may have had in history. Research suggests that humor in humans can be linked to play behaviors in other species. Smiling and laughing is not unique to humans. A growing number of studies suggest that the tendency for play and engagement in positive emotions can be inherited and may serve specific survival-based functions. I also review studies detailing the development brain systems shown to be involved in humor processing in humans and positive emotions in other species.

In the final chapter, I discuss directions for future research. These include the possibility that researchers could develop a brain-based method for detecting humor in participants. Such an innovation would require researchers to identify a neural signature for humor, which occurs similarly across people and across different types of humor, and to create an algorithm that could detect this signature. I discuss how an algorithm of this type could be useful in research exploring how humor-based interventions could be used to improve mental and physical health. There is also a discussion of how individual differences in humor processing may exist, which would mean that there would likely need to be multiple algorithms to detect humor, each tailored to a specific type of person and/or type of humor. I recommend future research on the effect of humor on cognition, which may yield application in education and workplace training.

It is my hope that this book provides readers with some understanding of the biological basis of humor. Although humor is one of our most pleasurable cognitive processes, it may be one of the most complex. For those readers who are inspired to take up research on the topic, they likely share my view that despite how much we know about the cognitive neuroscience of humor, there is much to be learned. The coming decades will likely yield exciting new research on the topic.