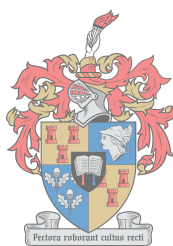# Reversing Time: The Effects of Mirror Reading and Writing Exercises on the Mental Timeline

by Jenna Crossley

Thesis presented in fulfilment of the requirements for the degree of MA in Psycholinguistics in the Faculty of Arts and Social Sciences at Stellenbosch University

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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof, that reproduction and publication thereof by Stellenbosch University will not infringe any third-party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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Abstract

This study assessed the influence of experience and embodied cognition on the mental timeline through investigating the effect of exposure to reversed orthography reading and writing exercises. The main research question of this study is "What effect does exposure to reversed orthography have on the mental timeline?", which is divided into two further questions: "What effect does exposure to reversed orthography reading exercises have on the mental timeline?" and "What effect does exposure to reversed orthography writing exercises have on the mental timeline?".

This study consisted of a total of 257 English/Afrikaans participants, divided across six reading or writing conditions. These conditions were studied in five comparisons, which each assessed the effect of orthography on the mental timeline under different circumstances.

The results of this study firstly replicate and expand on previous research that has shown that exposure to reversed orthography reading has an effect on the mental timeline. Further, the study found that exposure to standard orthography reading/writing following reversed orthography reading/writing can have a reverse priming effect on the mental timeline. Another finding of this study was that exposure to reversed orthography writing does not appear to have an effect on the mental timeline. A final comparison isolated writing as the cause of this lack of effect.

Opsomming

Hierdie studie het die invloed van ervarings en beliggaamde kognisie op die verstandelike tydlyn evalueer deur die effek van blootstelling aan omgekeerde ortografiese lees- en skryfoefeninge te ondersoek. Die hoofnavorsingsvraag van hierdie studie is: "Hoe affekteer blootstelling aan omgekeerde ortografie die geestelike tydlyn?", wat in twee verdere vrae verdeel word: "Hoe affekteer blootstelling aan omgekeerde ortografiese leesoefeninge die geestelike tydlyn?" en "Hoe affekteer blootstelling aan omgekeerde ortografiese skryfoefeninge die geestelike tydlyn?".

Hierdie studie het uit 'n totaal van 257 Engelse / Afrikaanse deelnemers bestaan, wat verdeel is tussen ses lees- of skryfstoestande. Hierdie toestande is in vyf vergelykings bestudeer, wat die invloed van ortografie op die geestelike tydlyn onder verskillende omstandighede evalueer het.

Eerstens, die resultate van hierdie studie herhaal en brei uit op vorige navorsing wat bewys het dat blootstelling aan omgekeerde ortografiese leeswerk 'n effek op die geestelike tydlyn het. Hierdie studie het verder bevind dat blootstelling aan standaard ortografiese lees / skryf na aanleiding van omgekeerde ortografie lees / skryf 'n omgekeerde aanwakerings effek op die geestelike tydlyn kan hê. Nog 'n bevinding van hierdie studie was dat blootstelling aan omgekeerde ortografiese skryfwerk nie 'n effek op die geestelike tydlyn het nie. 'n Finale vergelyking het bevind dat geïsoleerde skryf die oorsaak van hierdie effekloosheid is.

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1. Introduction

Language has been found to have an effect on a wide range of cognitive processes including shape perception, aesthetic preferences, numerical and magnitudinal reasoning and perception, and musical and auditory pitch. This thesis focuses on temporal cognition, and how language not only affects this but also mediates our spatialisation of time. Specifically, the effects of language looked at in this study focus on that of a linguistic artefact, orthography, rather than effects of linguistic categories. This thesis therefore represents an extended view of the effects of language on thought.

Our perception of time in terms of space can be seen through the use of linguistic metaphors (such as when saying things like, "time is running out", or "I have so little time"), and the way that individuals map time onto space itself (which is seen through everyday items like clocks, as well as through the way that we gesture). A further example of how people map time onto space is through timelines, where events are organised flowing from one side of space to the other. A growing body of evidence has led to the recent proposal that human beings conceptualise events along a so-called "mental timeline" when thinking about them.

The mental timeline is said to be affected by experience, and central to this is the notion that because people speak different languages, come from different cultures and have different bodies, they will think differently. The components of this trio are individually referred to as linguistic, cultural and bodily relativity, and collectively are called Experiential Relativity. Bodily relativity further relates to the notion of embodied cognition (the proposal that much of cognition is mediated or moulded by bodily interaction with the physical world), which is relevant to this study in that the comparisons performed make use of reading and writing exercises, which entail bodily interaction with materials.

There is a growing body of research suggesting that the mental timeline is malleable, and can be altered through exposure to different cultural artefacts types, specifically orthography (which ties in with the notion of experiential relativity). Seminal studies on this topic have found that exposure to standard, reversed, and upwards- and downwards-rotated orthography can have an effect on the mental timeline (Casasanto and Bottini, 2014:474; Román, Flumini, Lizano, Escobar and Santiago, 2015:2-7).

1.1   Adherence to Seminal Studies

This study adheres closest to the studies of Casasanto and Bottini (2014:474) and Román et al. (2015:2-7). The current study differs from Casasanto and Bottini (2014:474) in a number of ways: i. This study focuses on deliberate time-space mappings (assessed through a temporal diagram task) rather than reaction times, ii. Rather than reading separate phrases, the participants in this study were required to read an entire +-1000-word story, and iii. This study was presented on paper rather than on a computer, and participants responded on paper rather than by clicking keys. This study is similar to that of Román et al. (2015:2-7) in that participants were presented with a +-1000-word narrative to either read or write. However, it differs from their study in that participants in this study were not required to do a drawing task or read the story aloud. In this study, participants read all of the instructions themselves, while Román et al.'s (2015:2-7) study consisted of task instructions that were read aloud to the participants. The only instance in which the participants in this study had auditory input was when performing the reversed orthography writing exercise.

1.2   Project Aims and Research Questions

This study assesses the effects of experience and embodied cognition, as instantiated in orthography, on the mental timeline. The study more specifically examines the effect of standard and reversed orthography on the mental timeline, which is assessed through both reading and writing exercises. In order to address the abovementioned aims, the following primary research question is detailed:

1.   What effect does exposure to reversed orthography have on the mental timeline?

This research question can be divided into two further questions:

1.1. What effect does exposure to reversed orthography reading exercises have on the mental timeline?

1.2. What effect does exposure to reversed orthography writing exercises have on the mental timeline?

Based on the outcomes of previous studies (such as Casasanto and Bottini, 2014:474 and Román et al. 2015:2-7 above), it is hypothesised that exposure to reversed orthography reading exercises will have an effect on the mental timelines of participants in this study, causing them to conceptualise the future as to the left and the past as to the right. Previous research in

embodied cognition has shown that bodily movement can have an effect on an individual's temporal cognition (e.g. Hartmann and Mast, 2012:1559; Boroditsky and Ramscar, 2002:185-189). Writing entails hand movement in the same direction of that in which orthography flows, and thus based on these previous findings, it is hypothesised that reversed orthography writing exercises should have an even larger effect on the mental timeline than reading exercises.

1.3 Methodology

This study consists of five comparisons, which comprise combinations of six conditions. The conditions consist of either reversed or standard orthography reading and writing exercises, coupled with reversed and standard orthography task instructions accompanying a temporal diagram task. The temporal diagram task requires participants to map their conceptualisation of time spatially (and on paper), and is thus used to assess whether they have had their mental timelines reversed or not.

The first comparison assesses whether exposure to reversed orthography reading exercises can have an effect on the mental timeline, and thus contrasts the effects of reading a standard orthography versus a reversed orthography text. The second comparison assesses whether different modes of input (reading versus writing) can have an effect on the mental timeline, and entails exposing participants to reversed orthography writing exercises and comparing these effects with those observed in the reversed orthography reading exercise. The third comparison examines whether exposure to standard orthography following exposure to reversed orthography can invert the possible priming effect of exposure to the reversed orthography. The fourth comparison investigates this further, once again questioning whether mode of input plays a role. Finally, the fifth comparison assesses how much exposure to reversed orthography is required in order to reverse the mental timeline.

In total, the study consists of 257 participants, all who speak English/Afrikaans as a native language. Data analysis uses quantitative methodology, performed using an IBM SPSS Statistics 23 binary logic regression (Wald Chi Square test). Where applicable (Comparison IV), a Bayesian Contingency Tables Test is used to assess whether the data used in each comparison is sensitive enough to be considered reliable.

1.4 Thesis Structure

This thesis is structured as follows:

Chapter 2 comprises a Literature Review. This provides an overview of what similar research has focused on, and positions the study in terms of previous research. The chapter touches on studies looking at orthography and (temporal) cognition (specifically those that centre in on the mental timeline), as well as studies exploring embodied cognition and its effects.

Chapter 3 consists of a Theoretical Overview. The purpose of this overview is to frame this study (as well as many of the studies covered in the Literature Review) theoretically, and to explore key theoretical components such as experiential relativity and embodied cognition.

Chapter 4 focuses on the Method and Results of this study. This chapter describes the techniques, methods and procedures used to conduct the comparisons in this study, as well as the analyses used to derive results. Additionally, Comparisons I to V are described and their outcomes are presented and discussed.

Finally, Chapter 6 comprises the Discussion and Conclusion of this thesis. The discussion will look at what the outcomes of the comparisons were, as well as what the significance and implications of these are. The chapter will also discuss recommendations for further/future research.

2   Literature Review

2.1   Introduction

This chapter aims to introduce studies relevant to this research project by providing an overview of literature in the field. The chapter will begin with an introduction to orthography and the ways that it differs across languages. Second, the chapter will look at the relationship between orthography and cognition, specifically focusing on shape perception, aesthetic preferences, numerical and magnitudinal reasoning and perception, and musical and auditory pitch. Third, the chapter will discuss orthography and temporal cognition, specifically focusing on the proposed mental timeline, the effect that orthography has on the mental timeline, and the development of the mental timeline. In the final section of this chapter, the focus will be on embodied cognition. In this section, the relationship between embodied cognition and judgements of valence, conceptions of space, and conceptions of time will be discussed.

2.2   Orthography

Wide variation exists when comparing languages. Relevant to this thesis is the direction in which writing flows in languages, as this has been found to have an effect on various cognitive processes, including temporal reasoning.

Modern languages are written in a multitude of ways. Western languages such as French, Italian, German, Spanish and Dutch are written horizontally from left to right; while the opposite can be seen in languages such as Taiwanese, which is written from top to bottom, flowing from right to left. Some languages, like Hebrew and Japanese, alternate between writing direction, and can be seen presented from the right to the left, or from the left to the right (Nachson and Hatta, 2001:178).

2.3   The Effects of Orthography on Cognition

This section aims to provide an overview of the cognitive processes influenced by the direction of a language's orthography. These processes include: shape perception, aesthetic preferences, numerical and magnitudinal reasoning and perception, and musical and auditory pitch.

An individual's orthography direction can have an effect on shape perception (Smith, Szelest, Friedrich and Elias, 2014:422-432). Speakers of left-to-right orthography languages have been found to identify targets lit from an upper-right light source faster than those lit from the

opposite direction, while these results are seen to be reversed when testing participants who speak languages with orthography that flows from right to left.

The above effect has further been found to extend to the domain of aesthetic preferences. A study by Nachson, Argaman and Luria (1999:108-113) found that speakers of Arabic and Hebrew (both languages which run from right to left) show a preference for images of individuals who are presented as facing towards the right. In contrast, Russian speakers preferred the opposite arrangement, which correlates with the left-to-right flow of their language. These results suggest that aesthetic preferences are strongly associated with the reading/writing habits of an individual, as the participants in this study chose images which faced the same direction in which their orthography flows.

The effect of orthography on aesthetic preferences is further present in the arrangement of people in photographs. An example of this can be seen in a study by Pérez González (2012:518-529), which contrasted Spanish and Iranian 19th century photographs. The study found that Spanish photographers, who have a left-to-right orthography, showed a preference for arranging people ascending in height from left to right, while Iranian photographers (who have a right-to-left orthography), showed the opposite arrangement. This effect was additionally visible when looking at photos consisting of people with chairs and tables, where Iranian photographers tended to place individuals on the left side of space, and furniture on the right side of space, ascending in height from right to left.

Musical and auditory pitch show similar representations to numerical mappings in the minds of humans. Multiple languages (including English, German, Chinese, French, Polish and Spanish) use spatial orientations to describe musical and auditory pitch (Rusconi, Kwan, Giordano, Umiltà and Butterworth, 2006:114). An example of this can be seen in English metaphor, through the spatial terms *high pitch* and *low pitch*. These descriptions have been found to not simply be metaphorical, but to also influence vertically aligned responses in study participants (Melara and Marks, 1990:491-492). Additionally, pitch has been shown to affect speed and accuracy of manual responses, even when the location of a sound source is kept constant (Rusconi et al., 2006:126-128). In their study, Rusconi et al. (2006:126-128) asked participants to compare pitches of varying frequency tones by pressing keys. It was found that pitches were paired to different keys, where high-frequency pitch was mapped onto upwards responses and low-frequency pitch was mapped onto downward responses. Furthermore, through a comparison of response times, it was found that participants responded faster to high-

frequency pitch when using a key positioned on the right, and to low-frequency pitch when using a key positioned on the left.

2.4   Language and Temporal Cognition

The previous section focused on the effect that language can have on cognitive processes such as spatial orientation, aesthetic preferences, numerical reasoning, and auditory recognition and processing. The present section aims to focus on temporal cognition, and to illustrate that language, space, and time share a relationship in cognition. In this section, various forms of temporal processing will be discussed, namely front-back, durational, and sequential processing.

The study of the relationship between time, space, and language in the human mind originally focused on the metaphorical nature of language. While languages differ greatly in terms of their orthographic direction, they further differ in terms of their speakers conceptualisations of space and time. Although metaphor is not the focus of this thesis, a few of these metaphorical differences will be discussed briefly, as they illustrate the nature of the relationship between space, time, and language in the (human) mind. One of the earliest observations made on metaphorical variance between languages is Whorf's contrastive analysis of speakers of Hopi (an Uto-Aztecan language) and speakers of European languages (Whorf, 1956:148-152). Whorf observed that speakers of European languages were said to view time as "a motion on a space", while speakers of Hopi were said to view time as something that is accumulated. Further variation can be seen in other Amerindian languages, such as Aymara, Toba and Tzeltal. In Aymara, speakers conceptualise the future as behind them and the past as in front of them (Núñez and Sweetser, 2006:437-438); while speakers of Toba conceptualise time as a cycle, and as a progression through space, where the future comes before the past (Klein, 1987:176-182).

An area in which one can observe great difference between languages is that of "frames of reference", which refer to the ways that individuals compute and describe how objects are positioned in relation to other objects. The use of frames of reference can be divided into three categories, namely: relative, intrinsic and absolute frames of reference (Majid, Bowerman, Kita, Haun and Levinson, 2004:108). Relative frames of reference make use of egocentric coordinates (*left*, *right*, *forward(s)*, *backward(s)*, *up*, *down*), which describe objects according to how they appear in relation to an individual. For example, if one looks at a table and views a water bottle and a cell phone, that individual will describe the objects as they appear to

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him/her, such as in "the water bottle is to the left of the cell phone". Intrinsic frames of reference refer to those that are based on object-centred coordinates (*side*, *back*, *front*). For example, "the dog is by the side of the house" describes a dog in relation to the position of another object (the house). Finally, absolute frames of reference make use of cardinal directions (*North*, *South*, *East*, *West*, *uphill*, *downhill*). For example, if one were to say that "the dog is to the west of the house", the dog is described as a separate entity from an individual or the position of another object (Majid et al., 2004:108).

Speakers of Tzeltal (a Mayan language) describe space according to absolute reference, and refer to northern directions as uphill, and southern directions as downhill (Levinson, 1996:111).

On the west coast of Cape York Peninsula in Australia, speakers of Pormpurraaw show similar patterns. Time is arranged according to cardinal directions, where time flows from right to left when facing south, from left to right when facing north, away from oneself when facing west, and towards oneself when facing east (Boroditsky and Gaby, 2010:1636-1638).

Further differences in the way languages conceptualise space and time can be seen when contrasting Western languages with those which originate within Asia. In languages such as Chinese, the up-down axis is used extensively when speaking about time, such as when using *shàng* meaning "up" and *xià* meaning "down" (Boroditsky, 2001:18-19). In Chinese, spatial order and temporal sequence share the same terms; while in English, different prepositions are used to describe these relationships (Xue, Yang and Zhao, 2014:269). Furthermore, English speakers conceptualise events horizontally, while Chinese speakers tend to conceptualise events vertically, with earlier events presented as *above*, while later events are presented as *below* (Fuhrman, McCormick, Chen, Jiang, Shu, Mao and Boroditsky, 2011:1309-1322).

Evidently, there are differences when comparing languages in terms of time and space. However, a few universal properties should be acknowledged (Clark, 1973:48-54; Traugott, 1978:384-387). One-dimensional spatial terms (such as *front/back*, *up/down*) are used to describe time, as time is typically conceived to be one-dimensional. A further property is that ordered terms (such as *forwards* or *backwards*) are used rather than symmetrical ones (such as *left* or *right*), due to the sequential nature of the ordering of events. Across languages, terms describing front/back motions are used more widely.

As shown in the discussion thus far, the study of spatial-temporal metaphors shows us that in language, space and time are deeply intertwined. Furthermore, when speaking about, and conceptualising, the abstract domain of time, the concrete domain of space is universally drawn

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from. The effect of space on conceptualisations of time can be seen in studies which focus on the activation of spatial concepts during temporal reasoning. Even when accessing spatial information is not vital for temporal reasoning, individuals are affected by the spatial characteristics of tasks (Santiago, Lupiáñez, Pérez and Funes, 2007:513-515). Participants have been observed to respond faster to stimulus which is congruent with their orthography's conceptualisation of space and time. For example, English individuals map earlier events to the left and later events to the right side of space. These findings show us that temporal reasoning activates spatial concepts in the mind, which suggests that these domains share a relationship not just in metaphor, but also in cognitive processing.

Although space and time share a strong relationship in the (human) mind, this relationship is rather one-sided, as the domain of space is drawn from to talk about time far more frequently than the domain of time is drawn from to talk about space. This is evident in spatial-temporal research, where individuals have been found to use and be influenced by primed spatial information when thinking about time. However, the same effect is not seen when using temporal information to think about space (Boroditsky, 2000:8-11). Furthermore, it has been shown that while humans use spatial schemas to think about time, this is not a necessity. In a study by Boroditsky (2000:8-11), English participants' responses to questions regarding spatial and temporal relations were recorded. An example of one of these temporal relations is a statement such as "March comes before May", where a participant would have to judge whether the statement was true or false. The spatial relation questions consisted of a combination of images and sentences. For example, the sentence "M is in front of X" would be combined with an image consisting of two boxes, one with the letter "X" and one with the letter "M". Once again, participants had to judge whether the statement was true or false, in relation to the image. The results of this experiment showed that while information made available by spatial primes was useful for thinking about time, the information made available by temporal schemas was not equally useful when thinking about space. Furthermore, when information from spatial primes was not available, participants relied on information found in the temporal primes. These findings suggest that temporal processing may have outgrown the use of the spatial domain, and has perhaps developed to the point where it can be used independent of spatial information (Boroditsky, 2000:8-11).

Further evidence for the proposed asymmetric relationship between space and time can be seen in studies focusing on brain damaged subjects with left perisylvian lesions, which affect language in the brain. An example study would be one which was conducted by Kemmerer

(2005:779-802), wherein subjects were given two tests. The first test assessed their understanding of spatial information in prepositions, and the second test assessed their understanding of the corresponding temporal information in these prepositions. Two subjects failed the first test and passed the second test, while two other subjects passed the first test and failed the second test. These findings suggest that although space and time share a strong relationship, they can be conceptualised and processed independently of each other within the (human) mind.

The asymmetric relationship seen between space and time is not limited to language and language processing, but further extends to domains of cognition, such as into one's basic conceptualisations of distance and duration. This was assessed in a study by Casasanto and Boroditsky (2008:580-593), where participants viewed either lines or dots on a screen and were asked to reproduce the stimuli's displacement or duration. The results of these experiments showed an asymmetric dependency of duration on displacement, where temporal-duration judgements (judgements which entail participants estimating lengths of time) required spatial information, but not vice versa. As all stimuli and responses were non-linguistic, these findings show that the asymmetric metaphorical relationship between space and time in language extends into our basic conceptualisations of distance and duration. Furthermore, these findings reiterate that thinking about time makes use of spatial information, while thinking about space does not make use of temporal information.

2.4.1   The Mental Timeline

The previous section discussed the role of language in temporal processing. This section will focus on sequential processing, looking specifically at the proposed *mental timeline* (MTL) and the effect that orthography has on it. The mental timeline refers to a proposed spatial continuum upon which individuals place time when conceptualising it. This line extends from one extreme to the other, where the past and future are on contrasting sides of the spectrum. The mental timeline is culturally specific and embodied, and the writing direction of a language seems to have an effect on its development, as will be discussed further in this section (Bonato, Zorzi and Umiltà, 2012:2258).

2.4.2   Orthography and the Mental Timeline

The mental timeline appears to develop according to the orthographic direction of an individual's language. This topic has been studied extensively, and research has incorporated a wide range of languages with varying orthographic conventions.

One of the first studies on this topic was Tversky, Kugelmass and Winter (1991:515-557), which aimed to examine how space can be used to represent non-spatial relationships. The study consisted of 1200 participants (of varying ages), who were speakers of English, Hebrew and Arabic. As English orthography flows from left to right and Hebrew and Arabic orthography flows from right to left, the study could compare temporal conceptualisations and attribute variations to orthography. In the tasks, adult participants were asked to produce graphic representations of different relations (such as those between time and space), while children placed stickers on items according to their preferences. The study found that language had an effect on temporal concepts in the minds of these participants. These included words like *breakfast*, which is attributed to the start of the day, and *dinner*, which is attributed to the end of the day. Speakers of different languages mapped concepts according to the orthographic direction of their language. English speakers tended to map concepts from left to right, placing "breakfast" to the left of "lunch", and "dinner" to the right of it; while Arabic speakers tended to map them from right to left, placing "dinner" to the left of "lunch", and "breakfast" to the right of it. These results suggest that English speakers map time sequences as progressing from left to right, while Arabic speakers map them in the opposite direction. These results correlate with the writing direction of the participants' languages, which suggests that a language's writing direction affects the way an individual lays out time (Tversky et al., 1991:529).

A subsequent study by Fuhrman and Boroditsky (2010:1430-1451) assessed the notion that writing direction affects the way a person lays out time. The authors asked participants to arrange images depicting temporal sequences, such as a set of four images depicting the process of a chicken hatching from an egg. In accordance with the results of Tversky et al. (1991:529), English speakers arranged temporal sequences as progressing from left to right, while Hebrew speakers arranged them from right to left. In the second and third experiments, participants made rapid temporal order judgements, which entailed indicating whether images displayed a time that was earlier or later than another image. The response times of these judgements showed that Hebrew participants automatically associated side of space (left vs. right) and temporal order (earlier vs. later) according to how these are represented in their culture. Where

English speakers responded faster to earlier events mapped on the left side of a space, Hebrew speakers responded faster to earlier events mapped on the right side of a space (Fuhrman and Boroditsky, 2010:1444-1445).

The writing direction of a language has been found to have an effect on information recollection, visual attention focusing, and image ordering. This can be seen in a study by Chan and Bergen (2005:412-417), which focused on English, Mainland Chinese and Taiwanese participants. Taiwanese is written vertically from top to bottom, flowing from right to left; English is written from left to right horizontally; and Mainland Chinese is written from left to right (in the past 50 years) horizontally. In the study, English and Chinese participants were asked to perform an image recollection task, which entailed viewing images on a screen and then trying to remember the images afterwards. The results of this experiment showed that English and Chinese speakers were more likely to remember images which appeared on the top left-hand side of a screen than Taiwanese speakers, who were more likely to remember those that appeared on the top right-hand side of the screen. In a further task, participants were asked to compose sentences based on non-directional images presented to them, such as images of a horse facing the viewer head-on. It was found that English and Chinese speakers were more likely to start their sentences with the image presented on the left, while Taiwanese speakers were more likely to start their sentences with the image presented on the right. Finally, results of image arrangement tasks showed that English speakers arrange images in sequences that flow from left to right, while Taiwanese speakers arrange them in the opposite manner. Combined, the above results suggest that information recollection, visual attention focusing and image ordering can be affected by orthography direction.

Similar results can be seen in a study by Ouelett, Santiago, Funes and Lupiáñez (2010:310-313), where Hebrew and Spanish participants responded to auditory temporal words referring both to the past (e.g. the Spanish word *dijo*, which means "he said") and the future (e.g. the Spanish word *dirá*, which means "he will say"). The participants were asked to decide whether a word referred to the past or the future by pressing keys. It was found that Spanish speakers responded faster to past words with their left hand and future words with their right hand. This effect was observed to be reversed with Hebrew participants, where past words were responded to faster when responding with their right hand, and future words were responded to faster when responding with their left hand. These results, once again, provide evidence for the notion that orthographic direction influences an individual's conceptualisation of time.

A further study which made use of temporal words was Torralbo, Santiago and Lupiáñez (2006:749-755). Participants within this study made verbal temporal judgements based on speech bubbles which consisted of temporally inflected Spanish words (such as *hablé*, which means "I talked") positioned either behind or in front of silhouettes of people which were presented in profile. As with the results of studies discussed in this section thus far, responses were found to be faster when the location of a word was congruent with back-past/front-future mappings. In a further task, responses were changed to be projected onto left-past/right-future space when participants were asked to respond manually with a keyboard consisting of left and right response keys. These findings showed that time is mapped onto space flexibly, and that several options exist when relating time to spatial dimensions.

The effects of orthography on the mental timeline are not limited to the mapping of temporal concepts and events, but further extend into the realm of meaningful event sequences (Santiago, Román, Ouellet, Rodríguez and Pérez-Azor, 2010:60-69). Meaningful event sequences are those which we experience daily, whether in everyday life or through exposure to narratives like TV shows or books. These event sequences are not arbitrary but are connected by goal structure, and are learned instantaneously with very minimal (if any at all) repetition. In contrast, other sequences (like numbers, the alphabet, etc.) are experienced in writing from left to right (or from right to left, depending on the speaker's language), and are thus experienced differently to meaningful event sequences. Therefore, a participant's response to meaningful event sequences allows one to investigate whether the mental timeline is truly affected by one's orthographic direction. In Santiago et al.'s (2010:60-69) first experiment, participants viewed 5-minute-long video clips, and were then asked to judge the order of the events using left and right keys for their responses. In their second experiment, participants were exposed to photos of everyday activities in sequences, and then performed temporal order judgement tasks in the same manner as in experiment 1. The results of these experiments showed that the left-right mental timeline was used for ordering meaningful event sequences. This indicates that this timeline is not solely primed by visual stimuli, and is perhaps fully dependent on language.

In addition to meaningful event sequences, the effects of orthography on the mental timeline also extend to potential events. Potential events are those that are presented as possibilities. For example, the sentence: "If he had worked" presents an alternative scenario to one that actually occurred, namely that he had not worked. In their study, Aguirre and Santiago (in press:4-15)

examined native Spanish-speaking participants using a space-time congruency task.[1]. In these tasks, response times are calculated in order to determine whether one arrangement occurs more naturally to a participant than another. Aguirre and Santiago's (in press:4-15) first experiment mixed potential events with factual ones (events which have actually happened). They found that the effect of potential events on the mental timeline is indistinguishable from that of factual events. The second experiment consisted of only potential events, and showed that this effect is genuine (it exists away from stimulus that provokes the response), and can be seen even when potential events are judged in isolation. These results contribute to the body of evidence in favour of the effect of orthographic direction on the mental timeline.

The effect of orthographic direction on the mental timeline has been discussed in this section, and correlational evidence which supports this proposal has been described. The relationship between the mental timeline and orthography has further been found to be causal, as will be discussed in following studies.

Casasanto and Bottini (2014:474) assessed the extent to which reading and writing direction is a cause or effect of culturally varied space-time mappings, and whether reading and writing is sufficient to alter the directional flow of an individual's mental timeline. Native Dutch speakers were asked to complete space-time congruity tasks over two experiments. In these space-time congruency tasks, participants had to press left and right buttons to indicate whether a phrase referred to a time that was earlier or later in time. The instructions for these tasks were presented in either standard, mirror reversed, or (90') rotated orthography. When exposed to temporal phrases (such as *eendag later*, which means "one day later") presented in standard orthography, participants exhibited response times that were consistent with a rightward-directed mental timeline. This means that they would produce left button responses for times that were earlier, and right button responses for times that were later. However, after brief exposure to mirror-reversed orthography, their mental timelines were reversed, which was evident in their responses. Furthermore, when exposed to orthography rotated 90' (counter) clockwise, participants displayed a rotation in their mental timelines. These findings provide evidence that there is not only a causal relationship between orthographic direction and the mental timeline,

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[1] In space-time congruency tasks, participants are presented with response options that differ over conditions: one response option that is congruent with a response (in this case, pressing a left key in response to past events), and one that is incongruent with a response (such as pressing a right key in response to past events).

but further that the mental timeline can be altered through brief exposure to an alternative orthographic direction. Thus, although the mental timeline appears to develop according to reading and writing experience, it is still flexible.

A similar study by Román et al. (2015:2-7) aimed to determine whether a causal relationship between reading orthography and the spatial biases that we develop from language exposure exists. This study differed from that of Casasanto and Bottini (2014:474) in that it consisted of reading a narrative and performing a drawing task rather than drawing tasks rather than reading short phrases and performing space-time congruity tasks. Monolingual Spanish participants were presented with either standard (left-to-right), mirror (right-to-left), downward-rotated, or upward-rotated orthography. The content of the orthography was writing that described spatial information about objects, such as "The triangle is between the square and the circle". Participants were asked to draw the contents of the orthography that they were exposed to. By assessing the directionality of drawings, it was found that brief reading experience caused spatial bias. For example, rather than drawing a square to the left of the triangle and a circle to the right (correlating with Spanish's left-to-right orthography), participants would draw a square to the right of the triangle and a circle to the left of it. This observed flexibility was, however, limited. Furthermore, it was found that there was a strong preference for arranging models along the horizontal dimension, even amongst participants who read orthography that was rotated downward or upward. Furthermore, it was also shown that spatial bias caused by orthographic direction is short-lived and may disappear after a few minutes.

Further research on directional variation in the mental timelines of multilingual individuals has focused on speakers of Japanese, Hebrew, and English. Japanese speakers read both Kanji (which consists of logographs) and Kana (consisting of phonographs). Kanji is presented from right to left in vertical columns, while Kana is presented from left to right in a horizontal direction (Nachson and Hatta, 2001:178). On the other hand, Hebrew readers have a combination of left-to-right and right-to-left reading habits, which have previously been found to cause inconsistencies in their directional tendencies (Nachson, 1985:161-174, cited in Nachson and Hatta, 2001:178). Inconsistencies in reading direction have been found to result in greater inconsistency in directional conceptualisation. In a study by Nachson and Hatta (2001:178-179), Japanese, Hebrew and English participants observed and reproduced horizontal displays of stimuli such as letters, digits, circles and geometric figures. All the groups were found to reproduce the stimuli from left to right. However, English readers showed smaller variability on the tests, as well as stronger directional tendency on the circle and digit

tests, than Hebrew and Japanese readers. These results suggest that readers of languages that have consistent reading habits (such as English) have stronger directionality than readers of languages that have inconsistent reading habits (such as Hebrew and Japanese).

As the directional flow of the mental timeline is influenced by orthographic direction, it is unsurprising that multilingual individuals (who speak languages with opposing orthographic directionality) have been observed to have multiple timelines. In Mandarin, speakers make use of both front/back and up/down metaphors when speaking about time (Scott, 1989:295). Thus, Mandarin-English bilinguals may have exposure to both horizontal and vertical language, which could result in two mental timelines. Miles, Tan, Noble, Lumsden and Macrae (2011:599-601) tested this proposal by giving participants sets of images of celebrities who were at different ages in each image, and asking them to order the images according to visible aging. Since the participants were Mandarin-English bilingual speakers, images of Brad Pitt (an American actor) and Jet Li (a Chinese actor) were used to assess whether the language the actor was associated with (English or Mandarin) would influence the ordering of images. It was found that, in sociolinguistically compatible contexts, Mandarin-English bilinguals classified items representing the past and future faster, regardless of whether this was done along the horizontal or vertical axis. A further result was that individuals ordered images from left to right and from top to bottom. It was also noted that participants were more likely to arrange images of Jet Li vertically than they were those of Brad Pitt. The results of this study contribute evidence towards the proposition that more than one timeline exists in the mind of bilinguals (Miles et al., 2011:602).

While the above findings provide insight into the flexibility of the mental timeline, a subsequent study by Wu (2012:2-7) failed to replicate these results. The study used non-spatial responses and assessed whether previously observed mappings of time can be generalised in non-spatial tasks, or whether spatially oriented responses are necessary for compatibility effects. Like Miles et al. (2011:599-601) above, this study made use of sequences of photos of actors, both Caucasian (like Brad Pitt or Britney Spears) and Asian (such as Jackie Chan and Jet Li). The studies differ slightly in methodology. In Wu's (2012:3) study, participants (American Mandarin-English bilinguals) completed an online task which asked questions such as "Is the second picture earlier?" and "Is the second picture later?" rather than "Arrange the images from earliest to latest". Wu (2012:6) failed to replicate the findings of Miles et al. (2011:599-601), and found that the subjects did not arrange Asian faces vertically from top to bottom. One suggestion is that this was due to the participants, as Miles et al. (2011:599-601)

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made use of Singaporean individuals, while Wu (2012:6) focused on American individuals. The difference here may be the result of writing direction, as vertically written orthography is more likely to be common in Singapore than in the United States of America. Further results showed that participants responded faster to Caucasian faces presented on a horizontal axis than on a vertical axis, while there was no difference in the response times associated with Asian faces presented on either axis. Although the effect was small, the response times associated with Asian faces showed that both the vertical and horizontal axes were activated, although there was no real "compatibility effect" as seen in previous studies, as either of these axes are compatible with the activated timeline.

As discussed in the previous section, there is strong evidence in favour of an asymmetry in the mental timeline, which is caused by reading-writing direction. Research focusing on children is useful when studying the malleability of the mental timeline, as if this is something experiential, differences should be observable between children and adults. An example of a study is Fagard and Dahman (2010:40-50), which tested the effect of reading/writing direction on the asymmetry of space perception and directional tendencies in children. The participant groups consisted of French and Tunisian children (who are Arabic speakers), who both had learnt to read and write and those who had not yet learnt to read and write. Participants were asked to perform bisection tasks (which entailed drawing a line through a circle), circle drawing tasks, and dot filling tasks (where participants had to colour in a dot). In the bisection task, a difference was found in the nine-year-old group, where French children bisected the line to the left of the true centre of the circle, and Tunisian children showed no bias. In the circle drawing task, the groups differed from the age of seven, where French children showed increasing use of clockwise movements. Tunisian children, on the other hand, showed no clockwise/anti-clockwise bias. Finally, in the dot-filling task, French children were found to fill more dots when colouring from left to right, while the opposite was found for Tunisian children. These comparisons demonstrate that learning to read and write has a large impact on a child's spatial tendencies, even after just a few years of literacy learning. The results of these studies not only contribute to the growing body of evidence in favour of orthography influencing the mental timeline, but further shows that the relationship between these two factors is a causal one.

Despite its malleability, the mental timeline has been found to be limited to the horizontal axis. This formed the basis of a study by Ishihara, Keller, Rossetti and Prinz (2008:455), which examined the *spatial-temporal association of response codes* (or STEARC) effect. The STEARC effect is seen between representations of space and time, such as when individuals

map the future to the right and the past to the left. In their first experiment, the authors tested horizontally presented left/right responses, and in their second experiment they tested vertically presented bottom/top responses. The second experiment further looked at the arrangement of "early" events (which consist of small quantities of temporal information) and "late" events (which consist of larger quantities of temporal information, accumulated over time), and their arrangement in either the lower or upper part of the vertical axis. It was found that the STEARC effect was present in the horizontal dimension, but not in the vertical dimension. In the first experiment, left-side responses were faster for earlier times, while right-side responses were faster for later times. The methodology for both of these experiments was identical except for the position of the response keys, which suggests that the mental timeline is limited to the horizontal axis and does not extend into the vertical dimension (Ishihara et al., 2008:459).

At present, the effect of orthography direction on cognitive functions, temporal conceptualisations and the mental timeline has been discussed. Additionally, it is evident that the mental timeline is not fixed, but that it is somewhat flexible (even if temporarily), and can vary with multilingualism. These findings suggest that one is not born with a timeline that simply flows from left to right, but that this is something that develops according to language, and is thus (at least partially) experiential. In the next subsection of this literature review, the development of the mental timeline will be discussed.

2.4.3   The Development of the Mental Timeline

In Section 2.4 (The Effects of Orthography on Temporal Cognition), the effect of orthography direction on various aspects of temporal processing has been discussed. Additionally, it has been proposed that the mental timeline is malleable. In the present subsection, the development of the mental timeline will be discussed, with a focus on research looking at children and individuals with disabilities that may affect it.

Under normal circumstances, reading and writing consists of a combination of visual, mental, and physical processes, where we use our vision to scan over information. Additionally, the use of other graphic items such as calendars is predominantly visual, which suggests that vision plays a role in the development of the mental timeline. However, studies that focus on blind participants show us that the effect of orthographic direction on the mental timeline is not limited to sighted individuals. One such study is that of Bottini, Crepaldi, Casasanto, Crollen and Collignon (2015:69-71) where early blind (individuals who were always blind, or who went blind at a young age), late blind (individuals who went blind later on in life), and sighted

Italian participants were tested in a space-time congruity task. In the study, participants were asked to classify orally-presented temporal words (such as *passato* and *prima*, meaning *past* and *earlier*) by pressing right and left keys, with their hands either crossed or uncrossed. The participants used either crossed or uncrossed hands to ensure that any effect found was the result of spatial bias rather than handedness. The results showed that the mental timeline is similar in blind and sighted individuals, where even early blind participants showed a rightward-directed mental timeline. It was further shown that in cases of both sighted and blind individuals, the mental timeline is based on some external frame of reference. For sighted individuals, this reference originates from reading printed text, and for blind individuals this may come from reading braille, which flows from left to right. These results suggest that vision is not necessary for the development of the mental timeline, and that the mental timeline is directly linked to reading direction.

As space is generally conceptualised in the right hemisphere of the brain, lesions in this hemisphere often lead to spatial neglect, where patients struggle to perform tasks (both mentally and physically) which occur on the left side of space (Driver and Vuilleumier, 2001:40). Furthermore, patients with left hemi-spatial neglect struggle to represent events that exist on the left side of the mental timeline. In a study focusing on encoding, recollection and recognition in French-speaking individuals, right-hemisphere stroke patients exhibiting spatial neglect were contrasted. The patients were first compared with right hemisphere patients with no signs of spatial neglect, and then with healthy control patients. The study consisted of a memory experiment, which included an encoding phase, a recall-test phase, and a recognition-test phase. The encoding phase entailed the participants learning about a fictional character who liked to eat various foods, at different times. For example, "10 years ago, David liked to eat eggs". In the recall-test phase, the participants were asked to recall the food items mentioned in the encoding phase. Finally, in the recognition-test phase, participants were presented with food items previously shown to them in the encoding phase, as well as new items that they had not seen before. The participants were then asked to indicate which items they had been exposed to previously. The control participants and patients without neglect symptoms were found to have full access to food items presented as belonging to both the past and the future, while those with neglect symptoms struggled to recall and attribute items from and to the past. These findings suggest that problems with spatial representations caused by left hemisphere neglect also impact representations along the mental timeline (Saj, Fuhrman, Vuilleumier and Boroditsky, 2014:208-212).

This section has focused on the development of the mental timeline, and has briefly discussed research on children, as well as research on individuals with disabilities that may disrupt temporal/spatial reasoning, and as a result, the mental timeline. Combined, these findings suggest that the mental timeline is not entirely innate, but that it rather develops, at least partly, according to experience.

2.5   Embodied Cognition

Embodied cognition comprises the notion that an individual's cognitive processes and conceptual content are shaped by bodily interaction with the world (Wilson, 2002:625). In more recent studies of embodied cognition, the relationship between bodily experience, language and perception has been emphasised. This relationship will be discussed further in this section.

2.5.1   Embodied Cognition and Judgements of Valence

When we speak about emotion and valence (the intrinsic positive or negative associations an individual has with objects, events and situations), we make use of spatial metaphors (Lakoff and Johnson, 1980:3-14). Examples of these include describing oneself as "feeling down" when discussing sadness, or telling someone to "lighten up" and be happy. These metaphors are said to originate from the way that we are physical beings in a physical environment, and spatial metaphors are a way of describing the way our bodies function in this environment (Lakoff and Johnson, 1980:14). Beyond this, valence has been found to share a relationship with embodied cognition, which will be discussed in this subsection.

A large number of studies have focussed on valence and embodied cognition in the vertical dimension. A study by Dudschig, de la Vega and Kaup (2015:153-155) examined whether evaluations of word valence interact with motor responses in the vertical domain. In this study, it was found that when participants made positive evaluations, they exhibited upward responses; while when they made negative evaluations, they exhibited downward responses. Additionally, words that do not require valence judgements but are still associated with spatial meanings, such as implicit location words (like *bird*, which is associated with "up" since birds fly, and *worm*, which is associated with "down" since worms live in the ground) had a similar effect on motor responses, where participants exhibited upwards responses for words such as *bird* and downwards responses for words such as *worm*. A further result found that valence words associated with bodily posture, such as *confident* (associated with an upright posture) and *sad* (associated with bad posture), also had an effect on the participant's results. These yielded responses that corresponded with the words either being positive (like *confident*) and therefore having an "up" result, or words being negative and thus having a "down" result.

A subsequent study focusing on valence and embodied cognition in the vertical dimension was that of Meier and Robinson (2004:243-246). In this study, participants evaluated words with positive (e.g. *hero*) and negative (e.g. *liar*) connotations, which were presented at the top or the

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bottom of a computer screen. The results of this study showed that participants judged valence words faster when they were congruent with vertical position. Thus, words like *hero* were judged faster when presented at the top of a computer screen, while words like *liar* were judged faster when presented at the bottom of a computer screen. These results show that movement is not only affected by the meaning of spatial words, but also by valence.

The effect of valence on movement was further assessed in a study focusing on academic achievement. Wapner, Werner and Krus (1957:752-756) examined this through the use of a square-bisection task, where participants were asked to draw a line through a square following a mid-term examination. The results of this study showed that individuals who achieved low scores on the examination showed a downward bias in their bisection, while those who achieved high scores exhibited an upward bias. These findings suggest that valence has an effect on movement, and is further linked to the vertical dimension.

The findings discussed above were supplemented in a study by Ansorge, Khalid and König (2013:3-14), which assessed the effect of subliminal spatial and valence words (such as *happy* or *sad*) on classification tasks, where participants were asked to categorise words according to primes (such as *up* and *down*). The authors observed that participants classify subliminal primes that are congruent with their targets (such as the prime *up* before the target *happy*) faster than those that are incongruent (such as the prime *down* before the target *happy*). These studies suggest that, in addition to spatial words and valence having an effect on movement, these two factors are also related.

In a further study, Casasanto and Dijkstra (2010:180-183) assessed whether movements that are irrelevant to the encoding of emotional memories could influence the retrieval of these memories. The study consisted of two experiments, where participants were asked to perform meaningless tasks while describing their memories. In the tasks, the participants moved marbles continually between cardboard boxes, either in an upward or downward motion. In the first experiment, participants were asked to recount memories that followed either a positive or negative theme, such as a response to the prompt: "Tell me about a time when you felt ashamed of yourself", while moving the marbles. The results of this experiment showed that participants recounted their memories faster when the memory was consistent with the direction of an associated valence metaphor (i.e. upwards is good, downwards is bad), and slower when the memory was inconsistent with the direction of this metaphor. Participants therefore recounted positive memories faster and more fluently when moving the marbles upwards, and recounted

negative memories similarly when moving marbles downwards. In the second experiment, participants moved marbles either upwards or downwards, and were given valence-neutral prompts (such as "tell me about something that happened yesterday"). It was found that participants who were arranging marbles in an upward direction recounted positive memories, while those who were arranging them in a downward direction recounted negative memories.

A subsequent study by Koch, Glawe and Holt (2011:216-221) aimed to replicate the findings discussed in Casasanto and Dijkstra (2010:180-183) above, and further to extend them to motion-meaning relations in the sagittal/horizontal axis. The study consisted of two experiments, both which were performed using a device that looked like a large slider. For their responses, participants were required to move the handlebar of the device from a middle position to the end of the device. In the first task, German participants were given words that were associated with either an up or down motion (such as *turm* which means "tower" for up, and *krankheit* which means "disease" for down). The words were presented in two different colours, and the participants were required to move the slider towards a direction on the screen which was the same colour as the given word. For example, if *himmel* or "heaven" was displayed in purple, the participant would have to move the slider towards a section on the screen that was also purple. These words were presented in colours that were either congruent or incongruent with the direction associated with the word (i.e. *himmel* is a positive word, so it would be congruent with an upwards response). In the second task, the procedure was the same as the first task, except the slider was presented in front of the participant in order to make horizontal axis movements possible. In this task, participants were presented with forward/backward words (such as *morgen* which means "tomorrow", and *gestern* which means "yesterday"). The results of both tasks found that responses were significantly faster when participants responded to congruent trials (Koch et al., 2011:221).

Furthermore, physical posture has been found to have an effect on valence, where individuals associate upright postures with positive emotions, and slouched/slumped over postures with negative emotions. This was assessed in a study by Riskind and Gotay (1982:275-283). In their first experiment, the authors placed participants either in a stooped or upwardly expansive position. The participants were then asked to solve four geometric puzzles, two of which were insoluble. It was found that those participants who were placed in a stooped position developed helplessness more readily, and struggled to persist in the task. A further experiment consisted of subjects making judgements of the emotions of people depicted in photographs. Subjects in the photographs who were depicted with slumped posture were judged to be more depressed

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and helpless, while those who were depicted with upright posture were seen as happy or content (Riskind and Gotay, 1982:283-286). A final experiment consisted of placing participants in either hunched over, uncomfortable positions; or upright, relaxed positions. The participants were asked to make judgements based on their level of stress, and it was found that those participants who were in hunched over positions judged themselves to be more stressed than those in relaxed positions (Riskind and Gotay, 1982:286-292).

To summarise, this section has discussed the effects of valence on embodied cognition, and vice versa. In doing so, it has demonstrated that word valence, academic achievement, the encoding of emotional memories, and posture all share a relationship and can be affected by movement. Further, the effect exists in both horizontal and vertical domains, as seen through studies focusing on up/down and left/right movements.

2.5.2   Embodied Cognition and Conceptions of Space

In this section, the relationship between embodied cognition and conceptions of space in the human mind will be discussed. As discussed previously in the "The Effects of Orthography on Cognition" section of this thesis, speakers of Western languages such as English and French have been observed to represent ascending numbers on a *mental number line*, flowing from left to right (Dehaene et al., 1993:393-395). On this number line, smaller numbers are placed to the left and larger numbers are placed to the right. It has been found these effects extend to judgements of quantity, where individual's judgements of height can be altered through bodily displacement. In a study by Eerland, Guadalupe and Zwaan (2011:1511-1513), participants stood on a Wii Balance Board, and were surreptitiously (as they were unaware of any displacement) made to either stand upright, lean slightly to the left, or lean slightly to the right. Across two experimental conditions (one where estimates were limitless, and the other where estimates were limited to fall between the numbers 1 and 10), participants were asked to estimate the heights of objects in different images. It was found that when participants were made to lean to the left, their estimates were smaller than when they were upright or leaned to the right; while when they were made to lean to the right, their estimates were larger than when upright or leaned to the left.

While the previous study focused on full body displacement, head turning and eye movement have also been found to have an effect on cognition. Loetscher, Schwarz, Schubiger and Brugger (2008:2-4) focused on numerosity and spatial direction. The authors asked participants to generate random numbers between 1 and 30, with their heads kept straight, and then turned

to the right or left. Participants were observed to produce more small numbers when their heads were turned to the left, while they produced more large numbers when their heads were turned to the right. A subsequent study by Loetscher, Bockisch, Nicholls and Brugger (2010:R264-R265) additionally found that eye position can be used to predict the number that an individual is thinking of. The authors observed that participants looked to the left and downwards before announcing a number smaller than the one they had mentioned before, while they looked to the right and upwards before announcing one bigger than a previously mentioned number.

Embodied cognition has been found to influence one's perception of spatial scale, and further their perception of the size of an environment in relation to an individual. This was assessed in a study by DeLong (1981:681-682), where participants were required to observe different scale-model environments. These environments represented small living spaces, much like a bedroom, bathroom, lounge and kitchen in a dollhouse. Following this period of observation, participants imagined themselves as scale figures in these environments, using these figures to create activities in the environment for a certain period of time. Afterwards, the participants were asked to judge how much time had elapsed between different events. From these experiments, it was found that participants' experiences of temporal duration shifted according to the size of the environment which they were exposed to. This suggests that spatial scale, in addition to physical movement, has an effect on the mental timeline and spatial perception.

The evidence up to this point suggests the existence of a strong relationship between movement and cognition. This relationship further appears to be an automatic one, where movement affects cognition and cognition affects movement. The automaticity of this relationship was tested in a study by Dudschig, Lachmair, de la Vega, De Filippis and Kaup (2012:1084-1090), which focused on the bottom-up activation (where perception begins in touch, rather than in the brain) of motion-related experiential traces. Experiential traces refer to traces of experience that remain in the brain after interaction with the world. In the study, participants were asked to indicate the font colour of motion words such as *rise* or *fall* by using up/down responses. Participants were found to respond faster if a response matched the implicit motion of words (such as a downward response for the word *rise*). Furthermore, this effect was stronger when the experiments required upward or downward movement. The results showed that, regardless of word meaning, directional motion verbs influence manual up/down responses, which demonstrates the automaticity of the relationship between motion/action and language.

This relationship was further assessed in a subsequent study by the same author (Dudschig, de la Vega, De Filippis and Kaup, 2014:153-157). This study questioned whether responses found in tasks (such as the ones in Dudschig et al. (2012:1084-1090) above) are triggered automatically during word processing, or whether they arise from more strategic language processing. In the study, participants were subliminally presented with direction-associated nouns such as *hat* (which has an upward association) and *shoe* (which has a downward association) presented in grey font on a black background. These words were presented for 35 milliseconds before being replaced by a coloured rectangle. The participants had to provide up/down responses which mapped the rectangles according to their colour. It was found that the subliminal presentation of words influenced the subsequent mappings of triangles to colours, which prompted a further experiment. The methodology of this experiment was the same as in the first one, except that the direction-associated nouns were not presented subliminally. The outcome of this experiment showed that consciously or unconsciously, the processing of words results in movements towards locations cited in the words; where "up" words yield upward responses, and "down" words result in downward responses. These results contribute evidence to the notion that the relationship between language, cognition and action is automated.

The above studies show not only that the relationship between language, cognition and action is automated, but also that words with spatial representations can trigger certain movements in participants. It has further been observed that individuals experience difficulties in comprehending meaning when meaning and movement are in opposition. This was assessed in a study by Glenberg and Kaschak (2002:559-564), where participants made sensibility judgements for two sets of sentences, one with implied direction, such as "put your finger under your nose"; and the other with nonsense notions such as "boil the air". Participants responded to the sentences using a response that incorporated movement to or away from the body. The results of this study showed that individuals experience difficulty making sensibility judgements that required action in the opposite direction of that which was implied in a sentence. Thus, if a participant had to make a toward-the-body response to a sentence like "close the drawer", which implies action away from the body, they had difficulty. These results suggest that meaning comprehension and movement are related, and that individuals find the former to be difficult if it is in opposition with the latter. This contributes further evidence to the proposal that language, cognition and action are related, and that this relationship is automated.

2.5.3   Embodied Cognition and Conceptions of Time

The previous section of this chapter, "The Effects of Orthography on Temporal Cognition" looked at the mental timeline, and how this is affected by orthography. According to Arzy, Adi-Japha and Blanke (2009:184), the mental timeline extends into thinking about life, the future and the past. In these cases, humans "project" themselves and events onto a fabricated mental timeline. According to Tulving (2002:311), this involves the process of *chronesthesia*, which refers to an individuals' ability to travel mentally and subjectively through time. This mental time travel has been found to influence bodily movement, where people have been observed to produce forward and backward motion (or postural sway) while pondering the past and future. Miles, Nind and Macrae (2010:222-223) tested this by fitting movement sensors onto participants, and additionally asking them to wear blindfolds in order to promote imagery (therefore enhancing postural sway). Participants were asked questions that provoked either retrospection or prospection, and a correlation between mental time travel and forward/backwards movement was found. When participants were asked to speak about the past, they tended to lean backwards; while those who were asked about the future exhibited forward movement. These findings suggest that conceptualisations of time in the mind influence bodily movement.

The findings of the previous study suggest that temporal thought can influence motion. The inverse effect (that motion can influence thought) was assessed in a study by Hartmann and Mast (2012:1559) which entailed the use of a motion platform to passively displace participants forward and backward. During displacement, participants categorised verbal stimuli according to "future" or "past". The results of this showed that verbal stimuli were processed faster during forward motion when compared to backward motion. These results further suggest that not only can concepts of time have an effect on motion, but the inverse effect can be observed too.

A subsequent study assessed this effect on a smaller scale. Matlock, Holmes, Srinivasan and Ramscar (2011:269) asked participants to perform tasks that incorporated abstract motion in a forward or backward direction, before answering questions about the temporal domain. In the first experiment, participants filled in missing numbers on an ascending or descending number line, while in the second experiment they filled in missing letters on an array of letters. In the final experiment, participants read a story about a person who was performing a countdown, either in ascending or descending order. Following each of these conditions, the participants were asked a question about "moving forward" a meeting. In all of the experiments,

participants were found to be affected by the tasks performed before answering the "moving forward" a meeting question, which provides further evidence for the notion that not only does temporal thought influence motion, but that motion can also have an effect on temporal thought.

The effect of movement on the mental timeline can further be observed in everyday activities. This can be seen in a study by Boroditsky and Ramscar (2002:185-189), which assessed two perspectives on the movement of time, the ego-moving and time-moving perspectives. In the ego-moving perspective, people see themselves as moving through time; while in the time-moving perspective, time moves towards and past an individual. The experiments in this study focused on people who were waiting in a line for approximately ten minutes, people who were embarking and disembarking on plane journeys, and people who were riding on trains. It was found that people waiting in lines were more likely to make use of the ego-moving perspective when they were closer to the front of the line (thus, the more they had moved forward in space) than those who were further back in the line. This suggests that the perspective is triggered by physical movement, and that an individual's way of thinking about time is therefore influenced by said movement. This proposal was confirmed by the results taken from people at the airport, which showed that those waiting to embark on their journey were less likely to display the ego-moving perspective than those who had just climbed off a plane. This suggests that not only does physical movement influence time perception, but that a lack of movement can also have an effect. This was further seen in Boroditsky and Ramscar's (2002:185-189) final experiment, which found that within five minutes of getting on or off a train, people were highly likely to take the ego-moving perspective, while those who were in the middle of their train trip only exhibited a slight bias towards this. These results suggest that any kind of movement, whether slowly moving through a line or being on a plane or train, can influence the mental timeline.

This section aimed to introduce the notion of embodied cognition, and demonstrate that there exists a relationship between cognition and movement. This has been demonstrated through a discussion of studies evaluating the effect of body movement on numerosity, temporal duration, language, and valence.

2.6   Conclusion

This chapter aimed to introduce studies relevant to this research project by providing an overview of literature in the field. The chapter began with an introduction to orthography and the ways that this differs across languages. The chapter then went on to discuss the relationship

between orthography and cognition, specifically focusing on shape perception, aesthetic preferences, numerical and magnitudinal reasoning and perception, and musical and auditory pitch. Third, the chapter looked at orthography and temporal cognition, specifically focusing on the effect that orthography has on the mental timeline, and how the mental timeline develops. Finally, the chapter discussed the notion of embodied cognition, and looked at the relationship between embodied cognition and judgements of valence, conceptions of space, and conceptions of time.

3   Theoretical Overview

This chapter aims to provide an overview of the theoretical framework used in this study. The chapter will begin with a discussion of concepts, categories and word meanings. This first section introduces the notion of ad hoc concepts, and then provides definitions for concepts, categories and word meanings. Next, the section covers the proposal that information and concept cores cannot be context-independent and that concepts, categories and word meanings are not stable. Finally, the section provides an explanation of concepts, categories and word meanings on three time scales. The second section of this chapter focuses on experiential relativity. In this section, linguistic, cultural and bodily relativity will be discussed, and then the section will end with a consideration of the Hierarchical Mental Metaphors Theory. The next section of this chapter will look at (dis)embodied cognition. In this section, disembodiment and secondary embodiment theories will be discussed first, followed by theories of weak and strong embodiment. The final section of this chapter will focus on reading and writing. This section will begin with an explanation of the relationship between reading and writing, and will then move on to discuss reading and writing in the brain. Next, the section will look at reading and writing as embodied skills, and then finally centre in on mirror writing. At the end of this chapter, a brief explanation of the relevance of each chapter (and its components) to this thesis is provided.

3.1   Concepts, Categories and Word Meanings

For centuries, humans have questioned how knowledge is accessed, stored, and used. Today, cognitive scientists propose that human thought and communication can be explained in terms of concepts, categories, and word meanings (or CC&Ms; Casasanto and Lupyan, 2015:543). Concepts are thought to grant us the ability to categorize, these categories extend to concepts, and words have meaning in that they trigger concepts (Casasanto and Lupyan, 2015:543-548). For example, the word *housecat* can trigger the concept of a furry, carnivorous, four-legged mammal. In categorising, we can extend on the concept of the common housecat and liken it to the concept *lion*, a so-called "big cat" which is also furry, carnivorous, four-legged and a mammal.

Previously, CC&Ms were thought to be stable and common to groups of individuals. Furthermore, they were considered to be fully formed entities that were instantiated according to necessity (Casasanto and Lupyan, 2015:545). In the past, CC&Ms were thought to possess stable properties or cores that were accessed during instantiation. An example of this is seen in

prototype theory as applied to the study of concepts (Osherson and Smith, 1981:35). In prototype theory, it is proposed that concepts and the categorisation of concepts is graded, and that membership to groups of concepts is determined by how similar or dissimilar one concept is from another. For example, *chair* is regarded as more of a member of the category "furniture" than *lamp* is (Rosch, 1975:200).

A view similar to prototype theory is presented by Armstrong, Gleitman and Gleitman (1983:304), who suggested that concepts have interrelated principles. Here, "principles" refers to rules which, when combined with experience, would result in lexical concepts. These principles may both have properties that are universal across conceptual domains, and may also have properties that are unique to each independent conceptual domain. In this view, principles react to data, such as linguistic or perceptual experience/input (like hearing a word or picking up an object), and result in a category. For example, a set of linguistic principles could be exposed to linguistic data and result in a category such as a noun or a verb (such as when an individual hears the word *dog* and knows that *dog* is a noun, and therefore combines with other word categories, like determiners and verbs, as a noun does in the language). Similarly, perceptual principles could react to visual stimuli and result in a category such as "object". These more traditional conceptions of CC&Ms are fairly different from the one proposed by the framework of ad hoc concepts (discussed in the following section) in that these conceptions view CC&Ms as stable and common across individuals.

3.1.1   Ad hoc Concepts

In their work on cognitive semantics, Casasanto and Lupyan (2015:543-545) contend that CC&Ms are used flexibly, which leads to the discussion of ad hoc concepts. The authors suggest that, rather than stable and fully formed, CC&Ms should be thought of as human creations, where the neurocognitive activity that CC&Ms mirror are constructed according to context (both physical and social) on (at least) three overlapping timescales (which will be discussed in the section titled "Concepts, Categories and Word Meanings on Three Time Scales" further in this thesis). Furthermore, the authors propose that: researchers need to abandon the idea that CC&Ms possess stable properties or "cores" that are accessed when instantiated, and that instantiations are rather constructed according to retrieval cues that are embedded in various ever-changing contexts.

A further view is brought forth by Allott and Textor (2012:192), who suggest that ad hoc concepts are complementary, and that they are used for a limited number of situationally

relevant inferences in a specific concept. What this means is that rather than storing information for use in different circumstances, ad hoc concepts are brought about to serve specific occasions. Furthermore, categorical information held in long-term memory is activated in working-memory according to necessity, and ad hoc concepts and categories are ideal for the communication of context-dependent meaning (Barsalou, 1987:115; cited in Allott and Textor, 2012:187). This view differs from that of the ad hoc cognition framework (discussed below) in that Allott and Textor (2012:187) view ad hoc concepts and categories as being brought about only when "standard" concepts and categories are not useful.

In order to account for the flexibility observed in concepts, Casasanto and Lupyan (2015:543) propose the ad hoc cognition (AHC) framework. This framework proposes that all words have multiple meanings in their different contexts, all communication is sufficient if it results in mutual understanding, and all ideas are completely original. In this view, concepts are seen as temporary, only existing when they are in use. When one accesses a concept, there is a process of connecting with a network of ad hoc, stored information that reacts to contextual cues. In this view, word forms are seen as meaningless, except for their role as cues in context which draw meaning for instantiations. If word forms are context-dependent, their meanings will never be fully reproduced, as a context cannot ever be fully reproduced. In word processing, humans are further thought to understand and predict meanings ahead of time, according to context (Casasanto and Lupyan, 2015:545-548).

The ability of human beings to understand and predict meanings ahead of time according to context can be explained by looking at models of predictive processing. These models suggest that humans (and animals) do not merely wait for sensory stimulation, but rather constantly predict this stimulation ahead of time. Prior to stimulation, we are thought to predict the possible implications of the sensory input using predictive errors. Clark (2015:21) describes predictive errors as "calculated deviations from predicted states". Our predictions work in a top-down (which here refers to perception being driven by cognition) probabilistic manner, which allows for continuous processing aimed at targeting only important deviations, which are signified by precise prediction errors. The precision of a prediction error can be seen through its inverse variance, that is, how it is aggregated (along with other random variables) to minimize the variance of their weighted average. These estimates vary according to the task we are trying to complete and the environments and contexts we find ourselves in, and thus it is necessary to access reliable information that is relevant to our needs and desires. These estimates grant us the ability to suppress certain prediction errors and highlight others; thus

resulting in a balance between sensory input and previous experience, and allowing us to predict our next state (Clark, 2015:21-22).

Standardly, action is viewed as a response to input. For example, we put food in our mouths and then proceed to chew and swallow it in order to obtain nutrition. However, in Clark's (2015:21) view, action is a means of selecting consequent "input", which results in a cycle that constantly predicts upcoming states and continues to move to bring them to fruition. Therefore, it is a way of creating continuous streams of sensory information that allow us to survive. For example, we chew our food so that it can be broken into smaller particles and so that digestion-aiding saliva can be released. This is necessary so that when we move onto swallowing, we will not choke or put too much pressure on our oesophagus. When we swallow, our food is delivered to our stomachs, and it is easier to digest as a result of our preceding chewing. Thus, the process of eating is a cycle which predicts and prepares for upcoming states.

This idea that humans predict states ahead of time will be discussed in the section titled "(Dis)Embodied Cognition".

3.1.2   Concepts, Categories and Word Meanings (Re-)Defined

In the beginning of this chapter, concepts, categories, and word meanings were defined according to how they are standardly used in cognitive science. The AHD framework presents alternative definitions for CC&Ms. Within this framework, concepts are referred to as patterns of information (activated by cues) which are transiently and, according to necessity, active in memory. Ad hoc information is accessed in agreement with verbal (such as the word *dog*), non-verbal (like the bark of a dog), exogenous (derived from the outside world), or endogenous (generated internally) cues; and experienced consciously or unconsciously. One's internal neurocognitive state changes constantly, while still forming a part of context. Thus, even if a concept (like *dog*) is instantiated twice according to cues in a context where all other factors are stable (e.g. the word *dog* is presented on the same sheet of paper, in the same room, at the same time of the day, to the same person), the context will still not be exactly the same, as one's neurocognitive state is ever-changing and thus changes the context (even if incrementally). Concepts are only in existence when being utilised, and since context cannot be replicated even if the same cue is used twice (and under similar circumstances, such as in the example of *dog* above), no two instantiations of a concept are ever the same. Similar instantiations may exist, but these purely contribute to the fallacy of stable concepts (Casasanto and Lupyan, 2015:546).

In cognitive science, concepts are defined as groups of knowledges that are used in higher cognitive activities (such as perception and thinking, which entails voluntary and controlled awareness) and stored in long-term memory (Machery, 2009:2). Cognitive science traditionally viewed concepts from a computational perspective, where cognition was seen as independent from perception and action. Perception here was viewed as input, action was viewed as output, and cognition was viewed as something between the two (Hurley, 2007:2). From this perspective, concepts were analysed according to formal abstract models (like those seen in mathematical logic), and were kept separate from the impact of the body and of brain regions that conduct functioning with the outside world (Gallese and Lakoff, 2005:455). The early cognitive view saw the mind as functional in nature, and described its processes in terms of abstract symbols, based on formal syntactic rules. Knowledge was thus also viewed as symbolic, and concepts were seen as symbolic representations that could be reduced to symbolic computation (Gallese and Lakoff, 2005:456).

Categorising is standardly defined as the process of composing groupings into which comparable items can be divided. For example, "chair" and "table" can be categorised as "furniture". The AHC framework draws on Barsalou's (1987:121) work on the graded structure of categories, which states that all categorising is an ad hoc process. Further, the AHC framework states that while categorisation is a vital function in human cognition, categories themselves cannot be static components in long-term memory.

Standard definitions of words describe them as consisting of finite sets of meanings, where meanings are accessed according to context. When a word's meaning is accessed, an appropriate concept is retrieved. This concept can activate further information, which is stored in one's long-term memory. Within the AHC framework, information is activated by words (which serve as cues) according to contexts (which includes neurocognitive, physical and social contexts). In this view, words do not possess set meanings, but rather activate meanings according to context and according to an individual's cue processing history. Thus, while one meaning may appear to be similar to another, the context in which these meanings are activated is never exactly the same, and therefore a word can never have an entirely duplicated meaning.

As discussed above, meanings are activated according to words-in-context, rather than merely words-in-isolation. Since word meaning and context cannot be separated, it is unsurprising that individuals are able to predict the meaning of sentences and phrases before they are fully exposed to them (Casasanto and Lupyan, 2015:548). When listening or reading, context

constrains and "tunes" an individual's activated meaning choices, and thus the meanings of words are somewhat constructed before the individual has fully absorbed the sentence or phrase in question.

3.1.3   The Fallacy of Context-Independent Information and Concept Cores

Along with the flexibility of concepts, the AHC framework further suggests that there is no such thing as context-independent information. In this view, a word may activate certain information more readily and more automatically than other information; however, all information will be context dependent. This claim has been legitimised by a number of studies, which will be discussed briefly below.

The notion that concepts are activated as an automatic response to words is often said to be backed up by the results of tests studying the Stroop effect (Stroop, 1935:643-662). A classic Stroop task entails stimuli with the names of colours printed in ink that is either the same colour as the colour mentioned in the word, or of a different colour. Individuals are instructed to name the colour of the font, while disregarding what the word says. When an individual reads a word that is in a certain colour, the meaning of the colour is activated and thus the concept of that colour is also activated. For example, if an individual is required to name the text colour of the word "green", their response will be faster if the text is printed in the colour green (an example of a congruent Stroop trial) than if it were printed in purple (an example of an incongruent Stroop trial).

Previously, the results of these tests led to the conclusion that concepts are activated automatically and detached from processing context, such as the instruction to focus on one meaning (that of the colour in which text is printed) in Stroop tests. However, Besner, Stolz and Boutilier (1997:224), argue that incongruent Stroop trials, which comprise up to 50% of trials in the experiments, create an effect of colour-meaning interference. In early Stroop trials (such as Stroop, 1935:656), an effect was said to be found because participants resorted to processes that examined words on a semantic level, even when being instructed otherwise. When exposed to stimuli where ink colour and words are matching (for example the word "green" is printed in the colour green), individuals have their expectations (that these colour-meanings should match; "green" should be printed in the colour green) reinforced, which makes processing incongruent trials more difficult. Thus, the Stroop test may be regarded as an effect of context, as incongruent trials are made challenging due to the context created by congruent trials. A set of experiments performed by Besner et al. (1997:222-224) confirmed

that the Stroop effect is indeed a fallacy. The results of these experiments showed that instructions in an experimental setting are far less powerful than the effect of an individual's actual context.

The findings of Besner et al. (1997:222-224) thus exemplify a failure to activate "core" features of a word's meaning. Indeed, in Casasanto and Lupyan's (2015:551) view, CC&Ms do not consist of any "core" features. This proposal is illustrated through the example of the concept *tiger*. One could argue that the core of this concept is that it is animate, living, or fierce. However, this does not account for stuffed toy tigers, dead tigers, tame or lame/injured tigers. A further example is given in Casasanto and Henetz (2012:369-370), with the concept of *kindness*. Here, the authors question the core features of all instances of kindness. In this discussion, the kind act of throwing someone a surprise party is contrasted with euthanasia, two acts which are related only through the fact that they can both be considered acts of kindness in their different ways. If one cannot assert, according to principle, what the core of a concept is, then it is not possible to state whether a feature of a concept is just a part of it, or whether the feature plays a role in defining the concept.

Under some circumstances, it appears possible to define certain concepts in terms of their core. However, people respond to well-defined categories in a graded fashion (Armstrong, Gleitman and Gleitman, 1983:280). For example, the concept of an odd number appears to have a clear definition: "an integer not divisible by two without any remainders". However, in one experiment, Armstrong et al. (1983:277) observed that participants judged some odd numbers to be more "odd" than others. This suggests that concepts are non-definitional, as even though we claim to be able to define them, we cannot seem to access their "core". Armstrong et al. (1983:303) further suggest that a concept is not the result of sets of features, and that features that relate to a set of concepts do not comprise a single concept. An example here is that of a bird. Common features of a bird could include that they have wings, they can fly, they are animals, and so on. However, these features cannot amount to the concept of bird, and the concept of bird does not comprise solely of these features, unless they are held together in a sort of "birdness". The above suggests that CC&Ms do not consist of stable "cores" accessible by individuals (Armstrong et al., 1983:305), which is in line with the notion that research searching for these cores should be abandoned and replaced with a view that sees CC&Ms as ad hoc and context-dependent (Casasanto and Lupyan, 2015:545).

3.1.4   The Illusion of Stable CC&Ms

As discussed thus far in this section, CC&Ms are not as stable as previously thought by cognitive scientists. Three possible sources of this illusion include conceptual change blindness, the power of words, and the fallacy of shared concepts and mutual understanding.

In everyday life and in experimental conditions, individuals are not often aware of changes (both small and big) around them, from one moment to the next (Simons and Levin, 1998:645-648). This gives rise to change blindness. An example of visual change blindness can be seen in a study by Simons and Levin (1998:645-648), where experimenters initiated conversations with pedestrians, and were inconspicuously replaced by another experimenter during the conversation (when a door was carried between the two individuals with an experimenter hiding behind it). Only half of the pedestrians noticed that the experimenter was different following the switch, and those who did notice belonged to the same age group as the experimenters. Casasanto and Lupyan (2015:559) suggest that conceptual change blindness works similarly to visual change blindness, and refers to the lack of thought given to the contents of mental representations. In this view, the authors suggest that if individuals were to pay attention to the contents of their mental representations, they might be more able to notice variations in the ways that these representations are cued.

The second proposed source of the illusion of stable CC&Ms is the power of words. When children learn words, this learning process serves (amongst others) the function of creating stable repertoires of concepts. Nouns are analysed and placed in object categories, which are categories that group together certain words that often have similar functions, for example *spoon, knife* and *fork* (Waxman, 2003:295-296). Further, scientific disciplines use processes of categorisation as a means of understanding the world. As a result, certain features are observed while others are forgotten. One consequence of this is that it is easy to essentialise a focus, and overlook the context in which subject matter appears (Barrett, Mesquita and Smith 2010:1). Since human beings use words to describe objects and concepts, it is easy to think of these objects and concepts as stable, and as separate from their user and context.

Traditionally, language processing theories viewed comprehension output as systematic results of input. However, studies focusing on garden-path[2] and passive sentences[3] suggest that derived meaning is often not an accurate reflection of original content. Comprehension appears to be sufficient for communication some of the time, where comprehenders often overlook aspects like semantic anomalies and syntactic complexities (Ferreira, Bailey, Ferraro 2002:13). Thus, language use is not quite as accurate and precise as one may suspect, being more a process of creating representations based on cues-in-context.

Furthermore, communication is deemed successful when communicative goals are achieved (i.e. when mutual understanding has been reached), which does not account for the variability in mental representations between individuals. An example provided by Casasanto and Lupyan (2015:560) describes one speaker talking about having seen a friend "yesterday". While the speaker may have a memory of seeing their friend yesterday morning, the hearer may perceive the speaker as having seen their friend yesterday afternoon. These minor errors in communication often go unnoticed, but show that understanding is an incremental and rather flawed process. Therefore, CC&Ms cannot be seen as stable and shared across human beings.

3.1.5   Concepts, Categories and Word Meanings on Three Time Scales

The variability of CC&Ms is often seen as occurring on (at least) three overlapping time scales: activation dynamics, local context and experiential relativity. Activation dynamics refer to representations that occur from one microsecond to the next within an instantiation. Local context refers to internal factors (within an individual) that affect representations from one instantiation to the next. Finally, experiential relativity refers to representations from person-to-person and group-to-group as a result of experience.

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[2] Garden-path sentences are grammatically correct sentences which mislead a parser into misinterpreting the meaning of the sentence (Bever, 1970:279-362). This is typically achieved through the use of an ambiguous word. An example is "the old man the boat". In this sentence, the parser is likely to combine "old" and "man", which leads them to misinterpret the sentence. If "the old" is treated as a noun phrase on its own, and "man" is treated as a verb, the parser will be able to understand the sentence.

[3] Passive sentences are those in which the subject of the sentence is having an action done to it by something or someone.

In terms of activation dynamics, it is not possible to assert exactly when or where CC&Ms are actualised. Since our brains are always changing, our thoughts are also never stable (Casasanto and Lupyan, 2015:553). When one receives a conceptual cue, this information is divided according to the processing of where (occurring in the parietal cortex, a part of the brain which plays a role in spatial reasoning) and what (processed by the parvocellular system, which holds information about shape). In the first 150 milliseconds of processing, this information has nearly completed its journey. However, the visual cortex neurons keep firing beyond this, while lower-level neurons respond to reactions from the higher brain areas. Throughout this process, the brain reconfigures itself according to visual cues. While this occurs, episodic memory (which is responsible for autobiographical events and their associated emotions) and semantic memory (which is responsible for meanings such as names of colours, sounds of letters etc.) processes are activated incrementally by the changing visual stimuli. Evidently, the processing of a cue is not instantaneous or stable, and one can therefore not pin down a specific time or place in or at which CC&Ms occur. An individual's perception of stimulus is dependent both on their previous neurocognitive activity, as well as the context in which they are to process stimuli (Spivey, 2008:27-29). For example, if an individual views a photo of their dog on different occasions, the processing of these instances will differ. If the individual views the photo while their dog is sleeping happily next to them, they may feel differently about it than if they were to view the photo while on a business trip away from their dog, or after their dog has died.

As discussed repeatedly in this section so far, CC&Ms are viewed as context-dependent. Previously, cognitive-psychological studies focusing on concepts aimed to separate context from concepts for the sake of isolating their experimental interest. This is problematic as, in the real world, individuals construct their understanding of concepts according to cues that they receive in context. For example, the words "I'm hot" are difficult to interpret without information about who is saying it to whom (whether the actor is a person standing in the sun or one's partner), when they are saying it (whether it is in the middle of winter or summer) where they are saying it (whether they are laying in the sun or on a bed) and why they are saying it (whether they are physically warm, physically attractive or sexually aroused). All of these factors contribute to a concept's meaning (Clark, 1997:568). Further, it is impossible to separate CC&Ms from context, even under experimental conditions, since an individual will always find themselves in particular physical, social, and neurocognitive contexts. The effect of these contexts on thought can be seen in studies focusing on emotion, valence, and

movement (for example, Wapner, Werner and Krus, 1957:752-756; Ansorge, Khalid and König, 2013:3-14; Casasanto and Dijkstra, 2010:180-183), which are discussed in the Literature Review chapter of this thesis. Although context influences our neurocognitive representations, these effects are predominantly unconscious, and go completely unnoticed by us.

The final aspect of variability seen in CC&Ms, experiential relativity, will be discussed in the following section.

3.2   Experiential Relativity

This section aims to provide an overview of experiential relativity and its components. It will begin with a description of the term itself, and will then focus on linguistic, cultural, and bodily relativity.

The notion of experiential relativity proposes that people's minds are influenced by linguistic, cultural, and bodily experience. Thus, individuals who speak different languages, come from different cultures, or have different kinds of bodies, will perceive and think differently (Casasanto and Henetz, 2012:370; Casasanto and Lupyan, 2015:555). This view combines the notions of linguistic, cultural, and bodily relativity.

3.2.1   Linguistic Relativity

Linguistic relativity is traditionally associated with the Whorfian or Sapir-Whorf Hypotheses. According to Wolff and Holmes (2011:253), linguistic relativity consists of the following syllogism: i. Languages vary in how they partition reality semantically, as seen in a range of studies and papers, including those focusing on accepting and rejecting linguistic universals (Evans and Levinson, 2009: 430-439; Malt, Gennari and Imai, 2010:29); ii. An individual's perception and conceptualisation of the world around them can be influenced by semantic structure; and thus iii. Speakers of different languages conceptualise and perceive the world differently.

Extreme views of the influence of language on thought are referred to as linguistic determinism, while lighter versions are now termed linguistic relativity. Linguistic determinism is the notion that one's language forever determines one's thoughts, an empirically untenable claim that is an after-construction of Whorf's (1956:148-152) ideas. Linguistic relativity has often been said to be a weaker version of linguistic determinism. However, recent research has resulted in the

classification of several effects of language on thought (or linguistic relativity phenomena) that cannot necessarily be seen along a set continuum of weak-to-strong, such as Language as Meddler[4] and Language as Augmenter[5]. These refer to how, in different cases, language can either interfere with or facilitate in decision making processes (Wolff and Holmes, 2010:255).

More recently, work focusing on linguistic relativity has extended to cultural and bodily relativity (discussed in the following subsections), and has looked at aspects such as time, space, motion and colour. These domains are discussed in the Literature Review of this thesis.

3.2.2   Cultural Relativity

Linguistic relativity, as discussed previously, suggests that language has an influence on perception and interpretation, and that speakers of different languages think about and perceive the world differently. On this note, cultural relativity proposes that, much like language, cultural and bodily experience also shape the brain and mind (Casasanto, 2016:715). Across languages and cultures, individuals appear to conceptualise time along what is termed the mental timeline. Although the existence of this timeline is thought to be universal, its directionality varies according to culture.

The mental timeline cannot be accounted for by linguistic metaphors that conceptualise time according to left-right space (such as if we were to say that *yesterday* is to the left of *today*, rather than *yesterday* came before/preceded *today*), or physical experience (in the real world, we do not experience past events to our left and future events to our right). However, the mental timeline still flows horizontally (from left to right or right to left) or vertically (from top to bottom) (Casasanto, 2016:722). This phenomenon has been attributed to the reading and writing systems of an individual (Casasanto and Bottini, 2014:477), as well as to an individual's experiences of interacting with cultural artefacts such as calendars (Tversky, Kugelmass and Winter, 1991:529). When we read or write, we move our bodies, eyes, and attention laterally, from left to right or from right to left, depending on the language. An example is that of English. In English, we write from left to right, and when we conceptualise

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[4] "Language as Meddler" refers to the way that linguistic codes interfere with nonlinguistic codes when we make decisions (Wolff and Holmes, 2010:256).

[5] "Language as Augmenter" refers to how language sometimes supplements thought by providing tools for processing that allow thought to be successful (Wolff and Holmes, 2010:257).

time laterally, we tend to do so from left to right, where earlier events such as breakfast fall before later events like lunch. This effect varies across cultures, as individuals with orthographies that flow from right to left show the opposite arrangement (Casasanto, 2016:722).

Beyond the mental timeline, cultural relativity has been observed in broader forms of cognition. The notions of individualism (which favours an individual's needs and freedom over a collective or group's needs and freedom) and collectivism (which places emphasis on the collective needs and freedoms of a group rather than each individual in the group) are useful here. Research (Nisbett, Peng, Choi and Norenzayan, 2001:294) suggests that Westerners (e.g. European and American individuals) tend to favour individualistic thought, while Easterners (e.g. Chinese, Japanese and Korean individuals) are more likely to favour collective thought. Further, contextual information during task performance appears to play a bigger role for Easterners than it does for Westerners, who tend to ignore contextual information (Kitayama, Duffy, Kawamura and Larsen, 2003:203).

3.2.3   Bodily Relativity

In the next section of this review, the notion of embodied cognition will be discussed. This proposal of embodied cognition suggests that bodily experience influences or guides human thought. Bodily relativity suggests that if human thought is truly embodied, then individuals who have different kinds of bodies will think, feel, and make decisions differently, as well as form different neural and cognitive representations (Casasanto, 2009:351; Casasanto and Henetz, 2012:370). Since the body is indispensable to contextual interactions with the world, it is proposed that the mind will be dependent on the structure of the body (Casasanto, 2011:378). This makes up the bulk of Casasanto's (2009:351) body-specificity hypothesis, which corresponds to the notion of bodily relativity and has been validated by dozens of experiments, spanning across populations (Casasanto, 2009:353-360; de la Vega, de Filippis, Lackmair, Dudschig and Kaup, 2012:375-385; Casasanto and Jasmin, 2010:2-5; Brunyé, Gardony, Mahoney and Taylor, 2012:231-237; Casasanto and Chrysikou, 2011:420-421; Brookshire, Graver and Casasanto, 2013:246-249; Brookshire and Casasanto, 2012:2-4; Willems, Hagoort and Casasanto, 2010:68-69; Willems, Toni, Hagoort and Casasanto, 2009:2; de la Vega, Dudschig, Lachmair and Kaup 2014:1228-1230). Early experiments in this field looked at handedness, as laterality results in differences in body use and function. Since the right side of the body is controlled by the left side of the brain (and vice versa), right and left-

handed individuals will use the opposite hemispheres of the brain to conceptualise actions (Casasanto, 2014:108-109). For example, right-handed individuals will use the premotor regions in their left hemisphere to represent verbs (Casasanto et al., 2010:877).

One of the prominent findings of bodily relativity studies is that emotional valence appears to be related to motor experience (Casasanto, 2014:110). Right-handed individuals tend to associate positive ideas (such as intelligence, kindness, etc.) with the right side of their body, while left-handed individuals do the opposite. Additionally, right-handed people show a preference for items on the right side of space, while the opposite arrangement has been observed in left-handed people. Furthermore, results of functional magnetic resonance imaging (fMRI) scans show that different neural tissues are used by right- and left-handers when understanding action verbs (Willems, Hagoort and Casasanto, 2010:72). These findings correspond with the notion of bodily relativity, displaying that different kinds of bodies can impact on, and result in, different conceptual processes.

These positive and negative associations are thought to be derived from positivity expressed towards greater motor fluency (Casasanto, 2016:725). The human body is lopsided, where individuals have dominant and nondominant sides that result in one side having greater motor fluency than the other. This is clearly demonstrated through handedness in human beings. Due to the ease of interacting with one's dominant side, positive emotions arise; while difficulties in interactions using one's nondominant side result in negative emotions. Thus, valence judgements are made according to implicit good and bad associations with the left and right side of the body.

These connotations are likely to be enforced by cultural taboo in many cultures. For example, the Quran (the central religious text of Islam) associates the right hand with good fortune and happiness, while the left hand carries the opposite associations (Murata, 1992:82)

Importantly, these associations are flexible. In studies such as Casasanto and Chrysikou (2011:420-422), it is seen that individuals can have their implicit associations between space and valence altered. It is suggested that, like the mental timeline discussed in the previous subsection, emotional valence entails an over-hypothesis (Casasanto, 2016:726). This over-hypothesis could consist of something like, "the fluent side of space is good", and thus right-handed individuals view the right side of space as good, while left-handed people view the left side of space as good. Since it appears that one can alter this view, it is proposed that positive and negative associations between left and right are strengthened through action, and that when

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one has trouble using their dominant side, their perception of valence and space can be altered and strengthened by new patterns of experience. This ties in to the Hierarchical Mental Metaphors Theory, which will be discussed in the next section of this overview.

Further, the effects of experiential relativity as a whole are flexible. This can be seen through studies that entail exposing participants to new patterns of linguistic (Boroditsky, 2001:18-19), cultural (Casasanto and Bottini, 2014:474), and bodily experience (Casasanto and Chrysikou, 2011:421). These references are discussed in the literature review of this thesis. While one may argue that this observed flexibility is problematic when studying longer-term experiential relativity effects, this would only be an issue if one considered concepts as consisting of stable cores which can be affected by these relativity effects. However, if one is to consider concepts as ad hoc according to cues-in-context, these effects can be accounted for. Our language, culture, and bodies are deeply embedded in the context in which we use our minds. If these aspects are constant (which they are: we speak specific language(s), are brought up in a specific culture, and have specific bodies which move in distinct ways), then our mental representations will also appear constant. However, if these aspects are varied (if we are exposed to different language or cultural patterns, or if we are made to move in different ways), then these representations can vary (Casasanto and Lupyan, 2015:558).

3.2.4   The Hierarchical Mental Metaphors Theory

A prominent theory proposed to explain the effect of language on our conceptualisation of time and space is the Hierarchical Mental Metaphors Theory (Casasanto and Bottini, 2014:474). As human beings, we talk and think in metaphors, even when we are not making use of metaphorical language. According to Casasanto (2008b:159), we think in so-called mental metaphors. Mental and linguistic metaphors differ in that mental metaphors refer to mappings between non-linguistic source and target domains, while linguistic metaphors refer to mappings between linguistic representations (Casasanto, 2017:2). In linking more concrete source domains with more abstract target domains, we are able to understand more abstract and different concepts. For example, we use the concrete source domain of space to talk about the more abstract target domain of time. When we speak about time, we conceptualise it in terms of space and physical quantities, as in the example: "time is marching on", "you are running out of time", "he has too much/too little free time".

The Hierarchical Mental Metaphors Theory (HMMT) aims to describe the construction of mental metaphors, their flexibility despite being fundamental to our understanding of abstract

domains (like the abstract domain of time), and their ability to be shaped and moulded into language-specific, culture-specific, and body-specific mental metaphors through interaction with the environment (Casasanto, 2017:1). Mental metaphors develop according to linguistic, cultural, and bodily experiences, and are deeply engrained in our thought processes. Although highly automatic and intrinsic, these mental metaphors are still flexible This flexibility has been shown in numerous studies, such as those focusing on temporal sequences, the directionality of orthography, and the directionality of culture-specific artefacts such as calendars, graphs and written timelines (Casasanto and Bottini, 2014:474; Fuhrman and Boroditsky, 2010:1430-1451; Santiago et al, 2010:60-69; Tversky et al., 1991:515-557). The results of these studies show that after very brief exposure (as little as five minutes, in some cases) to different cross-domain relationships, mental metaphors can be altered. This brings about the question of how, if mental metaphors are so deeply engrained into the human psyche, it is possible to alter them after such short periods of exposure to stimulus.

The HMMT proposes that the cross-domain mappings (such as time conceptualised in terms of space) we create when conceptualising the world belong to a "superordinate family of mappings" (Casasanto, 2017:6). These mappings develop according to source-target relationships in our environments, such as the metaphor of "more time is more distance". The mappings are proposed to be either learned from early experience, or to be part of innate human knowledge. The particular mapping of "more time is more distance" is relevant to human survival (if we are to travel for a long time, we will likely be covering more distance, and will therefore need more resources to survive), and thus could be derived from either of these sources. Either way, from a young age, people acquire a superordinate family of source-domain mappings from their environment. To the extent that these mappings are true to all environments in the world, this family of mental metaphors should also be universal.

Variation can, however, still be observed in the metaphor use of different individuals and groups. This variation can be explained through the strengthening and weakening of mappings from superordinate families. Throughout an individual's lifetime, they are exposed to specificities of life while speaking their language, and while living in their particular culture and body. Through competitive associative learning, these specificities strengthen one of the mappings from a superordinate family. For example, if one is regularly exposed to a particular linguistic metaphor, such as "forward into the future", the corresponding mental metaphor mapping will also be activated, and one will conceptualise the future as before them, rather than behind them as some cultures (such as speakers of Aymara) do. The strengthening of

certain metaphors also results in the subsequent weakening of other mappings, solely through our lack of exposure to them. If we have never been exposed to the metaphor of "backwards into the future", this mapping will be incredibly weak. The process of strengthening and weakening mappings can explain how mental metaphors can have both their foundations in universal source-target connections, and still differ from person to person, and from group to group (Casasanto, 2017:7).

The next question that arises is that if these mappings are strengthened and weakened to the point where we have language-specific, culture-specific and body-specific conceptualisations of the world, then how can we account for the flexibility seen in studies like Casasanto and Bottini (2014:474)? As discussed above, our mappings are strengthened and weakened according to linguistic, cultural and bodily experience. Although there are mappings that may be significantly weakened, these mappings still belong to the same superordinate family as strengthened mappings, and are thus not really "new". These mappings lay dormant due to lack of stimulation. If one is to repeatedly stimulate a mapping (by means of exposing an individual to experience that differs from that which conditions their usual mapping), this mapping can easily be strengthened to the point that it has more strength (at least temporarily) than an individual's usual mapping (Casasanto, 2017:7).

3.3   (Dis)Embodied Cognition

Embodied cognition entails the proposition that one's cognitive processes and conceptual content are shaped by bodily interaction (the experience of sensory and motor systems which are responsible for aspects such as physical senses and bodily movement) with the world (Wilson, 2002:625). Early cognitive studies focussed on the suspicion that human behaviour is mediated by internal factors, such as innate linguistic capabilities in language learning (Wilson and Golonka, 2013:2). These studies tended to adopt a symbol processing approach, similar to what could be seen in artificial intelligence studies at the time. *Symbols* here refer to external events and objects, which have the same nature when examined as internal entities, regardless of their differences in the real world. This makes it possible for them to be processed according to *cognitive architecture* (i.e. within relevant units of the brain), as opposed to processed according to what the symbols represent in the real world. In this view, the structure of the brain is seen as more important than the content of these symbols, where the symbols never change, but the processes that modulate them do. In contrast, embodied cognition rejects

symbolic processing approaches, as cognitive architecture is thought to be malleable and shaped according to sensory-motor interaction with the world.

Initially, cognitive science viewed the relationship between the mind and the body as insignificant, and studies that focused on understanding cognitive processes looked at the mind (Wilson, 2002:625). Additionally, it was thought that our perceptual access to the world was flawed; which would mean that not only is our perception not a sufficient resource for cognition, but neither is our environment. If our perception and environments are not sufficient resources, our brains would be left isolated, burdened with the task of coordinating behaviours based on approximations of requirements that are created using supposedly unknown systems of sensory input and knowledge (Wilson and Golonka, 2013:2).

Advances in the 1960s changed the view of perception as a set of flawed devices to being indispensable tools for navigating the world. Resultantly, there was a shift from viewing perception and our environment as problems that we need to overcome, to treating them as resources that we can use to explore human cognition.

Modern embodied cognition theories view the sensory and motor systems as indispensable to cognitive processing, where direct interaction is necessary for accessing knowledge and developing cognitive abilities (Engel, Maye, Kurthen and König, 2013:203). A variety of views on embodied cognition exist; these including disembodied (or unembodied), secondary embodiment, weak embodiment, and strong embodiment theories. These will be discussed in the following sub-sections.

3.3.1   Disembodiment and Secondary Embodiment Theories

Disembodiment theories view the sensory-motor systems as entities that are separate from cognition, while secondary embodiment theories view sensory-motor systems and cognition as related but independent.

Much like classical cognitive approaches, disembodied (or unembodied) theories view mental representation as "abstract" and "symbolic", where focus lies on the organisation of cognitive structures and how different parts of the brain are responsible for different tasks (Mahon and Caramazza, 2008:59; Meteyard, Cuadrado, Bahrami, and Vigliocco 2012:790). In these approaches, the sensory-motor systems are viewed as completely independent to processing. If this view is plausible, then problems with sensory and motor systems should not impact the processing of meaning (Meteyard et al., 2012:198).

There are several views in favour of this notion, such as Levelt (1989:6-7). This perspective sees language as symbolic, where lemmas (concepts which are representative of word meanings, and which carry some syntactic features) are selected by the activation of preverbal messages. These lemmas are seen to be holistic and symbolic, separate from external factors like sensory-motor information.

A further view that represents disembodiment is that of *Latent Semantic Analysis* (LSA). In this perspective, word meanings are defined according to their relations to other words, rather than by their referents (i.e. the thing a word refers to in the real world). The result of this is that word meanings are represented by sets of abstract symbols, rather than by their physical depiction (Landauer and Dumais, 1997:13-18).

Secondary embodiment theories propose that sensory and motor systems are independent to processing. Sensory-motor systems and semantic representations are thought to share a non-arbitrary relationship, where interactions between the two can be interpreted as a result of their associated connections (Meteyard et al., 2012:791-792). An example of such a perspective is that of the *grounding by interaction view*. This view serves as an interface for embodied and disembodied hypotheses, accounting both for the notion that concepts are, on some levels, abstract and symbolic, but that sensory and motor information may also play a role in processing. Both the disembodied cognition hypothesis and the grounding by interaction view assume that sensory and motor information cannot account for a certain level of abstract conceptual content. However, the grounding by interaction view proposes that instantiating a concept must, on some level, include the retrieval of motor and sensory information. Thus, if the sensory and motor systems were severed (as in certain forms of brain damage), concepts would be left in isolation. While the sensory and motor systems are thought to not fully constitute a concept, concepts are incomplete without these systems, as these systems provide concepts with context (Mahon and Caramazza, 2008:67-68)

An example given by Mahon and Caramazza (2008:67-68) is that of a hammer, where in the view of embodied cognition, an individual would receive information about the usage of a hammer merely by lifting and holding one (and therefore retrieving the concept at the same time). Disembodiment, on the other hand, would entail retrieving the hammer and the abstract or symbolic concept of a hammer through visual input, and contacting information in the motor system about the usage of the hammer before making use of it.

3.3.2   Weak and Strong Embodiment Theories

As opposed to accounts of disembodied and secondary embodiment theories, theories of embodied cognition assume a stronger dependence of conceptual structure on the sensory-motor systems.

More recently, it has been proposed that concepts may be embodied (Gallese and Lakoff, 2005:456); that is, mapped within our sensory-motor systems. From this perspective, concepts are not only structured by the sensory-motor system, but their semantic content is also characterised by how we interact with the world. Conceptual embodiment is typically studied in research on embodied cognition, and is approached from three viewpoints. The first of these viewpoints sees sensorimotor simulation ((re)imaginings of sensory and motor states) as being central, while the second focuses on action preparation (the motor control system's preparatory stage preceding an action) (Dove, 2014:372). A third view combines the above perspectives, and looks at the relationship between simulation and action. This view further focuses on the predictability of simulations, and how they can be useful for guiding action (Gallese, 2009:491), which is similar to predictive processing (as discussed in the section on ad hoc concepts).

In the study of embodied cognition, abstract concepts can be seen as problematic as certain concepts seem to bear no resemblance to representations in the sensorimotor system. Examples of these concepts include *beauty* and *happiness*. These concepts cannot be accounted for in terms of bodily experience (Dove, 2014:372). There are a number of views that aim to bridge the gap between embodied cognition and abstract concepts.

An example of one of these perspectives is metaphoric extension, where abstract concepts are mapped onto more concrete ones. In Lakoff and Johnson's (1980:3) view, metaphors are conceptual and are paramount to constructing our social and political reality. Additionally, all concepts that do not emerge directly out of physical experience are thought to be metaphoric in nature. In this view, some concepts are understood by metaphorical references to different domains, rather than by their own representations. An example provided describes emotions, a domain we do not understand, which are mapped to temperatures, one that we do understand. We can describe someone as being *cold* (they are difficult to connect to on an emotional level), or say that we are *warming up* to a person (we are beginning to like them) (Murphy, 1996:176-177).

Theories of embodied cognition consist of strong and weak counterparts. Weak embodiment theories propose that conceptual processing is partially dependent on the sensory-motor system; and that sensory-motor information does, to an extent, constitute semantic representations. During semantic processing, sensory-motor information is representational rather than truly meaningful, and as a result this information gets somewhat abstracted. Although processing is partially dependent on sensory-motor systems, this is not the case with primary cortical regions. Semantic processing activates areas which surround and are linked to primary sensory-motor areas. Furthermore, this action is thought to be able to influence processing in these areas (Meteyard et al., 2012:792-793).

An example of a view that follows the weak embodiment paradigm is that of the *Featural and Unitary Semantic Space* hypothesis (or FUSS; Vigliocco, Vinson, Lewis and Garrett, 2004:248). This view suggests that the human semantic system encompasses two levels of representation: that of conceptual structures and that of lexico-semantic representations. Here, "conceptual structure" refers to a level of autonomous cognitive representation. Conceptual structure forms an arrangement of output which is modelled from gathered information derived from cognitive and sensory modules. The lexico-semantic representations are then derived from this conceptual structure according to features (such as visual and motor features), and are organised according to the properties of these features. An example provided by the authors is the lexico-semantic representation for the Japanese *ashi* (meaning "leg" or "foot"). *Ashi* would consist of a combination of features for both "foot" and "leg". However, in English, there would be distinct lexico-semantic representations for features belonging to "foot" and "leg".

While theories of weak embodiment suggest that perception is *partially* dependent on sensory-motor systems, theories of strong embodiment propose that perception is actually *dependent* on sensory-motor systems; where, during semantic processing, sensory-motor information is activated in primary cortical areas (Meteyard et al., 2012:793).

There are several approaches that follow a combination of both weak and strong views of embodiment. The most notable of these are Pulvermüller (1999:259-263) and Barsalou (1999: 582-605). Pulvermüller (1999: 259-263) suggests that word meaning is neurally motivated (i.e. word meaning is driven by the nervous system), where representation is achieved through the collective action of neural connections in different cortical areas. This action is mediated by the sensory-motor systems in that this collective action results in the co-activation of networks

of regions of the brain. This activation is spatio-temporal, in that these networks of regions affect each other and trigger simultaneous activation. Comprehension of word meaning is achieved through associating areas dealing with word form with those that describe the perceptions and actions that the word is related to. Neurons that are co-activated frequently will alter an assembly[6] that represents a word, and will morph into "higher-order" assemblies. In an assembly, stimulus specificity (a particular response triggered by a particular stimulus) is only displayed if all of the areas are fully developed and connected. Hence if there is damage in a part of the assembly, a representation will be flawed. Thus, this view suggests that representation is dependent on sensory-motor information, and is therefore strongly embodied.

A further theory which straddles the border between weak and strong embodiment is the *Perceptual Symbol Systems* (PcSS) account (Barsalou, 1999:582-605), which proposes a view of how simulation[7] might drive cognition. This proposes that perceptual symbols (PcS) are derived from sensory-motor neural systems which are activated during perception. When we perceive, bottom-up patterns of activation are captured in the sensory-motor areas, and these are later partially reactivated in a top-down manner in order for perceptual symbols to be utilised. Groupings of memories with common characteristics form simulators, such as a simulator for *cold* or for *hot*. In the case of lexical items, simulations represent words according to context. The incorporation of both abstract and simulated information in this account demonstrates both weak and strong embodiment.

As discussed above, theories of strong embodiment propose a dependency of perception on sensory-motor systems (Meteyard et al., 2012:793). Furthermore, strong embodiment views propose that action and sensorimotor processing actually constitute cognition (Glenberg and Gallese, 2012:906). Wilson and Knoblich (2005:468-469) present a view which proposes that perception is simulated through the motor system, where motor resources are activated even in the absence of motor movement. This motor activation feeds back into perceptual processing, which results in top-down expectations and predictions of actions. This is what makes coordinated interindividual tasks possible. When we cooperate with another person to perform a task, our motor resources are activated through watching them perform their component of

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[6]Pulvermüller (1999:259-263) defines an assembly as "a functional unit exhibiting activity states such as full activation after appropriate sensory stimulation (possibly related to perception) and continuous reverberation of excitation within the assembly (a putative memory process)".

[7] Simulation here refers to the mental enactment or imitation of something in the physical world.

the task, even when we are stationary. This makes it possible for us to predict what actions we have to perform next, according to the actions performed by the other individual. For example, when we play a game of tennis, we can anticipate the actions of our opponent even though we are stationary and waiting to return a serve.

Gallese and Lakoff (2005:12-15) proposed a hypothesis which suggests that sensory-motor system structure is capable of characterising both sensory-motor and more abstract concepts. This view rests on how when we imagine seeing and doing, the same part of the brain is activated as when we actually see and do. The example sentence of "Harry picked up the glass" is used to demonstrate that one cannot understand the sentence unless they can imagine a person picking up a glass. If one has never experienced someone picking up a glass before, the sentence is unimaginable because it describes an action that does not yet exist in the mind of the parser. Thus, understanding is imagination, and like perceiving and doing, imagination is embodied.

A further view that incorporates strong embodiment is the *Immersed Experiencer Framework* (or IEF; Zwaan, 2004:37-38). This framework describes the role of embodied processes in language comprehension, and suggests that language comprehension entails three processes; namely activation (which operates at word level), construalisation (which operates at clause level) and integration (which operates at discourse level). The basic notion of this view is that words activate experiences with their referents, and that reading or hearing a word activates experiential representations of words, as well as experiential representations of their referents. An example given is *The ranger saw the eagle in the nest* vs. *The ranger saw the eagle in the sky*. Although neither of these sentences consist of information describing the shape of the eagle, when we envision these sentences, an eagle is either sitting in a nest with its wings closed (as prompted by the first sentence), or flying in the sky with its wings spread (as prompted by the second sentence). Thus, we have incorporated the experiential aspects of the words (the word "eagle", and our knowledge of the appearance of eagles), as well as the experiential representations of the referent (such as the image of an eagle sitting vs. flying). Thus, as shown in the example, words are activated by their referents, which suggests that concepts are strongly embodied.

Glenberg and Robertson (2000:383-384) suggests that there exists a link between language and the preparation of action within an environment. The *Indexical Hypothesis* proposed here describes how perception and action codes form the basis for symbols of language. It is

suggested that words are assigned to real world objects, such as calling a cat a "cat". In a given situation, an individual will derive sets of potential actions (called affordances) from the meaning of the situation. These affordances are based firstly on the connection of objects and physical ability. For example, a chair does not afford sitting for elephants, but it does afford sitting for humans. Secondly, actions are based on an individual's experiences with the objects and their physical ability, so a person will know how to make use of a chair because they have sat on one before, or learnt how to sit on one by watching other humans do so. Finally, actions are mediated by an individual's goals for action, such as whether someone wants to sit on a chair or climb onto a chair to reach something. The above describes comprehension through a simulation of a situation, which displays the link between action and language in an environment.

3.4   Reading and Writing

This section aims to provide a brief overview of knowledge on reading and writing and their role in cognition. The section will begin with a discussion of the relationship between reading and writing and then move onto reading and writing in the brain. The section will then look at mirror writing, and finally mirror writing as a mechanism.

3.4.1   The Relationship between Reading and Writing

This project focuses specifically on the effect that experience with (mirror) reading and writing has on the mental timeline. In this subsection, the relationship between reading and writing will be discussed.

Human communication can take various forms, and can be verbal or non-verbal. Verbal forms of communication entail the use of spoken words to convey meaning, while non-verbal communication includes reading, writing, and the use of body language (such as gesture and facial expression) (Hogg and Vaughan, 2011:568).

Oral language preceded written language in human language evolution. This is reflected by language acquisition patterns in children. Receptive forms of language (such as listening), are thought to be more "basic" than reading and writing, playing a more formative role in overall language learning (MacArthur, Graham and Fitzgerald, 2008:172). Most children begin to speak at around 12 months of age (Coon and Mitterer, 2011:94), while written language hardly ever occurs before 36 months (if at all), and the early stages of reading usually begin between 60 and 84 months (Wood, 1981; cited in MacArthur et al., 2008:172). While the acquisition

onset of oral language is (commonly) prior to that of written language in first language acquisition; speaking, listening, reading, and writing do not develop in distinct stages, but rather in "overlapping and parallel waves" (Berninger, 2000:66). Thus, while reading and writing develop at later points in language acquisition, these can still influence and be influenced by oral language (MacArthur et al., 2008:174).

Reading and writing share commonalities in knowledge base; namely domain or content knowledge, metaknowledge about written language, knowledge about universal text attributes, and procedural knowledge (MacArthur et al., 2008:174; Fitzgerald and Shanahan, 2010:40). Domain and content knowledge includes all knowledge that readers and writers possess, and which helps them to produce or consume information. Metaknowledge refers to knowledge surrounding purpose and functions of reading and writing. This includes: metacomprehension (the monitoring of an individual's own meaning-making), and the monitoring of one's own knowledge, which further includes motivational factors (such as one's expectation of success or failure). Knowledge about universal text attributes entails three subcategories, graphophones (the identification and production of letters and words), syntax (the structure of a language or a text), and format (syntax in larger text types). Finally, procedural knowledge includes the ability to use, access and generate knowledge, as well as the ability to use these (at least partly) seamlessly (Fitzgerald and Shanahan, 2010:40). While the commonalities between reading and writing have been studied at length, little evidence exists of the difference between these two skills.

3.4.2   Reading and Writing in the Brain

Reading and writing are fairly recent developments in human evolution. However, until recently, the skills of reading and writing have not been widespread, and it would therefore be illogical to assume that certain regions of the brain developed for these purposes. Rather, it is thought that brain tissue that evolved for other uses has been reorganised to facilitate reading and writing (Perfetti and Tan, 2013:56).

During reading exercises, a number of left-hemisphere regions of the brain are activated (Bolger, Perfetti and Schneider, 2005:96-100), some of which are also responsible for spoken language processing. It is likely that most of these areas evolved specifically in the brains of humans for the sake of spoken language processing. One of these areas, however, appears solely when a person processes written words rather than spoken ones (Dehaene, 2002:322-324). This region, although not entirely dedicated to reading, has been termed the *visual word*

form area (VWFA), and is positioned in the left occipitotemporal sulcus (Deheane and Cohen, 2007:386). The VWFA region responds to word-like forms in both alphabetic writing (which represent the phonological structure of a language) and non-alphabetic writing (such as syllabaries or logographies, where symbols represent syllables or words and morphemes, respectively), which suggests that this region is universal to language and writing systems. However, the region further supports writing system variations by connecting (visual) word recognition processes with areas in the temporal and frontal regions that are responsible for language, and additionally recruits areas that assist with the processing of a specific writing system (Bolger et al., 2005:96-100). For example, in alphabetic writing systems, the VWFA links areas that convert alphabetic writing to phonology; while for non-alphabetic writing systems, it recruits areas that convert phonology to syllables (Tan, Laird, Li and Fox, 2005:87). Thus, the VWFA system supports both seemingly universal language characteristics (i.e. the VWFA reacts to numerous writing forms), as well as language-specific ones.

The topic of writing and the brain is quite scarcely researched. Previously, small bodies of research focused on the motor aspects of writing, and looked at whether speech and writing are located in the same, or in separate, cortical centres. More recently, there has been an increase in studies focusing on agraphia (a writing disorder caused by brain damage), and specifically on the relationship between writing, language and movement. The main premise of this is that neural injury should not cause a dissociation between written language skills and motor skills if language skills are intrinsically dependent on language or motor substrates. In studying the relationship between writing, language and action, neural substrates that support these can be seen as a continuum which spans from motor levels of processing to more abstract levels, such as morphological, syntactic and semantic levels (Rapp, Fischer-Baum and Miozzo, 2015:892). Recent findings of research focusing on these more abstract levels of processing show that the brain is capable of processing functions such as written language independently to the older functions from which they are thought to have originated. Further, written language can be processed independently to sensorimotor levels of processing, and extends to higher levels of language representation (Rapp et al., 2015:893).

While there appears to be limited evidence on the topics of reading and writing in the brain, there is a growing body of research that supports the notion that reading and writing are dependent upon certain foundational cognitive capabilities, such as visual, phonological and semantic abilities. Furthermore, improvement in these capabilities has been linked to developments in reading and writing abilities (MacArthur et al., 2008:174).

3.4.3   Reading and Writing as Embodied Skills

Writing is a skill that encompasses the coordination of cognition, perception and motor skills (Mangen and Balsvik, 2016:100). When writing, we make movements which produce marks on a page and which provide feedback to the brain about the physical properties of a letter, and thus the brain is provided with continuous motor, visual and kinaesthetic feedback (Mangen and Balsvik, 2016:70).

Handwriting practice facilitates visual recognition and the categorisation of letters. This has been shown through letter recognition tests (Longcamp, Zerbato-Poudou and Velay, 2005:74) and fMRI scans (James and Engelhardt, 2012:35-39; James, 2010:283-285). During the letter recognition tests children who learned the letters of the alphabet through writing letters out by hand, were shown to have better letter recognition after three weeks of training than another group of children who had learned the letters through typing them. Further, the fMRI scans showed that during letter perception, individuals make use of a "reading circuit" in the brain only after handwriting (and not after typing). Furthermore, studies focusing on training subjects to learn new letters through handwriting have shown that training results in more accurate spelling (Cunningham and Stanovich, 1990:161) as well as better letter recognition (Longcamp, Boucard, Gilhodes, Anton, Roth, Nazarian and Velay, 2008:806-808). It is unsurprising then that when individuals view letters that they are familiar with, this recognition activates both the motor and visual areas of the brain (James and Gauthier, 2006:2941-2942).

As reading is a skill that entails recognising, categorising and perceiving letters, these studies suggest that handwriting not only improves writing itself, but can also improve reading performance.

3.4.4   Mirror Writing

Mirror writing refers to reversed orthography which flows in the opposite direction to one's normal writing. In this orthography, every individual letter is reversed, so it is easier to read it by holding it up to a mirror. English mirror writing flows from right-to-left. In some other languages, such as Chinese, characters that are usually written from right-to-left are reversed. While the characters themselves are reversed, the rightward ordered vertical lines in which they are arranged are not (Chia and Kinsbourne, 1987:786-787).

While learning to write, children tend to go through a stage where they reverse certain letters, especially those that are "reversible", such as *b* and *d* (Hildreth, 1950; cited in Schott, 2007:5-

13; Brennan, 2013:20). This usually happens between the ages of 3 and 7, where mirror writing fades into disuse following this (Cornell, 1985:176-178). The shift to conventional writing styles is usually due to correcting caused by exposure to conventional writing (Davidson, 1935:458).

Mirror writing is performed both by ordinary people, and by people with certain neurological disorders or damage, such as a traumatic brain injury (Gottfried, Sancar and Chatterjee 2003:97). Furthermore, patients with right hemiparesis (which refers to weakness, or even paralysis, of one half of the body) have been found to develop mirror reading and writing habits. While these patients can discriminate between the left and right sides of their own bodies, they demonstrate right/left spatial disorientation which affects their writing (Heilman, Howell, Valenstein and Rothi, 1980:775). Peripheral injuries can result in a loss of usage of one hand and in the case of standardly right-handed individuals, writing with one's non-dominant hand can result in transient mirror writing (Schott, 1980:771).

While some individuals are aware that they are writing in a reversed form, others are not. According to Schott (2007:5-13), the mirror writing abilities of humans are likely to be underestimated, as many left-handed individuals suppress their handedness and mirror writing (Hughes, 1908:88). This is likely because in the past, left-handedness was seen as perverse and, at times, pathological (Schott, 2007:5-13).

Reports of mirror writing in concordant identical twins, as well as reports that span generations of people, suggest that the mirror writing trait is hereditary. It is also hypothesised that individuals who write in mirrored orthography have bilateral language centres (a language centre that is not specific to one hemisphere of the brain). It is further proposed that people who write in mirror writing possess a pathway via the corpus callosum which links their bilateral language centres (Mathewson, 2004; cited in Schott, 2007:5-13).

Mirror writing is presumably a form that is suppressed by standard writing for the sake of legibility. Several factors may contribute to this suppression (and are discussed in the following paragraphs), but there appears to be a few circumstances in which this is not the case. First, while children eventually learn to write conventionally (not in mirrored form), they initially do not seem to notice the difference between their mirrored and standard letters (Davidson, 1935:458). Furthermore, adults who have suffered strokes do not seem to notice their mirror writing either (Schott, 2007:5-13). Second, the appearance of standard orthography is supposedly enough to correct mirror writing. However, evidence from stroke patients suggests

that this may not always be the case, and perhaps the visual influence of standard orthography is not always enough to correct the mirrored form.

Additional factors which may contribute to the suppression of mirror writing include motor and visual interactions, cultural factors, and spatial and orientational factors. Very young left-handed children tend to scan items from right-to-left (Lebrun, 2009:279-285; cited in Schott, 2007:5-13), while the opposite can be seen in right-handed children. It is suggested that ocular motor control during the early stages of reading may be specialised in the right hemisphere of the brain (Skoyles, 1992:25), which would favour leftward-directed reading and writing. This conflicts with the (rightwards) direction in which Western language orthography flows, and suggests that when eye movements and hand movements are controlled by different hemispheres in the brain, individuals are likely to experience spatial disorientation which could result in mirror writing (Corballis, 1983, cited in Schott, 2007:5-13).

The impact of cultural factors on the suppression of mirror writing can be seen when comparing speakers of rightward-directed languages with those of leftward-directed languages. Speakers of leftward-directed languages (such as Chinese, Japanese and Hebrew) have a higher prevalence of left-handed mirror writing, in comparison to speakers of rightward-directed languages (Schott and Schott, 2004:1849-1850). The significance of this is derived from the notion that learning leftward writing entrains and is entrained by leftward eye and hand movements. As a result, mirror writing may occur when using the left hand (Schott, 2007:5-13).

The suppression of mirror writing by spatial and orientational factors can be observed by looking at the relationship between left and right hemispace and the left and right hemispheres of the brain. Directional and spatial confusion can result in mirror writing, presumably as a result of obstructed spatial and orientational influences. When one writes in their right hemispace (the area to the right side of their body), the left hemisphere of their brain is activated. Damage in the spatial system of the left hemisphere results in an inability of the system to translate right-hand functions into appropriate left-hand functions, which results in right hemispace mirror writing. On the other hand, the right hemisphere's spatial system is activated when writing in the left hemispace, which results in writing which is consistent with the left hand used in the left hemispace (Buxbaum, Coslett, Schall, McNally and Goldberg, 1993:1419-1420; Schott, 2007:5-13).

3.5   Theoretical Framework: Synthesis

The title of this thesis is "Reversing Time: The Effects of Mirror Reading and Writing Exercises on the Mental Timeline". As such, this study explores the mental timeline by examining the effects of mirror reading and writing on time perception. In this section, the relevance of these themes to the content of this Theoretical Overview will be discussed.

Figure 1: Diagram detailing how the themes of "The Mental Timeline" and "Mirror Reading and Writing" are related to the content of this Theoretical Overview.
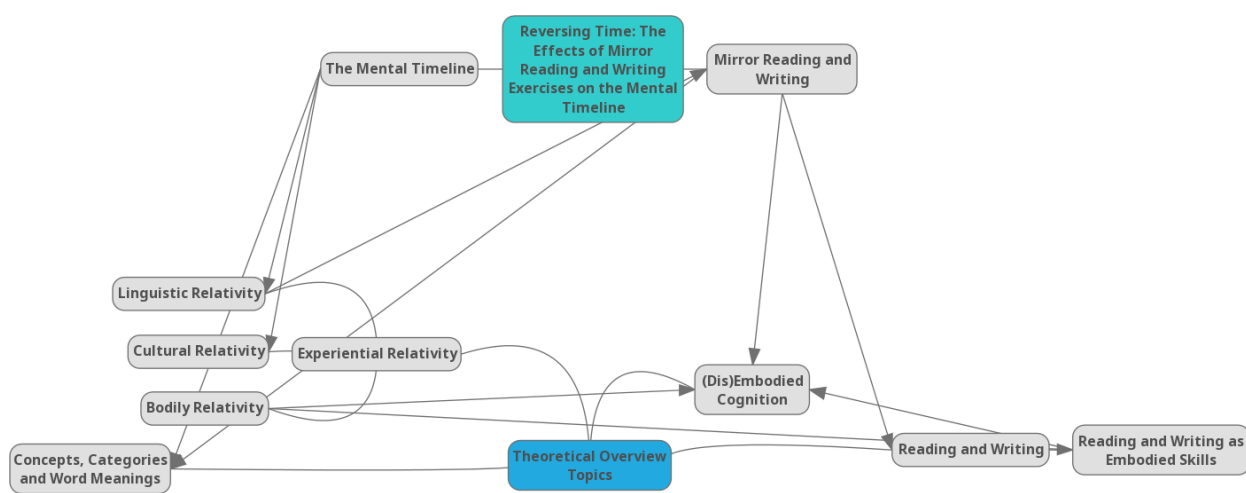
Figure 1 consists of a diagram detailing how the themes of "The Mental Timeline" and "Mirror Reading and Writing" are related to the content of this Theoretical Overview. The mental timeline is related to

the notion of experiential relativity (including linguistic, cultural and bodily relativity) in that it is governed by our experiences with our environment, whether they be linguistic, cultural, or bodily. This is relevant to the present study because participants will be exposed to different forms of experience in order for the effects of these to be assessed.

Bodily relativity suggests that bodily interaction with the world influences thought, and thus different bodily interactions will result in an altered perception of one's environment. This ties in with embodied cognition as these both place emphasis on the sensory-motor systems and their role in experience and cognition. Bodily relativity and embodied cognition also relate to the theme of "Mirror Reading and Writing", as well as the sections on reading and writing (as embodied skills), as these all discuss the effects of physical interaction with the world on perception. These are all relevant to the present study as participants will be exposed to reading and writing exercises, which entail bodily interaction with stimuli.

The section on concepts, categories and word meanings relates to the sections on experiential relativity, (dis)embodied cognition and reading and writing in this Theoretical Overview, as it covers the proposal that CC&Ms are ad hoc and built according to experience and context. The above are all relevant to the present study as the possible effects observed can be explained through the proposed flexibility of CC&Ms.

4   Method and Results

The main research questions formulated for the present thesis are repeated below:

1.   What effect does exposure to reversed orthography have on the mental timeline?

This research question can be divided into two further questions:

1.1. What effect does exposure to reversed orthography reading exercises have on the mental timeline?

1.2. What effect does exposure to reversed orthography writing exercises have on the mental timeline?

This chapter describes the research methodology used to address these questions, as well as the results obtained from the comparisons made in this study. Owing to the fact that this study has a multi-comparison design, this chapter is laid out in a similar manner to a multi-experiment paper. Although this may be a less typical formatting for a Master's Thesis, it is necessary to ensure that this chapter is comprehensive and coherent.

4.1   Overview of Comparisons

The overall aims of the comparisons in this study are as follows. Comparison I assesses findings from previous research, which indicate that exposure to reversed orthography reading can have an effect on the mental timeline (Casasanto and Bottini, 2014:474; Román et al., 2015:2-7). This comparison examines whether exposure to standard orthography following exposure to reversed orthography can reverse the priming effect of the reversed orthography, by contrasting Reading Conditions I and II. Reading Condition I is a control condition, and consists of a standard orthography reading exercise and standard orthography instructions for the temporal diagram task (discussed in section 1.1.1.2). This is compared with Reading Condition II, which consisted of a reading exercise with reversed orthography, and a set of standard orthography instructions.

Comparison II assesses whether the lack of effect observed in Comparison I extends across modes, and can apply to engagement in reversed orthography writing exercises. This contrasts Reading Condition II and Writing Condition I. Writing Condition I consists of a reversed orthography writing exercise and standard orthography instructions.

Comparison III replicates and expands on previous research on the topic of reversed orthography reading and the mental timeline, by contrasting Reading Conditions II and III.

Reading Condition III entails a reversed orthography reading task, as well as reversed orthography instructions.

Comparison IV assesses whether the effect of reversed orthography reading on the mental timeline (observed in Comparison III) can extend across modalities and to reversed orthography writing. In this comparison, Writing Condition I is contrasted with Writing Condition II. In Writing Condition II, the participants performed a reversed orthography exercise, with corresponding reversed orthography instructions.

The final comparison (Comparison V) examined whether the lack of effect observed in Comparison IV could be attributed to engagement with reversed orthography writing exercises. In this comparison, Writing Condition II is contrasted with Reading Condition IV. In Reading Condition IV, participants were only exposed to reversed orthography instructions with an accompanying temporal diagram task.

Due to the scope of this MA thesis, the same data batches are used across comparisons. The thesis in its current format contains 257 participants, and collecting new data for each comparison would result in a total of +-400 participants, which was deemed unrealistic for this thesis. Further, these substudies are referred to as "comparisons" rather than "experiments" as the same data batches are used across comparisons.

The comparisons and conditions are summarised in the following table:

Table 1: Table detailing the comparisons and conditions in this study.

Comparison	Conditions	Reading/Writing Exercise Orthography Direction	Instruction Orthography Direction
I	Reading Condition I	Standard	Standard
	Reading Condition II	Reversed	Standard
II	Reading Condition II	Reversed	Standard
	Writing Condition I	Reversed	Standard
III	Reading Condition II	Reversed	Standard
	Reading Condition III	Reversed	Reversed
IV	Writing Condition I	Reversed	Standard
	Writing Condition II	Reversed	Reversed
V	Writing Condition II	Reversed	Reversed

	Reading Condition IV	N/A	Reversed

4.2 Comparison I

Previous studies (such as Casasanto and Bottini, 2014:474 and Román et al., 2015:2-7) provide evidence that suggests that exposure to reversed orthography reading can have an effect on the mental timeline. However, these studies have not examined the possible reverse priming effect of exposure to standard orthography following exposure to reversed orthography. Comparison I examines this by contrasting the responses of participants who were exposed to all standard orthography stimuli (Reading Condition I) to those exposed to a reversed orthography stimulus text and standard orthography task instructions (Reading Condition II).

4.2.1 Method

4.2.1.1 Participants

A total of 77 English/Afrikaans bilinguals living in the Western Cape took part in Comparison I. Participants were between the ages of 18 and 35 years, and it was required that they had some form of university experience, whether they were currently completing a degree, or they had graduated already. This was partly due to ease of access, and partly to ensure the participants had the level of literacy required to take part in the comparisons (all of which relied on fluent reading and writing abilities, as well as a certain degree of abstract thinking).

Participants had been randomly allocated to Reading Conditions I and II, where Reading Condition I consisted of 36 participants, and Reading Condition II consisted of 41 participants.

In Reading Condition I, 19 participants were female while 17 were male. 20 of the participants considered their first language to be English, while 16 considered it to be their second language. Additional languages spoken by participants in this group included Portuguese, Spanish, German, French, and Mandarin; but the participants did not note these as being languages they were proficient in, or that they used frequently. The average participant age in this group was 23, with a range of 18-35 and a standard deviation of 3.9.

In Reading Condition II, 30 participants were female, while 11 were male. 17 participants considered their first language to be English, while 24 considered it to be their second language. Additional languages spoken by participants in this group included Mandarin, French, Spanish, Italian, German and isiXhosa, although the participants did not cite these as being frequently

used languages, or languages that they were especially proficient in. The mean age of this group was 23, with a range of 18 to 32 and a standard deviation of 3.8.

The participant profiles for Comparison I are summarised in the table below.

Table 2: Table summarising the participant profiles for Comparison I.

Condition	Total Participants	Female Participants	Male Participants	L1 English	L2 English	Average Age
Reading Condition I	36	19	17	20	16	23
Reading Condition II	41	30	11	17	24	23

4.2.1.2 Materials

Stimulus Text

The stimulus text comprised a short story by Kevin Hughes called "A Mortal Friend". The story was chosen due to its compatibility with the narrative used in Román et al. (2014:3), which consisted of 1195 words. "A Mortal Friend" consists of 1252 words. The story details an interaction between a human and a vampire.

In Reading Condition I, the story was presented in standard orthography, as this condition is a control condition. In Reading Condition II the story was presented in reversed orthography, in order to assess the effect of reading reversed orthography on the mental timeline.

Task Instructions and Temporal Diagram Task

On the page following "A Mortal Friend", a short paragraph detailing a person's visit to friends was attached. This paragraph differed slightly across four series, which were counterbalanced.

On the page following the task instructions, participants were presented with a temporal diagram task. A temporal diagram task usually consists of an image of a person or thing (such as the man in birds-eye-view in Figure 2 below), with boxes positioned around them/it (such as the boxes to the left and right of the man in Figure 3). Participants indicate their perception of time by creating marks or writing letters (as in this study, participants placed a "P" or an

"A" in the boxes according to their perception of where events occurred in time) in the boxes surrounding the person or thing.

For example, an English speaker standardly conceptualises events as flowing from left to right, where earlier events are placed to the left, and later events are placed to the right. If an English speaker is given the sentence "Tomorrow John is going to visit a friend who likes plants, and yesterday he visited a friend who likes animals" and asked to position the events around John (who is represented by the man in birds-eye-view in the diagram), they will standardly place "plants" to the right of John, and "animals" to the left of him.

The temporal diagram task used in this study was adapted from those used in Casasanto (2009:354) and de la Fuente et al. (2014:1684). The task used in the present study differs from that of previous studies in that it consists of a person in birds-eye-view with boxes on either side of them. The task used in Casasanto (2009:354) presents a birds-eye-view depiction of an individual with boxes to the front and on either side of them, while the task used in de la Fuente et al. (2014:1684) consists of a person with boxes in front of and behind them.

A temporal diagram task was chosen for this study as these tasks give us an indication of an individual's perception of time. If a participant's mental timeline is affected by reading mirrored writing, their response on the temporal diagram will be indicative of this. For example, the sentence "Tomorrow John is going to visit a friend who likes plants, and yesterday he visited a friend who likes animals." would yield a response of "plants" to the left, and "animals" to the right.

Figure 2: Temporal diagram task used in the present study (adapted from Casasanto, 2009:354 and de la Fuente et al., 2014:1684).

Control Questions

On the page following the task instructions and temporal diagram task, a set of control questions was attached to ensure that participants were fully processing the story they had to transcribe. These asked simple questions about the story, and read as follows:

1. What were the main character's names?

2. Which character was a vampire?

3. What colour were the bullets that did not work?

Incorrect responses to these questions resulted in 10 participants' responses being excluded from the study.

Language Questionnaire

Following the temporal diagram task, participants were required to fill out a language questionnaire. This questionnaire requested information about language use and proficiency. In the first question, participants were required to list the languages they spoke and rate their proficiency in each language according to a scale that ranged from 1 to 5, where 1 was "rudimentary" and 5 was "excellent". In the second question, participants were asked about the frequency of their language use in everyday, oral communication, and rated this on the same scale as detailed above. The third question asked which language the participant learnt first (their home language/native tongue). Finally, participants were required to indicate where (e.g. school, home) and when (e.g. age of 5, primary school) they learnt any additional languages they had listed.

Consent Form

Finally, the participants were required to sign a consent form. This form detailed that participants were taking part in the study voluntarily, that they were aware that they would not be compensated financially for their participation, that there were no perceived risks associated with the study but that they could still terminate their involvement in the study at any time, and that any required personal details collected would be kept anonymous and confidential.

4.2.1.3   Procedure

Sampling Technique

The following paragraph is relevant to all conditions discussed in this chapter.

The study was advertised at the end of some lectures and tutorials, and students were invited to provide their email addresses on a sheet if they were interested in taking part. If they provided their information, they were sent an email with more information about the study, requesting that they make an appointment with the researchers to take part at a time that was convenient

for them. Data collection took place in a quiet setting in the Multilingualism and Cognition Laboratory in the Department of General Linguistic, Faculty of Arts, Stellenbosch University. When this default venue was not available, one of the other rooms in the department (a seminar room or private office) was used. It was ensured that the room was always quiet and that there would be no interruptions or distractions for the participants.

Data Collection Procedure

In this comparison, the effect of reversed orthography on the mental timeline was assessed. In order to achieve this aim, one condition comprised a standard orthography story and task instructions, while another condition entailed a reversed orthography story and standard task instructions. These conditions were randomly allocated to participants during data collection periods.

Before beginning each data collection session, participants were asked to turn their cell phones off (not simply put them on silent mode). The participants were given an opportunity to ask any questions they had before the experiment began. Following this question period, the participants were asked to not converse.

Participants were told that they were required to read a story, read a set of instructions and perform a task.

Participants were then taken through what was required of them for the rest of the study. They were told that they would be reading a set of instructions and that they would have to follow the instructions in order to fill in the temporal diagram. In all conditions, the participants were told that they would be filling in a language questionnaire and signing a consent form.

Following the experiment, the participants were asked questions such as "how did you find the task?", "was the task difficult?" and "what did you find to be the most difficult part of mirror writing/reading?". These responses will be discussed in section 4.7 of this thesis.

Data Analysis

The main data analysis used the software package IBM SPSS Statistics 23. The specific test used was a binary logistic regression, also known as the Wald Chi Square test. This test is used to reveal whether a given variable ("explanatory variable") in a model exerts a statistically significant effect on a dependent variable. An explanatory variable is a variable that is not clearly independent, and which requires a test (such as the Wald Chi Square test) to ascertain

whether it is independent or not. "Significant' here refers to whether or not a variable contributes meaningfully to a model (i.e. above the margin of error). If a variable is found to not be significant, it means that removing the variable from the model will not influence the outcome of the model. For example, if "condition" was found to not be a significant variable, it could be removed from the model without influencing the outcomes of the comparison.

In this study, condition was the explanatory variable and the mapping of "yesterday" and "tomorrow" was the dependent variable. Mapping thus refers to whether the participants perceived the past as to the left (and thus responding with past-to-the-left responses on the temporal diagram task) or to the right (and thus responding with past-to-the-right responses on the temporal diagram task) following exposure to stimulus.

4.2.1.4 Ethical Considerations

This project received the status of "approved with stipulations" from the University of Stellenbosch Research Ethics Committee: Human Research (Humanities). The research proposal number was SU-HSD-004172. The required addition to the application was that it needed to obtain Institutional Permission from the Department of Institutional Research and Planning, as the research involved University students. This permission was granted, upon which final ethical clearance from the Research Ethics Committee was received.

At the beginning of each data collection session, it was explained to the participants that their participation in the study was purely voluntary and uncompensated, and that they could withdraw from the study at any stage. Further, they were informed that there were no perceived risks associated with the study and that any gathered personal details collected from the participants would be kept anonymous and confidential. The participants were required to sign a consent form, which is detailed in section 1.1.1.2 above.

4.2.2 Results and Discussion

8.3% of the participants exposed to a standard orthography stimulus text and standard instructions (Reading Condition I) provided responses associated with a reversed mental timeline, placing the future to the left in the temporal diagram. 4.9% of the participants exposed to a reversed orthography stimulus text with standard instructions (Reading Condition II) exhibited this behaviour (illustrated in Figure 3 below). A binary Wald $\chi2(1, N = 77) = .369$, p $= .544$, 95% confidence interval (CI) = [.089, 3.581] revealed that these differences were not

statistically significant, and thus the conditions did not have a meaningful effect on the mental timeline.

While previous studies have provided evidence for the notion that exposure to reversed orthography can have an effect on the mental timeline, these results suggest that, if there is a priming effect of reversed orthography on the mental timeline, exposure to standard orthography following this priming can cause the mental timeline to revert to its "standard" state.

Figure 3: Results from Comparison I. The percentage of future-to-the-right and future-to-the-left responses is shown separately for Reading Conditions I and II.
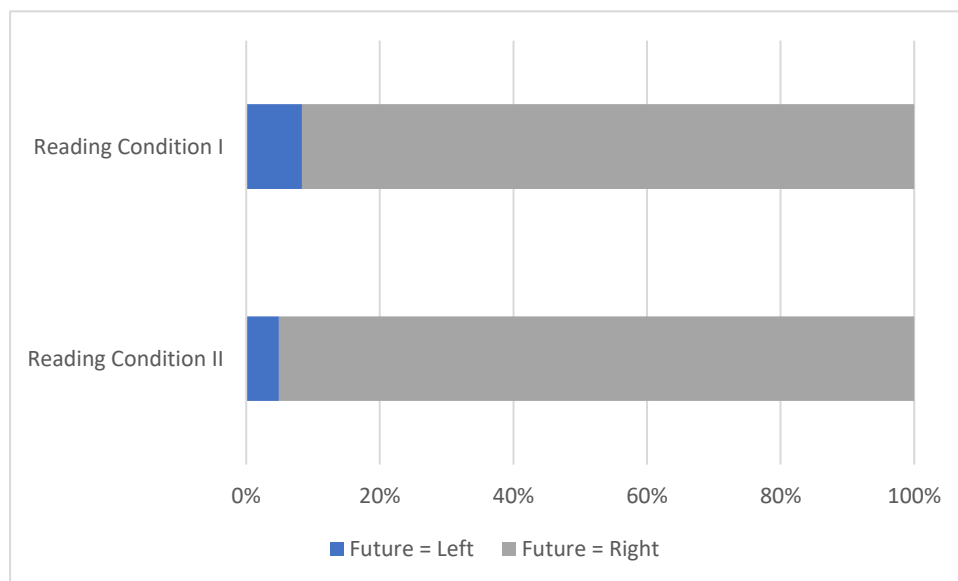
4.3   Comparison II

As Comparison I established that exposure to standard orthography following exposure to reversed orthography can have a reverse priming effect on the mental timeline, Comparison II assesses whether mode of input (i.e. reading versus writing) plays a role in this reversal. In this comparison, participants were exposed to reversed orthography reading (Reading Condition II) or writing (Writing Condition I) exercises, which accompanied standard orthography instructions.

4.3.1   Method

1.1.1.1   Participants

A total of 80 participants were involved in this comparison. 39 of them belonged to Writing Condition I, with 24 female participants and 15 male participants. 19 participants considered English to be their first language, and 20 cited it as their second language. Additional languages spoken by participants in this group include Dutch, isiXhosa, Portuguese, French, German, Spanish, South African Sign Language, Arabic and Hindi. However, these were not languages that the participants used frequently, or that they were proficient in. The one participant who listed Arabic as an additional language had exposure to the language only through family relations, and cited their proficiency and frequency of use of the language as extremely low. Since Arabic flows from right to left, a higher proficiency in the language may influence the participant's response, however their mental timeline was found to not be reversed by engagement in a reversed orthography writing exercise. The mean age of this group was 20, with a range of 18-31 and a standard deviation of 2.5.

The remainder of the participants are those from Reading Condition II, described in Comparison I above. Table 3 below summarises the participant profiles for Comparison II.

Table 3: Table summarising the participant profiles for Comparison II.

Condition	Total Participants	Female Participants	Male Participants	L1 English	L2 English	Average Age
Reading Condition II	41	30	11	17	24	23
Writing Condition I	39	24	15	19	20	20

1.1.1.2   Materials

Stimulus Text

The stimulus text used in this comparison was the same as in Comparison I.

In Writing Condition I, participants were asked to transcribe a story that was read out loud to them. The participants performed the writing exercises on plain lined A4 paper.

Task Instructions

The task instructions and temporal diagram used in this comparison are identical to that described under Comparison I.

Language Questionnaire

The language questionnaire used in this comparison is identical to that used in Comparison I.

Consent Form

The consent form presented in this comparison is identical to that used in Comparison I.

1.1.1.3   Procedure

Data Collection Procedure

The Data Collection Procedure for Reading Condition II is detailed in Comparison I.

Participants in Writing Condition I were told that they were required to perform a mirror writing exercise. Mirror writing was explained to them and demonstrated. The participants were asked to practice writing a sentence in mirror writing before the task began, to ensure that they were performing the task correctly.

The participants were then taken through what was required of them for the rest of the study. They were told that they would then be reading a set of instructions and that they would have to follow the instructions in order to fill in the temporal diagram. The participants were told that they would also have to answer a set of questions following their diagram task, and that they would additionally fill in a language questionnaire and sign a consent form.

The participants were given an opportunity to ask any questions they had before the experiment began.

1.1.1.4   Ethical Considerations

The same Ethical Considerations discussed in Comparison I apply to Comparison II.

4.3.2   Results and Discussion

7.7% of the participants exposed to reversed orthography writing exercises with standard orthography instructions (Writing Condition I), and 4.9% of the participants exposed to reversed orthography reading exercises and standard orthography instructions (Reading Condition II) displayed results associated with a reversed mental timeline (see Figure 4). The results of a Wald $\chi2(1, N = 80) = .266$, $p = .606$, 95% confidence interval (CI) = [.507, 3.208] revealed that these results were not significant and thus, the conditions did not have a meaningful effect on the mental timeline. Mode of input was therefore not found to influence the effect of reversed orthography on the mental timeline.

Figure 4: Results from Comparison II. The percentage of future-to-the-right and future-to-the-left responses is shown separately for Reading Condition II and Writing Condition I.
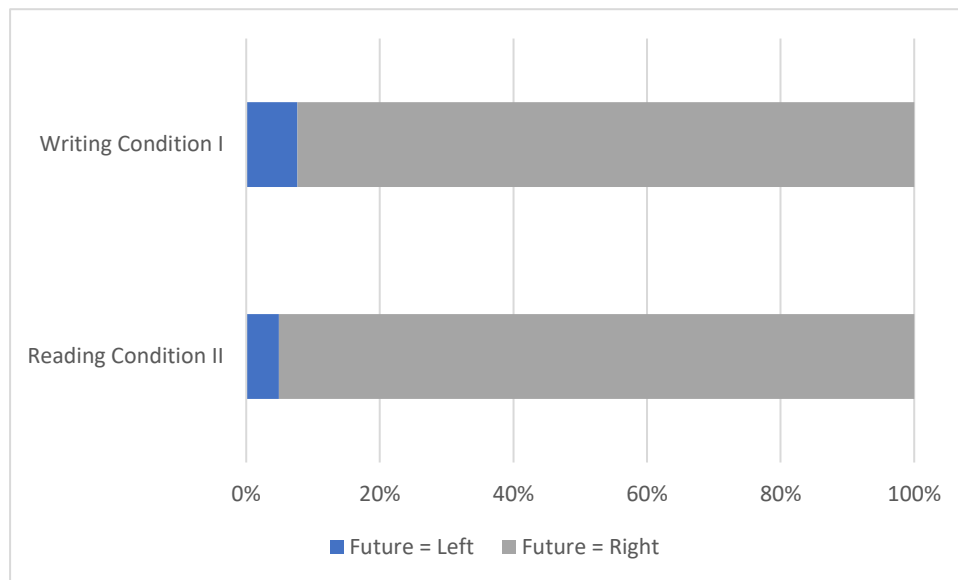
Reading Condition II and Writing Condition I both consisted of a reversed orthography task (whether it be reading or writing) and a set of standard instructions. Neither of these conditions revealed a significant effect on the mental timeline, which suggests that exposure to standard orthography following exposure to reversed orthography can reverse the priming effect on the mental timeline, regardless of mode of input.

4.4   Comparison III

In the previous Comparison, it was shown that exposure to standard orthography following reversed orthography reading and writing can reverse the priming effect on the mental timeline. Comparison III expands on and replicates the findings of Casasanto and Bottini (2014:474) and

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Román et al. (2015:2-7), which show that exposure to purely reversed orthography (rather than reversed orthography followed by standard orthography) can have an effect on the mental timeline. The comparison differs from previous studies in that it makes use of a temporal diagram task. In this comparison, participants who were exposed to a reversed orthography stimulus text and standard instructions (Reading Condition II) were compared with those who were exposed to all reversed orthography stimuli (Reading Condition III).

4.4.1   Method

1.1.1.5   Participants

Comparison III consisted of a total of 90 participants, with 49 belonging to Reading Condition III. In this condition, 22 participants were female and 27 were male. 24 participants considered English to be their first language, while 25 considered it to be their second language. Additional languages spoken by participants in this group include isiZulu, French, Sabela, Mandarin, Dutch, German, Japanese and isiXhosa; however, these were not languages that the participants were particularly proficient in, and they were not frequently used. The mean age of this group was 23, with a range of 18-33 and a standard deviation of 3.5.

The participant characteristics of Reading Condition II are detailed under Comparison I and II. Table 4 below summarises the participant profiles for Comparison III.

Table 4: Table summarising the participant profiles for Comparison III.

Condition	Total Participants	Female Participants	Male Participants	L1 English	L2 English	Average Age
Reading Condition II	41	30	11	17	24	23
Reading Condition III	49	22	27	24	25	23

1.1.1.6   Materials

The same stimulus text and temporal diagram as in the previous comparisons was used in Comparison III, with the exception that Reading Condition III consisted of a set of task

instructions that were presented in reversed orthography. Thus, one condition consisted of a reversed orthography stimulus text with standard instructions, while the other condition consisted of reversed orthography stimulus text and reversed orthography instructions.

1.1.1.7   Procedure

The procedure used for this comparison is identical to that of Comparison I.

1.1.1.8   Ethical Considerations

The ethical considerations for this comparison are identical to those detailed under Comparison I.

4.4.2   Results and Discussion

4.9% of participants exposed to reversed orthography stimulus text and standard orthography instructions (Reading Condition II), and 35% of participants exposed to reversed orthography stimulus text and reversed orthography instructions (Reading Condition III), provided responses associated with a reversed mental timeline (as seen in Figure 5). The results of a Wald $\chi2(1, N = 90) = 8.877$, $p = .003$, 95% confidence interval (CI) = [2.225, 48.223] revealed an effect of exposure to reversed orthography on the mental timeline.

Figure 5: Results from Comparison III. The percentage of future-to-the-right and future-to-the-left responses is shown separately for Reading Conditions II and III.
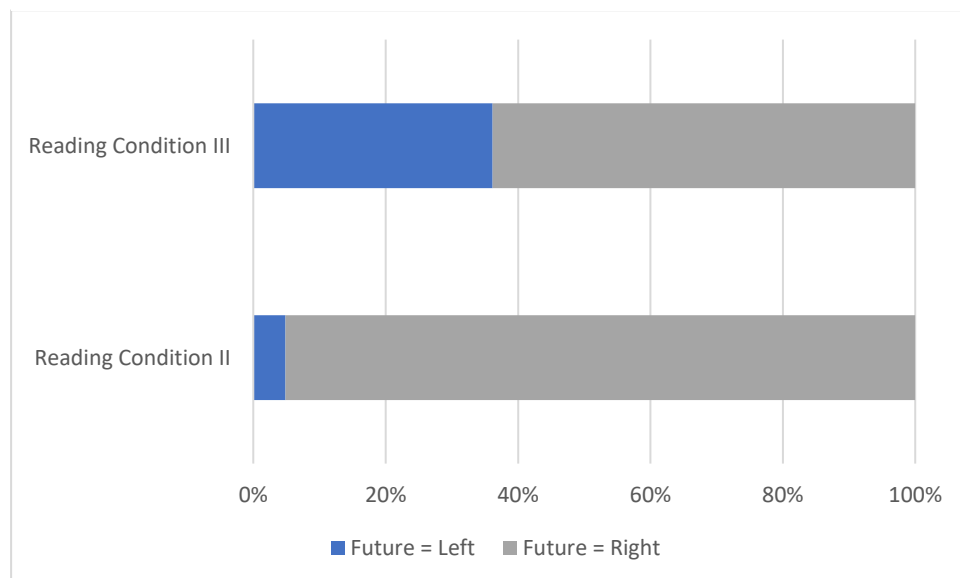
These findings further confirm that exposure to standard orthography (as in Reading Condition II) following exposure to reversed orthography can reverse the priming effect seen in reading reversed orthography. Further, this comparison expands on and replicates the findings of Casasanto and Bottini (2014:474) and Román et al. (2015:2-7), and contributes further evidence towards the notion that exposure to reversed orthography can have an effect on the mental timeline.

4.5   Comparison IV

The forth comparison in this study returns to the notion of mode of input (reading versus writing). In the previous comparison, it was found that exposure to reversed orthography reading can have an effect on the mental timeline. This comparison aims to address the question of whether reversed orthography writing exercises can also have an effect on the mental timeline (and thus whether this effect can be observed across modes). In this comparison, participants who were presented with a reversed orthography writing exercise and standard instructions (Writing Condition I) were compared with those exposed to a reversed orthography writing exercise and reversed orthography instructions (Writing Condition II).

4.5.1   Method

1.1.1.9   Participants

Comparison IV consisted of a total of 86 participants, with 47 belonging to Writing Condition II. Of the participants in Writing Condition II, 35 were female and 12 were male. 32 participants considered English to be their first language, while 15 considered it to be their second language. Additional languages spoken by participants in this group include French, isiZulu, isiXhosa, Portuguese, Arabic, Albanian, Shona, Dutch, German, South African Sign Language, Siswati, Sipedi, Spanish, Sesotho and Chinese. However, these were not languages that the participants were particularly proficient in, and they were not used frequently. The mean age of this group was 20, with a range of 18-32 and a standard deviation of 2.8.

The participant characteristics of Writing Condition I are detailed under Comparison II. Table 5 below summarises the participant profiles for Comparison IV.

Table 5: Table summarising the participant profiles for Comparison IV.

Condition	Total Participants	Female Participants	Male Participants	L1 English	L2 English	Average Age
Writing Condition I	39	24	15	19	20	20
Writing Condition II	47	35	12	32	15	20

1.1.1.10 Materials

The materials used for Writing Condition I are detailed under Comparison II. The materials for Writing Condition II are identical to those used in Writing Condition I, except Writing Condition II uses a set of reversed orthography task instructions.

1.1.1.11 Procedure

The procedure used in this comparison is identical to that described for Writing Condition I, under Comparison II.

Data Analysis

Following the Wald Chi Square Test, a Bayesian Contingency Tables test was run on this comparison using JASP 0.8.3.0. JASP is hypothesis-driven, and is used to predict differences between groups. In this particular comparison, it is hypothesised that participants who are engaged in reversed orthography writing exercises and also exposed to reversed orthography instructions will display responses that correspond with a reversed mental timeline.

In predicting differences between groups, JASP allows one to assess whether data used in an experiment is sensitive enough to display these differences. A Bayes factor (the result of the analysis) can be interpreted as follows: i. A result of 1 indicates that the data does not favour one hypothesis over another (i.e. the null hypothesis and the alternative hypothesis), ii. A result greater than 1 is indicative that evidence exists for rejecting the null hypothesis, iii. A result less than 1 indicates that there is evidence for accepting the null hypothesis (Dienes, 2014:4). Since it is expected that engagement in reversed orthography writing exercises will have an

effect on the mental timeline, the null hypothesis for this comparison is that reversed orthography writing exercises will not have an effect on the mental timeline.

### *1.1.1.12 Ethical Considerations*

The ethical considerations for this comparison are identical to what is detailed under Comparison I.

4.5.2   Results and Discussion

While 7.7% of participants exposed to reversed orthography writing exercises and standard orthography instructions (Writing Condition I), and 19% of participants exposed to reversed orthography writing exercises and reversed orthography instructions (Writing Condition II) showed responses associated with a reversed mental timeline (as shown in Figure 6), the results of a Wald $\chi2(1, N = 86) = 2.189$, $p = .139$, 95% confidence interval (CI) = [.712, 11.341] revealed that this effect was not significant, and thus writing in reversed orthography does not appear to have an effect on the mental timeline.

A subsequent Bayesian Contingency Tables Test indicated that the data contrasted in this comparison is sensitive enough ($BF_{10} = 0.061$) to be comparable. This result provides evidence in favour of the null hypothesis (that exposure to reversed orthography writing exercises will not have an effect on the mental timeline), which means that there truly is not an effect of reversed orthography writing exercises on the mental timeline.

Figure 6: Results from Comparison IV. The percentage of future-to-the-right and future-to-the-left responses is shown separately for Writing Conditions I and II.
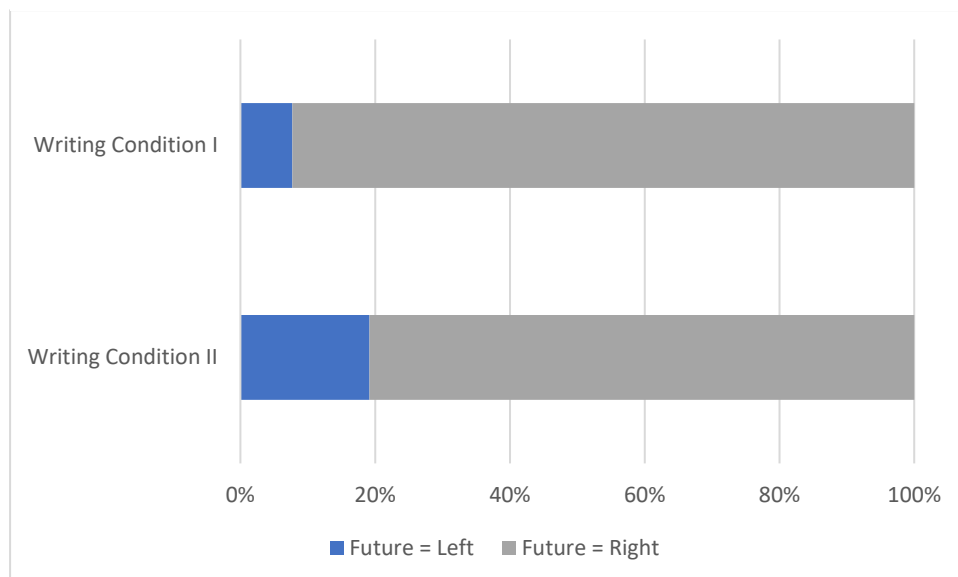
4.6   Comparison V

The final comparison of this study examined whether the lack of effect observed when comparing engagement in reversed orthography writing exercises with standard instructions (Writing Condition I) to reversed orthography writing exercises with reversed instructions (Writing Condition II) could be attributed to engagement in the reversed orthography writing exercise itself. In this final comparison, reversed orthography writing exercises with reversed instructions (Writing Condition II) was compared to a condition that entailed solely of a set of reversed instructions (Reading Condition IV). Thus, if an effect was found in the final comparison (which consisted solely of a set of reversed instructions), the reversed orthography writing exercises would be isolated as problematic, and it could be inferred that engagement in reversed orthography writing exercises may have a reverse priming effect on the mental timeline.

4.6.1   Method

1.1.1.13 Participants

This comparison consisted of a total of 92 participants. 45 of these belonged to Reading Condition IV. In Reading Condition IV, 33 of the participants were female, while 12 were male. 36 of the participants considered their first language to be English, while 9 considered it to be their second language. The average participant age in this group was 22, with a range of 20 to 28 and a standard deviation of 2.9.

The participant characteristics for Writing Condition II are detailed under Comparison IV. Table 6 below summarises the participant profiles for Comparison IV.

Table 6: Table summarising the participant profiles for Comparison IV.

Condition	Total Participants	Female Participants	Male Participants	L1 English	L2 English	Average Age
Writing Condition II	47	35	12	32	15	20

Reading Condition IV	45	33	12	36	9	22

1.1.1.14 Materials

The materials used for Writing Condition II are detailed under Comparison IV. The materials used for Reading Condition IV are identical to that of Reading Condition III, except that Reading Condition IV does not possess a story, and the only reading exposure participants receive is through the set of reversed orthography instructions.

1.1.1.15 Procedure

The procedure used for the conditions in this comparison is identical to that described under Comparison I.

1.1.1.16 Ethical Considerations

The ethical considerations for this comparison are identical to those detailed under Comparison I.

4.6.2   Results and Discussion

40% of participants exposed to only reversed orthography instructions (Reading Condition IV) and 19% of participants exposed to reversed orthography writing exercises and reversed instructions (Writing Condition II) showed responses that correspond with a reversed mental timeline (as seen in Figure 7). The results of a Wald $\chi^2(1, N = 92) = 4.656$, $p = .031$, 95% confidence interval (CI) = [1.100, 7.206] suggest that performing a reversed orthography writing exercise may have a reverse priming effect on the mental timeline, which can cancel out the effect of subsequent exposure to reversed orthography reading exercises.

Figure 7: Results from Comparison V. The percentage of future-to-the-right and future-to-the-left responses is shown separately for Writing Condition II and Reading Condition IV.
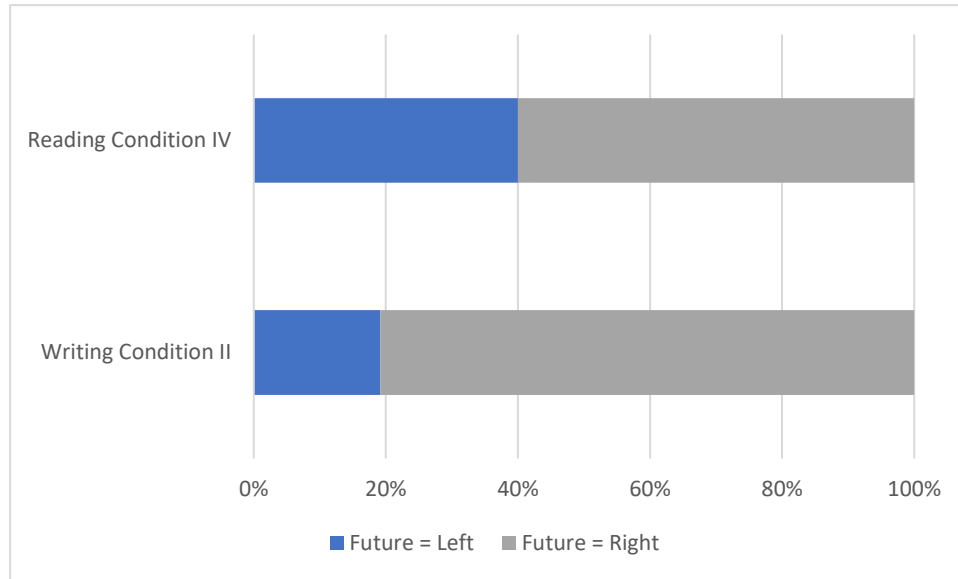
4.7   Participant Feedback

Following each data collection session, participants were debriefed and asked to comment on the experiments and the difficulties they experienced when taking them.

Since writing is an under-researched modality, it was necessary to collect data on the experiences of participants. While these responses were rather generic, this feedback may be helpful when conducting further research on this topic. The participant feedback was as follows:

i.   Many participants struggled with letters that are reflections of each other, such as *d* and *b*. Additionally, participants experienced difficulties with vowels such as *a*, *e* and *u*. *o* and *i* were not found to be problematic, which is not surprising as these letters are the same when reversed as they are in their original form.

ii. Participants found that capital letters were easier to write than small letters. One of the participants stated that she would preferred the whole exercise to be in capital letters as it would have "flowed" better.

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5   Discussion and Conclusion

The objective of this chapter is to discuss and interpret the results obtained in this study, as well as to provide a conclusion. In particular, this chapter will begin with a discussion of the research questions, and how the findings of this study answer the main research question and the two subquestions formulated for the study. This chapter will then discuss findings pertaining to reversed orthography reading and the mental timeline, before discussing findings on to reversed orthography writing and the mental timeline. Next, the chapter will look at the significance and implications of the study, as well as recommendations for future research. The chapter will end with a conclusion to this thesis.

5.1   Discussion of the Research Findings

5.1.1   Research Questions

This section discusses the research questions set out in the introductory chapter of this thesis, and how the observations and findings laid out in the previous section pertain to these questions. The overall aim of this study was to assess the effects of experience and embodied cognition on the mental timeline. This aim was achieved by exposing participants to different reading and writing conditions, in which combinations of reversed and standard orthography exercises were used.

The section will begin by discussing the two subquestions focused on in this study, and will then comment on the main research question of this study. The questions are restated below for easy reference.

5.1.1.1   *Subquestion 1: What effect does exposure to reversed orthography reading exercises have on the mental timeline?*

The data indicates that exposure to reversed orthography reading exercises has an effect on the mental timeline. This effect is, however, cancelled out by exposure to standard orthography following this exposure to reversed orthography.

5.1.1.2   Subquestion 2: What effect does exposure to reversed orthography writing exercises
have on the mental timeline?

According to the data gathered for this study, exposure to reversed orthography writing exercises does not appear to influence the mental timeline. Further, data from Comparison 5 isolates the act of performing mirror writing exercises as the cause of this lack of effect.

5.1.1.3   Main research question: What effect does exposure to reversed orthography have on
the mental timeline?

The data suggests that exposure to reversed orthography in reading form has an effect on the mental timeline, but exposure to reversed orthography through writing does not yield the same effect.

The overall, expanded findings of this study are as follows:

i.   Exposure to reversed orthography reading exercises can have an effect on the mental timeline

ii.   Brief exposure to standard orthography following reversed orthography reading and writing exercises may reverse the priming effect of exposure to reversed orthography

iii.   Engagement in reversed orthography writing exercises appears to not have an effect on the mental timeline

iv.   The lack of effect that exposure to reversed orthography writing exercises has on the mental timeline may reverse the priming effect of exposure to subsequent reversed orthography reading exercises

5.2   Reversed Orthography Reading and the Mental Timeline

The first comparison of this study contrasted Conditions I and II, and assessed whether exposure to reversed orthography can have an effect on the mental timeline. Condition I was a control condition and Condition II consisted of a reversed orthography text and standard instructions. No meaningful effect of exposure to reversed orthography was found in this comparison.

These results conform with an assumption made in previous research, which is that exposure to different forms of orthography (whether reversed or standard) can have an effect on the

mental timeline (Casasanto and Bottini, 2014:474; Román et al., 2015:2-7). However, this study is the first to actually assess whether exposure to standard orthography after exposure to reversed orthography can de-prime the effect of reversed orthography. This finding is in line with the notions of experiential relativity (and specifically, the Hierarchical Mental Metaphors Theory) in the theoretical framework of this study.

If very brief exposure to reversed orthography can have an effect on the mental timeline, it stands to reason that the same effect would apply for exposure to standard orthography following exposure to reversed orthography, especially if one chooses to accept the Hierarchical Mental Metaphors Theory (Casasanto and Bottini, 2014:474). In this view, numerous conceptual mappings would exist for all the orthography options available to an individual. As an individual gains exposure to their language, a particular mapping would be strengthened (in the case of English speakers, this mapping would be that "standard" orthography flows from left to right). Other mappings (such as "reversed" orthography flowing from the right to left for English speakers) would be weakened. Therefore, if one is exposed to both reversed and standard orthography (even if they are exposed to a large amount of reversed orthography, such as the stimulus text in this study, which consists of +-1000 words, and a small amount of standard orthography, such as the task instructions used in this study, which consist of +-120 words), the strong mapping of standard orthography would easily be able to override the effects of brief exposure to reversed orthography.

As stated in the previous paragraph, the results of Comparison 1 conform with previous empirical findings on the topic of reversed orthography and the mental timeline. The results strengthen these findings as there is now further evidence in the form of deliberate time-space mappings as opposed to different types of behaviour such as reaction time.

The results of this experiment led to the question of whether mode of input (i.e. reading versus writing) plays a role in the reversal of the mental timeline. Comparison 2 addressed this question by comparing Reading Condition II and Writing Condition I. Writing Condition I consisted of a mirror writing exercise and a set of standard orthography instructions.

The results of this second comparison showed that mode of input did not influence the effect of exposure to reversed orthography on the mental timeline. These findings are in line with the theoretical frames of experiential relativity and embodied cognition. The findings correspond to the frame of experiential relativity in that the participant groups in this comparison were exposed to the same set of instructions, just with different exercises (reversed orthography

reading versus reversed orthography writing). If exposure to small amounts of reversed orthography can have a priming effect on the mental timeline, it stands to reason that the same should be true for exposure to small amounts of standard orthography, especially since this is the "standard" orthography for participants, and this particular mapping should be stronger in their minds. The findings are also in line with the frame of embodied cognition in that bodily experience supposedly alters perception. Thus, if participants are exposed to standard orthography last (before performing the task), their final input will be in standard orthographic form and their minds should be primed towards this.

While mode of input was not found to have an effect in this comparison, these are the first known findings that assess the difference between reversed orthography mode of input (reading vs. writing) and their effect on the mental timeline.

With this first question answered, the second question (whether previously observed priming effects of exposure to reversed orthography is cancelled out by exposure to standard orthography) was addressed by Comparison 3. This consisted of a comparison of Reading Conditions II and III. Reading Condition III consisted of a reversed orthography reading exercise and a set of reversed orthography instructions. As expected, the comparison revealed an effect. This has two implications: i. that exposure to reversed orthography can have an effect on the mental timeline, and ii. that exposure to standard orthography following exposure to reversed orthography can possibly reverse the priming effect of the initial exposure to reversed orthography.

The first of these findings replicates the observations of previous studies, in that it shows that exposure to reversed orthography can have an effect on the mental timeline. Specifically, these results strengthen the notion that reversed orthography reading can have an effect on the mental timeline.

5.3   Reversed Orthography Writing and the Mental Timeline

In Comparison 4, the effect of reversed orthography writing exercises on the mental timeline was assessed. This comparison contrasted Writing Conditions I and II. Writing Condition II consisted of a reversed orthography story as well as reversed orthography instructions, so that the reverse priming effect of standard orthography instructions (as in Writing Condition I) would not occur.

It was expected that the results of this comparison would show that exposure to reversed orthography writing exercises has an effect on the mental timeline. The first reason for this is that, in language acquisition, reading, writing, speaking and listening are said to develop in an overlapping manner (Berninger, 2000:66), and one would therefore expect reading and writing to yield similar effects. Second, writing encompasses a combination of reading and hand movement. When we write, we move our hands in the direction in which an orthography flows. If we are to write in reversed orthography, we combine the effect of reading reversed orthography with that of moving one's hand in the direction of the reversed orthography. Thus, the effects observed in previous studies on reversed orthography effects and the mental timeline (Casasanto and Bottini, 2014:474; Román et al., 2015:2-7), as well as those observed in studies on embodied cognition and perceptions of time (such as Hartmann and Mast, 2012: 1559 and Matlock et al., 2011: 269) should also be present in writing exercises. Third, writing practice has been found to improve reading as it facilitates visual recognition and the characterisation of letters (Longcamp, Zerbato-Poudou and Velay, 2005:74; James and Engelhardt, 2012:35-39; James, 2010:283-285). Since an effect of reversed orthography reading exercises on the mental timeline have been observed in both seminal research and in this study, an improvement in reading ability should result in a heightened effect. Fourth, reading is an embodied task in that our eyes scan across (or down) a page. In some cases, we even use our hands to turn pages or to scroll down or swipe across. Writing combines the above with hand movement in the direction in which the orthography flows. Further, when we write, our brain is sent continuous motor, visual and kinaesthetic feedback (Mangen and Balsvik, 2016:70). Thus, if the proposal of embodied cognition is to be true, engagement in reversed orthography writing exercises should have a heightened effect on the mental timeline. Finally, as English/Afrikaans speakers, when we read and write in standard orthography, our associations of "left is the past" and "right is the future" are strengthened. Since there is greater motor involvement in writing exercises, we would expect a stronger effect of reversed orthography writing on the mental timeline than we would reversed orthography reading, as we form more "left is the future" and "right is the past" associations than when we are just reading.

The results of Comparison 4 showed that the effect of exposure to reversed orthography writing exercises is not significant. These findings are surprising, and suggest that reversed orthography writing exercises perhaps cancel out the effect of exposure to reversed orthography reading exercises. In order to assess whether this is the case, a fifth comparison was conducted. In this experiment, Writing Condition II was compared with an additional

reading condition, Reading Condition IV. Reading Condition IV consisted only of a set of reversed orthography instructions and a temporal diagram task. This was so that it could be confirmed whether or not exposure to reversed orthography writing exercises really can reverse the effect of exposure to reversed orthography reading exercises.

The results of this comparison showed that exposure to reversed orthography writing does appear to reverse the effect of exposure to reversed orthography reading exercises. This is problematic, as one would expect writing exercises to heighten the effect of reversed orthography reading on the mental timeline.

5.4   The Significance and Implications of the Key Findings

While previous studies (Casasanto and Bottini, 2014:474; Román et al., 2015:2-7) have assessed the effects of reading reversed orthography on the mental timeline, this study is the first, in our knowledge, to examine the effects of reversed orthography writing exercises on the mental timeline. Comparisons 1 to 3 mirror the findings of previous studies (Casasanto and Bottini, 2014:474; Román et al., 2015:2-7). The mental timeline is flexible in that exposure to reversed orthography reading exercises can cause individuals to think about time differently (i.e. to view the future as to the left and the past as to the right). Further, the mental timeline is flexible to the point that a reversal of the timeline primed by exposure to reversed orthography text can be cancelled out by very brief exposure to standard orthography text. On the one hand, one could hypothesise that this is because individuals are exposed to standard orthography on a daily basis, and this strengthened mapping would therefore be easy to revert to. However, the effect found in Comparison 5 suggest that the mental timeline is so flexible that even very brief exposure to reversed orthography can cause a reversal.

The most surprising finding of this study is that exposure to reversed orthography writing exercises does not yield a significant effect on the mental timeline. Reading and writing are skills that are learnt simultaneously. Writing exercises have been found to be beneficial to reading skill, combining hand movement in the direction of writing progress (when writing standard English, we move our hands from left to right, while writing in reversed orthography entails moving one's hand from right to left), as well as scanning over what one is writing (effectively reading). One would therefore expect that exposure to reversed orthography writing exercises preceding reversed orthography reading exercises would have a heightened effect on the mental timeline. However, Comparisons 4 and 5 show that this is not the case. The results of Comparison 5 indicate that there is something problematic about reversed

orthography writing exercises, and that there appears to be something in the process of mirror writing that reverses the priming effect of reversed orthography reading.

Additionally, the mental timeline is so flexible that even very brief exposure to reversed orthography reading can have an effect (as seen in Reading Condition IV). Even if there is not an effect of mirror writing exercises on the mental timeline, exposure to reversed orthography reading following these exercises should still yield an effect.

5.5   Limitations of the Present Study and Recommendations for Further Research

5.5.1   Mirror Reading

This section will comprise a discussion of recommendations for future research on mirror reading.

One of the most obvious gaps in research on orthography and the mental timeline is the lack of variety in languages assessed. Casasanto and Bottini (2014:474) and Román et al. (2015:2-7) examined Dutch and Spanish speakers, while the present study focused on English/Afrikaans speakers. These are all languages with left to right flowing orthography. The first step that future research should take is to include languages that do not follow a left to right directionality (such as Arabic and Hebrew). Previous studies have shown that, like speakers of left to right flowing languages, speakers of right to left flowing languages have mental timelines that follow this same directionality (Tversky et al., 1991:515-557) as their orthography. It stands to reason that the mental timelines of these speakers would be reversed in a similar manner to that of left to right directed languages. However, this flexibility still needs to be assessed.

As previously mentioned, this study provides further evidence in support of the proposal that exposure to reversed orthography through reading can alter the mental timeline. Future research should focus on assessing under which conditions this effect is the strongest, and should therefore aim to immerse participants in their tasks as completely as possible.

When we learn to read, we typically sit and read along with someone else (sometimes using our fingers to track the words as we progress). This process involves a combination of visual, auditory and verbal skills. When we read along with someone else, we scan orthography with our eyes, we receive auditory input from the person reading the story to us, and we read along with the person. Future research on reversed orthography could take advantage of this and try to simulate reading learning conditions in order to try and heighten the priming effect of

exposure to mirrored text. In such experiments, participants could be required to read a text out loud, accompanied by a voice track reading the same text. This would also be beneficial for the sake of immersion, as if a participant is required to keep up with a voice reading a text, they are unlikely to get distracted like they may if they read in silence.

With modern technology in mind, orthography is typically presented multimodally. In advertising, orthography is combined with image and audio; in movies, orthography is often used to introduce locations or people, and further can be viewed in subtitles. Even the most boring of textbooks combines orthography and image on its cover. Future research should take advantage of this multimodality and the effects it may have on our conceptualisations of the world around us, as the majority of language we are exposed to comes in this form. Additionally, with the rise of technology, a lot of our reading input is digital. In education, materials are presented on slides in lectures, or are placed on online platforms where individuals can download them and read them on their devices. Recreationally, many of us get our news from online sources, and even read books on E-Readers such as Kindles. Future studies should therefore additionally assess whether there are differences in the effect of orthography in print form and digital format, especially in cases where interactivity comes into play.

The introduction of "Stories"[8] to social media platforms such as Snapchat, Instagram and Facebook bring forth a new element to reading: time pressure. Stories on these platforms are limited to 10 seconds, and can include a combination of image, video, audio and text. Text here can be presented in the form of short hashtags, as well as long sentences. Future research could assess the effect of reversed orthography when time pressure plays a role. Participants could be exposed to stories with reversed text and images with limited viewing periods to assess the effect that short, limited durations of exposure can have on the mental timeline. Another way that exposure duration can be assessed is through exposing participants to reversed orthography on an LED display. In these experiments, the flow of the text speed could vary so that investigators could assess whether combining reversed orthography and time pressure could result in a heightened effect on priming the mental timeline.

Orthography is a linguistic artefact that is also, in a sense, a cultural artefact. Pertinent to this study is the mental timeline, and the proposal that our mental timelines develop according to

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[8] "Stories" are short snippets (limited to 10 seconds) of media (images or videos) uploaded to social media platforms, which disappear after a short period of time (usually 24 hours).

both our orthography and our exposure to cultural artefacts. If this is true, then future research on the mental timeline should focus on a combination of linguistic and cultural artefacts in order to assess their combined effects. While these linguistic and cultural artefacts have been studied separately, to the best of the researcher's knowledge, no studies have focused on combining these artefacts. One way of combining these in an experiment would be to design a task where participants are required to arrange lists of events on calendars. These lists could be presented in reversed orthography, and the participant could arrange them on a calendar that has been horizontally flipped. The combined interaction with linguistic and cultural artefacts may display a heightened priming effect on the mental timeline.

5.5.2 Mirror Writing

The most surprising finding of this study is that mirror writing exercises do not appear to influence the mental timeline. As this topic required more consideration than that of mirror reading (which was found to have an effect), this section is divided into two parts for the sake of comprehensibility and coherence.

5.5.2.1 *Potential Adjustments to the Present Study*

Before entirely dismissing the notion that mirror writing exercises can have an effect on the mental timeline, a few aspects should be considered. Firstly, while the results of Comparison 4 (which compared Writing Conditions I and II) were not statistically significant, Writing Condition II still showed that 19% of participants had their timelines reversed (versus the 7.7% in Writing Condition I). This is not an extremely large difference, but perhaps altering the writing conditions slightly could yield a stronger effect.

The first alteration that could be made to the present study is how the participants perform the writing exercises. Participant feedback indicated that there is less difficulty in mirror writing capital letters than small letters. If participants were to write in capital letters throughout the exercise, they may focus less attention on individual letter creation (and crossing out letters that are written wrong) and more attention on actually getting the writing to flow.

Secondly, it is not ideal to have an investigator recite a story out loud for participants to write down. This is problematic for individual data collection as the investigator has to watch over the participant in order to see when they next need to recite a sentence, and since the participants are writing in mirrored orthography, it is sometimes difficult to see what they are writing, especially if it is also being read upside down and the investigator is trying to be

inconspicuous. Similarly, if the investigator happens to miss their cue, the participant's immersion in the task may be affected. This is also problematic for group data collection as individuals write at different speeds and may therefore find themselves either ahead of or behind the group in speed.

In order to remedy this, experiments could be designed in such a way that the participants can run them by themselves. For example, they could be presented with a tablet or iPad loaded with audio clips of short sentences that the participants have to write down. In order to prevent the possible distraction of jumping between modalities (such as pressing a button on a tablet and then picking up one's pen to write a sentence on a piece of paper), participants could write out their sentences on the tablet themselves in a sort-of "self-paced writing" exercise.

Group data collection was not ideal for these experiments either. During group data collection sessions, the investigator watched the fastest participant and read sections of the story according to where that participant was. At the beginning of the session, participants were told that if they had not completed a sentence before a new one was read aloud, they should move onto the next sentence. This is obviously not an ideal situation as the same problems as with individual data collection would arise with the fastest participant in the room, and the others could potentially be thrown off by the disruption of moving onto a new sentence before completing a previous one.

5.5.2.2 *Recommendations for Future Research on Mirror Writing*

Towards the end of this study, it was noted that left handed children often scan texts and images from right to left, which is in conflict with the rightwards directionality of English and most Western languages (Lebrun, 2009:279-285). Further, Hughes (1908:88) notes that lefthanders with a tendency to mirror write often suppress these habits due to societal pressure and exposure to "standard" language and artefacts. Participant feedback in this study showed that most participants struggled with performing reversed orthography writing tasks; however, some reported that the task was far easier than they expected it to be. The present study did not gather data on the handedness of participants, but future research should take this into account, as lefthanded individuals may be predisposed to mirror writing, and may therefore be more easily primed than righthanded individuals. Research on handedness may prove beneficial in terms of unearthing the cause of the lack of effect observed in Comparison IV of this study.

Further, research should assess the flexibility of the mental timeline in children. If left handed children are reported to often scan from right to left (Lebrun, 2009:279-285) and are then forced to scan from left to right due to standard directionality in their language, perhaps their mental timelines are more flexible than those of righthanded children (who usually scan from left to right). If the HMMT (Casasanto and Bottini, 2014:474) is correct in its predictions, it is likely that there is a window of heightened flexibility in the mental timelines of children while they are acquiring their language.

It has also been noted that speakers of left-directed languages (such as Chinese, Japanese and Hebrew) have a higher prevalence of natural mirror writing compared to speakers of rightward directed languages (Schott and Schott, 2004:1849-1850). At present, research on the effect of reversed orthography on the mental timeline has been limited to languages that flow in a rightward direction. Future research should aim to expand this scope, including languages that flow in a leftward direction. If speakers of these languages have a higher prevalence of natural mirror writing (in this case, mirror writing would flow from left to right, as the languages are standardly right to left in orthography), it stands to reason that they would find mirror writing exercises in experimental settings to be easier than speakers of rightward directed languages, and may also be more susceptible to priming that effects the mental timeline.

While the acquisition onset of oral language is prior to that of written language in first language acquisition, speaking, listening, reading, and writing do not develop in distinct stages, but rather in "overlapping and parallel waves" (Berninger, 2000:66). While there are many clear similarities in the modes of reading and writing (they develop at the same time, writing consists of a combination of reading *and* writing, writing exercises are beneficial for reading skill), there is very little research that focuses on the difference between these two modes. This poses a challenge for interpreting the results of the present study (that mirror writing exercises do not seem to have an effect on the mental timeline) as there is very little evidence which could explain this lack of effect.

Our language exposure is not limited to interaction with pen and paper. Thus, future studies should further investigate mirror reading and writing exercises combined with other modes, in settings that are perhaps more relevant to modern modes of communication. For example, in this study, the participants were required to listen to a story recited out loud, and write the story in reversed orthography. Future experiments could incorporate all of this into digital form, such as an experiment on a tablet or iPad. In this type of experiment, participants could be given

short audio tracks to listen to and write down in mirror writing (on the tablet). Following this, they could be provided with a set of instructions and a temporal diagram task.

In this study, the effect of orthography on the mental timeline was assessed only through examining orthography that flows horizontally. Casasanto and Bottini (2014:474) showed that reading exposure to rotated text could have an effect on the mental timeline. Further studies focusing on writing and the mental timeline should explore other options for directionality, such as writing text rotated 90' clockwise or writing vertically in columns (such as how languages like traditional Chinese, Japanese and Korean are written).

5.5.3   Recommendations for Temporal and Spatial Cognition Research

Since the mental timeline is developed according to not just orthography but other linguistic and cultural artefacts, further research could combine linguistic and cultural artefacts and assess the effects that these have on the mental timeline. An example entails combining the fields of semiotics and psycholinguistics in order to examine the effect that signs can have on our mental timelines. Many of the signs (particularly directional and interdict signs) we encounter are arbitrary, and we learn their meanings from other people in our culture. Since signs, to a large extent, dictate our movement (for example, traffic lights indicate to us whether we must stop or go), altering them could have an effect on an individual's perception of space, and even on their actions.

5.6   Conclusion

This study aimed to assess the effects of experience and embodied cognition, as instantiated in orthography, on the mental timeline. More specifically, the study focused on the effects of standard and reversed orthography on the mental timeline, which was assessed through both reading and writing exercises.

It was hypothesised, based on the outcomes of previous studies (such as Casasanto and Bottini, 2014:474 and Román et al. 2015:2-7 above), that exposure to reversed orthography reading exercises would have an effect on the mental timelines of participants in this study, causing them to conceptualise the future as to the left and the past as to the right. The results of this study confirmed this hypothesis to be true, as participants were found to have their mental timelines reversed after exposure to reversed orthography reading exercises.

The second hypothesis of this study was that reversed orthography writing exercises should have a heightened effect on the mental timeline compared to reading exercises. This hypothesis was formulated with the notion of embodied cognition in mind. Writing is an embodied skill, and if findings of previous studies on embodiment and its effects on cognition (e.g. Hartmann and Mast, 2012:1559; Boroditsky and Ramscar, 2002:185-189) are to be trusted, writing should therefore have yielded a larger effect on the mental timeline than reading. The results of this study found that exposure to reversed orthography writing exercises did not have an effect on the mental timeline, thus refuting this hypothesis.

This study achieved its aims and opened up the world of research into reversed orthography writing. The first comparison of this study filled a gap in reversed orthography research, by providing evidence that exposure to standard orthography reading following reversed orthography reading can have a reverse priming effect on the mental timeline. The third comparison of this study replicated previous findings (Casasanto and Bottini, 2014:474 and Román et al. 2015:2-7 above) and expanded on them through the use of methodology that has never been used in reversed orthography experiments before. The second and fourth comparisons of this study delved into reversed orthography writing research, providing the first research of its kind into mirror writing and its effects. While the results of Comparison 5 confirmed that mirror writing exercises are problematic for priming the reversal of the mental timeline, these results have implications for research not only on the mental timeline, experiential relativity and embodied cognition, but also on writing and its relations to other modes of language.

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7 Appendices

7.1 Appendix A: A Mortal Friend

The following is a short story by Kevin Hughes called "A Mortal Friend". This story was used in Reading Conditions I, II and III, as well as Writing Conditions I and II. The story was presented both in standard orthography (as below) and reversed orthography.

A MORTAL FRIEND

by Kevin Hughes

Bam! Bam! Bam!

Three shots before you could even say: "One!"

Vlad staggered under the impact. He went down to one knee. His face pale, ashen, like a dead man. Which he was.

He looked up, his fangs dripping some kind of clear fluid.

"Were…were…were (his voice fading to a whisper with each word) were those …silver…bullets?"

Quincy felt a pang of mercy for the fallen, and failing creature:

"Yes. Yes they were."

At that Vlad sprung to his feet, forcing Quincy to back up, startled. Vlad's cape flowed out, and his long arms extended towards Quincy…

when Vlad opened his hand, there they were: three perfectly formed, shiny, silver bullets.

"They didn't work."

Vlad loved the look on Quincy's face, as it changed from startled, to bewildered, to baffled, to …fear. A kaleidoscope of emotions. He loved how humans could say so much without a single word. It was one of the things Vlad loved best about them. He wasn't cruel, as vampires sometimes are, but he did make humans die slowly, because he loved the expressions, especially the ones of ecstasy when his fangs first fed on them. It was way better than any movie he had ever seen, and much more real. When humans die, there is no acting, it is the one

time in their lives (as short as they are) where there is no artifice, no phoniness, no fake smiles, or worthless platitudes. No. Not at all. A human dying is a beautiful moment full of truth.

"But…but…but…"

"I know, Quincy. I know. "

At this point Vlad took up the posture of a pedantic professor, and waved an imaginary pointer at an imaginary chalkboard. In a remarkable impression of a professor who has given that same lecture to many times- his voice capturing just the right tint of boredom, but hope that at least one of the students …this semester, might make it worthwhile to keep talking. He pointed:

"You can use silver bullets to kill a vampire. You do not have to hit him in a vital organ. Anywhere will do. When silver touches him it is like a poison. If you hold up a cross, he will cower long enough for you to drive a stake…preferably wood, or some other once living thing, like a thigh bone, will kill him too. But…well, you have to make sure it is right through the heart- or the wound will heal. You can't kill a vampire with garlic, but you can make him leave the room. "

Vlad laughed out loud:

"Quincy, those are all folk tales, old wife's tales, and none of them work. Well, okay, the garlic can make us leave a room, but garlic in the amount you put on to protect yourself will make other humans leave the room too. Not so?"

Quincy had recovered his wits, at least the few he had left that would work for him.

"Yes. I guess that is true. To be perfectly honest with you, I never thought the garlic would work. I did think the other two methods would though."

"See, Quincy. That is what I like about you. You are honest. Well, except for not knowing a damn thing about Vampires, that is. "

Quincy blushed. He knew what the Vampire was talking about. Before tonight, Quincy had never met a vampire. Not in real life. Or death. Quincy was known as the world's foremost expert on them though. He had written more than 20 books on the subject, even tracing the ancestral roots of vampires back, way back, way before a "Dracula" was made up, and the image stuck. Now, everything he wrote must look very silly to a real vampire. Especially one standing in front of you holding your three silver bullets. The only ones he has. Or anyway, had.

"It was a nice tight shot group. I mean all three bullet holes could be covered by a quarter. "

Vlad pulled aside his cape to show Quincy the three neat holes in his vest. The wounds, of course, had healed immediately.

"Okay, Quincy, we need to have a chat. Are you going to try anymore tricks? Holy Water, maybe? A crucifix with Jesus's body on it? Garlic?"

"No. No. I will take your word that those things are not going to help me."

"Help you? (again he laughed) You mean kill me, don't you?"

"Err…ummm…eh…yeah, well, to put it bluntly, yes."

"See? That is why I like you. You are basically honest when faced with the truth. Stop looking so scared. I am not going to kill you. Feed off of you. Or enslave you. That is movie stuff. We only need to eat about every fifty years or so. Granted, we do need all the blood in a human body. Some Vamps do eat two, but that is just greedy. The second one is much like a third piece of pie, or cake, for you guys…not anywhere near as tasty as the first piece, and later you regret even having eaten the second piece, and the third piece makes you hate yourself. It is like that. Kind of."

"Then what do you want with me? Do you want me to write a book about you or something?"

Vlad laughed so hard he floated into the air. It turns out, that vamps (as they call themselves) have to concentrate fairly hard to maintain contact with the earth. Kind of like the concentration on a drunk trying to walk the line, but much easier for the Vamp.

"Don't take this the wrong way, but nobody is going to beat Ann's book about the Interview with a Vampire. Or any of her other books. She made fantasy real. Your books are boring academic tomes in comparison. And that is a good thing…because your books are interesting to me. I love the historical part of them. Some of what you dug up, I did not know. All the wacky things you thought about how we feed, how often, and how to kill us, that is all crap, as you have just discovered. But …finding us in China, South America, and Africa, and Australia, tracing our migrations and evolution across eons, and continents, well, that is a remarkable piece of work. I applaud you. "And he did.

"Well, (emboldened by this compliment, that bordered on flattery) what DO you want with me? It hasn't been fifty years…er…has it?"

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Vlad laughed again. This time floating almost to the ceiling. It took a long time for him to float back down.

"Will you please stop thinking I am going to eat you? I am not. I just want to talk. I never talk to mortals. I just eat them. Actually, I drain them, these teeth (and he bared his fangs, which made Quincy tremble and fall back not out of fear, but something much more primal- survival. Vlad drew his fangs back in) are not really good for chewing. I will never be a vegetarian." Another laugh, and he was off floating again.

"Okay, so, in your last book, you said….."

I won't bore you with the rest, just rest assured that Quincy and Vlad had a long, sometimes heated discussion over Quincy's latest book. There was much laughter (mutual laughter) some bitter sweet moments, and even a few times where either Quincy, or Vlad forgot that they were not the same species. It was the beginning of a friendship that would last…well, fifty years.

7.2   Appendix B: Instructions

The following are the different sets of instructions presented to the participants. These were presented in either standard or reversed orthography, and were presented with a temporal diagram (Figure 2).

7.2.1   Series 1

Yesterday John visited a friend who likes plants, and tomorrow he is going to visit a friend who likes animals. Imagine that the boxes on the next page represent these events, and that the figure between the boxes is John. Write the letter P (for plant) in the box that you think represents what happened yesterday, and the letter A (for animal) in the box that you think represents what will happen tomorrow.

7.2.2   Series 2

Yesterday John visited a friend who likes animals, and tomorrow he is going to visit a friend who likes plants. Imagine that the boxes on the next pages represent these events, and that the figure between the boxes is John. Write the letter A (for animal) in the box that you think represents what happened yesterday, and the letter P (for plant) in the box that you think represents what will happen tomorrow.

7.2.3   Series 3

Tomorrow John is going to visit a friend who likes animals, and yesterday he visited a friend who likes plants. Imagine that the boxes on the next pages represent these events, and that the figure between the boxes is John. Write the letter A (for animal) in the box that you think represents what will happen tomorrow, and the letter P (for plant) in the box that you think represents what happened yesterday.

7.2.4   Series 4

Tomorrow John is going to visit a friend who likes plants, and yesterday he visited a friend who likes animals. Imagine that the boxes on the next pages represent these events, and that the figure between the boxes is John. Write the letter P (for plant) in the box that you think represents what will happen tomorrow, and the letter A (for animal) in the box that you think represents what happened yesterday.

7.3   Appendix C: Language Questionnaire

What follows is the language questionnaire used in this study.

Age: _____

Gender: _____

1. Please indicate which language(s) you speak and rate your proficiency in each one of them, using the following scale:

    1 < - - - - - - 2 - - - - - -3 - - - - - - 4 - - - - - - > 5

    Rudimentary   Excellent

Language: _____   Self-rated proficiency (1-5): _____

Language: _____   Self-rated proficiency (1-5): _____

Language: _____   Self-rated proficiency (1-5): _____

Language: _____   Self-rated proficiency (1-5): _____

2. Please indicate how often you use these languages in your everyday, oral communication, using the following scale:

    1 < - - - - - - 2 - - - - - -3 - - - - - - 4 - - - - - - > 5

    Seldom   Almost all the time

Language: _____   Frequency of use (1-5): _____
      Hours per week_____

Language: _____   Frequency of use (1-5): _____
      Hours per week_____

Language: _____   Frequency of use (1-5): _____
      Hours per week_____

Language: _____   Frequency of use (1-5): _____
      Hours per week_____

3. Which   language(s)   did   you   learn   first,   that   is,   as   a   baby?
    _____

4. If you speak any other languages than the one(s) you learnt first, please indicate which ones, where you learnt them (e.g., school, playground etc.) and at what age you learnt them.

Language: _____   Where it was learnt: _____   Age of learning: _____

Language: _____   Where it was learnt: _____   Age of learning: _____

Language: _____   Where it was learnt: _____   Age of learning: _____

Language: _____   Where it was learnt: _____   Age of learning: _____

I hereby give my consent to the data, in anonymised form, being used for research purposes.

Date and signature: _____

7.4   Appendix D: Consent Form

The following is the consent form used in this study. This form was approved by the University of Stellenbosch Research Ethics Committee: Human Research (Humanities).

STELLENBOSCH UNIVERSITY

CONSENT TO PARTICIPATE IN RESEARCH

Reversing Time: The Effects of Mirror Writing Exercises on the Mental Timeline.

You are asked to participate in a research study conducted by Jenna Crossley (BAHons General Linguistics) and Manne Bylund (PhD Bilingual Research), from the Department of General Linguistics at Stellenbosch University. The results of this study will contribute towards the Master's thesis of Jenna Crossley. You were selected as a possible participant in this study because you are between the ages of 18 and 40, and are a speaker of English and/or Afrikaans.

1. PURPOSE OF THE STUDY

This study aims to contribute to a growing body of knowledge about language in the mind.

2. PROCEDURES

If you volunteer to participate in this study, we would ask you to do the following things:

Firstly, we will ask you to complete a mirror writing exercise. This will entail you transcribing, or writing out, a story that will be read to you by Jenna Crossley. After this, you will be asked to complete a simple task which involves reading a set of instructions and providing a response in the form of a letter on a diagram. Finally, you will be asked to fill out a short language survey, which will ask you about how much you speak your different languages.

Your contribution will take between 30 and 40 minutes, and will be a once-off participation. The study will take place in room 503 (in the Department of General Linguistics) of the Faculty of Arts building, at a time that suits you.

3. POTENTIAL RISKS AND DISCOMFORTS

There are no perceived risks or discomforts associated with this study.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

This research will contribute to the growing body of knowledge about language in the mind.

5. PAYMENT FOR PARTICIPATION

No payment will be made for this study. Participation is completely voluntary.

6. CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of coding data into an excel spreadsheet, according to numerals. The only individuals who will have access to these codes is Jenna Crossley (the Principle Investigator of this study) and Manne Bylund (her supervisor).

Aside from the participants' age, gender and language background; this study does not require personal details. The only other details given are those required by the consent form at the end of this document. These consent forms will be stored in Manne Bylund's office, locked in a cupboard.

If this study yields results that are publishable, no personal details will be included.

7. PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you do not want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

8. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact:

- Jenna Crossley: Principal Investigator, 17402468@sun.ac.za, 078 458 4144
- Prof. Manne Bylund: Supervisor, mbylund@sun.ac.za, 021 808 2006,

9.   RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

The information above was described to me by Jenna Crossley in English and I am in command of this language or it was satisfactorily translated to me. I was given the opportunity to ask questions and these questions were answered to my satisfaction.

I hereby consent voluntarily to participate in this study and have been given a copy of this form.

_____

Name of Subject/Participant

_____

Name of Legal Representative (if applicable)

_____   _____

Signature of Subject/Participant or Legal Representative   Date

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to _____.
They were encouraged and given ample time to ask me any questions. This conversation was conducted in English and no translator was used.

_____   _____

Signature of Investigator   Date