Personality and pronunciation talent in second language acquisition

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Cognitive aspects of pronunciation talent

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1. The significance of language and speech abilities

Pierre Fouché, a renowned professor of phonetics at Sorbonne, allegedly told his students who could imitate a number of different pronunciations, that "a strong personality requires just one accent". In his case it was evidently true as he spoke lots of languages with a strong Catalan accent.

Are there really personality factors that prohibit from acquiring new languages (L2) and speaking them with a native-like capacity? Imagine two hypothetical individuals who are living in the same foreign environment. Presumably, a highly motivated subject will try to take advantage of every given circumstance to improve his pronunciation skills, while a less motivated person will devote fewer resources to this task. In such a case, are there psychological and cognitive characteristics that might help the reluctant learner and give him an advantage over one who is more motivated? Is there an innate or acquired set of personal skills, which even though apparently unrelated to speech production, might facilitate the process of building up linguistic competences, thus paving the way to a native-like pronunciation of L2?

The answers to these questions have crucial pedagogical implications. Usually, grammar notions and phonetic abilities are used as selection criteria to enroll students into language classes. However, tailoring selection criteria, as well as teaching techniques, to the abilities and the needs of the students would allow them to benefit more from the courses. The importance of individual differences, and the way they impact the acquisition of L2 has long been overlooked. Similarly, the question as to why some people have less difficulties learning L2, and why some develop a finer phonetic proficiency than others remains unanswered.

Stimulated by this lack of evidence, we investigated crucial cognitive factors and tested their relevance in groups of subjects classified on the basis of their proficiency and talent in L2 pronunciation. In the present chapter, we address the results of this research with respect to empathic skills, mental flexibility, working memory abilities and intelligence.

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2. Empathy

Essentially, to learn a second language
is to take on a new identity

Guiora, 1972

Are empathetic capacities important for the acquisition of certain cognitive skills and for the ability to correctly pronounce L2? The debate on the nature of empathy first came to light in the last century. Robert Vischer coined the concept of *Einfühlung, in-feeling* or *feeling-into* in 1873, and the German philosopher Theodor Lipps firstly applied it in psychology. Lipps identified in empathy a crucial component for the fruition of aesthetic experiences in art. Nowadays, the term *empathy* describes the mechanisms that form the ability to perceive and feel the emotional states of others, the *emotional resonance* that takes place in an individual when he/she engages in an affective communication or in an emotional exchange. The concept of empathy accounts for the emotional and cognitive reactions elicited in a person when he/she observes another person's emotional expressions and/or behaviour. In this sense, Mehrabian and Epstein (1972) suggested that empathy is a *vicarious emotional reaction*, and they proposed an *emotional contagion* hypothesis to define its nature.

An alternative perspective emphasizes the cognitive components of empathy and defines it as a cognitive understanding of the other's situation, based on the capacity of assuming his/her point of view on things (the *perspective taking* hypothesis, Hogan 1969).

Salovey and Mayer (1990) stressed the importance of empathetic abilities for an effective and satisfying interaction and coined the term *emotional intelligence*. According to the authors, individuals who possess an accurate ability to perceive and appraise others' emotions are able to respond in a more flexible way to changes happening in their social environment, and to build up and maintain supportive social networks over time (Salovey et al. 1999). The concept of emotional intelligence is relatively new. However, the importance of non-intellective abilities such as sensitivity and emotional skills for predicting individual success in life has been recognized for years. Rosenthal and colleagues discovered that people who could better identify others' emotions are more successful in their private lives, as well as in their jobs (Rosenthal 1977). An empathic person is prone to support others and is likely to get more support back (Håkansson and Montgomery 2003). According to the *empathy*-

altruism-hypothesis (Batson 1990), empathy nurtures the willingness to engage in pro-social behaviors, and to act altruistically. With this regard, empathy might be seen as a core component of *social intelligence* (Amelang et al. 1989), and presumably sustains the recognition of relevant social cues, integrating this knowledge into social interaction.

Some researchers showed that the importance of empathic abilities is not limited to real-life situations, but extends to fictitious circumstances as well (Davis 1983; Stotland et al. 1978). In particular, the *Don Quixote effect* (Shapiro and Rucker 2004) creates the basis for highly empathic reactions to films and movies. This phenomenon works by making the viewers experience fictitious idealized schemas where emotional contents can become even more intense than in real-life contexts.

In the 70's, Guiora and his colleagues proposed the idea that interpersonal competence plays a role during the acquisition of phonetic skills, thus favouring L2 pronunciation. Guiora postulated that individual differences in L2 pronunciation reflect the degree of empathic capacities that people possess. These researchers proposed the concept of *language ego* (Guiora et al. 1972a), which is a representation of the self defined by physical and psychological boundaries. According to this conceptualization, the development of native speech abilities takes place during a state of *ego-permeability*, which is prevalent in early development stages, and progressively decreases with age. For a child the assimilation of L2 represents a natural process. However, this process is progressively inhibited in adulthood, and may be the reason for maintaining a foreign accent even when L2 is spoken fluently. Kris (1952) anticipated this concept by identifying in ego-relaxation processes the mechanisms that promote creative acts. During their creation, verbal-logical operations are abandoned and a *primary thinking mode*, typical of the childhood, emerges. According to Guiora and co-workers (1972a), the acquisition of L2 *poses a challenge to the integrity of basic identifications*, because it requires the individual to *step into a new world* and *take a new identity*. In their definition, empathy requires a process in which a *temporary fusion of object-self boundaries* takes place, thus opening up to an *immediate emotional apprehension of the affective experience of the others*. This process is a crucial component for the development of native-like pronunciation skills because L2 learners need to acquire a new identity to achieve new linguistic competences. Ego-permeability enhances the speaker's sensitivity to social interaction. It forms the basis of enhanced abilities in pronunciation because it allows speakers to discern subtle speech nuances and to learn to reproduce them.

Guiora and colleagues tested their model in a number of experiments. In one of the first studies (Guiora et al. 1967), they observed a correlation between accuracy in French pronunciation and scores on empathy skills obtained with the Micro-Momentary Expression Device. In this experiment, Guiora and colleagues assessed empathy by addressing the ability to detect subtle changes in facial expressions. This indirect measure of empathetic skills failed to correlate with pronunciation abilities in further investigations (Taylor et al. 1970). The researchers recruited 28 college students who participated in a short course in Japanese, and observed a negative correlation between their pronunciation performances and the MME scores. In a further study, 401 students belonging to the Defense Language Institute were administered the MME and other tests. This research led to a positive correlation between pronunciation scores for several languages (Japanese, Spanish, and Russian) and the MME scores. The existence of controversial evidence in these results might be attributed to the fact that the MME does not address the totality of the empathy phenomenon in its multiple sub-components such as body posture, voice intonation etc. Being able to decipher facial expressions is an important component of emotional intelligence, but it certainly does not embody the totality of it.

Guiora identified different methods to operationally induce ego-permeability. He viewed alcohol consumption as a useful means to lower subjective inhibitions and feelings of *separateness of identity*, and tested it in a series of experiments (Guiora et al. 1972a, 1972b). Guiora and colleagues investigated the pronunciation of Thai sentences and suggested that a temporary improvement of L2 pronunciation abilities follows the ingestion of small doses of alcohol (1 to 1 ½ ounces of alcohol, not on an empty stomach). In his explanation of the phenomenon, Guiora describes an induced *flexible psychic state* (Guiora et al. 1975), with temporary lower inhibitions and presumably heightened empathy. He hypothesized that an *early positive stage of intoxication* is optimal for L2 pronunciation skills. Although this claim might sound very appealing, it is clear that the recourse to alcohol cannot be considered an acceptable pedagogical method.

Encouraged by those results, Guiora and colleagues extended their research to the use of benzodiazepine (valium) and hypnosis. Schumann *et al.* (1978) reported a significant improvement of L2 pronunciation for deeply hypnotized subjects, thus providing support for the claim that a *letting go* state of feelings facilitates performances. This intuition failed to find confirmation in further studies that addressed the role of benzodiazepine (Guiora et al. 1980). While it seems that relaxation and low anxiety levels have a positive effect upon subjective abilities, no causal correlation between ingestion of small doses of benzodiazepine and L2 pronunciation was observed.

2.1. Assessing empathy

On the basis of this pioneering work, we decided to consider empathetic skills among those psychological factors that might correlate with talent in L2 pronunciation and, therefore, to test them. We examined empathetic skills using the questionnaire E-Scale, a psychometrically sound instrument devised by Leibetseder and colleagues (2001). The authors adopted the definition of empathy as *the effort to identify with persons in fictitious or real-life situations* (Leibetseder et al. 2007). The questionnaire explores two different dimensions: *sensitivity*, and *concern*. The dimension *sensitivity* addresses empathetic abilities elicited towards fictitious imagined situations. The dimension *concern* assesses empathy experienced when imagining real-life contexts. The 26 items that constitute the questionnaire investigate a total of four factors: cognitive-sensitivity, emotional sensitivity, emotional and cognitive concern. The questionnaire addresses cognitive sensitivity by means of items that describe fictive but concrete social situations where empathic reactions are to be elicited. Emotional sensitivity is investigated by questions that induce the empathizer to put himself into the emotional situation of the actor and deal with fictitious situations. Items address emotional concern by investigating reactions to situations characterized by a high degree of reality. Cognitive concern is studied by means of items that stimulate empathetic feelings to concrete situations of real-life, which require a cognitive analysis. The general score on empathy obtained by means of this questionnaire gives an IQ on empathy (E-IQ), which mirrors the general ability of the individual to experience empathetic feelings in both fictional and real-like life situations.

Our research group investigated with a large-scale assessment the question whether phonetic abilities in L2 pronunciation correlate with empathetic openness to others, as suggested by Guiora and his co-workers. German subjects underwent multiple phonetic assessments (for details, refer to Jilka in this volume), where we investigated phonetic proficiency in both L2 pronunciation and perception.

Subjects were classified into three groups: highly talented subjects, average subjects, and anti-talented individuals. Mean levels of E-IQ calculated taking into account the scores for all the items of the E-Scale questionnaire were 47,6 for the talented subjects (N= 20), 45.2 for the average talent group (N = 20), and 42.2 for the anti-talent subjects (N= 20). Correlation analyses were calculated for proficiency, talent, scores on the Modern Language Aptitude Test (MLAT), Hindi (as an unknown language) imitation and E-IQs scores. Furthermore, we correlated the E-IQ scores with responses on the following three introspective questions: 1. How much do you like imitating voices? (scale 1–5 points, 5=max), 2. How much do you like imitating accents? (1–5) and 3. How many instruments do you play?

The results were several significant correlations, which were in the weak-middle range only for the first subscale "empathic readiness" (not for the second subscale of the E-Scale "social concern"). E-IQ (empathic readiness) scores correlated positively and significantly with: talent of pronunciation (according to our talent score (see chapter M Jilka)) (r = 0.26, *P* = 0.024*, N = 60), with MLAT3 – phonetic coding ability – r = 0.2, *P* = 0.04*, N = 60) and with the total MLAT score (comprising the three sub-scales: phonetic coding ability, grammatical sensitivity and vocabulary learning), r = 0.2, *P* = 0.047, N = 60). Furthermore, it correlated with performance (proficiency in L2 pronunciation) r = 0.29, *P* = 0.013*, N = 60; imitation capacity for unknown Hindi words: r = 0.16, *P* = 0.048, N = 60, as well as with the three introspective questions: 1. "Do you like imitating voices?" r = 0.23, *P* = 0.005**, N = 60; 2. "Do you like imitating accents?" r = 0.31, *P* = 0.001**, N = 60; 3. "Number of musical instruments you play" r = 0.24, *P* = 0.004**, N = 60. Thus, the higher the subjects were rated on the "talent" score in pronunciation, the higher their score on the Modern Language Aptitude Test for "phonetic coding ability", the higher their actual performance or proficiency in pronouncing L2 texts, the higher their scores given by Hindi native speakers on the Hindi word imitation task, the higher the Empathy score on the subscale "Empathic readiness" were.

When asked to self rate (on a scale from 1–5), their liking for imitating voices and accents the correlation was even higher and more significant. What can be seen as an interesting collateral result is that their empathic readiness correlated even with the number of instruments they played (the more instruments, the more empathic).

These correlations between empathic readiness and musical instruments point to the intrinsic and often hypothesized intervowenness between phonetic language talent and music (for this aspect see Chapter by Nardo and Reiterer, pp. 213). However, the correlations of Empathy to our various measures of phonetic pronunciation talent show that the theory of Empathy (in connection also with personality, see also Chapter 4) in speaking and learning a foreign accent is perhaps not a myth, but a must to be further elucidated.

3. Mental flexibility

Do we need a certain degree of mental flexibility to learn L2 and to be able to pronounce phonetic features that greatly differ from the ones we are used to in our native tongue? Does speaking a second language, or multiple languages, affect brain plasticity? Can we maintain a high cognitive functioning if we continue to train our brain as time passes? Questions such as these animate scientists as they contend about the role of nature and nurture in shaping individual predispositions and abilities. A child possesses an extraordinary brain plasticity that allows him to learn every language existing on earth. As he grows up, his linguistic skills specialize for his mother tongue and the ability to assimilate new languages gradually diminishes. As he becomes older, he is still able to learn foreign languages, but he is likely to retain an accent that traces back to his native pronunciation. Are there mechanisms that shape this process? If this is the case, can we identify them and possibly reverse their effect?

Studies on genetics have just begun to explore how the brain develops and functions. The human brain is a dynamic and constantly reorganizing system that benefits from stimulating environments at every age: its plasticity is a lifelong phenomenon. Since the 50s, numerous studies conducted on animals have attempted to determine whether the brain develops differently in response to a variety of environmental conditions. Researchers devised standardized paradigms, typically raising two groups of rodents in enriched and/or un-enriched environments (Rosenzweig and Bennett 1972; Rosenzweig et al. 1969). The experimenters kept the animals of the first group in isolation, a condition of poor sensory, cognitive and motor stimulation. They provided the animals of the second one with increased social interaction, and great exposure to stimulation (e.g. many animals were typically housed together in big cages containing a great variety of toys with different shapes and color). When examining the brains of both groups, they discovered significant differences in the growth of the animals' cells: the rodents raised in the enriched environment had a larger cortex and a higher cortical density due to an increased amount of brain cells and cellular connections. Is there an analogous effect in children who grow up in a bilingual or multilingual – highly stimulating – environment? Does a linguistically stimulating environment affect other cognitive domains as well?

The claim about the positive effects of bilingualism on cognitive performances was first made in 1962. Peal and Lambert (1962) studied French Canadian children and observed a greater mental flexibility and verbal fluency for this bilingual group. They proposed that the bicultural environment in which the children grew up enriched both verbal and non-verbal skills. Since this study was published, great interest has arisen regarding the cognitive advantages that may derive from exposure to multiple languages from childhood onwards. A further study conducted on Finnish students suggested that bilingualism might influence intelligence: an average of higher school grades for bilinguals was observed when their performance was compared to monolingual subjects (Sundman 1994). Existing evidence suggests that bilingual children often perform better than monolingual children in tasks that require cognitive control (Bialystok 2001). From an early age, bilingual children are exposed to multiple languages and trained to process information on different registers. As a result of this process, they may develop enhanced attentional capacities. While speaking, fluent bilinguals need to suppress irrelevant intrusions of the language not currently in use. Usually, interlocutors do not perceive this suppression and they are not aware of the effort that sustains such a process. However, psycholinguistic studies conducted on bilinguals indicated that even if the speaker engages in a communication speaking one language only, the representations of both his native languages become simultaneously active (Kroll and Dijkstra 2002; Gollan and Kroll 2001; Francis 1999). According to Bialystok (2006), bilinguals are constantly trained to direct selective attention to relevant information and to ignore irrelevant but highly distracting representations. As documented by Bialystok and Codd (1997), 4- and 6-year-old bilinguals perform better than comparable monolinguals during counting tasks challenged by contradictory information. Similarly, an analogous performance is observed when bilinguals engage in sorting tasks where the label on the sorting compartment misleads the decision task (Bialystok and Martin 2004).

The same response-trend has been observed for the Simon task. Martin and Bialystok (2003) evaluated the performances of bilingual preschool children and showed that these subjects had faster reaction times when compared with the monolingual peers. This evidence was found not only for incongruent trials, but for congruent ones as well. This result was replicated in further investigations that recruited subjects whose age varied between 30 and 80 years. Older bilingual volunteers were faster and more accurate than younger ones (Bialystok et al. 2004).

The Simon Task (Simon and Rudell 1967) was originally devised as a tool to test the effects of handedness and gender on selective attention. So far, this test has been widely explored in a number of paradigms that range from executive functions to cognitive control (for review refer to Lu and Proctor 1995). When engaging in this task, participants need to simultaneously process stimuli (e.g. colored circles that appear on a display) that have relevant features (e.g. the colour) and irrelevant highly distracting ones (e.g. the position on a screen, such as left or right). Participants are required to perform speeded button-press responses when they detect target features of the stimuli, while ignoring irrelevant misleading information. Subjects are faster when responding to congruent stimuli (e.g. red stimuli appear on the left side of the screen and they have to press a key on the left for red) and slower when responding to incongruent ones (e.g. blue stimuli appear on the left side of the screen and they have to press right for blue). Subjects need to inhibit automatic response processes to respond correctly to incongruent stimuli. Response-inhibition is a time-consuming process and typically leads to lower accuracy levels and slower reaction times, e.g. around 20–30 milliseconds (Ridderinkhof 2002; Gratton et al. 1988; Simon 1969; Fitts and Seeger 1953). This phenomenon is known as the *Simon effect* and it has been observed for a number of relevant features such as pitch and form (Simon and Berbaum 1990; Craft and Simon 1970; Simon 1969).

To explain why the Simon effect arises, researchers have referred to a *dual-routes processing* model (Wiegand and Wascher 2005; Ridderinkhof 2002; Eimer 1995). According to this model, there is an *unconditional* route in which responses are performed in a quick and semi-automatic way, and a *conditional* route, in which appropriate responses need a relatively slow intentional process in order to be performed. In the Simon task, the stimulus location induces a priming effect on the ongoing response decision by automatically activating the corresponding response. Interference arises during incongruent trials because an irrelevant feature of the stimulus activates the associated response in an automatic fashion. As the two responses enter in conflict with one another, the stimulus-response mapping process needs to override the incorrect response activation (Coles et al. 1985). This model has received an important validation from studies conducted on the lateralized readiness potential (LRP). The

LRP can be recorded by measuring event-related potentials of electrodes placed on the left and right motor cortices separately for left and right hand responses (de Jong et al. 1988; Gratton et al. 1988). The LRP indicates the preparation to move one hand to respond and its course over time. Numerous experiments have shown that incongruent trials immediately activate the incorrect response and are followed by a later activation of the correct one.

Many studies suggest that the neuronal network that is recruited during the Simon task sustains a number of other attention-demanding tasks as well (Fan et al. 2003a; Fan et al. 2003b; Peterson et al. 2002). Comparing competitive alternatives that generate conflictual tendencies and the suppression of interference seem to rely on a cortical network that encompasses the anterior cingulate cortex (ACC), the left prefrontal cortex (PFC), and the dorsolateral prefrontal cortex (DLPFC) (Kondo et al. 2004 a, b). An enhanced functioning of this network presumably affects all attentional performances that rely on these brain areas. The hypothesis that these attentional processes are regulated by cortical networks that may be modified by experience was suggested by Merzenich and Jenkins (1993). Training and experience seem to play a crucial role in shaping cortical plasticity and to be crucial for the specialization of brain networks (Fan et al. 2003b). Following these lines, prolonged experiences that rely on attentional control, as it happens in bilingualism, presumably modify its neuronal bases, and strengthen their functioning.

3.1. Testing mental flexibility

Bialystok suggests that bilingualism creates cognitive advantages, and argues that bilingualism is a sort of *mental fitness training*, a protective factor against the decline of cognitive control and attention switching abilities, which increases with age.

In our study, we tested the hypothesis that the acquisition of L2 after puberty influences selective attention and task switching capacities. We used a classical version of the Simon task and ran it on a laptop (HP, ADM Athlon 3200) with a 12-in monitor. We programmed and ran the task using the E-Prime software (Schneider et al. 2004). The task was constituted of 4 runs, presented in sequence, each of which lasting 47.4s. Each run started with a fixation cross (+) presented in the center of the screen for 3s and followed by a blank interval of 1s. We presented either a red or a blue circle on the left ($x = 0.02°$, $y = 0.36°$) or on the right ($x = 0.82°$, $y = 0.36°$) of the laptop screen. Each stimulus lasted 1s. We instructed the subjects to respond to the presentation of a red circle by pressing a key on the left side of the keyboard (i.e. the letter *s*), and to respond to the presentation of a blue cycle by pressing a key on the right of the keyboard (i.e. the letter *l*), independently of the circles' position on the screen. Circles (24 for each run, randomly presented) were separated by an interval of 900ms during which subjects could view a black screen only. For half of the cases, subjects were confronted with items that appeared on the same side of the screen as the key that they had to press (congruent condition), and for the other half to items that appeared on the opposite side (incongruent condition) of the screen. Before engaging in the Simon task, subjects underwent a practice run during which they were instructed to respond to 24 items (12 congruent and 12 incongruent).

We tested the performances (i.e. accuracy and reaction times) of our volunteers, classified in three groups (high, average and low proficiency talent in L2). We expected to find a significant difference in the performances in the subjects who were classified as talented versus the subjects who were classifies as untalented. In line with the hypotheses by Bialystok, we expected that talented individuals would show higher accuracy and reduced reaction times than controls (i.e. non-talented subjects). Talented subjects (N = 23) performed with an accuracy of 96% ± 4% (mean ± SD) during the congruent condition and with an accuracy of 83% ± 7% (mean ± SD) during the incongruent condition. Their reaction times were 385.6 ms ± 40.7 (mean ± SD) when responding to the congruent condition and 412.3% ± 44.6 (mean ± SD) when responding to the incongruent condition. Untalented subjects (N = 23) had an accuracy of 96% ± 4% (mean ± SD) for congruent trials and an accuracy of 92% ± 8% (mean ± SD) for incongruent trials. Their reaction times were 413.6 ms ± 71.4 (mean ± SD) for the congruent condition and 435.4% ± 64.08 (mean ± SD) for the incongruent condition.

We computed a linear regression analysis for the proficiency and accuracy scores of our subjects. We observed no significant correlation for L2 proficiency and accuracy in the congruent (one-tailed linear regression, r = –0.124, P = 0.311, N = 69), and incongruent conditions (one-tailed linear regression, r = –0.231, P = 0.056, N = 69). Reaction times negatively correlated with levels of proficiency (congruent condition: r = –0.268, P = 0.026*, N = 69; incongruent condition: r = –0.274, P = 0.023*, N = 69).

The results of our investigation indicate that no correlation between accuracy in the Simon task and L2 proficiency exists when L2 is acquired after puberty. The data suggest that mental flexibility as measured by the Simon task is not influenced by the subject's proficiency. In a series of experiments, Bialystok and colleagues (2004) showed that bilinguals perform better in the Simon task when compared to monolinguals. Bilingualism affects cognitive control as subjects need to train in the management of multiple languages since early age. The results of our study indicate that learning L2 after puberty does not affect brain plasticity as it does in early age. Recent findings show that bilingualism influences cortical plasticity enhancing the density of grey matter in left inferior parietal cortex (Mechelli et al. 2004). This effect correlates with the level of proficiency in L2 and its age of acquisition: brain structural changes are more evident when L2 is acquired before 5 years of age. This evidence and our findings lead us to suggest that the acquisition of L2 after puberty may have a reduced impact on brain plasticity, thus diminishing the effect of linguistic management on cognitive control.

4. Working memory

Working memory (WM) can be defined as a temporary retention of recently acquired information. While kept in memory, information can be actively manipulated and used for a variety of cognitive operations and goal-directed behaviors. The ability of holding information and manipulating it forms the substrate of multiple cognitive skills and is essential to operations such as reasoning, planning, the processing of speech and spatial inputs.

Baddeley and Hitch (1974) proposed a cognitive model of WM that has become highly influential over the years stimulating a great amount of research both in the fields of cognitive psychology and imaging neuroscience. These researchers coined the term *working memory* to indicate short-term storage of information and emphasized the key role of this system in cognitive processing and manipulation of data. They observed that individual performances deteriorate with the increase of concurrent memory load. WM refers to the total resources that the individual can rely on for simultaneous processing and storage. This system is an interface between perception and action and is the basis for a wide range of cognitive activities: the pieces of information acquired continue to be at the disposal of the cognitive system and is used for action and interaction.

The WM system comprises distinct components that sustain cognitive control and active maintenance of information: a *central executive* and two storage systems that retain verbal and spatial data, the *phonological loop* and the *visuospatial sketchpad* (Burgess et al. 2007; Stuss and Alexander 2007; Baddeley 1986). The central executive is a controller system that is responsible for the allocation of attentional resources and for the coordination of information within both verbal and spatial storage buffers. It is an interface between the two storage buffers and long-term memory that coordinates information originating from different sources. The central executive system activates when incoming cues force ongoing automatic behavior to be suspended, attentional control engaged, and action adjusted to meet new environmental demands. Evidence for the existence of the visuospatial sketchpad, which is involved in the manipulation of information on objects and spaces, originally came from clinical reports on soldiers who were wounded with gunshots during the World War I, and whose capacity to encode visuo-spatial information was impaired (Holmes 1919). A number of paradigms rely on this component, such as the Corsi's Block Tapping Test (Milner 1971). This test is constituted of an array of blocks positioned in a semi-random fashion. The experimenter shows a sequence of blocks and the subject has to reproduce it correctly for a number of times. The phonological loop is engaged in the maintenance of linguistic information. This sub-system plays an important role for the acquisition of L2, and will be addressed with more details in the next chapter.

Empirical studies of WM have relied on behavioral measures and neuroimaging techniques. These methods have enriched our knowledge on how this system works and have provided important insights into the neuronal networks that sustain its functioning. Already in the 50's, empirical studies showed that small amounts of information are rapidly forgotten unless actively rehearsed (Brown 1958). The very first reports to this regard came from the work by Miller (1956), who quantified the limit of the short-term memory capacity as being around the *magical number seven*. Miller demonstrated that memory span could be measured and proposed that young adults are able to remember a range of seven plus/minus two elements, regardless of whether the elements are words, letters, digits, or other units. Further observations showed that the ability to encode information depends on a number of features concerning the material to be remembered. For instance, WM span is usually lower for long words than for short words. When verbal material such as digits, letters, words, etc. need to be encoded and recalled, an important role is played by the time necessary to repeat those contents aloud and by the lexical status of the materials (Hulme et al. 1995). Cowan (2001) has proposed that young adults have a WM capacity of about four chunks, children and older adults a much poorer one. A number of other factors affect the WM span and so far the exact extent of the WM capacity across individuals remains an unsolved issue.

WM capacities have been recognized as a key factor for scholastic success. According to Gathercole and colleagues (2004), the expansion of WM span and the improvement of memory performances during development are due to an increase of rehearsal strategies that become available to the children. A number of studies show that WM skills predict children's academic achievements in a variety of sectors such as mathematics and reading (Swanson 2006; Swanson et al. 1996; Gathercole et al. 2004). On the other hand, WM skills are among the executive functions that are typically compromised in children with high levels of impulsivity and inattention who are affected by the attention deficit/hyperactivity disorder (ADHD, Barkley 1997; Castellanos et al. 2006; Martinussen et al. 2005). Martinussen and Tannock (2006) documented poor performances in ADHD children who engage in complex memory tasks involving the storage and processing of both verbal and visuo-spatial data.

The importance of WM has been observed for disparate sectors. We address here the question whether WM capacities play an important role while learning new languages and whether the extent of the WM span is a good predictor of the ability to pronounce L2 with a native-like accent. Could we assume that by training those skills, people would need less effort to learn L2, and/or would improve their pronunciation skills? Could this method be an indirect but effective way for stimulating and strengthening linguistic abilities?

4.1. The phonological loop

In the model proposed by Hitch and Baddeley, the WM system relies on a linguistic sub-component, called the phonological loop, consisting of a phonological store, which functions through an articulatory rehearsal process (Baddeley 2003). According to Atkins and Baddeley (1998), this system is the structure that allows for language learning. The phonological loop forms the basis of the ability to immediately repeat novel phonological strings or non-words, and more importantly, of the ability to memorize this material. The phonological loop is believed to hold memory traces of linguistic data for a short time, and the amount of material that it is able to store reflects its encoding capacity. Articulatory rehearsal processes allow for longer maintenance of the information. Active rehearsal of verbal material consists of its repetition, a process during which attention is repetitively directed to the items to remember, and subvocal articulation takes place (Baddeley 1986).

Empirical evidence shows that the suppression of articulation by means of tasks that engender cognitive interference (e.g. uttering nonsensical sequences of words during a detention interval) degrades retrieval (Murray 1968). On the contrary, sub-vocal repetition makes the information fade slower, and performed over time facilitates long-term encoding. The permanence of mnestic traces increases the likelihood that the information will pass from short-term memory to long-term memory. Re-articulation is not the only condition that facilitates encoding. Phonological characteristics of the material play an important role in preventing the loss of memory traces: when encoding unrelated letters, listeners recall sequences of dissimilar sounding letters (e.g. X, K, R, Y, Q) better than sequences of similar ones (e.g. P, B, T, etc.). While memorizing meaningless material, listeners need to rely on its phonological characteristics (Baddeley 2003). As for letters, the similarity of sounds is crucial for unrelated words. This process is analogous to what happens when listeners try to learn new languages, and they are confronted with phonological features that differ from their native tongue's ones.

Baddeley (2003) proposed that the phonological loop played a crucial role in the evolution of the human species because it permitted the acquisition and the preservation of language across generations. This claim was corroborated by the clinical observation of a patient, whose pure phonological loop deficit correlated with his inability to acquire the vocabulary of the L2 (Baddeley 2003). Moreover, this claim was sustained by the observation that critical factors such as long world-length and articulatory suppression, which impede the functioning of the phonological loop, do interfere with the acquisition of new languages (Papagno and Vallar 1992; Papagno et al. 1991).

It seems that phonological loop capacity is a good predictor for the ability to acquire L2 in developmental and adult ages (Service 1992; Atkins and Baddeley 1998). Gathercole and Adams (1994) investigated the ability of children to correctly repeat unfamiliar non-words. They observed a correlation between the performance in this task and the children's ability to acquire their native language. Conversely, linguistic disability seems to be a valid predictor for poor performances during non-word repetition tasks, even though the level of general intelligence is normal and no impairment in hearing and articulation can be reported (Gathercole and Baddeley 1990).

How can temporary storage capacities facilitate the process of learning new words? Baddeley proposes that the phonological loop temporarily stores the representations of new linguistic material and structures, and through reiteration impedes shading, thus allowing for a fixation of the mnestic traces to take place. This process does not require long-lasting exposure to L2 if the sequences are phonotactically regular, though it may need longer training if they are irregular (Baddeley 2003).

Neuroimaging studies have attempted to locate the cortical networks that house WM capacities and their sub-components. Studies on patients with brain injury and imaging investigations converge, suggesting that the different sub-components of the WM system are segregated in different parts of the brain, linked by reciprocal interaction (Fuster 2003). Brain regions that exhibit persistent neural activity during active maintenance of task-relevant information are good candidates for the neuronal networks that sustain WM. Left temporoparietal areas are engaged in phonological tasks that require WM (Paulesu et al. 1993; Vallar et al. 1997; Warrington et al. 1971). The supramarginal gyrus is where the phonological storage seems to be located in the brain. The ventrolateral frontal cortex (i.e. Broca's area) is often activated when subvocal rehearsal is the main strategy for encoding (Bench et al. 1993; Awh et al. 1996). Verbal tasks that require WM typically engage the left inferior parietal lobe, premotor cortices and the cerebellum (Awh et al. 1996; Paulesu et al. 1993). The right hemisphere plays an important function by primarily housing the visuospatial component of the WM system (Smith et al. 1996). However, the rehearsal of task-relevant representations relies on the interactions between networks of brain regions in both hemispheres (Fuster 2003).

4.2. Testing working memory span

Our group assessed the digit span and word span of all subjects who participated in our psychological tests. We used the Wechsler Digit Span test, a subtest of the revised version of the Wechsler Adult Intelligence Scale (Wechsler 1939), to measure digit span. In this test, subjects are required to perform forward and backward repetition of strings of numbers, which contain an increasing amount of items (from 3 to 9 numbers for forward repetition, and from 2 to 8 numbers for backward repetition).

To assess word span we devised a further test by creating strings that contain an increasing number (from 2 to 8) of monosyllabic non-words, with a German-like phonetic quality. For each string, subjects were required to repeat as many items as possible. We measured accuracy of repetition in both tests. On the basis of the mentioned literature, we hypothesized that subjects who develop exceptional skills in L2 pronunciation take advantage of enhanced rehearsal abilities, and/or improve their phonological store's capacity as an effects of the linguistic training.

Subjects with low L2 proficiency (N = 23) showed a digit span of 6.04 ± 1.18 (mean ± SD) numbers during forward repetition, 4.15 ± 0.93 (mean ± SD) numbers during backward repetition, and a word span of 5.1 ± 0.61 (mean ± SD) words during non-word repetition. Subjects with high proficiency (N = 23) were able to repeat 6.7 ± 1.26 (mean ± SD) numbers forward, 4.89 ± 1 (mean ± SD) backward, and 5.55 ± 0.82 (mean ± SD) nonwords. Consistent with our expectations, we observed a correlation between L2 proficiency and span capacity during forward (one-tailed linear regression, r = 0.253, $P = 0.036^*$, N = 69) repetition. Backward (one-tailed linear regression, r = 0.079, $P = 0.518$, N = 69) and non-word repetition (one-tailed linear regression, r = 0.193, $P = 0.112$, N = 69) failed to be significant.

A correlation of proficiency and forward repetition is consistent with our expectations and coherent with the findings previously reported. The development of exceptional L2 pronunciation skills, even when it starts after puberty, is facilitated and/or favours WM capacities. Papagno and Vallar (1995) studied polyglots' cognitive abilities, and observed an enhanced auditory digit span and higher performances during non-word repetition. Palladino and Ferrari (2008) investigated cognitive skills in children who exhibited difficulties learning a foreign language in the absence of any cognitive impairment. The researchers examined phonological encoding abilities and documented a poor word span in these children. Consistent with these findings, our results confirm a close relationship between phonological WM and the capacity to acquire foreign languages. Our preliminary investigation furthers previous evidence by showing that even in adulthood individuals who possess high WM capacities are likely to encounter less difficulties when learning L2. Training WM since childhood could be an indirect and effective way to develop high performances in other domains as well. Analogously, speaking multiple languages presumably affects WM span. Future longitudinal research should study the expansion of WM capacities over time, and systematically address the effect of linguistic competences on it. On the basis of our preliminary study it is not possible to rule out the existence of a correlation between proficiency and backward/non-word repetition abilities. A bigger corpus of data is needed to further investigate this topic.

5. Intelligence and L2 phonetic abilities

Individuals differ from one another in their ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought.

Neisser, 1998

The idea that intelligent behaviour reaches its highest expression in human beings has been claimed by philosophers of all times. Intelligence and intelligent behaviour are individually distinctive traits that greatly vary across individuals. Intellectual performance is context and situation-dependent, and shows a great variability over time even for the same subject. While the concept of *intelligence* possesses a very intuitive meaning, its scientific definition is challenging. Theorizations on the nature of intelligence have attempted to clarify this topic. The need for objective measures of intelligence first emerged at the end of the 19^{th} century, as psychologist Alfred Binet (1857–1911) was asked to devise a system to assess cognitive abilities and intellectual skills in children. This instrument was needed to identify children with mental retardation who would need to be assigned to special school classes.

Different perspectives exist with respect to the nature of intelligence and the ways it should be addressed. Some researchers suggest that a unified general ability is at the core of it. Other researchers believe that a wide variety of skills and aptitudes should be considered essential attributes of intelligence and that sets of completely independent intelligences can be identified.

Psychologist Charles Spearman (1863–1945) proposed a theory on intelligence that has become very influential. While examining the results of different intelligence tests that investigated cognitive skills, Spearman observed that the scores on these tests positively correlated. People who rated high scores on one cognitive test were likely to perform well on other tests, and vice versa for those individuals with poor performances.

On the basis of these studies, Spearman suggested that a general factor, termed *g*, influences intelligent performance and that various cognitive tasks picture different aspects of general intelligence. Spearman proposed that intelligence is a general cognitive ability that can be experimentally measured, and which can be conceptualized as the ability to think, analyze situations and solve problems (Spearman 1904). He proposed that specific skills (termed factors *s*), along with *g,* are at work during the execution of specific tasks (Spearman 1927).

Thurstone (1938) was one of the firsts to propose the idea that intelligence is not a general ability, but that it consists of a number of primary mental abilities such as verbal comprehension, word fluency, inductive reasoning, associative memory, perceptual correctness, spatial visualization, and numerical ability.

5.1. Gardner's theory of Multiple Intelligences

Gardner criticized the psychometric approach to intelligence initiated by Spearman, pointing out that such a traditional approach can address only certain human abilities, while it leaves out a wide variety of important skills. People are naturally predisposed to develop some skills instead of others, and they encounter less difficulty when they learn certain types of information as opposed to others (e.g. verbal versus visual information).

Gardner's conceptualization (1983) is known as the theory of *multiple intelligences.* He identified core abilities that are essential to coping with everyday life situations and described seven types of intelligence: verbal-linguistic, logical-mathematical, visual-spatial, interpersonal, body-related or kinaesthetic, intrapersonal, musical. In 1999, he added a further type to this list, the naturalistic intelligence. He proposed that these different domains are independent and result from a complementary but independent evolutionary course.

Bodily-kinaesthetic intelligence concerns the ability to dedicate oneself to physical activity such as dance, craft making, and sports. The learning process works according to the *learning by doing* motto. People with enhanced bodily-kinaesthetic intelligence enjoy physical activity and building things. Extroversion and sensitivity to other people's needs and feelings and a cooperative and respectful attitude are characteristics of interpersonal intelligence. Successful communication and empathetic skills are among those abilities that usually make individuals popular. These people typically learn best by working with others and often enjoy discussions and debates. Intrapersonal intelligence fosters introspection and the development of the skills of self-awareness and reflection. Verbal-linguistic intelligence together with logical-mathematical intelligence have always been more at the centre of the attention and concerns of scholars. Verbal intelligence relies on the ability to use language for an effective communication. People with verbal-linguistic intelligence master syntax and the structure of language very well and have fewer difficulties learning new words and foreign languages. They typically enjoy explaining or teaching. Logical-mathematical intelligence relies on logic reasoning and abstraction, such as is necessary for mathematics and computer programming. Spatial intelligence deals with the visualization and manipulation of spatial information. It is often associated with good visual memory and artistic talent. Individuals with musical talent have a good sense for music, tones and rhythm. They are likely to enjoy playing instruments. Naturalistic intelligence deals with nature and nurturing. Greater sensitivity to nature and naturalistic beauties are among the characteristics of this type of intelligence, along with the interest for animal species and their environment, the passion and the care for growing and nurturing living beings.

Gardner's theory suggests that the adoption of a unified educational method for all students is not the most suitable approach. Teachers should take advantage of the natural predispositions of the students and devote greater attention to those domains in which each student is weak. This theory has received some criticism both from the psychology and educational communities. Some critics argue that this approach is based on intuitions rather than experimental data, and that beyond those intelligences it is possible to identify traits of personality. Despite some scepticism, the perspective sketched by this theory has gained popularity over the last years. An important aspect of this approach is that it postulates that linguistic/verbal intelligence might constitute separate sets of skills that might develop independently, and which might be dissociated from general intelligence. We considered this perspective very interesting and decided to test it in our study. We used the Raven's Advanced Progressive Matrices (Raven 1938) to measure the general intelligence of our volunteers, and the Mehrfachwahl-Wortschatz-Intelligenztest (VMLT, Lehrl 1999) to assess verbal intelligence.

5.2. Testing general and verbal intelligences

We used the Raven's Progressive Matrices to assess nonverbal intelligence. Cultural factors such as social environment, status, schooling and occupation obviously influence the development of intellectual skills to a great extent. For instance, Gay and Cole (1967) showed that rice farmers in Liberia develop a good sense for estimation of rice quantities. Young adults in Botswana, who are continuously exposed to story telling from their early childhood, achieve good recall abilities for stories (Dube 1982). In an analogous way, enhanced intellectual performances are likely to be observed among people with a high occupational status and a high educational level. Kohn and Schooler (1973) evaluated through questionnaires a large sample of men with varying occupational profiles (managers, farmers, etc.). They observed that more demanding jobs on a cognitive level correlated with higher levels of intellectual flexibility. The question whether the cognitive efforts imposed by those jobs foster the development of intellectual skills or whether, on the contrary, pre-existing abilities made people able to engage in such occupations remains unanswered. Probably, a reciprocal influence of the two factors explains this process. Nevertheless, there is no doubt that enrolling in scholastic education trains intellectual skills such as reasoning, problem solving and attention, and that those skills develop to a different extent in individuals.

The Raven's Progressive Matrices make up a culture-free test devised to measure general intelligence irrespective of nationality, education, age, and sex. This test is widely used and has become a standard measure for reasoning and abstract thinking. It was originally developed by Raven (1938) to measure the *g* factor (Spearman 1904). The Raven's Progressive Matrices are constituted of matrices made up of geometric patterns with a level of progressively increasing difficulty. For each of these matrices, a geometric part of the series is missing. To complete the missing part of the pattern, the candidate needs to perform a multiple-choice process (i.e. he needs to identify the correct pattern among multiple alternatives). This task can be performed only if the participant is able to carefully observe the alternatives and make sense of the perceptual complexity of the matrix to complete.

The Advanced Progressive Matrices is a version developed for adults and adolescents with skills above average who were likely to continue with further education to graduate level. It contains 48 matrices, divided into two sets of 12, and 36 items. As the Standard Progressive Matrices, the level of difficulty progressively increases from the first to the last item.

We used the Mehrfachwahl-Wortschatz-Intelligenztest (MWT-B) to test verbal intelligence in our subjects. This German test is constituted of 37 strings of words. Each list contains 5 words, 4 of which are nonsense words. The task of the subject consists in identifying the correct word (one for each string). The level of difficulty of this choice increases from the first to the last string. Subjects who possess a rich vocabulary encounter less difficulties in this task.

We tested 60 participants on both the non-verbal IQ (Raven) and verbal IQ (MWT-B) and looked for correlations between these IQ measures and the subjects' scores on the linguistic measures: performance (pure pronunciation proficiency, M. Jilka) and the "talent" scores. Here we measured three independent "talent" indicators. 1. the pronunciation talent rating by M Jilka (see Chapter 2); 2. the MLAT (Modern Language Aptitude Test) with subtests (phonetic coding, grammatical sensitivity and vocabulary learning); and 3. an immediate imitation task of an unknown language (imitating Hindi words which were rated by 5 native speakers of Hindi).

The results showed no significant correlations of either the verbal or the non-verbal IQ with our above mentioned measures 1 (the "pronunciation talent score") and 3 (the Hindi imitation capacity), but it showed significant correlations with some of the MLAT scores and subscores. Thus, non-verbal IQ measured by the Raven Advanced Matrices was significantly correlated to the overall MLAT score (one tailed linear regression, $r = 0.44$, $P = 0.000$**, $N = 66$) and all three subscores of the MLAT MLAT3 – phonetic coding ability ($r = 0.36$, $P = 0.000$**, $N = 66$); MLAT4 – grammatical sensitivity ($r = 0.37$, $P = 0.000$**, $N = 66$) and MLAT5 Vocabulary learning ($r = 0.28$, $P = 0.003$**, $N = 66$)). Verbal IQ was significantly correlated to the overall MLAT total score ($r = 0.26$, $P = 0.005$**, $N = 66$) and its subscale phonetic coding ability, MLAT3 ($r = 0.37$, $P = 0.000$**, $N = 66$). These are highly interesting results, because they confirmed our hypothesis that there should be no significant correlation between the aptitude or ability for foreign language pronunciation and IQ measures. However, there was a significant correlation between both intelligence measures and the scores on the Modern Language Aptitude Test (MLAT). This result, or effect, can be partly explained by the fact that the MLAT, like many other language aptitude test batteries also measure some form of intelligence (for more information on that see Chapter by Hu and Reiterer pp. 97 and Chapter by Nardo and Reiterer, pp. 213).

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