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Embodied cognition in bilinguals: Differences in sensorimotor processes in a native and a learned language

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ABSTRACT

The Socially Situated Cognition approach argues that cognition emerges from the interaction with the physical and social context, as opposed to being abstract, symbolic and independent from the interactions with other agents and the environment. Therefore, human cognition is adaptive, shaped by the context and grounded in sensorimotor, perceptive and affective experiences. In other words, cognition is embodied. However, research with bilingual speakers suggests differences between the sensorimotor and affective processing in a native language (L1) and a second language learned later in life (L2). These differences seem to derive from the fact that while L1 is early acquired in rich sensorimotor and affective contexts, namely in the family, L2 is usually learned and used in formal contexts such as in school or at work. Therefore we suggest that L2 is not embodied or at least to the same extent as L1 is. In the current work we have replicated Spivey and Geng's (2001) paradigm, documenting the role of sensorimotor processes in cognition by measuring participant's eye-movements during auditory language comprehension tasks. Additionally we extended this research by including a visual detection task in which these sensorimotor processes are further examined. The results obtained partially document our hypothesis and open new research avenues for the examination of embodied processes in cognition.

Key Words: Socially Situated Cognition, Embodiment, Eye-tracking, Sensorimotor Processing

APA Classification Categories and Codes:

2340 Cognitive Processes

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RESUMO

A abordagem da Cognição Socialmente Situada argumenta que a cognição emerge da interação com o contexto físico e social, não sendo por isso abstrata, simbólica e independente das interações com outros agentes e com o meio ambiente. Assim, a cognição humana é adaptativa, moldada pelo contexto, e fundamentada em experiências sensoriomotoras, preceptivas e afetivas. Por outras palavras, a cognição é corporalizada. Contudo, a investigação com indivíduos bilingues sugere diferenças nos processos sensoriomotores e afetivos entre a língua nativa (L1) e uma segunda língua aprendida posteriormente (L2). Estas diferenças parecem decorrer do facto de L1 ser aprendida precocemente em contextos ricos em termos sensoriomotores e afetivos, como a família, L2 é geralmente aprendida e utilizada em contextos mais formais como a escola ou o trabalho. Assim, sugerimos que L2 não é corporalizada ou pelo menos não tanto com L1 o é. No presente trabalho replicamos o paradigma de Spivey e Geng (2001), que documenta o papel dos processos sensoriomotores na cognição através da medição dos movimentos oculares dos participantes em tarefas auditivas de compressão linguística. Além disso, alargamos esta investigação ao incluirmos uma tarefa de deteção visual na qual estes processos sensoriomotores são também investigados. Os resultados obtidos ainda que confirmam apenas parcialmente as nossas hipóteses e abrem novos caminhos à investigação dos processos corporalizados na cognição.

Palavras-chave: Cognição Social Situada, Corporalização, Eye-tracking, Processamento Sensório-motor

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PART I: INTRODUCTION

The traditional approaches adopted in the study of mental processes have been linked to the computer metaphor, suggesting that cognitive representations and processes are symbolic, abstract and stable. Therefore, and until very recently, the role of contextual factors in the study of cognition has been quite neglected. Current perspectives argue, however, that social cognition is adaptive and shaped by the context (e.g., Smith & Semin, 2004; Semin & Smith, 2013).

The Socially Situated Cognition approach suggests that mental processes emerge from "adaptive sensorimotor interactions with a dynamically changing social and physical environment and are grounded by the constraints of the human body and the environment" (Semin, Garrido, & Palma, 2013, p. 638; see also Semin & Garrido, 2015; Semin, Garrido, & Farias, 2014; Semin, Garrido, & Palma, 2012). Affective, perceptive and sensorimotor experiences also have their fair share in human cognition.

A situated cognition assumption that has been receiving vast empirical support is the idea that cognitive processes are grounded in perceptive, affective and sensorimotor experiences - thus, cognition is embodied. Embodiment is therefore considered as the sensorimotor basis of cognition (Semin, et al., 2012, 2013).

The main argument of this dissertation is that there are differences in the embodiment processes underlying the processing of a native, first language (L1) in comparison with a second language, learned later in life (L2), in bilingual individuals. This assumption is based on the work of several authors (e.g., Colbeck & Bowers, 2012; Keysar, Hayakawa, & An, 2012; Pavlenko, 2012; Schwanberg, 2010) suggesting differences in the processing of the two languages.

The main goal of this dissertation is therefore to investigate the sensorimotor differences in the processing of L1 and L2 in bilingual individuals. For that purpose, we will use the paradigm developed by Spivey and Geng (2001) in which participants listened to five prerecorded scenes that contained directional cues (upwards, downwards, leftwards, and rightwards), as their eye movements were being recorded with an eye-tracking device. The results of this study indicated that while participants

listening to these scenes, the direction of their saccades matched the directional cues included in the scene. These findings were taken as evidence of embodied cognition.

Based on these findings, as well as on the research with bilinguals reporting processing differences between L1 and L2, we advanced the hypothesis that the results obtained by Spivey and Geng (2001) would only be replicated when participants listen to the scenes in their native language, and would not be observed in L2, at least to the same extent. This dissociation would indicate that a second language is less embodied.

The current dissertation is divided into three sections. In the first section, we present the theoretical framework namely a brief description of the traditional and situated approaches to cognition, with particular emphasis on the concept of embodiment. In this section, we also address the main theories and research that suggest that affective and sensorimotor processing is more pronounced in a first language, when compared with a second language. In the end of this section, we will present some evidence of the operation of sensorimotor processes in language comprehension and we will detail the study by Spivey and Geng (2001), which documents these embodied processes by measuring eye movements.

In the second section of this dissertation, we present an empirical study. This study replicates the paradigm of Spivey and Geng (2001) but extends their work by testing participants in L1 but also in L2. Additionally, the study included a new visual detection task, in which participants were asked to detect dots presented in different parts of the screen as they heard the same pre-recorded scenes that were used by the authors in the original study.

In the third section, we present the discussion of the results of the empirical study, along with some limitations of the current work and some suggestions for future research in this field. Finally, we give credit (Prada & Garrido, 2013) to all the sources used to complete this dissertation.

Traditional and current approaches to cognition

Cognitive science emerged during the 1950s, as a product of an era when psychology, linguistics and anthropology were redefining themselves (Miller, 2003). Thus, cognitivism arises from a dissatisfaction with the behavioral approach, allied to the rapid evolution of computer science and information theory, two tools, which

became easily applicable to the study of the human mind (Gardner, 1987). Psychology could not join in the so-called cognitive revolution, until it had freed itself completely from behaviorism, reinstating cognition to scientific respectability (Miller, 2003).

Although, cognitivism constituted a major advancement to the study of mental processes, in the early stages of this movement, the focus was only on the organization of the structures and processes that operated on knowledge, such as attention, perception, problem solving, memory or language (Shapiro, 2010). The study of the content that was processed in the mind was completely undervalued by the early cognitivists (Gardner, 1987). At the time, the human mind was perceived as a Turing machine (Fodor & Pylyshyn, 1988) that translated and stored perceptual inputs into the form of a symbol-based representation. In other words, according to this amodal approach, cognitive processes where nothing less than a "closed loop of symbols or an internal model of the world" (Semin et al., 2012, p. 640). Thus, according to this perspective, cognition was perceived as static, timeless and largely immune to background influences (Semin et al., 2012).

In short, early approaches to human cognition isolated the basic components of the mind, analyzing them from a more individual, microscopic and symbolic point of view, in an attempt to understand more complex cognitive processes (Garrido, Azevedo, & Palma, 2011). Moreover, the materials used by early cognitive researchers often undermined the validity of the findings, due to their abstract and artificial nature (Gardner, 1987).

In the early 80's, Searle (1980) developed a very well know argument, called *The Chinese Room,* in order to refute this approach. In this experiment, a person is in a room with a computer program that reproduces Chinese characters. That person does not understand the language, but manages to reproduce the characters as they are manipulated by the computer. Does this mean that the person understands Chinese? Is the person meaningfully communicating? Absolutely not. Although the person is reproducing the characters, he/she is processing the information in a merely symbolic and amodal way, as a computer does, which does not produce real understanding.

Based on these, and other findings, it was time for researchers to embrace a perspective that took into account the body and the environment - the Situated Cognition approach. In the past, cognitive researchers underestimated the theoretical relevance of the outside world in the study of the human mind, which they considered to

be a mere abstract information processor (Wilson, 2002). In the mid-19th century some authors (e.g., James, Vygotsky and others) started to distance themselves from this closed up view of cognition, as they believe that environmental aspects had their fair share of impact in cognitive processes. For example, William James argued that the psychological mechanisms have to serve a purpose in our interactions with the world, otherwise they don't exist (Smith & Semin, 2004). Thus, he introduced a notion that remains in the situated cognition approach to date – cognition is for action (Smith & Semin, 2004).

In short, the movement defined as situated cognition emerged as a response to the decontextualized perspective of the human mind that prevailed at the time. With the emergence of this approach there was a new focus on the environment and the social context, and their influence on the cognitive processes (Hutchins, 1995).

Clancey (1995) underlined the subsequent assumptions of the situated cognition perspective: 1) Knowledge is explanatory. Writings, frames and strategies are the observable product of the individuals dynamic cognitive processes and the interactions between the agents and the context, instead of being existing structures; 2) Meaning is definitely not static nor fixed: knowledge acquisition is a constant process, as all the information is assembled and interpreted by an individual in the environment.

More recently this approach was organized around four fundamental assumptions that define cognition as action-oriented, embodied, situated and distributed (Smith & Semin, 2004; Smith & Semin, 2013; see Semin & Garrido, 2015; Semin et al., 2012, 2013; 2014 for reviews). *Cognition is action-oriented:* Under this assumption there is a very close link between cognition, motivation and the action itself; *Cognition is situated:* The approach of situated cognition rejects the individualistic conception of action, in which cognition is perceived as being implemented by abstract information processes, totally isolated from the context. In contrast, according to this perspective, mental processes emerge from the interaction with the environment*; Cognition is distributed*: Cognition does not rely solely in our mind, it is distributed, being implemented by systems that connect the mind with physical and social aspects of the environment; *Cognition is embodied:* This principle is one of the most studied within situated cognition and defines action as the aim of cognitive activity, and the body as the vehicle of all the action. This later assumption will be further developed in the next section.

Cognition is Embodied

One of the main assumptions of the situated cognition approach and that has gathered large empirical support, is the idea that cognition is grounded in perceptive, affective and sensorimotor experiences. Indeed, our bodies are involved in the way we represent others and the world. This sensorimotor foundation of knowledge is usually referred to as embodiment (e.g., Barsalou, 1999, 2008).

Specifically, a set of relatively static conditions including our body composition, influence our existence, way of being and experience. The sensorimotor experiences shape the actions and interactions of individuals, as well as their knowledge. According to Semin and colleagues (2012) embodiment originates from bodily interactions as the cognition is controlled by the limitation of our bodies.

In short, the embodied cognition approach can be summarized in two overall statements: 1) Cognition is neither abstract nor amodal. In reality, representations are multimodal and thus grounded in the sensorial modalities of the human brain and in our actions (Barsalou, 2003, 2008; Boncoddo, Dixon, & Kelley, 2010; Glenberg et al., 2008); 2) cognition is not just about thinking. If we identify the important role of perceiving and acting for cognition, than we have to take into account non-cognitive aspects in the very definition of cognition (Barsalou et al., 2007; Smith, & Sheya, 2010).

Furthermore, affective and emotional processes are an important contributor to cognition (e.g., Glenberg, 2008; Stapleton, 2013). Thus, it becomes clear that the understanding of thinking goes beyond the processing of symbols. Therefore, human functioning cannot be defined by a simple set of abstract features (classical representation), but by the actions between an individual and an object or other person (Gibson, 1966): cognition is embodied.

Empirical evidence supporting this assumption is currently vast and diverse. One of the first empirical demonstrations of embodiment can be found in early studies conducted by Solarz's (1996) who developed an experiment in which participants were presented with cards with names of objects. As they were exposed to the cards, they responded if they liked or disliked the object by moving a lever. Half the participants were instructed to pull the lever toward them (approach) whenever they liked the object displayed or to push the lever in the opposite direction (avoidance) when they disliked the object. For

the other half of the participants, the task was reversed: they should pull the lever towards them when they didn't like the object and in the opposite direction when they liked it. The results showed that participants were faster to pull the lever towards them when they liked the objects compared to when they did not. Subsequently, Kawakami, Phills, Steele, and Dovidio (2007), replicated this experiment in the context of the study of stereotypes. The outcomes showed that after performing approach tasks participants' attitudes towards African-Americans individuals were more positive, when compared with the reactions after avoidance tasks (see Paladino & Castelli, 2008).

In an early experiment conducted by Wells and Petty (1980) it also became evident that body movements shape individuals' attitudes. Specifically, shacking or nodding the head, was shown to influence whether participants agreed or not with persuasive messages. The authors asked college students to shake (horizontal movements) or nod (vertical movement) their heads at the same time they listened to persuasive messages, as they thought that they were participating in a study to test the quality of a brand of headphones. The persuasive messages were related to an increase (counter-attitudinal message) or reduction of the tuition fees (pro-attitudinal message). Results indicated that participants who nodded their heads agreed more with counter-attitudinal messages compared to those who shook their heads.

The studies presented above suggest that movements or bodily states have some influence in the responses of the participants, and provide evidence that human functioning can be defined as embodied (Semin et al., 2013). Additional evidence has been accumulated indicating that both concrete (cf. Pecher, Zeelenberg, & Barsalou, 2003; Taylor & Zwaan, 2008; Zwaan & Taylor, 2006) and abstract concepts (e.g., Farias, Garrido, & Semin, 2013; Lakens, Semin, & Garrido, 2011; Palma, Garrido, & Semin, 2011; Schubert, 2005; Semin & Garrido, 2012) are grounded in sensorimotor processes.

In short, the amodal approach, that defined the cognitive functioning as a closed loop of symbols, was challenged as the embodiment research showed that the human body is much more complex than a mere output device.

Processing in L1 and L2

Another essential subject in the current dissertation is language, since we will try to unravel whether there are any differences when a participant is exposed to verbal stimuli in his/her native language (L1) in comparison with a second language, learned later in life (L2). Specifically, while L1 refers to "a language or languages learned from birth, regardless of the speaker's current proficiency" L2 is a language "learned after early childhood" (Pavlenko, 2012, p. 407). In the current study we will only focus on bilingual speakers who acquired L2 after the age of twelve.

Many authors, from different perspectives (e.g., neurological, clinical, experimental) have dedicated their work to understanding the cognitive and emotional variations that individuals experience when faced with similar verbal stimuli in L1 and L2. It is now commonly believed that while the native language is learned at home, in a familiar context, a foreign language is usually learned (and used) later in life, in a classroom or work context. Therefore, the affective load during L1 acquisition is much higher when compared to the one in L2. Additionally, the learning context of L2 does not provide as much opportunities for the integration of all sensory modalities and verbal conditioning as L1. These contexts lead to the "development of disembodied words used freely by speakers who do not experience their full impact" (e.g., Pavlenko 2012, p. 421; cf. Dewaele, 2004, 2008, 2010; Pavlenko, 2004, 2005).

The previous assumptions are always conditioned by two factors: the age and the context of acquisition. If the L2 was learned after the age of 12 (late bilinguals) it is most likely, learned at school. Following this line of reasoning, in our study we will only focus on late bilinguals.

More than 100 years ago Sigmund Freud noticed differences in affective reactivity in bilinguals. Specifically, he started to realize that when his bilingual or multilingual patients were approached with the use of obscene words or the discussion on topics that entailed some anxiety load (e.g., sex) they were more comfortable speaking in L2.

After the second world war, this subject was again explored in *clinical contexts,* providing further evidence that supported the existence of a differential affective reactivity in bilinguals and multilinguals, at least when using taboo words (e.g., Amati-Mehler, Argentieri, & Canestri, 1993; Aragno & Schlachet, 1996; Javier, 1995). Indeed,

while L1 patients normally displayed higher anxiety levels, when they spoke in L2, they seem to be more detached and their verbalizations seemed to be less emotional.

For example, in a study conducted by Schwanberg (2010) the author asked 19 late Spanish–English bilinguals who suffered from posttraumatic stress disorder, to describe a traumatic memory and rate the intensity of the recall in both languages. The results showed that recalls were rated significantly higher in L1. These outcomes suggest that the same verbal stimuli can be internally processed in a different way, according to the language of the self-report. The authors explained this effect arguing that there is a direct link between languages of encoding and autobiographical memories (e.g., Pavlenko, 2012).

Undoubtedly, the clinical perspectives provided evidence of a different affective processing of negative memories and anxiety-related topics, through the study of bilingual autobiographical reports, however they failed to clarify the influence of the factors that promote this differences (e.g., Pavlenko, 2012).

The *psychophysiological study* of the differences in cognitive and affective processing between L1 and L2, has included several physiological makers (e.g., activation of smile, heart rate). One of the most sensitive markers of the human body is the skin, so when individuals are facing relevant stimuli, there is an increase in adrenaline on the blood stream that leads to sweat, which in turn, stimulates electrodermal reactivity. In this type of research authors frequently resort to fingertip electrodes. An increase that occurs between 1 and 1.5 seconds after the participant being presented with the stimulus is referred to as SCRs (Skin Conductance Response) (e.g., Harris, 2004).

Studies with monolingual English speakers show that there is a higher rate of SCRs when participants are exposed to words with negative connotation, such as taboo and anxiety-related words, when compared with neutral words and euphemisms. Caldwell-Harris and colleagues (e.g., Caldwell-Harris & Ayçiçegi-Dinn, 2009; Caldwell-Harris, Tong, Lung, & Poo, 2011; Harris, 2004; Harris, Ayçiçegi & Gleason, 2003) designed a number of studies in order to examine electrodermal reactivity in bilingual speakers.

In one of those studies Harris et al. (2003) asked 32 Turkish-English bilinguals, living in the US, to rate childhood reprimands as well as positive, negative, neutral and

taboo words in both auditory and visual modalities while the SCR was being measured. The outcomes indicated that words presented in L1 (Turkish) elicited higher SCR in comparison with L2 (English), particularly in the auditory task. The gap between the SCR values of the two languages was higher when they were exposed to childhood reprimands, in both tasks. Importantly, some of the participants reported that when they heard this reprimands, they went back in their mind to situations where their Turkish family members scolded them. These reports suggest a link between verbal conditionings and emotional socialization experiences, as childhood reprimands were associated with anxiety and fear.

The results from another study conducted by Caldwell-Harris and colleagues. (2001) revealed that the age of acquisition of the language is a game changer, because the younger the individuals learn a second language, more similar will be the results between L1 and L2. That is, they rate and feel reprimands with the same emotional intensity regardless of the language in which they are presented.

The embodied differences between L1 and L2, were also *experimentally investigated*. For example, using Stroop tasks (e.g., MacLeod, 1991; MacLeod & MacDonald, 2000), in which participants are asked to name the color of the printed word. When the color name does not correspond to the color in which the word is printed (e.g., if the word green is printed in yellow) there is a cognitive conflict and it is harder to name the correct color (e.g., Hennessey, Dourado, & Beilby, 2013). The emotional Stroop compares the color naming speed for words there are neutral ("truck" in blue ink) in comparison with emotional-laden words (e.g., "kiss" in blue), with the belief that the response times would be slower when participants were exposed to negative and taboo words, due to the interference emotional effects (Pavlenko, 2012).

Colbeck and Bowers (2012) used a modified version of the emotional Stroop called Rapid Search Visual Presentation (RSVP) task, where a sequence of words is displayed rapidly, in the same spatial positions. Usually, the first word is either a taboo or a neutral word and the second a color word. In this task, participants were told only to identify the color word, ignoring all the other words in the stream. The authors selected for this experiment native English speakers, and Chinese's who have learned English later on in life (late English bilinguals). Results revealed that L1 English speakers showed significantly higher error rates (13.9%), in comparison with the L2 English speakers (5.6%). Additionally, the authors further examined these differences,

by asking participants to only identify taboo words. The outcomes were similar, as the error rates in L1 were 13%, as opposed to 6.7% in L2, leading the authors to suggest that less emotionality reduces the interference in an automatic processing condition, providing a processing advantage in L2 (see Pavlenko, 2012).

We can assume from these findings indicating that in late bilinguals, there is an increased automaticity in affective processing in L1, and that in L2, on the other hand, exists a decreased automaticity of affective processing. This leads to a disembodied cognition on the L2 that reduces the negative weight of taboo words and swearwords.

A recent experiment by Keysar and colleagues (2012) suggested that "thinking in a foreign language" diminishes decision biases. The authors used an adapted version of the Asian disease task, in which participants are presented with two frames: a gain frame (if you do X, Y people will be saved) and a loss frame (if you do X, Y people will die). Most of the participants in the experiment by Keysar and colleagues (2012) were late bilinguals that were learning a Foreign Language as they were living in the L1 context: 1) L1 English learners of Japanese in the US; 2) L1 Korean learners of English in Korea; and 3) L1 English learners of French in France. In each group the participants were randomly assigned to L1 or L2 condition. The L2 randomly chosen group were the L1 English learners that lived in France, and the results did not differ from the other groups either because of the late age of acquisition or the low proficiency. The outcomes pointed to an asymmetrical preference in the gain-frame condition in the L1, yet that wasn't observed in L2. In a second experiment Keysar and colleagues (2012) tested loss aversion inclinations. The results indicated that Korean learners of English, took more bets in the second language. Furthermore, a third experiment by the same authors added a cash given variable, as they gave money if they chose the loss frame. The only group included in this experiment was the L1 English learners of Spanish, which demonstrated a higher inclination to take bets on L2 (Spanish). Overall, the outcomes of these studies showed evidence of the advantage in L2 emotional processing, since there was a clear reduction of framing biases and loss aversion.

In the few attempts to explore L1 and L2 differences in the *neuroscientific perspective*, authors have used ERPs (Event-related Potential) to tap attention changes toward words with emotional weight. These experiments (e.g., Conrad, Recio, & Jacobs, 2011; Opitz & Degner; 2012; Wu & Thierry, 2012), showed evidence that L2 affective processing may be less automatic and, therefore immediate. This probably

happens due to a delay on the lexical access. Nevertheless the study of brain activity during language processing in bilingual speakers requires further examination.

The research described above demonstrate the existence of clinical (e.g., Amati-Mehler, et al., 1993; Aragno & Schlachet, 1996; Javier, 1995; Schwanberg, 2010) experimental (e.g., Colbeck & Bowers, 2012; Caldwell-Harris & Ayçiçegi-Dinn, 2009; Caldwell-Harris et al., 2011; Harris, 2004; Harris et al., 2003; Keysar et al., 2012) and preliminary neuroscientific evidence (e.g., Conrad et al., 2011; Opitz & Degner; 2012; Wu &Thierry, 2012) supporting the hypothesis that there are differences in the processing in L1 and L2, namely driven by affective processes.

Sensorimotor grounding of cognition: Evidence from eye-tracking research

With each passing second the human eye unintentionally produces between three to four vertical saccades, ,making it the most common human movement (Bridgeman, 1992). This frenetic movement arises from the need to process images from the enormous amount of visual information that a person is exposed to every day. Through the eye saccades the visual stimulus are sequentially analyzed in small portions (Treue, 2001). The region of the eye, responsible for capturing a large amount of information from the eye field is called fovea, and it speeds of up to 500º every second, resting for about 200 to 300 milliseconds every time the eye closes (Richardson & Spivey, 2004).

Eye movements are crucial to the operation of vision. However, the research of these mechanisms provides insight that goes far beyond the study of perceptual systems, due to their relation to attentional mechanisms. Indeed, the analysis of the eye saccades provides comprehension of cognitive processes, like memory, decision-making, language and mental imagery (e.g., Richardson & Spivey, 2004). In the current work we will pay a closer attention to the relation between eye movements and mental imagery as an indicator of embodied processes in language comprehension.

The claim that mental simulation occurs during language comprehension has been gathering empirical support. For example, the results of Zwaan and Yaxley (2003) indicated that when word pairs were presented in iconic relation (e.g., basement presented bellow attic), participants' semantic relatedness judgments were significantly faster than when the word pairs were presented in reverse iconic relation (e.g., attic presented bellow basement). In a different but related study, Borghi, Glenberg, and

Kaschak (2004) presented the participants with sentences (e.g., There is a car in front of you) and asked them to indicate whether a target word (e.g., roof, wheel, or road) was part of the object (e.g., car) mentioned in the sentence (e.g., roof and wheel) or not (e.g., road). Participants responded by moving the arm upward to respond "yes" and downward to respond "no" (or the reverse, in another condition). The results indicted faster responses in congruent trials (e.g., when responding to the word "roof" required an upward movement versus when the response required a downward movement). In line with an embodiment perspective, reading the word "roof" should prepare us to act in a upward manner because that's the kind of action we execute to interact with a roof of a car, whereas reading the word "wheels" should prepare us to act downward.

The sensorimotor grounding of language was further illustrated by the work Matlock (2004), showing that participants were faster reading target sentences if they were in a context describing "plain terrains" compared with "rough terrains". These results suggest that participants were actually mentally simulating movement through the terrain.

Other researchers have examined these processes based on the assumption that when a person imagines an object, the same scanpaths associated with viewing it are automatically triggered. This means that the eye movements establish the link between elements of vision and a mental model (e.g., Hebb, 1968). Therefore, when individuals look at a blank white display, they would follow the actual block pattern that they created when staring at a similar object, recreating the images mentally. Their eyes also tend to follow the direction of the spatial expressions present in the speech.

In an illustrative experiment, Richardson and Spivey (2004) showed evidence that participants systematically fixate specific empty spaces as they were asked about past semantic events associated with certain locations. In this study, participants watched videos of four individuals with short parts of factual information. The clips were displayed along a grid in four distinct regions. In between the videos, participants were asked questions regarding the facts of the clips. The locations that had been previously linked to the information were clearly the ones with a larger rate of fixations, even when the location moved around right before the question. These outcomes indicate that the relevant settings where a specific event takes place are re-fixated after a memory is triggered.

More recent studies showed that eye movements are not only engaged by a memory of a perceptual experience, but constitute cognitive parts of imagination. For example, Spivey and colleagues (Spivey & Geng, 2001; Spivey, Tyler, Richardson, & Young, 2000) recorded the eye movements of participants while they listened to five prerecorded spatiotemporal scenes while staring at a blank white screen. These scenes contained directional cues (upwards, downwards, leftwards, rightwards and control), such as "On the 29th floor, two kids are sitting in the fire escape smoking cigarettes". Results showed that when participants were relaxed and unaware that their eye movements were being recorded, the direction of the saccades matched the cues of the auditorily presented scenes.

These results support the assumption of an embodied cognition, in which the eyes moved in several directions in order to construct a mental picture of the described scenes. Thus, many authors state that motor and cognitive processes work together to trigger a particular mental state. In other words, motor actions such as eye movements are driven both by mental processes and properties of the visual world (Richardson & Spivey, 2004).

The present work: Goals and Hypotheses

The main goal of the current work is to examine whether there are any sensorimotor differences between sensorimotor processing in L1 and L2, in a sample of Portuguese-English bilingual speakers. In other words, we will try to determine if L1 is more embodied than L2, as recent studies suggest (e.g., Colbeck & Bowers, 2012; Keysar et al., 2012; Pavlenko, 2012; Schwanberg, 2010).

For that purpose, we will use the paradigm developed by Spivey and Geng (2004), in which participants listen to five prerecorded stories of scenes containing directional cues (upwards, downwards, leftwards and rightwards). At the same time the eye movements of the participants will be recorded by an eye-tracking device. Moreover, we will extend their experiment by adding a L2 condition as well as a second task in which the participants will have to detect red dots that appear in different locations of the screen (top, bottom, left and right) as they hear the same prerecorded stories.

H1. It is expected that participants in the L1 condition will have more fixations and detect the dots more quickly in the location of the computer screen that matches the direction of the cues included in the story.

H2. In the L2 condition we expect neither a match between fixation zones nor a speeded reaction time when the direction of the story and the zone match or, if any, it will be to a less extent that than what is observed in L1.

PART II: EMPIRICAL STUDY

Method

Participants

Sixty-one[1] university students (63.9% females; M*age* = 22.55, *SD* = 5.37) participated in this experiment as volunteers or in exchange for course credit. Participants were all Portuguese-English bilinguals.

In order to determine if the participants were bilinguals we replicated a listening quizz from the Exam English[2] website using the Qualtrics Software[3].In this listening test participants heard two conversations, and answered ten multiple choice questions about each of them (see Appendix A). To sign up for the study all the participants had to complete this multiple choice quizz, with a minimum score of 75% correct answers (proefiency level).

Stimulus materials

As stimuli, we used five pre-recorded short stories (the same used by Spivey & Geng, 2001; see also Spivey, et al., 2000) in both Portuguese and English, containing directional cues (upwards, downwards, leftwards, rightwards; and control; see Appendix B). However, we think that it is not evident that the visual scenes described on each story are equally clear regarding the spatial dimension they represent (with the stories that describe visual scenes with upwards and downwards directional cues being the more obvious ones).

For the Portuguese version, the stories were translated into Portuguese and checked by two independent bilingual judges. The stories had approximately 65 words each. Both the Portuguese and the English stories were recorded by native speakers in a

[1] Ten participants were excluded from the analysis because they were problems with the calibration of their eyes or because they did not comply with the dot detection task.

[2] Web site that contains free online tests to practice for the most relevant international exams (e.g., IELS); see (http://www.examenglish.com/)

[3] Simple online software solutions used to create surveys.

female and in a male version. The duration of the spoken version of each story was about half a minute.

For the second stage of the study we used the same five pre-recorded stories in both languages. Additionally we used a set of thirty visual stimulus (10 black and 20 red dots) placed in different locations of the computer screen. The red dots were strategically distributed such that five dots appeared in the right upper corner, five in the upper left corner, five in the down right corner and five in the down left corner; see Appendix C)**.**

Procedure

Participants were tested individually. Prior to the experiment they were told that their participation was voluntary, and that no personal identifying information would be collected. The procedure complied with all the existent ethical guidelines.

Participants were randomly assigned to one of four experimental conditions. The difference between conditions was that in two of the conditions participants heard the stories in English and in the other two in Portuguese. In half of the conditions the stories were read by a female voice and in the other half by a male voice.

Participants were seated in cubicles in front of a computer monitor equipped with Tobii Eye Tracking Software[4] in interface with E-Prime[5], and informed that the goal of the study was to examine people's performance in auditory and visual tasks.

Participants were told that they were going to listen to a few short stories. Because we would be testing their multitasking ability, they should sit still as they listened carefully to the five pre-recoded stories while facing the computer screen where visual information would be presented any time. As they heard the stories, their eye movements were recorded by the Tobii Eye Tracking Software. To ensure that participants paid attention to the stories they were further informed that in the end of each story they would be asked a few questions about what they heard (e.g., "Is there a dog in this story?"). Participant's eyes were then calibrated as a few colored dots appeared on the screen. Although this task is part of the normal procedure of they eye-tracking device, participants were told that this constituted a training phase as

[4] Leading eye tracking software for computer interaction, gaming, analysis, research and AAC.

[5] Application used in psychology experiment design, implementation, and analysis.

subsequent tasks would require dot detection. Then the five stories were played. After each story participants responded to a simple question regarding the story (yes/no).

In a second stage we extended Spivey and Geng's (2001) experiment, by asking participants to detect dots on the screen as they heard the same pre-recorded scenes. For that purpose, participants heard the stories a second time while they had to indicate, as fast as possible, whenever a red dot appeared on the screen by pressing a computer key (ENTER). These 20 red dots, would be displayed (during 1 second) in different locations of the monitor (top, bottom, left and right). To increase the difficulty level of the task we added 10 black dots as distractors. In order to keep the participants focused on the stories, we told them that in the end they would have to answer a few questions about the scenes (but the questions never appeared).

At the end of the study we asked the participants if they had any comprehension issues regarding the stories and what they thought the purpose of the study was. Then participants were thanked and debriefed.

Results

Data Preparation

Due to several technical constraints we could only analyze the data of the second phase of the study. Initially we defined four zones where the dots were displayed (top right, top left; bottom right, bottom left), in order to assess whether the participants were faster to detect the dots when the zone in which they had appeared matched the directional cues (e.g., upward) implied in the story they had heard. To facilitate the analysis and presentation of the data, we grouped the presentation zones as follows: top (top-right, top-left); bottom: (bottom-right, bottom-left); right (right-top, right-bottom); and left (left-top, left-bottom).

Independent and Dependent Variables

The study configured a complex design of 5 Story (upwards, downwards, leftwards, rightwards, control) X 4 Zone (top, bottom, left, right) X 2 Language (Portuguese, English) X 2 Voice_Sex (female, male), the last two factors between participants.

The independent variables were:

- *Story* (direction of the cue present in the story: upwards, downward, rightwards leftwards, and control);
- *Zone* (zone of the screen in which the dots were displayed – top, bottom, right and left);
- *Language* (Language of the condition to which participants were assigned – L1: Portuguese, L2: English);
- *Voice_Sex* (Gender of the voice of the person reading the recorded story: Female or Male).

The dependent variables were:

- *Hits* (number of times that participants detected a red dot);
- *Errors* (number of times that participants detected a black dot);
- *Reaction Time* (amount of time that participants took since the moment the red dot appeared on the screen until the moment that participants detected it).

Hits and Errors

In each story participants' saw red (20 per story) and black dots (10 per story) on the computer screen. They were asked only to detect the red dots by pressing "ENTER" as they were displayed on the screen. The red dots were always associated with a specific area (top, bottom, right or left) while the black ones appeared randomly on the screen.

The analysis of hits and errors was based on the number of responses (number of times participants detected a dot) per number of dots that appeared during each story.

For the errors, if participants erroneously detected the 10 black dots then the proportion of errors would be 1 (10/10). If they detected 5 black dots this proportion would be 0.5. Overall, the results indicated that the proportion of errors was only 8% (M = 0.83, SD = 0.17).

The proportion of hits (detection of the red dots) was based on the number of detected red dots in each zone per number of dots appearing in each zone. There were 20 red dots per story (5 per zone). Results indicated a proportion of hits of 97% (M =

0.97; *SD* = 0.09). Therefore, the average performance in detecting the red dots was quite high.

Taken together, the lower rates of errors and the higher rates of hits suggest that participants were performing extremely well on this very difficult task.

Subsequently, we examined whether the hits were affected by the match between the directional cues implied in the story and the zone where they appeared (e.g., story with directional cues upwards and dots presented at the top of the screen), as well as by the two between participants' independent variables (language, and voice_sex). Our hypothesis was that the number of hits would be higher when the area where the dot was displayed and the directional cues implied in the story were a match, particularly when the story was presented in L1 (Portuguese).

A repeated measures analysis of variance on the proportion of hits indicated that, contrary to what was expected, the results did not reveal any significant main or interaction effects.

Reaction Times

In a second stage, we calculated the average amount of time participants took since the moment each red dot appeared on the screen until the moment participants detected it. Overall participants were very fast in this task (*M* = .434 ms; *SD*= .69 ms).

We then proceeded to the analysis of variance with repeated measures, in order to examine the influence of the independent variables in the reaction time of the participants. The results only revealed a Story x Zone x Language interaction, $F(12,636) = 1.74$, $p = .054$, $\eta^2 = .032$). This effect is in line with our main hypothesis suggesting that participants were faster in detecting the red dots when there was a match between the directional cues of the story and the zone where the red dots were presented, particularly in L1.

To better understand these results we reanalyzed the data decomposed in two dimensions: 1) *vertical:* upwards and downwards Story / top and bottom Zone; 1) *horizontal:* leftwards and rightwards Story / Left and right Zone. Language was also entered as a between variable.

Vertical Dimension

As shown in Figure 1, and as expected, when hearing a story with downwards cues in their native language (L1) participants were faster in detecting the red dots when they appeared in the bottom of the screen (M = 441, SE = 17) compared to when they appeared at the top (M = 445, SE = 16). When hearing a story with upwards cues reaction times were faster for dots appearing at the top of the screen (M = 431, SE = 15) and slower when the dots appeared at the bottom (M = 433, SE = 13).

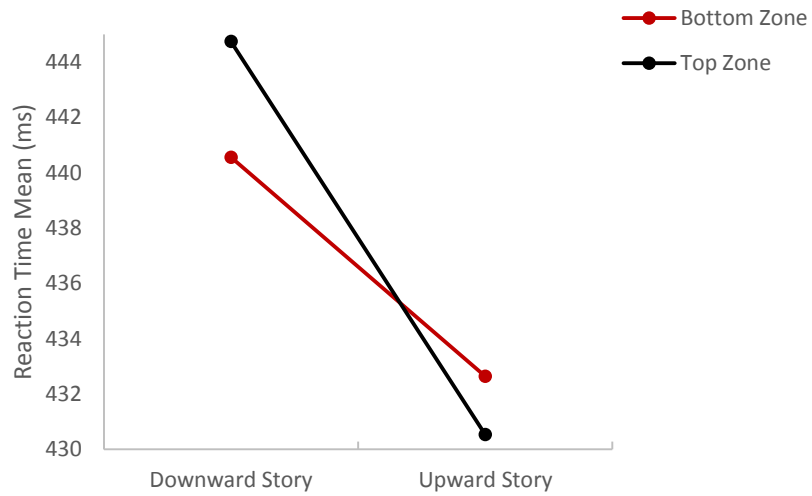

Figure 2.1. Reaction times as a function of Story and Zone in L1 (vertical dimension)

When the stories were presented in L2 (see Figure 2) the interaction between story and zone was no longer observed.

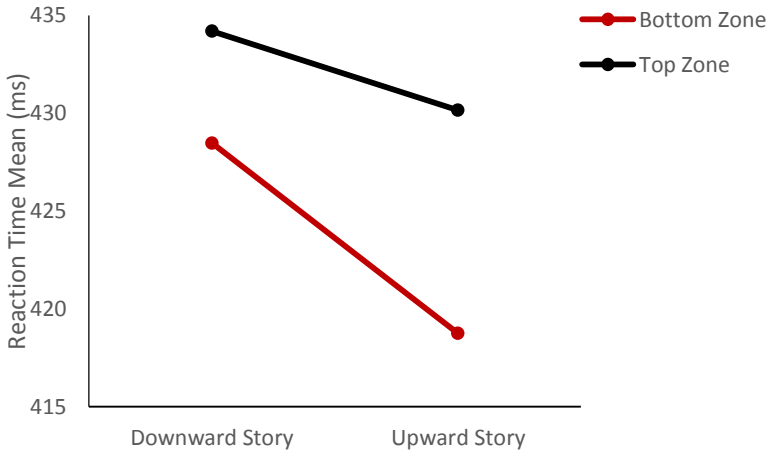

Figure 2.2. Reaction time s as a function of Story and Zone in L2 (vertical dimension)

Participants were always faster when detecting the dots at the bottom of the screen particularly when the story included directional cues upwards. Thus, when the story included downward cues participants were faster detecting dots at the bottom (M = 428, SE = 14) and slower when they appeared at the top (M = 434, SE = 14). Surprisingly the same pattern emerged but even more pronounced when the story contained directional cues upwards. In this condition participants were also faster when the dots appeared at the bottom (M = 419, SE = 12) than when they appeared at the top of the screen (M = 430, SE = 14).

Horizontal Dimension

As displayed in Figure 3, and in contrast with our predictions, reaction times were not faster when there was a match between the directional cues of the story presented in L1 and the zone where the dots appeared. In fact, the opposite pattern emerged.

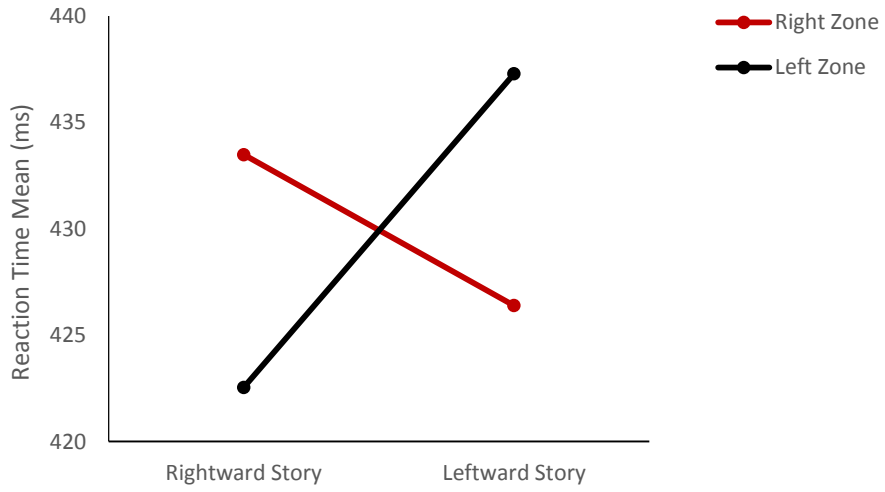

Figure 2.3. Reaction times as a function of Story and Zone in L1 (horizontal dimension)

When the story contained rightward cues, reaction times were faster the dots were displayed on the left (M = 423, SE = 14) than on the right (M = 433, SE = 13). The reverse pattern was observed in stories containing leftward cues. When the dots were

displayed in the left zone, the reaction time was slower (*M* = 437, *SE* =14), comparing to when they were displayed in the right zone (*M* = 426, *SE* = 14).

This pattern contradicts our hypotheses, as we expected participants to be faster in identifying a dot that matched the directional cues contained in the story. The possible reasons for these results are advanced in the discussion.

When participants heard the stories in L2 (see Figure 4) they were always faster in detecting the dots on the left side of the screen, but, and as expected, more so when the directional cues contained in the story were leftwards.

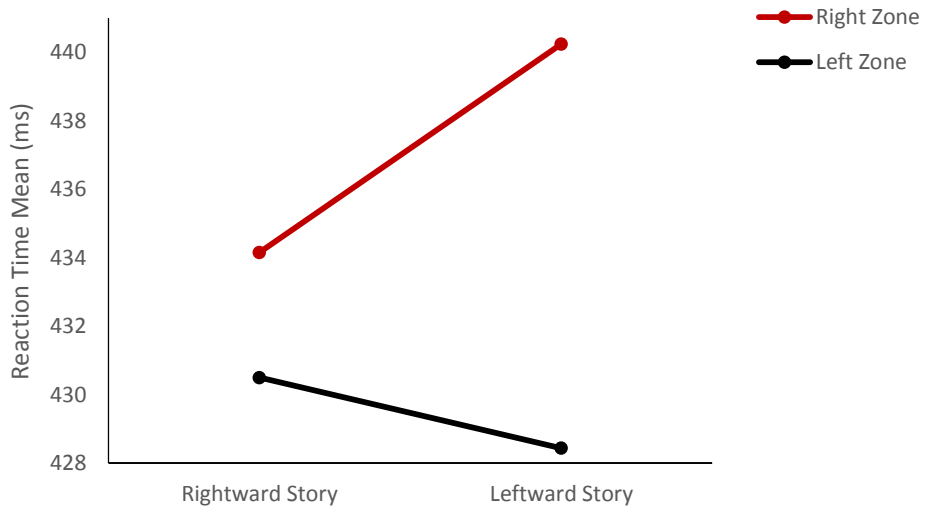

Figure 2.4. Reaction times as a function of Story and Zone in L2 (horizontal dimension)

When the story contained directional cues rightward, reaction times were faster when the dots appeared on the left (*M* = 430, *SE* = 12) than on the right (*M* = 434, *SE* = 12) on the left. When the directional cues of the story were leftwards, reaction times were faster for dots appearing on the left (*M* = 428, *SE* = 12) than for dots appearing on the right (*M* = 440, *SE* = 13) and this difference was more pronounced.

Surprisingly, we expected a different outcome in this condition, where the story is presented in L2. As we argued before, L2 is not as embodied as the L1. Therefore speeded reaction times in matching conditions should not be observed or, at least, observed to a lesser extent than those observed in L1. These results will also be discussed in more detail in the discussion.

PART III: DISCUSSION

The classical theories of the mind (e.g., Fodor, 1983; Newell & Simon, 1972; Pylyshyn, 2009; Tulving, 1983) define the human brain as a machine that processes information in the form of abstract symbols, being totally independent from the interactions with other agents and the environment. Thus, these theories postulated the divorce between mind, body and world (Myachykov, Scheepers, Fischer, & Kessler, 2013).

In contrast, the situated cognition movement draws the focus towards the assumption that cognition depends on the experiences of the organism that is in constant interaction with the environment (e.g., Smith & Semin, 2004). According to this approach cognition is embodied, as it is grounded in perceptive, affective and sensorimotor experiences. This perspective of the mind defends that both the body and the world work together to form and incorporate knowledge (e.g., Barsalou, 2008; Glenberg & Gallese, 2012; Lakoff & Johnson, 1999). Hence, the grounded mind "utilizes the environment and the body as external informational structures that complement internal representations" (Barsalou, 2010).

In the domain of language comprehension embodied processes were also examined. However, and to our knowledge the extent to which a second language is embodied has not been investigated. Several authors (e.g., Colbeck & Bowers, 2012; Keysar et al., 2012; Pavlenko, 2012; Schwanberg, 2010) have dedicated their work to the study of cognitive processing in bilinguals. Recent studies have supported the idea that the L2 differs from L1 (see Pavlenko, 2012), due to its reduced emotional connotation. This may happen because a foreign language is usually learned later in life, at school or at work. Thus, the affective impact in L1 acquisition is much higher when compared to the L2. However the differences in sensorimotor processes between two languages has not been addressed in this literature.

The central argument of this dissertation is that embodiment processes that underlie the processing of a first language (L1) are different from those associated to a second language (L2) is bilingual speakers.

Contributions of the present research

We tested this idea we have replicated the work of and Geng (2001), reporting that participants' eye-movements reproduced the directional cues implied in auditory presented scene description. With a sample of Portuguese-English bilinguals, we have extended this paradigm to L2 and to an additional visual detection task. We predicted more eye fixations and faster reaction times in detecting the dots in the locations that matched the directional cues of the scenes described. Because L2 is not grounded in sensorimotor processes, or at least to the same extent as L1, this pattern of results was not expected.

The results only partially confirmed our hypothesis. In the vertical dimension, (stories with directional cues upwards and downwards / dots presented in the top and bottom of the screen) reaction times were faster when there was a match between the direction of the cue implied in the story and the zone in which the dots appeared. As expected this was the case for stories presented in L1 but not in L2.

In the horizontal dimension (stories with directional cues leftwards and rightwards / dots presented on the left and right of the screen) the results were unexpected, as reaction times were completely independent of the match between directional cues and dots location.

As mentioned in the introduction, there may be a plausible explanation for this unanticipated outcome. Contrary to the stories with upwards and downwards directional cues, the scenes with leftwards and rightwards directional cues were ambiguous, especially on the Portuguese version. Take for example the rightward story "*a proa está voltada para a sua esquerda. Na traseira do barco está um pescador com uma cana de pesca na mão. A cana estende-se cerca de 3 metros para a direita"*. This story makes reference to both sides (left and right), and it is immediately clear to which side is the object moving. The same with the visual scene that includes leftwards cues "*Imagine a fishing boat floating on the ocean. It's facing leftward from your perspective. (...) The pole extends about 10 feet to the right beyond the edge of the boat*)".

Because we wanted to replicate Spivey and Geng (2001)'s experiment, we used they stimulus materials. In future studies the visual scenes should be properly piloted in both languages.

Overall, in the vertical dimension, results supported the operation of embodied processes. Participants in the L1 condition were faster when the direction of the story matched the zone in which the dots appeared. This may indicate that they were constructing a mental image of the story as their heard it, and their eyes moved on that direction, so it was easier for them to detect the red dots when they appeared in the zone that corresponded to the directional cue presented in the story.

In short, the results from the vertical dimension in both L1 and L2 support our argument, suggesting the existence processing differences between the two Still, is important to refer that this only happens in this dimension whereas the outcomes from the horizontal dimension require further investigation.

Limitations and suggestions for future research

In this part of the discussion, we shall enumerate and describe the limitations that were detected throughout this experiment, so they can be overcome in future research endeavors.

Left and Right stories: as we argued earlier in this section, although we wanted to replicate Spivey and Geng (2001)'s, we believe that the unclear content of the stories had serious implications on the results. In the future is best to use stories that only have cues in one direction and that are carefully piloted in both languages.

Repeated stories: In our experiment participants listened to the same stories twice, this may had led to a loss of attention the second time around. This is also something to improve in future research.

Difficulty level of the visual detection task: The rate of hits was so high (97%), and the errors so low (8%), and the task was so complex that we have reasons to believe that participants were so committed to having a good performance in the task that they may have been distracted from the story, which could have influenced the results. Another aspect that reinforces this supposition is that during data collection, participants expressed frustration several times (e.g., through vocalizations or movements) whenever they missed a red dot or detected a black one by mistake. Additionally, when the study ended, a great amount of participants reported the difficulty level of the task, describing his/hers performance (e.g., "I think I detected a black dot by mistake"), showing how committed they were to complete the task correctly. In the future we consider it best to

apply a simpler task so that participants can give proper attention to the stories. This task should also include a fixation point in the middle of the screen as well as a mask before and after the dot presentation.

Not using a chin rest: In our experiment the eye tracker device (*Tobii Eye Tracking*), did not have a chin rest, so we cannot be sure that the participants stood steal and looked to the screen at all times. We also do not know if their eyes were aligned with the middle of the screen (which can have varied with participants' high). This can be something to be improved in future studies.

Analyzing the eye-tracking data: Due to multiple constraints it was not possible to analyze the eye-tracking data. We believe that it would be important to do that in upcoming studies, so that we can compare the performance in the two tasks. Moreover, not only a better equipment is required but also proper training in eye-tracking configurations, interfaces, data cleaning, exporting and analysis.

In short, regardless the constraints our data presents, at least the results from the vertical dimension constitute a first indication that sensorimotor processing differs between a native language (L1) and a second language (L2). This reinforces the assumption that a native language (L1) is more embodied that a second language (L2).

It is our contention that by overcoming the limitations identified future studies based on this paradigm are likely to elucidate the sensorimotor processing differences in L1 and L2 and their implications for language comprehension in particular and for cognition in general.

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APPENDICES

Appendix A: English Listening Test

Qualtrics Survey Software

Block 1

Por favor, introduza o seu nº SPI

Leia atentamente as seguintes afirmações. Qual caracteriza melhor o seu nível de compreensão oral da língua inglesa?

- Sou capaz de reconhecer palavras e expressões simples de uso corrente relativas a mim próprio, á minha família e aos contextos em que estou inserido, quando me falam de forma clara e pausada.
- Sou capaz de compreender expressões e vocabulário de uso mais frequente relacionado com aspetos de interesse pessoal como por exemplo família, compras, trabalho e meio em que vivo. Sou capaz de compreender o anúncio e de mensagens simples, curtas e claras.
- Sou capaz de compreender os pontos essenciais de uma sequência falada que incida sobre assuntos correntes do trabalho, da escola, dos tempos livres, Sou capaz de compreender os pontos principais de muitos programas de rádio e televisão sobre temas atuais ou assuntos de interesse pessoal ou profissional, quando o débito de fala é relativamente lento e claro.
- Sou capaz de compreender exposições longas e palestras e até seguir partes mais complexas da argumentação, desde que o tema me seja relativamente familiar. Consigo compreender a maior parte dos noticiários e outros programas informativos na televisão. Sou capaz de compreender a maior parte dos filmes, desde que seja utilizada a língua padrão.
- Sou capaz de compreender uma exposição longa, mesmo que não esteja claramente estruturada ou quando a articulação entre as ideias esteja apenas implícita. Consigo compreender programas de televisão e filmes sem grande dificuldade.
- Não tenho nenhuma dificuldade em compreender qualquer tipo de enunciado oral, tanto face a face como através dos outros meios de comunicação mesmo quando se fala depressa, à velocidade dos falantes nativos, sendo apenas necessário algum tempo para me familiarizar com o sotaque.

Block 2

Por favor, carregue no Play do ficheiro de som. Vai ouvir um diálogo em inglês. Ouça atentamente e responda às questões de escolha múltipla:

You are studying at a language school in Britain. Your teacher has asked two students in the class to talk about their city, Beijing. She has recorded their discussion. You will listen to Lee and Amy discussing Beijing. Listen to their conversation and answer questions. You should listen to the audio twice.

Amy thinks that the roads in Beijing are:

- Unsafe for cyclists
- Very wide
- Very bad
- Less busy than in the past

Lee advises people to:

- Slow down on bicycles
- Use cycle paths

https://co1.qualtrics.com/ControlPanel/Ajax.php?action=GetSurveyPrintPreview&T=4uhz2vSbMPzYRajQpCzx6k

- Not cycle too much
- Cycle on the motorways

The number of people who own bicycles in Beijing is:

- A quarter of a million
- 3 million
- 9 million
- 12 million

Bikes in Beijing are:

- Difficult to buy
- Cheap to buy
- Easy to rent
- Expensive to rent

Lee and Amy agree that Beijing is:

- Beautiful and historical
- Beautiful but does not have any character
- Not beautiful but has character
- Beautiful and modern

What Amy says about old and new buildings in Beijing is that:

- They are mixed together in the city
- The old buildings are hidden by the new buildings
- They are found in separate parts of the city
- The majority of buildings are new

What Lee dislikes about shopping in Beijing is:

- Boring shops
- Shopping malls
- Prices
- Arguing with shopkeepers

There is a big variety of food available in Beijing because:

- It is the capital city and there are a lot of restaurants
- The food markets are cheap and are very good
- A lot of foreign people live there
- The city attracts people from every region of China

Lee likes Ghost Street because:

- It has the greatest variety of restaurants

Qualtrics Survey Software

- The restaurants serve international food
- The restaurants serve traditional food
- It has the cheapest restaurants in Beijing

The last time Amy went out for dinner she:

- Went with Lee
- Ate in the food market
- Drank snake wine
- Didn't enjoy the food

Block 3

Por favor, carregue no Play do ficheiro de som. Vai ouvir um diálogo em inglês. Ouça atentamente e responda às questões de escolha múltipla:

You are considering becoming a teacher. You hear a radio interview about a prize-winning teacher. Listen to the interview and answer the questions. Read all the questions before you start listening. You should listen to the audio twice.

What do we learn about Robert Haycraft?

- he is a teacher with a very good reputation
- he got an award for a book about teaching
- he is a government official responsible for education
- he is a journalist with a special interest in teaching

How fierce was the competition for the award this year?

- there was surprisingly little competition
- there was more competition than usual
- there were one or two other strong candidates
- there were a lot of strong candidates

What is the point of the story about the fish?

- to show how important fish is for young brains
- to explain why fishmongers love Liddell too
- to suggest Liddell's closeness to his own parents
- to illustrate how original Liddell's style is

What is Liddell's main subject?

- math's
- sport
- biology
- chemistry

Qualtrics Survey Software

What did Liddell use to teach children about catalysts?

- a sweet
- a doll
- a small child
- a firework

What was the main reason why Liddell won the award?

- his ability to teach a range of different subjects
- his memorable performances in the classroom
- his focus on children as individuals
- his involvement in other schools in his area

Why does Liddell require his pupils to learn the numbers in Japanese?

- to check pupils' learning ability
- to compare how quickly each pupil can do it
- to find out how pupils prefer to learn
- to make an initial strong impression on the class

What influenced Liddell's distinctive approach?

- a difficult class he had to teach
- something he read when training
- a teacher from his own childhood
- other teachers in his first school

What aspect of Liddell's style has particularly struck the head teacher?

- his popularity with former pupils
- his interest in teaching theory
- his determination to involve all pupils
- his enthusiasm for his subject

What does Liddell say about teaching in his own school-days?

- it bored him
- it was not appropriate for many of the pupils
- it was suitable for pupils who would become miners
- it was very advanced for its time

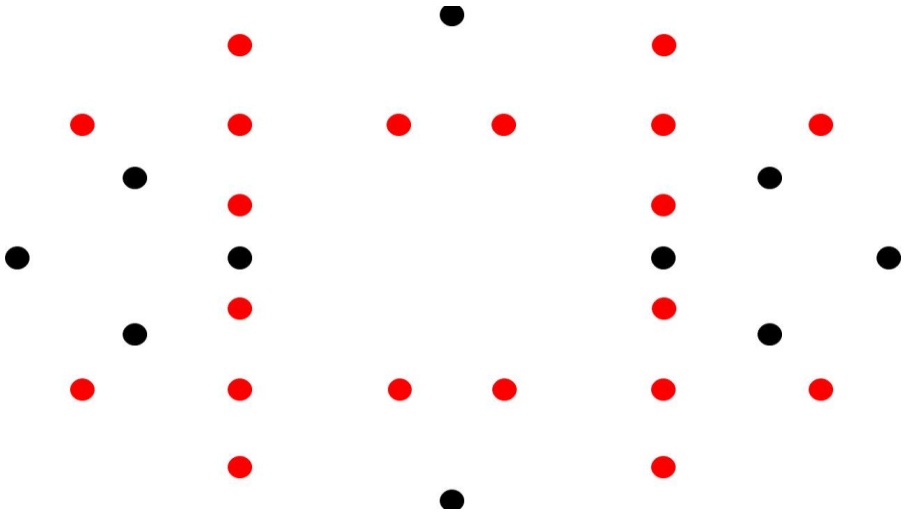
Muito obrigada pela sua participação

Appendix B: Pre-recorded scene descriptions in English and Portuguese

(Adapted from Spivey & Geng, 2001)

Direction	English	Portuguese
Upward	Imagine that you are standing across the street from a 40 story apartment building. At the bottom there is a doorman in blue. On the 10th floor, a woman is hanging her laundry out the window. On the 29th floor, two kids are sitting on the fire escape smoking cigarettes. On the very top floor, two people are screaming.	Imagine que está voltado para um edifício de 40 andares que se encontra do outro lado da rua. Na entrada está um porteiro vestido de azul. No 10º andar, uma mulher está à janela a estender roupa. No 29º andar, dois miúdos estão sentados na escada de incêndio a fumar. No último andar, estão duas pessoas a gritar.
Downward	Imagine that you are standing at the top of a canyon. Several people are preparing to rappel down the far canyon across from you. The first person desceds 10 feet before she is brought to the wall. She jumps again and falls 12 feet. She jumps another 15 feet. And the last jump, of 8 feet, takes her to the canyon floor.	Imagine que está no topo de um desfiladeiro. Várias pessoas estão a preparar-se para fazer *rappel* no lado oposto ao que você se encontra. A primeira pessoa desce 3 metros antes de ser trazida de novo para junto da parede. Ela salta outra vez e cai mais 4 metros. Volta a saltar outros 5 metros. No último salto, de 2 metros, chega ao fundo do desfiladeiro.
Leftward	Imagine a train extending outwards to the left. It is pointed to the right, and you are facing the side of the engine. It is not moving. Five cars down is a cargo holder with pink graffiti sprayed on its side. Another six cars down is a flat car. The train begins to move. Further down the train you see the caboose coming around a corner.	Imagine um comboio que se prolonga para a esquerda. A parte da frente está voltada para a direita, e você está voltado para a parte lateral do motor. O comboio não se mexe. Cinco carruagens atrás está um suporte de carga, com uma pintura em graffiti de lado. Outras seis carruagens atrás está um vagão de carruagem plano. O comboio começa a andar e ao fundo você consegue ver a carruagem a contornar a curva.
Rightward	Imagine a fishing boat floating on the ocean. It's facing leftward from your perspective. At the back of the boat is a fisherman with a fishing pole. The pole extends about 10 feet to the right beyond the edge of the boat. And from the end of the pole, the fishing line extends another 50 feet off to the right before finally dipping into the water.	Imagine um barco de pesca a flutuar no oceano. A proa está voltada para a sua esquerda. Na traseira do barco está um pescador com uma cana de pesca na mão. A cana estende-se cerca de 3 metros para a direita, para além da extremidade do barco. E a partir da cana de pesca, a linha estende-se outros 15 metros para a direita mergulhando finalmente no mar.
Control	Imagine that you are on a hill looking at the city through a telescope. Pressing a single button zooms a specific block into view. Another button brings a gray apartment building into focus. Finally a third button zooms in on a single window. Inside you see a family having breakfast together. A puppy appears and begs for a piece of French toast.	Imagine que está numa colina a vislumbrar a cidade através de um telescópio. Ao carregar num botão a imagem de um quarteirão específico é ampliada. Outro botão foca um edifício cinzento. Finalmente um terceiro botão foca uma janela. Através da mesma é possível ver uma família a tomar o pequeno-almoço. Aparece um cão a pedir um bocado de torrada.

Appendix C: Distribution of the dots



INFORMAÇÃO PESSOAL

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Sexo Feminino | Data de nascimento 17/01/1990 | Nacionalidade Portuguesa

EXPERIÊNCIA PROFISSIONAL

Para ver formato mais atrativo aceda ao link: https://ngg86e.s.cld.pt (Ctrl + Clique)

05/2015–Presente

Técnica de Recursos Humanos

S24 Group - Healthcare Solutions

- Recrutamento e Seleção de colaboradores internos;
- Acolhimento e integração de novos colaboradores;
- Definição e implementação de políticas de RH;
- Construção e aplicação de ferramentas de RH;
- Sistemas de Avaliação de Desempenho e Sistemas de Objetivos e Incentivos;
- Implementação de medidas motivacionais;
- Controlo de férias e assiduidade;
- Gestão Administrativa e Contratual;
- -Formação e Desenvolvimento.

02/2015–05/2015

Consultora de Recursos Humanos (Estágio Curricular) - 18 valores

WeChange, Consultoria em Recursos Humanos, Lisboa (Portugal)

Recrutamento e Seleção:

- Elaboração de anúncios e respetiva divulgação;
- Gestão de anúncios/candidaturas;
- Pesquisa e filtragem de candidatos no *BackOffice* do site da empresa;
- *Screenings* telefónicos a potenciais candidatos identificados no *BackOffice*;
- Triagem curricular;
- *Screenings* telefónicos a candidatos;
- Elaboração e atualização constante das bases de dados dos projetos;
- Confirmação de referências profissionais dos candidatos através de entrevistas telefónicas;
- Envio, cotação e interpretação de testes/provas.
- Realização de relatórios para o cliente.

Formação:

- Auditorias telefónicas (Cliente Mistério);
- Avaliação do desempenho das gestoras de contacto após a auditoria;
- Desenvolvimento de relatórios para o cliente;
- Tradução de exercícios;
- Propostas de exercícios de formação/sugestões de melhoria;
- Acompanhamento da formação;

- Esclarecimento de dúvidas dos formandos;
- *Debriefing* com formandos;
- Tratamento de dados de questionários de satisfação das formações.

Assessment:

- Elaboração e Proposta de alteração da matriz de competências de projeto de assessment;
- Desenvolvimento de exercício para ser aplicado em contexto de assessment center;
- Preparação da base de dados de assessment;
- Operacionalização da Base de dados com macros;
- Apoio logístico/técnico;
- Acompanhamento e esclarecimento de dúvidas dos participantes;
- Apresentação dos resultados individuais e de grupo em reunião de assessors;
- Melhoria dos gráficos para relatórios de assessment.

Outras:

- Gestão de arquivo físico de processos de recrutamento e seleção;
- Gestão de arquivo físico de exercícios de assessment;
- Redefinição das competências avaliadas nos exercícios;
- Criação de sistema em Cloud para alojar vídeos de momentos de avaliação para o cliente;
- Instalação de sistema de gravação de entrevistas em Skype.

EDUCAÇÃO E FORMAÇÃO

09/2013–Presente

ISCTE-IUL - Instituto Universitário de Lisboa, Lisboa

Mestrado em Psicologia Social e das Organizações

Unidades Curriculares:

- Psicologia Organizacional
- Diagnóstico e Intervenção Social e Organizacional
- Concepção e Avaliação de Projetos
- Métodos Avançados de Análise de Dados
- Psicologia Social do Consumo e da Comunicação
- Psicologia do Trabalho
- Psicologia dos Recursos Humanos
- Métodos Avançados de Investigação em Psicologia
- Desenvolvimento de Competências Profissionais
- Desenvolvimento de Competências Pessoais e Académicas
- Estágio
- Dissertação

09/2010–06/2013

Universidade do Algarve, Faro

Licenciatura em Psicologia

COMPETÊNCIAS PESSOAIS

Língua materna: Português

Outras línguas

	COMPREENDER		FALAR		ESCREVER
	Compreensão oral	Leitura	Interação oral	Produção oral	
inglês	C2	C2	C2	C2	C2
espanhol	B1	B2	A1	A1	A1

Níveis: A1 e A2: Utilizador básico - B1 e B2: Utilizador independente - C1 e C2: Utilizador avançado
Quadro Europeu Comum de Referência para as Línguas

INFORMAÇÃO ADICIONAL

Encontro Científico: Participação no X Encontro de Investigação em Psicologia Social e das Organizações:
Apresentação de Poster
ISCTE-IUL, Instituto Universitário de Lisboa
Lisboa, 22 de Maio de 2014

Carta Condução - Categoria B