The Relationship between Visuospatial Attention and the effect it has on Parsing Stimuli

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Table of contents

Contents

List of Figures

List of Tables

Abstract

It is widely known that visuospatial attention is critical for reading, especially for the phonological decoding of unfamiliar letter strings (Montani, et al., 2014). The current study aims to narrow the knowledge gap that currently exists between the disruption of visuospatial attention and parsing – more specifically; how the distribution of phonology affects the parsing of letters by exploring syllable number and vowel length effects. When conducting this experiment, 38 participants were assigned to one of four conditions to analyse 240 non-ambiguous and 20 ambiguous stimuli. Participants had to decipher whether the stimuli had two or three syllables. All stimuli were split into two equally counterbalanced groups and presented in either a static or a jiggling format – to replicate disrupted visuospatial attention. The results show that the jiggling effect displayed no significant difference in RTs or error rates with either of the ambiguous or non-ambiguous stimuli. Results for the syllable length effect showed that non-ambiguous two syllable stimuli had faster RTs and accuracy and that ambiguous stimuli recorded significantly faster three syllable RTs in comparison to two syllables – giving evidence against syllable length effects. We also found that participants do have a significant preference for long vowels over short vowels for two syllable stimuli and short vowels over long vowels for three syllable stimuli. Overall, the initial hypotheses about visuospatial attention are uninformative. Limitations such as the lack of effectiveness from the jiggling effect and negative effect of the button-pressing should be considered in future studies.

Declaration

"This thesis contains no material which has been accepted for the award of any other degree of diploma in any University, and, to the best of my knowledge, this thesis contains no material previously published except where due reference is made. I give permission for the digital version of this thesis to be made available on the web, via the University of Adelaide's digital thesis repository, the Library Search and through web search engines, unless permission has been granted by the School to restrict access for a period of time."

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Contribution statement

When writing this thesis, my supervisor and I collaborated to create a general research question, and the appropriate methodology. I completed the ethics application and conducted the literature search. I conducted the experiments and was responsible for the recruitment of participants and my supervisor created the Python code to run the experiments. I wrote the thesis and my supervisor reviewed a draft of each section.

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CHAPTER 1 – Introduction

Understanding the rules of literacy are crucial to the effective comprehension of language. One of the important processes surrounding the pronunciation of words is how we break words down into letters, also known as parsing – which is not to be confused with syntactic parsing (identifying the structure of language but not its meaning) (De Certeau, 1984). To effectively parse a word, we need to have the ability to distinguish and pronounce each of the different groups of letters associated with their phonemes. Phonemes are the smallest unit of sound that differentiates one word from another in a language. For example, the phonemes 'b' and 'p' create distinguished sounds between the words 'pad' and 'bad' (Oxford Dictionary, 2020). When transferring this notion over to reading, we use a similar concept called graphemes. Graphemes are defined as the smallest functional unit of a written word which correspond with phoneme sounds used for phonological decoding (Kohrt, 1986). Together, these elements are important contributors to modern literacy.

For more than a century, scientists have extensively studied the exact role that phonological coding plays during reading. Even when reading silently, we seem to experience the sensation of 'hearing' what we read in our head. This inner voice is a subjective manifestation of phonological coding, the recoding of orthographic (written) information into phonological (sound) information (Leinenger, 2014). Our ability to consciously reflect the nature of language (metalinguistic awareness) allows us to manipulate formal structures such as phonemes and their arrangements in words (Bialystok & Ryan, 1985). The functional processes behind our reading performance has been regarded by many scientists to be a combination of visual and spatial attention (Franceschini et al., 2012; McCandliss, Cohen, Dehaene, 2003). When an individual's visuospatial attention is poor, they often find it difficult to distinguish phonemes and will produce phonologically inappropriate nonword guesses deriving from visual confusions (Stein and Walsh, 1997). However, there is surprisingly very little research that has been conducted that directly manipulates visuospatial attention and examines the extent that it affects reading – rather, most of the research is correlational (Ruddock, 1991; Roach and Hogben, 2004; Casco and Prunetti, 1996) . The current study aims to narrow the knowledge gap that currently exists between the disruption of visuospatial attention and the effects it has on the parsing of letters. This will be applied to test the predictions of different models of reading.

1.1 The Main Models of the Reading Process

Multiple computational reading models have been shown to account for certain aspects of normal and impaired single-word reading. Currently, the two most popular models used to explain the reading process are the Connectionist Triangle Model (Plaut et al., 1996; Seidenberg and McClelland, 1989) which assumes reading is done in parallel and the Connectionist Dual Process Model (CDP++) which assumes that the graphemes are extracted serially (Perry, Zielger, & Zorzi, 2013). However, the Dual-Route Cascaded (DRC) Model is a lesser known model which will also be touched on as it has been mentioned in visuospatial research and shares similar qualities to the CDP++ (Coltheart et al., 2001).

1.1.1 The Connectionist Triangle Model

The Connectionist Triangle model (Seidenberg and McClelland, 1989) suggests that letters are fixed and that people always see and process the letters in parallel – resulting in phonology being generated in parallel (see Figure 1). Even with children, it suggests that linking orthography to phonology is done in parallel. This model theorises that children use an intact phonologysemantics system before they have the ability to go directly from orthography to meaning (sight word reading).

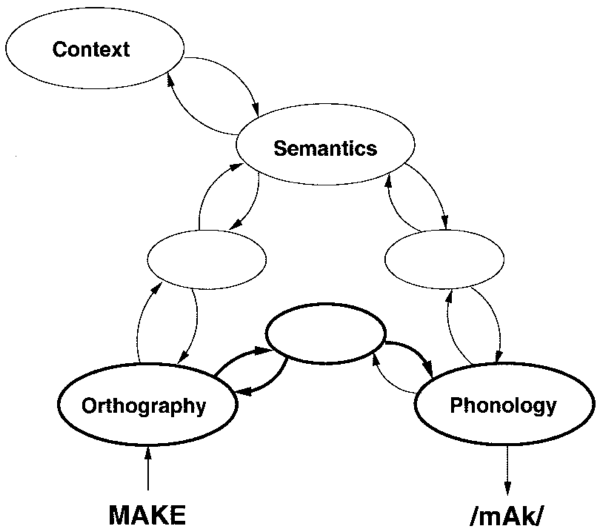

Figure 1. [The "triangle" model of Seidenberg and McClelland (1989). The implemented model examined how phonological codes are computed from orthography.]

1.1.2 The Connectionists Dual Process Model (CDP++)

Unlike the Triangle model, the Connectionist Dual Process (CDP++) model by Perry and colleagues (2013) suggests that letters are not always processed in parallel. In this respect, whilst it has one pathway that does recognize words in parallel (words that have been previously learnt by the individual), it also has a pathway that assumes graphemes are extracted serially from left to right from letter strings (see Figure 2). Quantitatively, this process has allowed it to make more accurate nonword predictions about reading performance than other models and has been used to account for skilled oral reading, learning to read and dyslexia. It can also predict ambiguity when parsing as there are letter strings that can be parsed more than one way. For example, if one did not know that the city Lobethal is pronounced with the syllables (Lo.be.thal) one may guess that it should have two syllables (Lobe.thal).

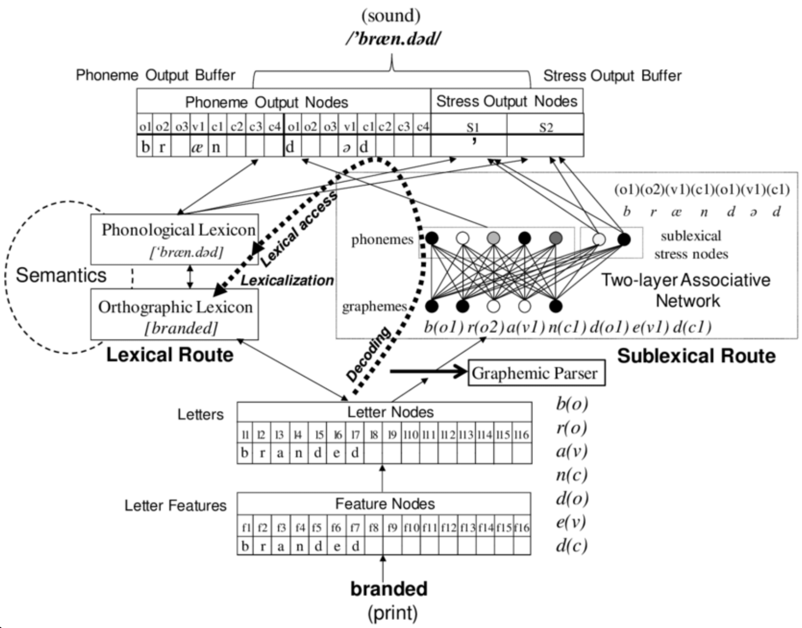

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Figure 2. [The most recent version of the Connectionist Dual-Process Model of Reading Aloud (CDP++). Note: f = feature, l = letter, S = Stress, o = onset, v = vowel, c = coda. Numbers correspond to the overall slot number within the Feature, Letter, and Stress nodes, or the particular slot within an onset, vowel, or coda grouping for other representations. The thick divisor in the Phoneme Output Buffer represents a syllable boundary. The thick dotted lines represent how self-teaching occurs (i.e., letters→ sublexical decoding→ output nodes→ phonological lexicon→ orthographic lexicon) (Perry, Zielger, & Zorzi, 2013).]

1.1.3 Dual-Route Cascaded (DRC) Model of reading

Apart from the CDP++, there is another model, the Dual-Route Cascaded (DRC) model of reading (Coltheart et al., 2001) that works in a similar way. The DRC model also has a parallel system for the retrieval of words that have been remembered by the individual and a second system for breaking words into graphemes (see Figure 3). When operating in isolation, the memory route can only produce the correct pronunciation of real words whereas the second system can produce the correct pronunciation of both nonwords and real words that obey the grapheme to phoneme conversion (GPC) rules. However, there are a few differences between the predictions of the Dual-Route Cascaded model and the Connectionists Dual Process mode. Notably, the Dual-Route model has never been extended to words of more than one syllable and nor does it make predictions as to what underlying factors are responsible for reading, which we will discuss next.

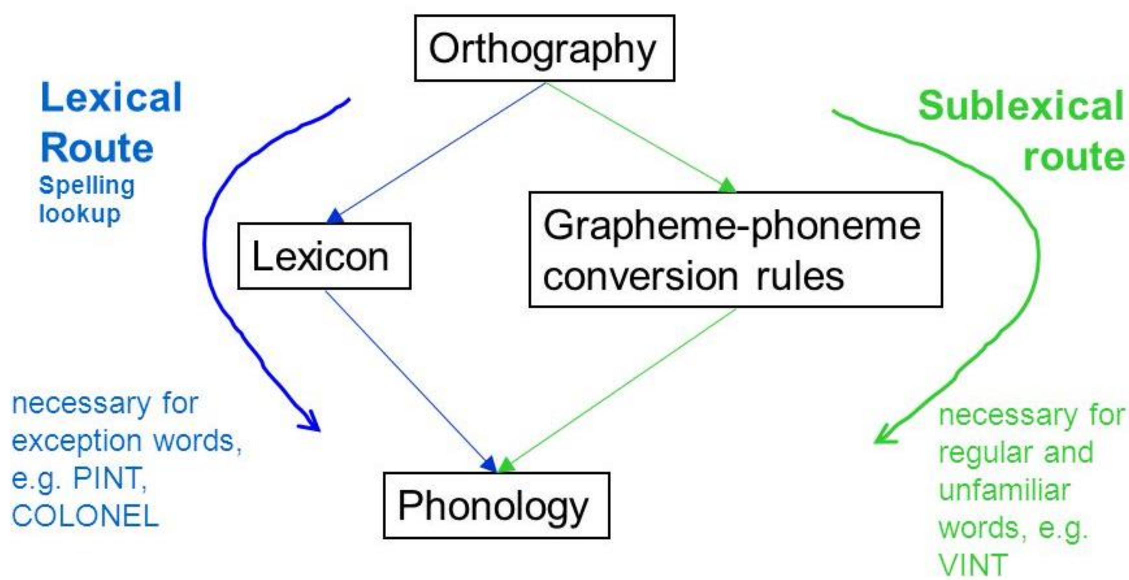

Figure 3. [Dual-Route Cascaded (DRC) Model of reading (Coltheart et al., 2001).]

1.2 The effects of Disordered Visual Attention

When an individual is learning to read, they need to learn a system for mapping between visual symbols and sounds (Ziegler & Goswami, 2005) to have the ability perceive printed words effectively (Turkeltaub, et al. 2003). These visual symbols become the detectors of letter shapes. From here, the letters are then organized into phonological units that are mapped onto sounds

(Perry et al., 2007, 2013). Studies of both developmental and acquired reading disorders provide growing evidence that visuospatial attention is critically involved in reading, especially for the phonological decoding of unfamiliar letter strings (Montani, et al., 2014; Slaghuis, Lovegrove, Davidson, 1993; Slaghuis, Twell & Kingston, 1996). To explore this further, information regarding visuospatial attention can be drawn from the effects of disordered visuospatial attention, primarily dyslexia.

1.2.1 Developmental Dyslexia

The development of our visual selective attention and reading abilities occur in parallel in our first few years of life (Casco, Tressoldi and Dellantonio, 1998). Stein and Walsh (1997) conducted a study which demonstrated that a child's phonological skills at the age of five predicted future reading progress. However, when a child does not develop visual selective attention abilities appropriately, deficits can occur (Snowling, 2000). As there is a clear link between disordered visuospatial attention and developmental dyslexia, is no surprise that reading ability is primarily affected (Stein & Walsh, 1997). To read effectively, we must undertake a series of visuospatial tasks. For example, the gaze of the eyes must be directed approximately at the middle of the word. From here, it must be read in a way that allows as many letters of the word as possible to be projected into the area of the retina (Werth, 2019). The field of attention must be extended to all letters that need to be recognized. The word has to be fixated for a sufficient amount of time so that the pattern and arrangement of the letters, their size and their position within the word can be processed by the visual system (Werth, 2019). When this does not occur, it has been theorised to be the result of an affected stream in magnocellular system. The magnocellular stream specializes in processing fast temporal information and the magnocellular system helps to guide and control visual attention through eye movements (Stein & Walsh, 1997). A damaged system destabilizes binocular fixation causing confusion as the eye perceives letters in the wrong places. One particular study by Galaburda and colleagues (1985) examined five post mortem dyslexic brains and control brains. Results of the examination show that the magnocellular layers of the lateral geniculate nucleus were disordered and the magnocellular cells were 20% smaller in the dyslexic brains compared to the control brains – displays evidence that dyslexics have a fundamental and biological impairment of their visual processing.

Many other studies have explored the effect of disordered visuospatial attention on the reading process by conducting a series of tasks for participants to complete. Their aim was to test if participants with dyslexia could identify elements such as letters (Casco and Prunetti, 1996) or a shape crowded in a background of similar elements (Ruddock, 1991; Roach and Hogben, 2004). These studies show that participants with dyslexia display a distinct lack of visuospatial attention compared to the participants without the disorder due to the 'crowding effect'. This effect reduces the ability for people with dyslexia to recognize a letter as it is flanked on both sides by other letters (Werth, 2019). For individuals with dyslexia, poorly distinguishing phonemes is a major cause of problems in reading. When someone with developmental dyslexia tries to read, they often complain that small letters move around or appear to blur. They also may transpose letters such as 'saw' for 'was' and might be unable to process fast incoming sensory information adequately (Roach and Hogben, 2017).

1.2.2 Visuospatial attention in skilled readers

Studies have used different approaches to investigate the effects of visuospatial attention on readers without deficits. Studies by Shiu and Pashler (1994) and Johnston and colleagues (1995) have used the psychological refractory period (PRP) paradigm as it requires participants to perform two tasks in rapid succession. Whilst the logic of this task is complicated, they have shown that visual attention is an important factor that predicts significant results within their study. Another study by Montani and colleagues (2014) investigated how the allocation of spatial attention might influence the perception of letter strings in participants classed as skilled readers. The study presented high frequency words, low frequency words and nonwords in either the left or right visual field. Allocation of attention was modulated by a spatial cue before the target string – while accuracy in reporting the target string was modulated by the spatial cue. Results show that when participants read the unfamiliar letter strings, processing was facilitated when the attention was focused on the string location but hindered when it was diverted from the target. This suggests that the function of visuospatial attention is of great importance when reading.

1.3 The Length Effect

Multiple studies have found that the time it takes to read a word aloud is affected by the number of letters or syllables that word contains (e.g., Frederiksen & Kroll, 1976; Weekes, 1997; Ferrand & New, 2003) – that is, the evidence of a length effect. A length effect is also modulated by the frequency of the word. For example, words that are used with low frequency show a larger impact of the length effect than words which are used in high frequency (Content & Peereman, 1992; Ferrand, 2000). Interestingly, Weeks (1997) and Juphard and colleagues (2006) found that nonwords show a larger length effect compared to legitimate words of any frequency. When comparing the length effects of purely nonwords, Ferrand (2000) discovered that non-ambiguous three syllable nonwords had a slower response time in comparison to the two syllable nonwords.

The concept of a length effect is interesting because it provides evidence that people do not process words purely in parallel – thereby, disproving the sentiment of the Connectionist Triangle model. In this case, it is hard to see how length effects would emerge from a system where everything is essentially processed at once. Alternatively, the interactions of the length effect can be explained by the Connectionists Dual Process Model (CDP++) and the Dual-Route Cascaded (DRC) Model (Weekes, 1997).

1.3.1 Variables controlling Length Effect

The two most popular variables controlling word length are considered to be based on the number of letters it contains (orthographic measures) or by the number of syllables. These two measures are generally intercorrelated (New, et al. 2006). A study by Rastle and Coltheart (1998) aimed to show that the variable controlling the length effect on reading aloud is the letter, not the grapheme. What Rastle and Coltheart (1998) found, was that five letter nonword strings with three graphemes (FOOCE) have a longer time-span of comprehension compared to five letter nonword strings with five graphemes (FRULS) proving that the relevant variable controlling the length effect on reading aloud was the letter.

Meanwhile, a study by Ferrand and New (2003) investigated the syllable number length effect according to lexicality both in lexical decisions and when reading aloud. They found a syllable length effect in latency naming for nonwords and low-frequency words, while also finding a syllable number length effect in lexical decision for low-frequency words. Similarly, Muller and colleagues (2003) also conducted experiments demonstrating the syllable based word length effect, stating that this type of length effect is robust and can be demonstrated with multiple sets of stimuli. Another study by Schuchardt and colleagues (2011) also experimented with the syllable number length effect, however, by focusing on participants with dyslexia. The study aimed to compare the syllable length in children with and without dyslexia by using nonwords to pinpoint deficits in phonological processing. The study found that children in the control and dyslexic groups both found it easier to produce a series of one syllable words in comparison to words with three syllables. However, when focusing purely on the results of the dyslexic children, Schuchardt and colleagues

(2011) found that the children were able to repeat nonwords with two syllables at the same rate as the control children, however, their ability to pronounce three and four syllable nonwords declined dramatically. The results suggest that not only is the length effect caused by the syllable number, but also that individuals with dyslexia experience a stronger effect. With this in mind, it will be interesting to discover whether our replication of disturbed visuospatial attention – the jiggling condition – replicates this effect. So far, the studies above have each demonstrated results providing evidence of either the letter effect or the syllable number effect being considered as the variable controlling the length effect. However, due to the exact nature of our experiment, a syllable number effect would be assumed.

1.4 The Distribution of Long and Short Vowels

It is well noted that a grapheme can have different functions depending on where it occurs in a word (Perry, Ziegler, Zorzi, 2013). For example, in the English language the letter –e functions as a consonant grapheme (e.g. mice) and as a vowel (e.g. bet) (Plaut et al., 1996). Therefore the letter –e is seen as an ambiguous grapheme in the English language. A study by Perry and colleagues (2013) found that when –e is treated as a consonant, two syllables are more likely to be used to parse the word. However, if it is treated as a vowel, it is more likely that three syllables will be used to parse the word. Perry and colleagues (2013) also realized that when two syllable words have a vowel-consonant-e sequence, the first vowel will generally be pronounced long (e.g. homeless). Perry and colleagues (2013) were able to confirm an 80.5% occurrence of this sequence by using their database. However, three syllable words were found to be parsed with a short vowel when the word started with a consonant and was followed by an –e (e.g. revenue). This effect was found to occur 81.6% of the time according to the database belonging to Perry and colleagues (2013). When parsing ambiguous words only, participants generally pronounced the word with two syllables when the first syllable contained a long vowel. When three syllable responses were given for ambiguous words, the first syllable contained a short vowel – suggesting that the pronunciation of the first vowel determines the number of syllables participants decide to produce. This study suggests that syllabically ambiguous non-words are able to be parsed in various ways due to a vowel-e relationship. It also suggests that long vowel answers given by participants will be given predominately to two syllable words and short vowel answers by participants will be predominately given to three syllable words.

1.5 The Current Study

The overarching aim of the current study is to explore the relationship between visuospatial attention and the effect it has on parsing stimuli. By replicating similar visuospatial effects to individuals with dyslexia, we can verify whether there is a longer response time or processing component when distinguishing the correct amount of syllables in a word. Currently, there are no published studies which determine whether it is more difficult for individuals without reading disorders to process words that are under a 'jiggling' effect – that is, when the stimuli are deliberately moved around to disrupt visual attention. The results from Rastle and Coltheart (1998) show that the variable controlling length effect are the letters while Ferrand and New (2003) and Schuchardt and colleagues (2011) state that the syllable number has a level of control. In the current study, we will explore whether the variable controlling the length effect is the letter or the syllables when parsing. To do this, we will jiggle ambiguous and unambiguous stimuli with either two or three syllables to affect visuospatial attention and to determine whether a letter or syllable length effect is found. Lastly, we will explore how the distribution of phonology affects vowel length by assessing the answers given for three and two syllable stimuli. To do this, we will calculate the number of long and short vowel responses for the two and three syllable non-ambiguous stimuli. By uncovering these processes, we can use the information resulting from this study in multiple ways. By delving deeper into the effects of visuospatial attention, we can also gain a better understanding of reading disorders such as dyslexia. Our findings can also allow us to predict likely outcomes from reading training programs in the future and can help weed-out model falsification as there are many predictions relating to how visuospatial attention affects reading – our focus being on the aforementioned models (Triangle/CDP++/DRC). The hypotheses for this study are stated below.

1.5.1 Hypothesis 1: As visuospatial attention is used to help parse the letters of words, we hypothesise that the extent to which participants give two or three syllables will be affected by visual attention. If visual attention is disrupted, we predict that participants will break up stimuli into three syllables instead of two because three syllable 'words' use smaller letter groups to parse (e.g. L.o.b.e.th.a.l vs. l.obe.th.a.l) and these will be easy to use under high visual attentional load.

1.5.2 Hypothesis 2: There will be evidence of a length effect due to syllable number.

1.5.3 Hypothesis 3: The distribution of phonology will differ depending on two or three syllables in particular. We predict that participants will give more long vowel answers when they give two syllable responses (example such as dobe.foop) compared to three syllable (do.be.foop) responses because if two syllable parsing is given, the vowel and letter –e need to stay together, as they typically produce long vowels.

CHAPTER 2 – Method

2.1 Setting

The current study was undertaken from March 2020 amidst the covid-19 pandemic. Originally the study was to be conducted at The University of Adelaide by using a participant pool of first year psychology students. Due to the restrictions surrounding the pandemic, the study was altered to comply with the new conditions.

2.2 Participants

A total of thirty-eight participants based in South Australia took part in the visuo-spatial experiment. Each participant was assigned to one of four conditions – equaling eight subjects per condition.

2.2.1 Demographics

All participants were aged between 18 and 65 years (M = 29.9 years, SD = 10.6) consisting of 52% females and 48% males. The proportion of male and female participants were of similar proportion to the latest Australian demographic statistics (e.g. 51% female, 49% males) (Australian Demographic Statistics, 2018).

2.2.2 Recruitment procedure

Due to Covid-19, convenience sampling was used for half of the participants involved in the study. As these participants were known to the experimenter, they were able to use the experimenter's laptop to complete the study. The other half of the participants were recruited via an online advertisement promoting the experiment (see Appendix A). It was shared on the 'University of Adelaide's Psychology Students' Facebook page and on personal social media pages. The second lot of participants completed the experiment via an online link which allowed the program to run on their own computers. Before completing the experiment, all participants declared that they were native English speakers and did not have a reading disorder. All participants gave consent for the study to use their results within the experiment. Due to the change in participant accumulation, participants were also asked to complete the 15-20 minute experiment without incentive.

2.2.3 Analysis of statistical power

Whilst G*Power could technically be used to calculate an estimation for both effect and sample size, the variability found within the task is still undetermined. This variability would result in non-meaningful G*Power results. The counterbalanced design is utilized so that each participant can read the ambiguous stimuli and non-ambiguous stimuli in a high and low visual attention condition.

2.3 Materials and Apparatus

2.3.1 Software

Condition 1.1 and 1.3 of the experiment were run using PsychoPy (version 2020.1.3). Nineteen of the thirty-eight participants used this system to complete the experiment. The other nineteen participants completed conditions 1.2 and 1.4 by using JScript uploaded to Pavlovia.org. When using PsychoPy to run the experiment, a Microsoft Surface Laptop (version 2) was used featuring a 19 x 28.5 centimeter monitor. The participants who used JScript to complete the experiment did so on their own computers. Information was not collected regarding the participants' device models nor their dimensions. After the experiments were completed, the raw data sets were immediately uploaded to either PsychoPy or Pavlovia.org. Once uploaded, they would then be downloaded onto the experimenter's device. The experiment itself was programmed using Python software language using a scrip entitled "ReneeCodeCompress.py" by Conrad Perry. Rules of the PsychoPy and Pavlovia.org platforms were abided by, as were the rules of the National

Statement on Ethical Conduct in Human Research (2007) – including using a standard consent procedure.

2.3.2 Stimuli

The experiment consisted of two hundred and forty stimuli containing an equal amount of legitimate non-ambiguous English stimuli and ambiguous English formatted stimuli. Each participant involved in this study was to judge the number of syllables in each set of stimuli on the screen. One hundred and ten stimuli could be read with only two syllables (e.g. bas-int) and another one hundred and ten stimuli could only be read with three syllables (e.g. bas.in.tel). Both groups had non-word stimuli added into the mix as fillers (seen in Appendix B). These stimuli were deliberately constructed to elicit the predisposed syllable responses. However, the last twenty critical stimuli per cell (seen in Appendix B) were able to be ambiguously read by the participant. Participants had to sound out whether the ambiguous stimuli had either two or three syllables and had to decipher stimuli containing complex graphemes. As the syllabically ambiguous stimuli are able to be parsed in various ways due to a vowel-e relationship, it leads to participants attempting to process multiple letters at the same time. For example, stimuli such as *badefoop* can be pronounced as either ba.de.foop or bade.foop. The dots within the word represent the possible syllable boundaries. Stimuli which have complex graphemes, like -tch (e.g. match, fatch) are used in this experiment to determine whether it may be more difficult to process them under high attentional load in comparison to stimuli without complex graphemes. On average, stimuli containing six, eight and nine letters were mostly used for the two syllable, three syllable and the ambiguous stimuli. All of the stimuli were broken into two equally counterbalanced groups and presented in two different ways. One condition presented both the ambiguous and non-ambiguous stimuli in a 'static' (non-jiggling) and otherwise normal reading format. The other condition presented both ambiguous and non-ambiguous stimuli in a 'jiggling' format. To create a visually effective jiggling condition, it was designed to move 75% from the horizontal plane and the angle alternated from 20 to 135 degrees every 90 milliseconds. This effect was created to disrupt visual attention and to replicate effects of developmental dyslexia – creating a way to demonstrate letters moving around or blurring (Roach and Hogben, 2017).

2.3.3 Data Storage

Data was collected from PsychoPy and Pavlovia.org and was organized by the experimenter and their supervisor. Data was de-identified to ensure that no subliminal bias could occur and participant privacy was attained. All data associated with the experiment was stored on online folders which sat behind two password-protected laptops. The data collected may be kept after the completion of this thesis if it is informative for future research. All participants will be informed if future research involving the experiment's datasets are to go ahead.

2.4 Design

The design of this experiment will include the random assignment of participants into one of four counterbalanced groups. By using random assignment, we will be able to ensure that each of the participants have an equal chance of being placed into either of the four groups – making it easier to confirm that any differences found between groups are not systematic. It is also beneficial for ensuring that any differences between the groups can be confidently attributed to the experimental procedures (Stigler, 1992). Using four counterbalanced groups will enhance the study's interval validity as it allows us to systematically involve variations of other conditions in our study (SAGE Encyclopedia, 2017). To conduct the data analysis for this study, we will be using a linear mixed models design which will consist of both fixed and random factors. As our data has more than one source of random variability, we decided that a linear mixed model was going to be the most beneficial for conducting an effective analysis (Galecki and Burzykowski, 2013). We will also use the Kenward Rodger Method to retain the correct degrees of freedom as it will strengthen the validity of this experiment and the approximations give values which are known to be very close to the correct probability (Luke, 2016).

2.4 Procedure

2.4.1 Ethics

The researchers involved in this study made a declaration to immediately report to the HREC Secretariat any adverse events that might warrant a review of ethical approval. The ethics approval number for this thesis is 20/35.

2.4.2 Participant procedure

Social media advertising was used to gain awareness of the experiment and the appropriate amount of participants needed. Participants were provided with an electronic information sheet and consent declarations before starting the study. After agreeing to proceed with the experiment, participants were randomly assigned to one of the four counterbalanced groups. Participant group assignment was purely based on what time and day they were able to complete the experiment. The counterbalanced groups were based on two different factors. The first was whether the atimuli in the 'jiggling' condition were presented in the first or second half of the trial. The second factor involved the sets of stimuli that were either used for the first or second half of the trial. Exactly 50% of the participants completed the experiment using PsychoPy and the other 50% used JScript on Pavlovia.org. Due to Covid-19 precautions, the experimenters' laptop was sanitized before and after participants completed condition 1.1 and 1.3. A 1.5 meter distance was also maintained between the experimenter and the participant as per the Covid-19 restrictions. Participants judged how many syllables were found in each word and non-word by pressing down the left-arrow key if they thought the stimuli had two syllables or pressing down the right-arrow key if they thought the stimuli had three syllables. It took the participants between 15-20 minutes to finish reading through the three-hundred and ninety stimuli. A completion page appeared after each experiment thanking the participant and letting them know that they could now close the trial window. Once the required number of participants completed the experiment, the data sets were uploaded to the statistical processing software (RStudio) to analyse the data.

CHAPTER 3 – Results

3.1 Preliminary Analysis

3.1.1 Data Cleaning, Screening and Methodology

To maintain upmost accuracy, data from 6 participants were discarded from the 38 responses due to our initial data screening showing they had an error rate over 25%. To examine the data, mixed models were used where the factor(s) of interest were used. These factors consisted of both fixed and random factors. The random factors were allowed to vary by overall responses rate or time (i.e., a random constant) and by the slopes for both participants and items. To measure the response times, we approximated the degrees of freedom using the Kenward Rodger Method. This method was used as the degrees of freedom cannot be calculated directly with linear mixed models. The Kenward Rodger Method approximations gives us values which are known to be very close to the correct probability compared to a chi-squared distribution. The Kenward Rodger Method is neither anti-conservative nor overly sensitive to sample size (Luke, 2016). When responses were dichotomous, we used the same mixed models, without assuming a binomial distribution. When this distribution is given, the p-values were estimated using a chi-squared distribution.

3.2 Hypothesis 1: As visuospatial attention is used to help parse the letters of words, we hypothesise that the extent to which participants give two or three syllables will be affected by visual attention. If visual attention is disrupted, we predict that participants will break up stimuli into three syllables instead of two because three syllable ‘words’ use smaller letter groups to parse (e.g. L.o.b.e.th.a.l vs. l.obe.th.a.l) and these will be easy to use under high visual attentional load.

3.2.1 Non-Ambiguous Stimuli

3.2.1.1 Reaction Times

By using the data from Conditions 1-4, we examined how participants processed the non-ambiguous stimuli using a mixed effect with the Number of Syllables (2 or 3) and the Jiggling condition (Jiggle vs. Static) as independent variables. The results of this experiment showed that participants were faster at responding to the static stimuli with two syllables (1209ms) in comparison to three syllables (1546ms), F (1, 18.45)= 7.86, p -= 0.012, np2= .30. A similar effect was also seen for the jiggling stimuli, with participants responding faster to two syllables (1328ms) in comparison to three syllables (1640ms) (see Figure 4). However, when assessing whether the jiggling effect impacted the response time for deciphering the two and three syllable stimuli, we noticed that it failed to reach significance F (1, 36.6)=2.976, p -= 0.054, np2=0.08. We also determined that this study showed no interaction between the two and three syllable non-ambiguous jiggling stimuli F(1, 41.88)=43.64, p-=0.55, np2=0.51.

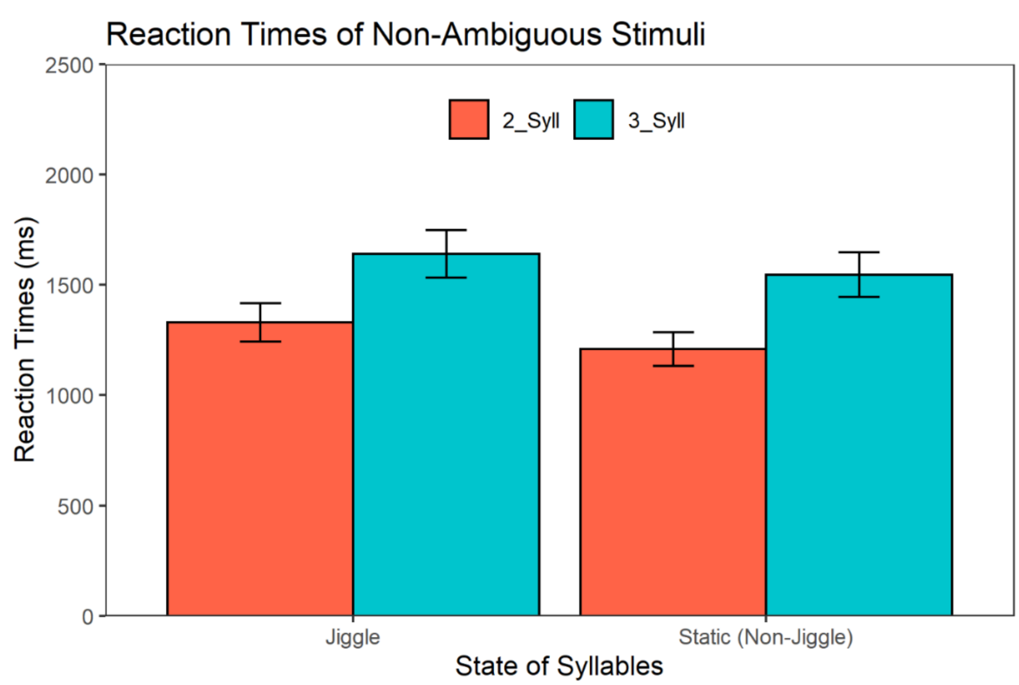

Figure 4. [Reaction times of non-ambiguous stimuli.]

3.2.1.2 Ex-Gaussian distribution

The ex-Gaussian distribution is a mathematical convolution of the normal (the Gaussian) and exponential distributions. It has three parameters which reflect the mean and standard deviation of the Gaussian distribution (mu and sigma) and reflects the mean and standard deviation of the exponential distribution (tau) (Heathcote et al., 1991). As we have noticed an ex-Gaussian distribution in the data, we acknowledge that this would be a violation of the assumption that the data is normally distributed. However, the ex-Gaussian distribution does not have any substantial effect on the F values (Andrews and Heathcote, 2001). Despite this, we re-ran the statistics using Log response time values as a precaution and found that the results were essentially identical. For the sake of clarity we are only reporting the statistics using the actual response time values.

3.2.1.3 Error Rates

After calculating the response time results of the two and three syllable stimuli, we next examined participant error rates. The results showed participants were more accurate at responding to the two syllable stimuli (5.9%) compared to the three syllable stimuli (8.5%), F(44.3) (see Figure 5). Surprisingly, the jiggling condition did not affect the error rates for two syllable stimuli (5.9% vs 5.9%) and three syllable stimuli (8.5% vs 9.7%), F(3.5). We also determined that this study showed no significant interaction between the two and three syllable non-ambiguous jiggling stimuli F(0.34).

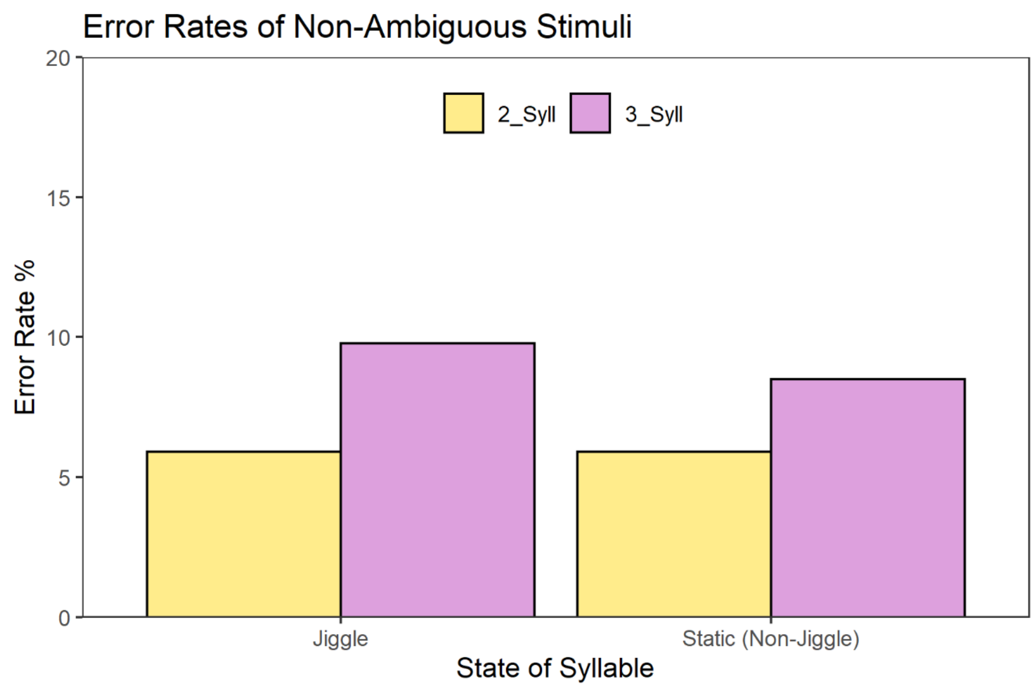

Figure 5. [Error rates of non-ambiguous stimuli.]

3.2.1.4 Ambiguous Stimuli (jiggling vs Static)

We started testing ambiguous stimuli by examining whether participants answered differently depending on the static and jiggling conditions. As these stimuli could be parsed either way, we were focusing on the proportion of times the participants gave either two or three syllable answers. The results show that participants gave two syllable answers 84.31% of the time in the static condition and 80.31 % of the time in the jiggling condition. The results show that the difference between the static and jiggling condition was not significant ($p = 0.44$).

3.3 Hypothesis 2: There will be evidence of a length effect due to syllable number.

3.3.1 Ambiguous Stimuli (RTs)

We next examined the Response Times of the ambiguous stimuli using the same model, without constraining it to dichotomous responses. Interestingly, the results showed that when participants gave three syllable responses (1667ms) to ambiguous stimuli they were faster than when they gave two syllable responses (2048s). The results show that the difference between the two responses are statistically significant ($p < .001$).

3.3.2 Letter effect of Ambiguous and Non-Ambiguous Stimuli

The results coming from the ambiguous stimuli showed that participants predominantly prefer to give two syllable answers but were faster to give three syllable responses. In terms of the non-ambiguous stimuli, participants unsurprisingly had more accuracy and speed when responding to the shorter (two syllable) stimuli than to the longer (three syllable) stimuli. What is surprising however, is that the jiggling condition had very little effect on the way participants broke down the stimuli into syllables. This gives evidence towards the length effect being due to the letters in the stimuli instead of the stimuli's perceived number of syllables. We assume this theory because the ambiguous stimuli – where only the phonology of the response differs – found that participants were slower at giving two syllable responses.

3.4 Hypothesis 3: The distribution of phonology will differ depending on two or three syllables in particular they will give more long vowel answers when they give two syllables (example such as dobe.foop) compared to three syllables (do.be.foop) because if a two syllable parsing is given, the vowel and letter –e need to stay together, as these typically produce long vowels.

3.4.1 Long Vowels vs Short Vowels in non-ambiguous stimuli

The last experiment we completed was performed to explore how participants decided on the vowel length of each stimuli. By using the cross tabs function, we were able to calculate the number of long and short vowel responses for the two and three syllable non-ambiguous stimuli. The results show that participants assumed a long vowel (104 times) over short vowels (41 times) for two syllable non-ambiguous stimuli. Alternatively, participants assumed short vowels (252 times) over a long vowel (74 times) for three syllable non-ambiguous stimuli. To understand if participants could have drawn the same conclusions for long and short vowels purely by chance, we decided to conduct a chi square test. The results show a significant effect ($p<0.001$) confirming a probability higher than chance. Therefore, the results of this experiment show that participants have a clear preference for long vowels in two syllable stimuli and short vowels in three syllable stimuli.

CHAPTER 4 – Discussion

The present study aimed to narrow the knowledge gap that currently exists between the disruption of visuospatial attention and the effects it has on the parsing of letters. To do this, an experiment was conducted with 38 South Australian participants who claimed to not have any reading disorders. The relationship visuospatial attention has with reading was explored by examining its effect on the segmentation of two and three syllabically ambiguous and non-ambiguous stimuli. To the authors knowledge, this is the first study investigating the relationship between visuospatial attention and the syllabic segmentation of stimuli under an explicit visuospatial manipulation, where the stimuli were made to jiggle to deliberately disrupt visuospatial attention. Results, implications, limitations and future directions are discussed below in terms of research aims.

4.1 Disruption of Visuospatial attention and the extent to which participants break up stimuli into three syllables instead of two

The reaction times of the non-ambiguous data were assessed against the number of syllables (two or three) while simultaneously in a static or jiggling condition. It was found that the participants were faster at responding to the two syllable stimuli in comparison to the three syllable stimuli held under the same effect. Interestingly, the jiggling visuospatial effect did not display a significant difference in the response times for either the two or three syllable stimuli. There was also no significant interaction between the response times of the non-ambiguous jiggling stimuli. When assessing error rates of the non-ambiguous stimuli, we found that participants had better accuracy when responding to stimuli with two syllables in comparison to stimuli with three syllables. When comparing the error rates of stimuli held static with stimuli under the jiggling effect, we found that jiggling stimuli did not create a significantly greater error rate. In fact, the error rate for the two syllable stimuli in both the jiggling and static conditions were identical. Therefore, it was no surprise that we found no significant interaction between the error rates of the jiggling two and three syllable non-ambiguous stimuli. Interestingly, the ambiguous stimuli displayed similar results where an almost identical percentage of two and three syllable responses were given for both jiggling and static stimuli. These results show that the jiggling condition had no significant effect on parsing ambiguous stimuli.

When combining the results for both non-ambiguous and ambiguous responses, we found no evidence of disrupted visuospatial attention due to the jiggling effect – therefore providing evidence against Hypothesis 1 of this study. This is quite surprising as ambiguous stimuli can be parsed with either two or three syllables, so it was predicted that participants would break up stimuli into three syllables instead of two more in the jiggling condition. This was assumed as three syllable ‘words’ use smaller letter groups to parse (e.g. L.o.b.e.th.a.l vs. l.obe.th.a.l) which therefore, would be easier to use under a high visual attentional load.

These results provide evidence for the Connectionist Triangle model by Seidenberg and McClelland (1989). As we were unable to see a jiggling effect, it leads to the possibility that individuals see and process letters in parallel and do not use a parsing mechanism – resulting from a link between orthography and phonology being generated in parallel (e.g. sight word reading). However, these results are contradictory to the previous work completed in the area. For example, a study by MacKay (1972), found that stimuli that could be parsed ambiguously by skilled readers (bade.foop vs bad.e.foop) were 70% more likely to be parsed into three syllables compared to two syllable answers. Similarly, an unpublished experiment by Perry (2015) discovered participants without reading deficits typically parse ambiguous stimuli into three syllables – displaying evidence of being affected by visuospatial attention.

This effect is also demonstrated when individuals with visuospatial attention deficits (such as dyslexia) are aiming to parse a word. When they parse written words, they try to avoid visuospatial ordering decisions by interpreting a potential coda as the onset of a different syllable. The result of this decision produces a three syllable word (CV.CV.CV) instead of the original two syllable word (CVC.CV) (C= Consonant V=Vowel) (Schneider-Zioga & Katada, 2007). Furthermore, multiple studies have found definite effects of disrupted visuospatial attention on skilled readers (Shiu & Pashler, 1994; Johnston, et al.,1995; Montani, et al., 2014) and clear visuospatial deficits from dyslexic readers (Ruddock, 1991; Roach and Hogben, 2004; Casco and Prunetti, 1996). The aim of the jiggling condition was to disrupt visual attention and to replicate effects of developmental dyslexia – creating a way to demonstrate letters moving around or blurring (Roach and Hogben, 2017). This was not found within this experiment, and together with the other data it suggests that our manipulation may simply not have been strong enough to affect reading. To explore the effect of visuospatial attention further, we will explore the results of Hypothesis 2 regarding the syllable number length effect.

4.2 Assessment of the length effect to determine a syllable number length effect – experimenting with ambiguous and non-ambiguous two and three syllable stimuli

As previously noted, the jiggling condition did not have a significant effect on any stimuli and participants had faster response times and better accuracy rates for non-ambiguous two syllable stimuli in comparison to three syllable stimuli. When response times were assessed for the ambiguous stimuli, we found that participants had a significantly faster three syllable response time compared to when participants responded with two syllables. These results show that syllabification definitely affects the response time and that a visual length effect is seen. The results suggest that the slower responses may be a potential re-evaluation of an initial response. In a previous study by New and colleagues (2006), it was found that due to saccades only having the ability to see a certain amount of characters at a time, words containing around six letters have the highest chance of being processed in a single fixation – whereas longer words are regularly re-fixated. Words with nine letters or more become more difficult to perceive as they are further from the fixation point (O'Regan, et al., 1992). Our stimuli varied from six (two syllable) to nine letters (three syllable).

With this in mind, the results from each experiment suggest that the length effect is actually due to letter length and not the number of syllables – effectively disproving Hypothesis 2 of this study that the variables controlling the length effect is the syllable. The assumption of a letter length effect is based in comparison with the results of the ambiguous stimuli. With those stimuli, only the phonology of the response differs with the ambiguous stimuli, and the results were the opposite of the non-ambiguous stimuli, where participants were slower in giving the two syllable compared to three syllable responses. This assumption is strengthened by the study Rastle and Coltheart (1998) completed on nonwords; displaying evidence of letters being the relevant variable controlling the length effect. Multiple other studies have also found that the time it takes to parse a word is affected by the number of letters that word contains (Frederiksen & Kroll, 1976; Weekes, 1997).

An interesting aspect of the letter length effect is that it provides evidence against words being processed purely in parallel. Instead, it predicts that we use spatial attention to move from left to right across the letter string in a serial manner (Vidyasagar, 1999; Vidyasagar and Pammer, 2010) therefore, providing evidence against Seidenberg and McClelland's (1989) Connectionist Triangle model approach to reading. Instead, the letter length effect involves an aspect of strategy that allows left to right serial parsing – found in the Connectionists Dual Process Model (CDP++). In this case, the CDP++ model has a pathway that assumes graphemes are extracted serially from left to right from letter strings. These assumptions are consistent with the work of Sieroff and Posner (1988) and Auclair and Sieroff (2002) and Montani and collegues (2014) who have all found parsing involves the sweeping of attentional focus from left to right across letters. So far, we have discovered that both Hypotheses 1 and 2 have not coincided with the results found from these experiments. However, Hypothesis 3 of our experiment will help decipher whether visuospatial attention has an effect on vowel length.

4.3 The distribution of long and short vowels depending on ambiguous and non-ambiguous two and three syllable stimuli

The last experiment we completed was created to assess vowel length in non-ambiguous stimuli. By calculating the number of long and short vowel responses for the two and three syllables non-ambiguous stimuli, we were able to test Hypothesis 3. We hypothesized that the distribution of phonology will differ depending on the syllable number as participants will give more long vowel answers when they give two syllables (dobe.foop) compared to three syllables (do.be.foop). This is because when two syllable parsing is given, the vowel and the letter –e need to stay together and these two combined typically produce long vowels. The results of this experiment showed that participants have a significant preference for a long vowel over short vowels for two syllable stimuli and short vowels over long vowels for three syllable stimuli. Therefore, the results of this experiment coincide with Hypothesis 3.

Similarly, a study by Perry and colleagues (2013) also found a distinct difference in the number of short and long vowels participants provided depending on their two or three syllable responses. Perry and colleagues (2013) explained that this relationship is learned with different grapheme sequences. When three syllable words have a single-letter first vowel which is followed by a consonant and then an –e , the first vowel is usually pronounced short. However, when two syllable words follow the same vowel-consonant-e sequence, the first vowel is pronounced long. Here lies two important takeaways from this research: (1) the difference in vowel length relates to the amount of phonological syllables in a word and (2) whether people use long or short vowels in the first syllable strongly affects the number of syllables they pronounce as people organise groups of phonemes into syllables differently.

Interestingly, the Connectionists Dual Process Model (CDP++) by Perry and colleagues (2010) was found to have the ability to replicate the vowel effect – further proving to support the assumptions of the model and simultaneously, further disproving the assumptions of the Connectionist Triangle and the Dual-Route Cascaded (DRC) models. In this case, Perry and colleagues (2013) ran their stimuli through the CDP++ model to assess syllable responses combined with the –e grapheme in either a vowel or consonant form. They predicted a two syllable response for consonant –e grapheme and a three syllable response for a vowel –e grapheme. The results from the CDP++ model produced a similar proportion of long and short vowel responses to the participants in the experiment.

4.4 Methodological Strengths

4.4.1 Procedure

A primary strength of this study is the experimental procedure undergone by participants. Participants were randomly assigned to one of four counterbalanced groups. By using random assignment, we were able to ensure that each of the participants had an equal chance of being placed into either of the four groups – helping to ensure that any differences found between groups were not systematic. It is also beneficial for ensuring that any differences between the groups can be confidently attributed to the experimental procedures (Stigler, 1992). Utilizing counterbalanced groups also strengthens the experiments' methodological approach. By controlling the effects of the nuisance variables in the design, participants were repeatedly subjected to differing conditions and stimuli. Counterbalanced groups enhance our study's interval validity as it allows us to systematically involve variations of other conditions in our study (SAGE Encyclopedia, 2017).

4.4.2. Software

Having the ability to record participant data on Pavlovia.org and PsychoPy (version 2020.1.3) was considered a strength of this experiment. PsychoPy is known for having elite timing precisions and the online version (Pavlovia.org) has the ability to display reaction time precision under 4 milliseconds. This is the only web browser with the ability to do so online (at the time of this study). By using these software programs to collect our experimental data, it eradicated not only the human error but also the computational error of inferior software which could potentially affect response times and error rates. The use of Python as our chosen programming language can also be seen as a strength. Python is very flexible and is great for data analysis and general scientific computing.

4.5 Limitations and Methodological Considerations

4.5.1 The jiggling effect

The first limitation of this study is the lack of effectiveness from the jiggling condition. This novel effect was created to replicate the effects of developmental dyslexia by disrupting visuospatial attention (Roach and Hogben, 2017). There is a possibility that the stimuli manipulation caused by the jiggling effect was simply too weak to produce significant results. However, the lack of significance from the jiggling effect could also be the result of too much variation within participant responses. We also found that one participant articulated that they perceived a four syllable stimuli in their experiment – showing a possibility of visuospatial disruption. Therefore, another limitation of this study is having only two different syllable options to assess visuospatial attention.

4.5.2 The experiment procedure

Due to the Covid-19 pandemic of 2020, we were unable to conduct the experiment with the procedure we had initially planned when commencing this experiment. Originally, participants were to parse the stimuli through a microphone which was to be recorded. This would give us the ability to hear where participants were breaking up the stimuli into either two or three syllables. Instead, we had to improvise by conducting a left and right arrow button pressing task which coincided with whether the participants thought the stimuli had two or three syllables. Pressing buttons that signify whether the stimuli is two or three syllables involves metalinguistic decision making which allows us to manipulate formal structures such as phonemes and their arrangements in words (Bialystok & Ryan, 1985). This element of linguistic reflection may have altered participant responses and therefore, we should be wary that this limitation may have affected the results. Another factor to consider was the monotonous task of pressing of the left and right buttons and how it accounts for human error. A few of the participants reached out to say that they had accidentally pressed the wrong button when reading the stimuli in the experimental task. This response was not surprising because when individuals normally read or speak, they perceive information quickly. However, when creating judgements to evaluate stimuli, individuals find that perceiving slower allows for better decision-making (Tormala, et al., 2011). Therefore, by assessing reaction times on a monotonous task, we limit judgements that use slower evaluation to be effective.

4.6 Future research directions

4.6.1 Incorporation of stronger visuospatial disruption techniques

Conducting further research into visual disruption techniques would be beneficial to retest the first hypothesis of this experiment. Results contradicted multiple studies on disrupted visuospatial attention with skilled readers (Shiu and Pashler, 1994; Johnston, et al.,1995; Montani, et al., 2014) and clear visuospatial deficits from dyslexic readers (Ruddock, 1991; Roach and Hogben, 2004; Casco and Prunetti, 1996), showing that our disruption effect was ineffective at producing similar results. Initially, the jiggling effect was seen as an interesting and novel way to demonstrate the disruption of visuospatial attention. However, the effect may not have been strong enough to provide significant results. By combining the jiggling effect with other visuospatial disruptions such as stimuli moving along a computer screen or switching in and out of a blurring condition could better replicate the effects of dyslexia (Roach and Hogben, 2007) providing future studies with more accurate results.

4.6.2 Incorporation of original experimental procedure

Further studies could also incorporate the original pre-covid-19 procedure where participants were to conduct the experiment by parsing the stimuli into a microphone instead of the updated button pressing task. This allows for participants to parse stimuli into as many or as little syllables as they perceive. It also allows for a quicker response time – leading to more authentic error rates and overall results.

4.7 Conclusions

The goal of this study was to explore the relationship between visuospatial attention and the effect it has on parsing stimuli. There are several points of interest that can be taken from the reported results. By replicating similar visuospatial effects to individuals with dyslexia, we were able to verify whether a longer processing component was found when distinguishing the correct amount of syllables in a word. Hypothesis 1 explored the disruption of visuospatial attention and the extent to which participants then break up stimuli into three syllables instead of two. We found that the jiggling effect had no significant difference in response times or error rates with either of the ambiguous or non-ambiguous stimuli. We also explored whether the variable controlling the length effect is the letter or the syllables when parsing by jiggling two and three syllable ambiguous and unambiguous stimuli. Hypothesis 2 assumed a syllable number length effect would be present in the data. We found that faster response times and better accuracy rates were found for non-ambiguous two syllable stimuli in comparison to three syllable stimuli. We also discovered that ambiguous stimuli recorded significantly faster three syllable response times in comparison to two syllables while also finding no impact of the jiggling effect. Therefore Hypothesis 2 was disproved and instead, we found a letter length effect. Lastly, we explored how the distribution of phonology affects vowel length by assessing the answers given for two and three syllable non-ambiguous stimuli. Hypothesis 3 predicted that participants will give more long vowel answers when they give two syllables (dobe.foop) compared to three syllables (do.be.foop). We reported that participants do have a significant preference for long vowels over short vowels for two syllable stimuli and short vowels over long vowels for three syllable stimuli – making Hypothesis 3 the only hypothesis supported by our results.

Overall, the initial hypotheses about visuospatial attention are uninformative. Limitations such as the lack of effectiveness from the jiggling effect and negative effect of the button-pressing should be considered in future studies. The study has not given us a clearer idea of dyslexia or best-fit reading models – however a strong case can be made for the CDP++. If anything, this study can be used in conjunction with other visuospatial attention studies to aide further research in the area.

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Appendix A

(As shared on Facebook)

Participants Needed

How do we determine the correct way to pronounce a word we’ve never seen before?

Please help me find out!

I am looking for participants to view a set of English-looking non-words to then decipher if there's either 2 or 3 syllables in each word. If you are a native English speaker without any reading disorders, we’d like to hear from you!

This study takes about 15 minutes to complete online so if anyone has the time today to help out that would be amazing! 😀

Appendix B

Non-Ambiguous Stimuli

fozolot	foabip	buglatten	drosten	poilid	ducrallod	bedip	bedipoid
gratulin	festild	ruckintot	flicken	dofak	dofakoot	vondol	vondolar
fomokin	mascop	doustalic	meastor	nodimp	nodimpal	solat	solatoil
felterik	darmer	belotine	rumbit	vamil	vamilid	sepind	sepindo
mostoluc	fontold	gracolous	baleck	doizot	doizottle	metol	metolkit
brintolad	scurpine	poskilpin	phoggil	bokat	bokatil	pookal	pookalot
chinolter	falost	rapintol	chacken	reaspod	reaspodic	bimploid	bimploida
dantalog	veboil	thoileck	lafintel	mostok	mostoko	ranap	ranapid
boskulin	docrast	monteg	prasoltin	folasc	folascue	rizan	rizanoid
remunder	trompad	mooskit	feckilo	thalot	thalotid	mospill	mospillid
stirkley	wusting	fintent	partindot	vistul	vistulok	doftul	doftulik
blonosto	doilen	ruskod	chukonic	gumpod	gumpodil	mustins	mustinson
tuffenter	gorper	troaner	finsorter	rostol	rostolik	bomgast	bomgastid
retounter	hilet	decount	gelupid	charat	charatoc	ristuk	ristukol
rispolet	hountel	feestel	stindolo	thibol	thibolot	bolop	bolopun
fosinder	jeskus	fontig	bloskoidal	fintok	fintokad	festot	festotid
linkartin	kilop	biltid	fosintoun	bazik	bazikan	chotond	chotondo
bulpodor	lourmen	prolonk	mowistal	ruskill	ruskilly	botal	botalid
chemecky	measting	seckor	feetundin	puzink	puzinker	fitont	fitonter
zatealor	noutic	blustid	cropalit	gelob	gelobit	rastop	rastopin
stubontil	probbid	gotine	focrosting	masoc	masocal	restippal	goulet
gistundit	restout	thilpuddy	yarent	maspilkin	pholtest	foskalut	chintod
vilkanid	sammil	bosconter	zontil	fisutid	thanter	folkentin	skopil
wittinel	souness	molfilper	bellap	nicolter	shompit	muskaloid	feastor
dokurky	teliff	rastontil	darfen	dempoida	whompus	fobbilen	runtoid
bustitsol	vinter	falkinter	fentest	garfuntil	brockat	sotopal	mailok
runkoltin	weskol	sintoutel	gowner	moratin	siller	vuskalin	suppil
restolink	chotten	bostither	himmick				

Ambiguous Stimuli

mospillid	ristukol	fitonter	gemeboil	zimepell
doftulik	bolopun	rastopin	nubestote	dafetort
mustinson	festotid	dobekon	bopenet	midetol
bomgastid	chotondo	chedelon	badefoop	botalid