The Effect of Morphological Priming on Dyslexics in a Memory Task

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Abstract

Developmental dyslexia is a language disorder characterised by a phonological deficit. Despite this deficit, high-functioning dyslexics can still attend university, and this is due to them having a sensitivity to the semantics of morphemes which enables them to compensate for their deficit. This sensitivity however has been shown only in lexical decision tasks. This current research investigates if high-functioning dyslexics have a sensitivity to morphology in a memory task, as dyslexics have been shown to have short-term memory impairments. A priming memory task was used to test this, with morphological and unrelated primes. It was hypothesised that if high-functioning dyslexics are more sensitive to morphology than non-dyslexics, dyslexics would have a larger difference between the accuracy of responses and reaction times for related and unrelated primes than non-dyslexics. It was hypothesised that the reaction times would decrease, and the accuracy of responses would increase with morphological primes. However, the results of this study give no evidence to conclude that high-functioning dyslexics are more sensitive to morphology than non-dyslexics in a memory task, therefore the hypothesis is not supported. The paper discusses the potential reasons why the results are not as expected.

Acknowledgements

Firstly I would like to express my enormous gratitude to my supervisor Titia Benders for her continuous support and invaluable feedback throughout the process of writing my thesis. I would also like to thank Dirk Vet who helped me with the formation of the experiment in the program he created: “Experiment Designer”. Additionally, this thesis would not have been possible without all the people who participated in the experiment, and for that, I am very grateful to them. I would also like to thank my friends and family who helped me with the recruitment of participants. Finally, I would like to thank my peers who have supported me in writing my thesis.

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1. Introduction

Dyslexia, also known as developmental dyslexia, is a language disorder that begins in childhood and continues for a lifetime. Developmental dyslexia is different from acquired dyslexia, as acquired dyslexia can occur at any point in a lifetime, often as a consequence of a head injury or stroke, and symptoms can also improve with time. (*Developmental Dyslexia,* 2022) This paper will focus on developmental dyslexia, and the term dyslexia will be used throughout. Dyslexia is characterised by a phonological deficit, which is an impairment in phonological representations, so dyslexics struggle to learn how letters correspond to speech sounds (Ramus et al., 2003). Characteristics of dyslexia therefore can include slow reading and writing, confusion of letter order in words, poor spelling, and difficulty with understanding written information (National Health Service, 2022a). High-functioning dyslexia is a term used to describe dyslexics, who despite their language disorder, have been able to attend higher education (Deacon et al., 2006), and this paper will focus on high-functioning dyslexics.

An additional deficit that dyslexics have is a short-term memory deficit (National Health Service, 2022b), and more specifically a verbal short-term memory deficit (Pennington et al., 1990; Martin et al., 2010). Short-term memory is the capacity to hold seven (plus or minus two) items (Miller, 1994) in the mind for 20 to 30 seconds (Atkinson & Shiffrin, 1971). Verbal short-term memory is the capacity to remember words and visual short-term memory is the capacity to remember images (Martinez Perez et al., 2015). Verbal short-term memory is made up of verbal item and order short-term memory. In memory studies, they are tested differently, with item short-term memory tasks requiring participants to remember words from a list, and order short-term memory tasks requiring participants to remember the order words were presented in (Majerus & Cowan, 2016). In older studies investigating short-term memory in dyslexics (Pennington et al., 1990; Martin et al., 2010) verbal item and order short-term memory were not tested separately. However, in recent studies they have been tested separately with dyslexics (Martinez Perez et al., 2013; Martinez Perez et al., 2015), as verbal item short-term memory relies on underlying phonological representations, whereas verbal order short-term memory relies on language-independent networks (Burgess & Hitch, 1999).

Some studies which have tested verbal item and order short-term memory separately (Martinez Perez et al., 2013; Martinez Perez et al., 2015) offer support for verbal item short-term memory being impaired in dyslexics. They suggest this is a result of their deficit in phonological representations (Ramus et al., 2003), as underlying phonological representations are necessary for verbal item short-term memory (Burgess & Hitch, 1999). One study

(Martinez Perez et al., 2013) involved dyslexic and non-dyslexic adults taking part in three experiments, each involving a task to test item memory and order memory. The dyslexic participants all had a university degree and therefore according to Deacon et al. (2016) could be considered as high-functioning dyslexics. The verbal item short-term memory tasks involved participants recalling words they had just heard, and the verbal order short-term memory tasks involved participants recalling the order of words they had just heard. Results of this study showed that both verbal item and order short-term memory are impaired in dyslexics. A neuroimaging study (Martinez Perez et al., 2015) looking at both verbal item and order short-term memory, recruited both dyslexic and non-dyslexic adults. All participants had a university degree, so the dyslexics could be considered as high-functioning dyslexics (Deacon et al., 2016). The experiment testing item memory involved participants being presented with four words, followed by a probe word that either matched a word in the previous list, or which differed by a phoneme. Participants then had to indicate if the word had been in the list or not. For testing order memory, participants were also presented with four words, followed by two words from the list, and participants had to indicate if they were in the same order as they had been in the list. This study showed dyslexics are impaired in verbal item and verbal order short-term memory and that they are connected to separate neural networks.

Research into high-functioning dyslexics has not just looked into their deficits, but also into what strengths they may have which enable them to compensate for their phonological deficit and attend university. Research conducted by Cavalli et al. (2016) investigated the dissociation between phonological and morphological skills in high-functioning dyslexics. They found that the greater the dyslexic’s morphological skills compared to their phonological skills, the better their reading abilities. There has been further research looking into the morphological skills of dyslexics and whether as shown in Cavalli et al. (2016), high-functioning dyslexics compensate for their deficit in phonological skills by their morphological skills.

The further research includes studies (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019) that show that high-functioning dyslexics are more sensitive to the semantics of morphemes than non-dyslexics. This was shown by dyslexics showing a greater priming effect with primes that are semantically and morphologically related to the target word in a primed lexical decision task than non-dyslexics. The studies also offer support for high-functioning dyslexics using morphology as a method of compensating for their phonological deficit, to enable them to attend higher education. The methods used in these studies (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019) were lexical decision tasks. In this type of task, participants are required to indicate if a target word is a real word or not, and the target word is preceded by a related or unrelated prime. The prime word can facilitate the identification of the target word, and therefore can reduce the speed, and increase the accuracy of the response (Schiff et al., 2019). The primes used in the study by Law et al. (2017) are given in table 1.

Table 1: Prime types and examples used in Law et al. (2017, p. 493)

Prime Type	Example
Morphologically and semantically related	jumper-JUMP
Morphologically related	corner-CORN
Semantically related	hound-DOG
Orthographically related	scandal-SCAN

In the morphologically and semantically related prime type in table 1, the prime and target share a morpheme “jump”, which has a shared semantics (meaning) in both the target and prime word, as well as the same orthography (form). In the morphologically prime type, the prime and target share the morpheme “corn”, but the semantics of this morpheme is different in the prime and the target. In the semantically related prime type in table 1, the prime and target do not share orthography or morphology but do share the same semantics. Finally, in the orthographically related prime type, both the prime and target include “scan”, however in the prime word, “scan” is not a morpheme, and the words do not share semantics. The primes used in the study by Cavalli et al. (2017) included all prime types from the primes in Law et al. (2017) in table 1, besides a morphologically related prime, and instead used an unrelated prime. In the study by Schiff et al. (2019), the primes included all prime types from the primes in Law et al. (2017) in table 1, besides a semantically related prime, and instead used a prime identical to the target word. These studies (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019) use multiple primes to compare the types of primes between the high-functioning dyslexics and non-dyslexics, to see if there is a greater priming effect for morphologically and semantically related primes than other prime types and if this effect is greater for dyslexics than non-dyslexics.

In the study by Cavalli et al. (2017), as well as recording reaction times and errors, they collected data from MEG (magnetoencephalography). The results of their study showed that high-functioning dyslexics show a greater priming effect than non-dyslexics with the prime which was both morphologically and semantically related. Their results also show that dyslexics rely on the semantic properties of the morphemes more than the orthographic properties. Law et al. (2017) showed that high-functioning dyslexics exhibited the largest significant priming effect with the prime that was both morphologically and semantically related to the target than the other primes, and this priming effect was greater than the priming effect for the non-dyslexics. Schiff et al. (2019) showed that the primes which were both morphologically and semantically related to the target resulted in a quicker reaction time for the high-functioning dyslexics, but not for the non-dyslexics.

As just discussed, research has shown that high-functioning dyslexics may compensate for their phonological deficit by increasing their reliance on the semantics in morphemes when processing words (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019), and this compensation might be what enables them to attend university. It is interesting to consider based on this whether high-functioning dyslexics are still more sensitive to morphology in other types of tasks where different processes are used, as it has only been shown in lexical decision tasks. Therefore this present study investigates whether high-functioning dyslexics do have a sensitivity to morphology in a primed verbal item short-term memory task.

High-functioning dyslexics were used in this study as previous research showing dyslexics have a sensitivity to morphology has only been conducted on high-functioning dyslexics (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019), therefore this group of dyslexics was chosen to be able to compare this present study to previous research. Furthermore, as there is no research showing non-high-functioning dyslexics have a morphological sensitivity only high-functioning dyslexics were used in this study. A memory task was chosen as studies, which were discussed earlier, show dyslexics have verbal item short-term memory deficits, which are a result of dyslexics' phonological deficits, and are still present in high-functioning dyslexics (Martinez Perez et al., 2013; Martinez Perez et al., 2015). Primed lexical decision tasks, which have previously been used to test high-functioning dyslexics' sensitivity to morphology (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019), test how dyslexics process a word to decide if it is a real word or a non-word. However, a primed verbal item short-term memory task tests how dyslexics process items in their short-term memory. This study is the first to investigate morphological sensitivity in high-functioning dyslexics in a process different from the one used in deciding if a word is real or not. It is important to investigate this in a new process as if high-functioning dyslexics have a sensitivity to morphology in multiple processes then it can be shown this sensitivity is not limited to one type of process and therefore the findings can be applied to real-world settings and interventions.

Therefore the question this present study aims to answer is “Does morphological priming affect verbal item short-term memory in high-functioning dyslexics more than non-dyslexics?”. If the results of this study show that morphological primes affect verbal item short-term memory more in dyslexics than non-dyslexics, the results of this study can be used to support the studies showing dyslexics are more sensitive to the semantics of morphemes than non-dyslexics (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019). Additionally, if the results show support that dyslexics are sensitive to morphology in another process, then this can be applied to real-world settings and dyslexics can focus on morphology when reading. The results would also show that despite dyslexics having verbal item short-term memory deficits (Martinez Perez et al., 2013; Martinez Perez et al., 2015), they are still sensitive to morphology in memory tasks. However, if the results do not support previous research showing dyslexics have a sensitivity to morphology (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019), then this will have implications for this theory.

To answer this research question a primed memory task was used, with high-functioning dyslexic, henceforth: dyslexic, and non-dyslexic participants. The participants were adults who attend or have attended university and will be fluent in English. Participants were presented with four words on the screen, one by one, followed by a prime word, then the target word, and then they were asked if the target word was one which they were initially presented with. The primes were semantically and morphologically related, henceforth: morphologically, or unrelated to the target word. The accuracy of the participants’ response and their response times were recorded.

Based on research that morphological primes in lexical decision tasks result in greater priming effects than other types of primes for dyslexics, and that these effects are greater for dyslexics than non-dyslexics (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019) it was hypothesised that morphologically related primes would lead to a greater priming effect for dyslexics than non-dyslexics. This would result in a greater difference in the accuracy of responses and reaction times between related and unrelated primes in dyslexics than non-dyslexics. It was expected that the accuracy of responses will increase with morphological primes and reaction times will decrease.

2. Methodology

2.1 Design

This study is attempting to answer the question “Does morphological priming affect verbal item short-term memory in high-functioning dyslexics more than non-dyslexics?” by having participants complete a memory task with either primes that are morphologically related or unrelated to the target word. Participants were asked if the target word was one they were initially presented with or not. The within-participant variable is the PRIME type: morphological prime and unrelated prime. The between-participant variable is GROUP: participants will either be dyslexic or non-dyslexic. An additional between-participant variable is LANGUAGE, and participants will either be native or non-native speakers of English. The factor LANGUAGE is not directly relevant to answering the research question, however, it is being considered because it may have an influence on the results. The dependent variables are the accuracy of the participants’ responses in the memory task and their reaction times. To answer “yes” to the research question a significant interaction between GROUP and PRIME would be needed. If dyslexics show a larger difference between their reaction times and accuracy with morphological primes and unrelated primes than non-dyslexics, with a shorter reaction time and higher accuracy for morphological primes than unrelated primes, the hypothesis will be correct.

2.2 Participants

For this study, the goal was to recruit at least 10 high-functioning dyslexics (dyslexics who attend or attended university (Deacon et al., 2006)) and 10 non-dyslexics who also attend or attended university. This criterion was important so that dyslexics were considered high-functioning. There needed to also be an equal split of native speakers of English and people who spoke English as a second language. This split of English speakers was not needed to answer the research question but was done to see if dyslexics have a morphological sensitivity in their second language as well as their first. This is due to all previous research showing dyslexics have a sensitivity to morphology testing participants only in their native language (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019). Furthermore, this split is done to see if this factor should be controlled in future studies. Participants were recruited through social media, personal contacts, and friends of friends. It was an unexpected challenge to recruit dyslexics who spoke English as a second language and who fitted the rest of the criteria. Reasons why this may be are mentioned in the discussion.

There were 13 non-dyslexics who were recruited, six who are native speakers of English, and seven who speak English as a second language. There were 11 high-functioning dyslexics who were recruited, eight who are native speakers of English, and three who speak English as a second language. One non-dyslexic participant was excluded from the data analysis due to them self-reporting as having another language disorder. Two dyslexic participants were excluded from the data analysis as they self-reported no university education.

This resulted in the responses of 21 participants being recorded, as they fitted the criteria. These included 12 non-dyslexics: six who are native English speakers, and six who are not, and nine dyslexics: six who are native English speakers, and three who are not. The dyslexics self-reported having a formal dyslexia diagnosis, and all participants self-reported as not being diagnosed with another language disorder. All participants also self-reported that they are either attending university or have done in the past, as well as self-reporting that their university education either is in English or was in English. They are all over the age of 18. All participants can read text on a computer screen. The genders and exact ages of the participants were not recorded, and the implications of this are discussed in the discussion section.

All participants read an information brochure about the study and gave informed consent before participating. The information brochure and informed consent form can be found in Appendix 2 and 3 respectively. The study was approved by the Ethics Committee in the Faculty of Humanities, University of Amsterdam.

2.3 Stimuli

There were four types of trials in this experiment and the stimuli were built based on these four types, which are given in table 2. In each trial participants saw four words which are the “Memory List” in table 2, then a *prime* word followed by a TARGET word. There were 92 trials in this experiment, and therefore 23 of each trial type. The first trial type had a morphological *prime* with the TARGET word not in the memory list. The second trial type had a morphological *prime* with the TARGET word in the memory list. The third trial type had an unrelated *prime* with the TARGET word not in the memory list. The fourth trial type had an unrelated *prime* with the TARGET word in the memory list. If the TARGET word was not in the memory list, then the TARGET was a minimal pair of one word in the memory list, as in

Martinez Perez et al. (2015). The minimal pair or TARGET in the memory list is shown in bold in table 2. A minimal pair is a word that differs by a phoneme, for example as seen in the trials in table 2 with the target not in the memory list: fire /faɪə/ and wire /waɪə/, lock /lɒk/ and rock /rɒk/. Minimal pairs in this experiment only differed by one phoneme and one orthographic letter.

Table 2: Four types of trials

Prime Type	TARGET in memory list	Memory List				*Prime*	TARGET
Morphological	No	goal	**fire**	free	roof	*wireless*	WIRE
	Yes	**peace**	wide	eye	grand	*peaceful*	PEACE
Unrelated	No	smooth	square	**rock**	born	*route*	LOCK
	Yes	**time**	soul	mode	north	*mud*	TIME

Every trial in this experiment was made up of four words in the memory list, one *prime,* and one TARGET, so six words in total. All stimuli besides the morphological *primes* were monomorphemic, monosyllabic, and free morphemes. In each of the 92 trials, three words from the memory list were not related to the TARGET and initially these 276 words were created. Then the TARGET word, the fourth word in the memory list, and *primes* were created and added to the stimuli for each trial. The stimuli were created with the aid of some websites (Bowen, 2016; *Improve Your English Pronunciation – Minimal Pairs,* 2022; *43 Minimal Pairs Examples,* 2022; *Minimal pairs list,* 2020; Manuel, 2022; *1 One Syllable Words | Monosyllabic Words,* 2022; *Monosyllabic – Examples of One Syllable Words and Adjectives,* 2022).

To begin with, the 276 words were created, and three words were randomly assigned to each trial (*Word Shuffler,* 2018). Then for trials with the TARGET word not in the memory list, 46 minimal pairs were found. One word in each of these pairs was the fourth word in the memory list for these trials, and the other was the TARGET word. For the trials with the TARGET word in the memory list, 46 TARGETS were created and were both the TARGET word and the fourth word in the memory list of these trials.

Finally, the *primes* were created. For the trials with a morphological *prime*, the *prime* was morphologically related to the TARGET word. For the trials with an unrelated *prime*, the *prime* created was unrelated to the TARGET word. The morphological *primes* were derivational, which means they are new words, and therefore get their own dictionary entry (Victoria State Government Education and Training, 2020). The Oxford English Dictionary (Oxford University Press, 2022) was used to confirm the morphological *prime* and TARGET words had separate dictionary entries, and to confirm the TARGET word and morphological *prime* were semantically related.

The order of the words in the memory list was randomised (*Random Sequence Generator*, 2022). The trials were also presented to participants in a random order. No words in the memory list in a trial were repeated in another trial's memory list. See Appendix 1 for all the stimuli.

2.4 Procedure

The task used in this study is based on the methodologies used in Martinez Perez et al. (2015), which tested dyslexics in a memory task, and Law et al. (2017), which tested dyslexics in a priming task. These methodologies from a priming task and a memory task were combined to form the methods for this current study, as described in further detail below.

Before the practice trials, the participants answered a few questions in an online questionnaire. The questions included if they were over the age of 18, if they had a formal diagnosis for dyslexia or if they were a non-dyslexic participant. They were also asked if they had any other language problems. Additionally, they were asked if English is their native language or their second language. Finally, they were asked if they were currently attending university or if they had already completed their university education in the past, and if their university education is or was in English.

Then the participants took part in the test trials. Before the 80 test trials, the participants took part in 12 practice trials to ensure they were familiar with what each trial entailed.

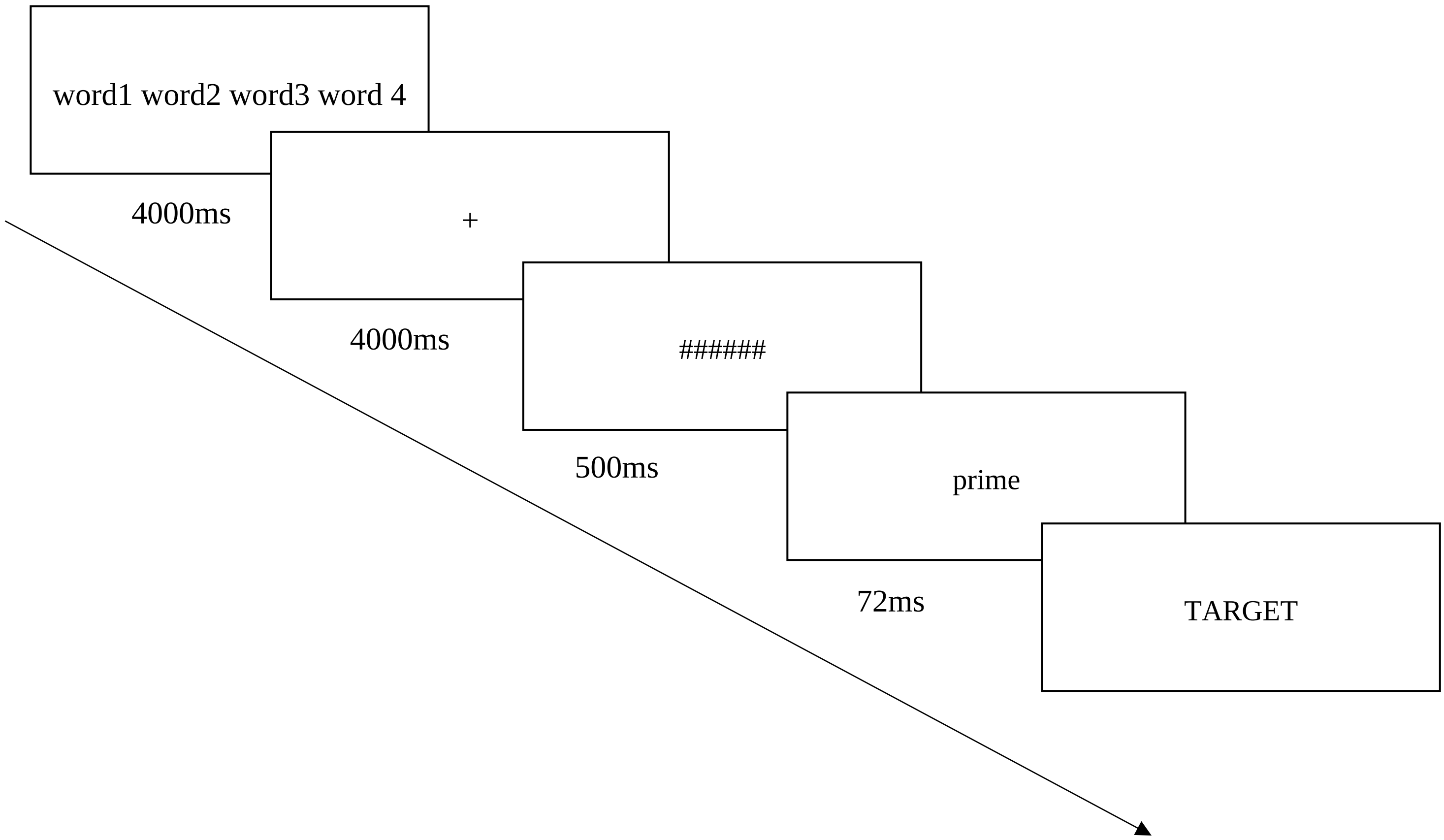

Figure 1: An individual trial

Figure 2: An individual trial

A trial is shown in figure 1 (diagonally) and figure 2 (horizontally). Figure 1 shows the length of time that each screen is presented to the participants, and figure 2 shows the trial in a timeline. In a trial, first participants saw four words presented on the screen horizontally, and in lower case for 4000ms, followed by a fixation cross for 4000ms, (following Martinez Perez et al., 2015). After this they saw a forward mask "######" for 500ms, then the *prime* word in lower case for 72ms, then the TARGET, which was in capitals, these parts are from the methodology in Law et al. (2017). When the TARGET word was on the screen the participants had to indicate if the TARGET word was in the memory list they saw on the first screen or not. They responded by clicking on their keyboard either “z” to indicate “yes” or “m” to indicate “no”. The time between each trial was 2000ms, as in Martinez Perez et al. (2015). Their reaction times and responses were recorded. Reaction time is measured from when the TARGET word appears on the screen until their response. Responses are measured as inaccurate or accurate.

The task was an online task and participants completed it on a computer. The online task was formed using the software “Experiment Designer” (Vet, D.J., 2022) which is software designed by Dirk Vet, who works at the University of Amsterdam. Dirk Vet assisted in putting the online task together using “Experiment Designer”.

3. Results

3.1 Participant Exclusion

Before participants completed the experiment, they were asked a few questions to ensure they fitted the criteria. Individual data points (out of the 80 test trial responses) were excluded from those participants if the reaction time was two standard deviations from their mean reaction time. Each participant had data points excluded, and in total out of 1680 data points, 93 were excluded, leaving 1587 data points to be analysed. A mean of 4.43 points per participant were excluded. Non-dyslexic participants had three to six points excluded, with a mean of 4.5. Dyslexic participants had three to seven points excluded with a mean of 4.3.

3.2 Descriptive Statistics

For each participant, a total of six averages were created to be used to calculate the descriptive statistics, and also for the statistical tests: Shapiro-Wilk normality test, Wilcoxon signed rank test, Independent samples *t*-test, and Mixed ANOVA in the following section. An average was created from all test trials for reaction time, and also for accuracy, to give one number for accuracy and one for reaction time for each participant. Averages were then calculated for reaction time and accuracy from the test trials with morphological primes and the test trials with unrelated primes. The averages for accuracy were then converted to percentages for the descriptive statistics.

The average accuracy of responses for dyslexic and non-dyslexic participants with morphological and unrelated primes are given in figure 3. Figure 3 shows that non-dyslexics on average had a higher accuracy than dyslexics with both morphological and unrelated primes. Figure 3 also shows that both dyslexics and non-dyslexics had on average more accurate responses with morphological primes than unrelated primes. From looking at figure 3, there is no interaction between PRIME type and GROUP (dyslexic and non-dyslexic) for accuracy, as the difference between the accuracy of responses for morphological primes and unrelated primes does not appear to be different between dyslexics and non-dyslexics. The standard deviation bars in figure 3 show a greater variation in accuracy for dyslexics than non-dyslexics.

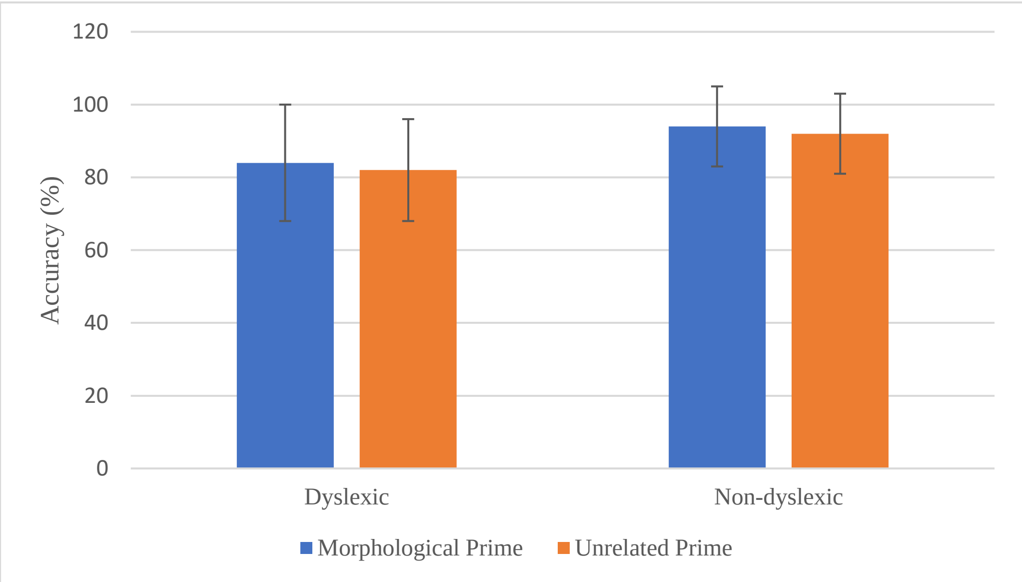

Figure 3: Average accuracy for dyslexics and non-dyslexics with morphological and unrelated primes

The average reaction times for dyslexic and non-dyslexic participants with morphological and unrelated primes are given in figure 4. Figure 4 shows that dyslexics on average had a slower response time than non-dyslexics with both morphological and unrelated primes. Figure 4 also shows that on average trials with morphological primes resulted in a slightly shorter response time for both dyslexics and non-dyslexics than unrelated primes. Figure 4 shows no interaction between PRIME type and GROUP (dyslexic and non-dyslexic) for reaction time, as the difference between the reaction time for the prime types is not noticeably different for dyslexics and non-dyslexics. The standard deviation bars in figure 4, show a greater variation in reaction times for dyslexics than non-dyslexics.

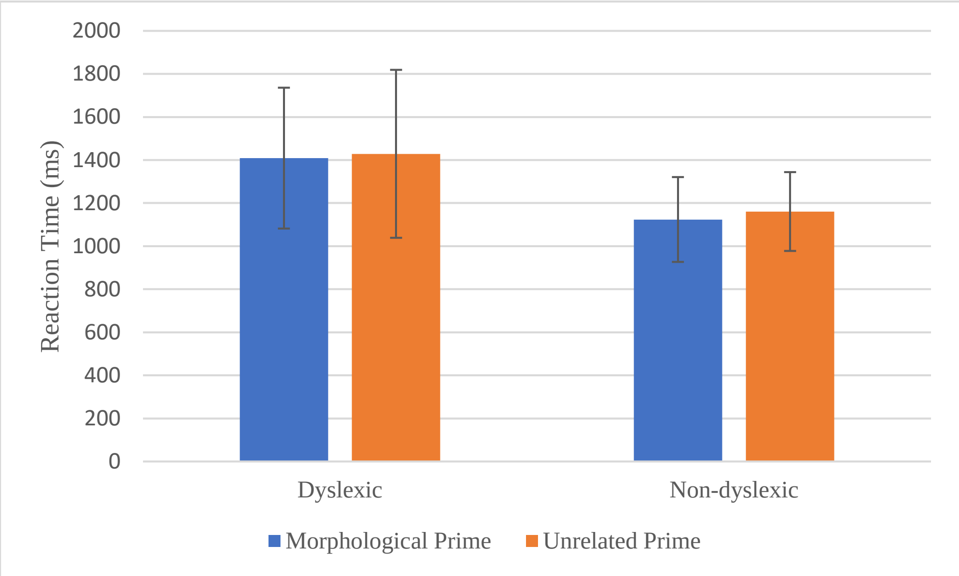

Figure 4: Average reaction time for dyslexics and non-dyslexics with morphological and unrelated primes

Tables 3 and 4, show the average accuracy of responses and reaction time respectively, giving the results for native and non-native speakers of English. LANGUAGE is not a factor that is directly related to the research question of this present study. However, the reason averages for LANGUAGE are included here is because this study is interested in seeing if dyslexics have a sensitivity to morphology in their second language as well as their first, henceforth: to control analyses. Therefore by comparing the data to see if there is a difference in averages between: native dyslexics, non-native dyslexics, native non-dyslexics, and non-native non-dyslexics with both morphological and unrelated primes, it can be seen if a morphological sensitivity is found in a native and non-native language for dyslexics.

Table 3 shows that native dyslexics, non-native dyslexics, native non-dyslexics, and non-native non-dyslexics had on average a greater accuracy for trials with morphological primes than unrelated primes. Table 3 also shows that on average non-native dyslexics had slightly more accurate responses with both prime types than native dyslexics. Native non-dyslexics are shown in table 3 to have on average more accurate responses than non-native non-dyslexics with both types of primes. This, therefore, suggests an interaction that non-native dyslexics outperform native dyslexics, but native non-dyslexics outperform non-native non-dyslexics.

Table 3: Average accuracy for dyslexics and non-dyslexics and natives and non-natives with morphological and unrelated primes

	Dyslexic		Non-dyslexic	
	Morphological Prime	Unrelated Prime	Morphological Prime	Unrelated Prime
Native	83%	82%	97%	95%
Non-native	86%	83%	90%	89%

Table 4 shows that three out of four participant groups: native dyslexics, native non-dyslexics, and non-native non-dyslexics have on average a lower reaction time with morphological primes than unrelated primes. Table 4 also shows that on average native dyslexics had a longer reaction time with both prime types than non-native dyslexics. Additionally, non-native non-dyslexics on average had a very slightly lower reaction time with both prime types than native non-dyslexics. Therefore non-native dyslexics and non-native non-dyslexics on average responded quicker than the native participants.

Table 4: Average reaction time for dyslexics and non-dyslexics and natives and non-natives with morphological and unrelated primes

	Dyslexic		Non-dyslexic	
	Morphological Prime	Unrelated Prime	Morphological Prime	Unrelated Prime
Native	1464ms	1539ms	1136ms	1183ms
Non-native	1300ms	1208ms	1113ms	1138ms

3.3 Statistical Tests

Statistics were then carried out on the results using RStudio (R Core Team, 2021). To begin with, Shapiro-Wilk normality tests were carried out to check if the data is normally distributed or not. A Shapiro-Wilk normality test is carried out with one dependent variable and one independent variable. Shapiro-Wilk tests with all possible combinations of dependent variables: reaction time and accuracy and independent variables: GROUP (dyslexic and non-dyslexic), PRIME (morphological and unrelated), and LANGUAGE (native and non-native) were carried out, and most combinations resulted in p-values < 0.05, indicating that the data is not normally distributed. However, when the reaction time was the dependent variable and the independent variable was GROUP, $p = 0.532$ for dyslexics and $p = 0.42$ for non-dyslexics, indicating normally distributed data. Therefore a non-parametric test is required to carry out the statistics for most of this data. The non-parametric test used is the Wilcoxon signed rank test. A Wilcoxon test requires one independent variable and one dependent variable, and the independent variable can be either a binary between-participant variable or within-participant variable. Below it will be indicated when a classical statistical test, either an Independent samples *t*-test or a Mixed ANOVA is used instead of the Wilcoxon test.

The first two Wilcoxon tests were conducted to test for a main effect of PRIME, with the accuracy of responses and reaction times combined across dyslexic and non-dyslexic participants. The output with accuracy as the dependent variable indicates that responses with morphological primes were significantly more accurate than responses with unrelated primes, $V = 182$, $p < 0.05$. The output with reaction time as the dependent variable indicates that responses with morphological primes were also significantly quicker than responses with unrelated primes, $V = 58$, $p < 0.05$. The results, therefore, show a significant main effect of PRIME, with morphological primes resulting in more accurate and faster responses than unrelated primes. This statistical result is somewhat surprising, from looking at figures 3 and 4, as the difference between prime types looks very small. An explanation could be as figures 3 and 4 show averages, however, the data is not normally distributed, which is not shown in figures 3 and 4, however it is taken into consideration in the Wilcoxon tests.

A Wilcoxon test was conducted to test for a main effect of GROUP with the accuracy of responses averaged across morphological and unrelated primes. The output indicates that the non-dyslexics' responses were significantly more accurate than the dyslexics' responses, $W = 82$, $p < 0.05$. Then an Independent samples *t*-test was used to test for a main effect of GROUP with the reaction time of responses averaged across morphological and unrelated primes, as this data is normally distributed. An Independent samples *t*-test is used for a binary between-participant variable. The results indicate there is not a significant difference between the reaction time of responses for dyslexics and non-dyslexics, $t(11.237) = -2.131$, $p = 0.056$. These results show a significant main effect of GROUP, with non-dyslexics' responses being more accurate than dyslexics' responses. However, the results also show a non-significant main effect of GROUP, with there being no statistically significant difference between the dyslexics' and non-dyslexics' reaction times.

The next Wilcoxon tests were conducted to test for a main effect of LANGUAGE, with the accuracy of responses and reaction times averaged across morphological and unrelated primes, and the factor GROUP not being considered. These statistical tests with the factor LANGUAGE were carried out, despite their results not being used to answer the research question, to control analyses. The output of the Wilcoxon test with accuracy as the dependent variable indicates that there is not a significant difference between the accuracy of native and non-native's responses, $W = 50$, $p = 0.808$. The output with reaction time as the dependent variable indicates that there is not a significant difference between the reaction time of native and non-native's responses, $W = 35$, $p = 0.193$. The results, therefore, do not show a significant main effect of LANGUAGE.

The difference was then calculated between each participant's average accuracy for morphological primes and unrelated primes, giving participants a number for their accuracy difference. Additionally, the difference between each participant's average reaction time for morphological and unrelated primes was calculated, giving participants a number for their reaction time differences. These differences were used for the Wilcoxon tests to test for interactions between GROUP (dyslexic and non-dyslexic) and PRIME (morphological and unrelated). First, a Wilcoxon test was used with the accuracy differences between prime types as the dependent variable and GROUP as the independent variable. The output indicates that there is not a significant interaction between GROUP and PRIME, $W = 51$, $p = 0.862$. As the data was normally distributed for GROUP with reaction time, but not normally distributed for PRIME with reaction time, both a Mixed ANOVA (a test for a binary within- and between-participant variable) and a Wilcoxon test were used to calculate an interaction. The Mixed ANOVA uses PRIME as the within-participant variable and GROUP as the between-participant variable. The Wilcoxon test used the reaction time differences as the dependent variable and GROUP as the independent variable. The outcome of the Mixed ANOVA indicates that there is not a significant interaction between GROUP and PRIME, $F(1,36) = 0.08$, $p = 0.78$. The output of the Wilcoxon test also indicates that there is not a significant interaction between GROUP and PRIME, $W = 49$, $p = 0.754$. The results, therefore, show no significant interaction between GROUP and PRIME for either accuracy or reaction time.

The differences in reaction time and accuracy between primes which were calculated above were then used for the Wilcoxon tests to test for interactions between LANGUAGE (native and non-native) and PRIME (morphological and unrelated). This interaction was tested, not because it is needed to answer the research question, but to control analyses. A Wilcoxon test was done with the accuracy differences as the dependent variable and LANGUAGE as the independent variable. The output indicates that there is not a significant interaction between LANGUAGE and PRIME, $W = 67$, $p = 0.3824$. Another Wilcoxon test is used with the reaction time differences as the dependent variable and LANGUAGE as the independent variable. The output indicates that there is a significant interaction between LANGUAGE and PRIME, $W = 83$, $p < 0.05$, with native speakers of English responding quicker with morphological primes than unrelated primes, and non-native English speakers responding quicker with unrelated primes than morphological primes. The results, therefore, are mixed, as the accuracy of responses does not show a significant interaction, but the reaction time of responses does show a significant interaction between LANGUAGE and PRIME.

4. Discussion

The aim of this study is to answer the research question "Does morphological priming affect verbal item short-term memory in high-functioning dyslexics more than non-dyslexics?". To answer the hypothesis of this present study as being correct, an interaction between the factors GROUP and PRIME is needed: it was hypothesised that dyslexics would show a larger difference between their reaction times and accuracy of responses for morphological primes and unrelated primes than non-dyslexics, with a shorter reaction time and higher accuracy with morphological primes than unrelated primes. The hypothesis of this study was based on research that shows that high-functioning dyslexics are more sensitive to the semantics of morphemes than non-dyslexics (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019), which enables them to compensate for their phonological deficit, and attend higher education. This study aimed to test if high-functioning dyslexics are sensitive to morphology in a different type of process than deciding if a word is real or not: their short-term memory process. If this present hypothesis is correct, it would offer further support for the sensitivity high-functioning dyslexics have towards the semantics of morphemes and would allow the findings to be applied to real world interventions.

The results show that the hypothesis is not supported. Therefore, the results cannot be used to support studies showing that high-functioning dyslexics are more sensitive to the semantics of morphemes than non-dyslexics are (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019). Firstly, as was expected, the results show that all participants on average responded quicker and more accurately with a morphological prime than an unrelated prime. Also, as expected dyslexics on average had less accurate responses than non-dyslexics. However, there was no difference between dyslexics' and non-dyslexics' response times. This result is unexpected, especially considering there was a difference in the accuracy of responses.

Most importantly, and unexpectedly the results did not show that the difference between dyslexics' response time and accuracy of responses for morphological and unrelated primes was bigger than the difference for non-dyslexics. Therefore the hypothesis is not supported.

There was no hypothesis for how natives would compare to non-native speakers, however, this was investigated to control analyses. The results show that there was no difference between native and non-native English speakers' reaction times and accuracy of responses. The results however do show that native speakers responded quicker with morphological than unrelated primes, and non-natives responded quicker with unrelated primes. Additionally, the descriptive statistics show that non-native dyslexics had a higher accuracy than native dyslexics, and native non-dyslexics had a higher accuracy than non-native non-dyslexics. Also, native dyslexics and non-dyslexics had a longer reaction time with both prime types compared to non-native dyslexics and non-dyslexics respectively.

Initially looking at the results of this study there are implications for the theory that high-functioning dyslexics are more sensitive to morphology than non-dyslexics. However as there are multiple limitations to this study, which will be discussed below, the implications are not so big. The previous studies which conclude that high-functioning dyslexics are more sensitive to the semantics of morphemes than non-dyslexics (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019) all used lexical decision tasks, giving an insight into the process of deciding if a word is real or not. Therefore since the results of this study do not support those studies, future studies should be conducted also using different tasks which rely on different processes to see if a morphological sensitivity is found across different processes or not.

A reason why the hypothesis may not have been supported is due to the fact that everyone with dyslexia has a unique set of symptoms and therefore there are lots of individual differences within dyslexics (National Health Service, 2022b). In this present study, due to time constraints in preparing for the study, as well as time limits with each participant, characteristics of the participants, including age, gender, exact educational level, IQ, and reading ability were not recorded. Previous research on dyslexics which was introduced in the introduction controlled for individual differences as much as possible (Cavalli et al., 2017; Law et al., 2017; Martinez Perez et al., 2013; Martinez Perez et al., 2015; Schiff et al., 2019). They did this by recruiting participants all from the same university who were matched in age, gender, educational level, and IQ. Additional to dyslexic participants having a formal diagnosis, they also carried out pre-tests to ensure there was a difference in reading abilities between the dyslexic and non-dyslexic participant groups. This ensured certain participant criteria were controlled for.

A lack of knowledge in this present study about the participant and a lack of control over criteria which has been controlled for in past research could have resulted in the hypothesis not being supported. Age, education level, IQ, and reading ability not being controlled could have impacted the current result pattern as they could influence high-functioning dyslexics' sensitivity to morphology. Perhaps having a sensitivity to morphology requires dyslexics to meet more criteria than just studying or having studied at university, for example being a certain age, currently being at university, and having a certain IQ and reading ability. In this study dyslexics could be any age over 18, they did not have to be currently at university, they just had to have completed a university education in the past, and they could have had any IQ or reading ability. However, if these factors are also predicting of whether a dyslexic has a sensitivity to morphology or not, if participants do not meet the criteria of these factors, they may not have a morphological sensitivity. In this present study, it is not known what these criteria are for the participants, therefore although they are considered high-functioning they may not meet the criteria to have a morphological sensitivity. This would lead to them not showing a greater difference in their reaction times and accuracy of responses with morphological primes and unrelated primes compared to non-dyslexics, as was shown by the current results. If these criteria had been controlled for and had matched the criteria of previous research which showed high-functioning dyslexics have a greater sensitivity to morphology than non-dyslexics (Cavalli et al., 2017; Law et al., 2017; Schiff et al., 2019) the hypothesis may have been supported. Future research should repeat this present study but with controlled participant criteria.

Not only were some participant variables not controlled for, but this study only used 21 participants, with only nine of these being dyslexic. This means that there could have been lots of participant variation among these nine dyslexics. Repeating this study with a larger controlled participant group, and therefore having more dyslexics, who have a similar age, current education status, IQ, and reading ability could result in the hypothesis being supported.

The reason only nine, not 12 dyslexics were used in this study, resulting in uneven participant groups was because it was surprisingly hard to find non-native dyslexic participants, meaning only three out of the desired six were recruited. A reason why this may be is perhaps non-native speakers of English would not choose to study in their L2 if they have dyslexia as it could be more difficult. It was mentioned in the introduction that dyslexics struggle with the mapping of letters to individual speech sounds (Ramus et al., 2003) and it has been shown that English, as compared to other languages, has a complicated mapping system, which leads to further difficulties for dyslexics learning English compared to languages with simple mapping systems (Dal, 2008, p. 443). This shows that learning English as a second language as a dyslexic is difficult, and therefore this supports the suggestion that non-native English speakers may not choose to study in their L2 if they have dyslexia. Therefore this could be a reason why it was a challenge to find non-native dyslexic participants for this present study.

The results of the native speakers compared to the non-native speakers of English will now be considered. The descriptive statistics show differences between scores for participants depending on if they are native or non-native speakers of English. Furthermore, this study showed that native speakers responded quicker with morphological than unrelated primes, and unexpectedly non-native speakers of English responded quicker with unrelated primes than morphological primes. Therefore, the results do not give clear evidence that non-native speakers of English have a sensitivity to morphology, as a result, it cannot be concluded that dyslexics have a sensitivity to morphology in their second language. Due to the mixed and unexpected results, future studies should be carried out with non-native and native speakers to further look into this and should also test participants in both their native and second language. Future research should also use larger and even participant groups. But based on the descriptive statistics and the interaction found in the current study, future studies should control if participants are native or second language speakers of the language of the study. Considering this, it would be interesting to repeat this experiment with just native English speakers and see if the hypothesis is supported.

Overall, future research should be conducted, replicating this study, but with improvements made to the limitations above.

5. Conclusion

In this study, the goal was to find out if high-functioning dyslexics are more sensitive to the semantics of morphemes than non-dyslexics in a memory task. The results of the study provide no evidence to show that high-functioning dyslexics have an advantage with morphological primes in a memory task compared to non-dyslexics. This study shows that dyslexics lack morphological sensitivity in memory tasks, which uses their short-term memory process, although this is present for them in lexical decision tasks, which uses a different process to decide if a word is real or not. This means that the hypothesis for the present study is not supported. This study does however support previous research (Martinez Perez et al., 2013; Martinez Perez et al., 2015) which shows that dyslexics have a verbal item short-term memory deficit. Due to the limitations of this study, this research should be repeated, with a larger group of participants, and with more knowledge and control of participant characteristics.

6. References

Atkinson, R. C., & Shiffrin, R. M. (1971). The Control of Short-Term Memory. *Scientific American*, *225*(2), 82-91. http://www.jstor.org/stable/24922803

Bowen, C. (2016, September 07). *Word Lists for Focused Auditory Input, Phonological Intervention, and Articulation Therapy*. Speech-language-therapy. https://www.speech-language-therapy.com/index.php?option=com_content&view=article&id=125:wordlists&catid=9:resources&Itemid=108

Burgess, N., & Hitch, G. J. (1999). Memory for serial order: A network model of the phonological loop and its timing. *Psychological Review*, *106*(3), 551–581. https://doi.org/10.1037/0033-295x.106.3.551

Cavalli, E., Colé, P., Pattamadilok, C., Badier, J. M., Zielinski, C., Chanoine, V., & Ziegler, J. C. (2017). Spatiotemporal reorganization of the reading network in adult dyslexia. *Cortex*, *92*, 204–221. https://doi.org/10.1016/j.cortex.2017.04.012

Cavalli, E., Duncan, L. G., Elbro, C., el Ahmadi, A., & Colé, P. (2016). Phonemic—Morphemic dissociation in university students with dyslexia: an index of reading compensation? *Annals of Dyslexia*, *67*(1), 63–84. https://doi.org/10.1007/s11881-016-0138-y

Dal, M. (2008) Dyslexia and foreign language learning. In G. Reid, A. J. Fawcett, F. Manis, & L. S. Siegel (Eds.), *The SAGE handbook of dyslexia* (pp. 439-455). SAGE Publications Ltd.

Deacon, S. H., Parrila, R., & Kirby, J. R. (2006). Processing of derived forms in high-functioning dyslexics. *Annals of Dyslexia*, *56*(1), 103–128. https://doi.org/10.1007/s11881-006-0005-3

Developmental Dyslexia. (2022). Dyslexia-Reading-Well. https://www.dyslexia-reading-well.com/developmental-dyslexia.html#:~:text=Use%20of%20the%20term%20primarily,is%20a%20life%20long%20condition

43 Minimal Pairs Examples: List for Pronunciation. (2022, May 17). All ESL. https://allesl.com/minimal-pairs-list-examples/

Improve Your English Pronunciation – Minimal Pairs. (2022). English-at-home.com. https://english-at-home.com/pronunciation-minimum-pairs/

Law, J. M., Veispak, A., Vanderauwera, J., & Ghesquière, P. (2017). Morphological awareness and visual processing of derivational morphology in high-functioning adults with dyslexia: An avenue to compensation? *Applied Psycholinguistics*, *39*(3), 483–506. https://doi.org/10.1017/s0142716417000467

Majerus, S., & Cowan, N. (2016). The Nature of Verbal Short-Term Impairment in Dyslexia: The Importance of Serial Order. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.01522

Manuel, J. (2022, January 14). *Pronunciation: List of Minimal Pairs.* EnglishPost.org. https://englishpost.org/pronunciation-list-minimal-pairs/

Martin, J., Colé, P., Leuwers, C., Casalis, S., Zorman, M., & Sprenger-Charolles, L. (2010). Reading in French-speaking adults with dyslexia. *Annals of Dyslexia*, *60*(2), 238–264. https://doi.org/10.1007/s11881-010-0043-8

Martinez Perez, T., Majerus, S., and Poncelet, M. (2013). Impaired short-term memory for order in adults with dyslexia. *Research in Developmental Disabilities*, *34*(7), 2211–2223. https://doi.org/10.1016/j.ridd.2013.04.005

Martinez Perez, T., Poncelet, M., Salmon, E., & Majerus, S. (2015). Functional Alterations in Order Short-Term Memory Networks in Adults With Dyslexia. *Developmental Neuropsychology*, *40*(7–8), 407–429. https://doi.org/10.1080/87565641.2016.1153098

Miller, G. A. (1994). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, *101*(2), 343–352. https://doi.org/10.1037//0033-295X.101.2.343

Minimal pairs list. (2020). Tiny TEFL Teacher. https://www.tinyteflteacher.co.uk/teach-english/pronunciation/minimal-pair-list

Monosyllabic – Examples of One Syllable Words and Adjectives. (2022) EnglishBix. https://www.englishbix.com/one-syllable-words/#

National Health Service. (2022a, March 07). *Overview Dyslexia*. https://www.nhs.uk/conditions/dyslexia/

National Health Service. (2022b, March 07). *Symptoms Dyslexia*. https://www.nhs.uk/conditions/dyslexia/symptoms/

1 One Syllable Words | Monosyllabic Words. (2022). Syllable Count. https://www.syllablecount.com/syllables/words/1_syllable_words

Oxford University Press. (2022). *Oxford English Dictionary*. https://www.oed.com/

Pennington, B. F., van Orden, G. C., Smith, S. D., Green, P. A., & Haith, M. M. (1990). Phonological Processing Skills and Deficits in Adult Dyslexics. *Child Development*, *61*(6), 1753. https://doi.org/10.2307/1130836

R Core Team. (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Ramus, F., Marshall, C. R., Rosen, S., and van der Lely, H. K. (2003). Theories of developmental dyslexia: insights from a multiple case study of dyslexic adults. *Brain*, *126*(4), 841–865. https://doi.org/10.1093/brain/awg076

Random Sequence Generator. (2022) Random.org. https://www.random.org/sequences/?min=1&max=4&col=1&format=html&rnd=new

Schiff, R., Cohen, M., Marton, R., & Sasson, A. (2019). Auditory Morphological Knowledge in Adults with Dyslexia: The Importance of Semantic Information. *Scientific Studies of Reading*, *23*(4), 317–333. https://doi.org/10.1080/10888438.2019.1568440

Vet, D.J. (2022). *Experiment Designer* [Program].

Victoria State Government Education and Training. (2020, November 02). *Word morphology*. https://www.education.vic.gov.au/school/teachers/teachingresources/discipline/english/literacy/readingviewing/Pages/litfocuswordmorph.aspx

Word Shuffler. (2018). Online Random Tools. https://onlinerandomtools.com/shuffle-words

7. Appendices

7.1 Appendix 1

7.1.1 Practice Trials

Prime Type	TARGET in memory list	Memory list				Prime	TARGET
Morphological	No	nail	art	tight	bold	*golden*	GOLD
		hint	own	nerve	east	*hunter*	HUNT
		race	rub	boy	vague	*joyful*	JOY
	Yes	smart	oak	fish	last	*fisher*	FISH
		deal	arm	hole	call	*caller*	CALL
		sing	keep	drop	meal	*singer*	SING
Unrelated	No	late	worst	nod	grab	*war*	LACE
		girl	white	die	loud	*fat*	TIE
		proud	cape	match	gap	*vast*	TAPE
	Yes	king	bus	rat	old	*grass*	KING
		love	one	pause	horse	*rough*	PAUSE
		guide	down	nest	queen	*key*	QUEEN

7.1.2 Test Trials

Prime Type	TARGET in memory list	Memory list				*Prime*	TARGET
Morphological	No	steep	near	door	juice	*fearful*	FEAR
		vile	beach	crow	round	*teacher*	TEACH
		pill	rose	rent	help	*killer*	KILL
		rest	keen	cold	talk	*walker*	WALK
		zone	found	seed	sweet	*feeder*	FEED
		dish	moist	street	weep	*deepen*	DEEP
		blind	patch	mate	quaint	*catcher*	CATCH
		frail	full	ship	raise	*shopper*	SHOP
		park	night	hot	earn	*darken*	DARK
		rope	glove	bomb	raw	*hopeful*	HOPE

		row	foul	guilt	wing	*winner*	WIN
		west	grin	might	school	*fighter*	FIGHT
		grow	fare	nice	ground	*careful*	CARE
		goal	fire	free	roof	*wireless*	WIRE
		mild	foot	loft	break	*soften*	SOFT
		paw	ring	join	deaf	*lawless*	LAW
		heel	glance	red	brace	*graceless*	GRACE
		salt	young	gain	yield	*painless*	PAIN
		wrong	true	name	farm	*harmful*	HARM
		root	harp	few	path	*sharpen*	SHARP
	Yes	age	drive	joint	tired	*driver*	DRIVE
		dry	rare	knee	point	*pointer*	POINT
		speak	yard	gun	dead	*speaker*	SPEAK
		knife	box	low	moon	*boxful*	BOX
		calm	food	cup	start	*cupful*	CUP
		dull	hair	ear	mail	*earful*	EAR
		man	bliss	high	eat	*blissful*	BLISS
		peace	wide	eye	grand	*peaceful*	PEACE
		left	bold	view	spoon	*spoonful*	SPOON
		drawn	black	straight	room	*blacken*	BLACK
		drunk	cord	vote	host	*drunken*	DRUNK
		mile	year	jet	thick	*thicken*	THICK
		count	bound	stiff	doll	*stiffen*	STIFF
		judge	flat	fresh	bare	*freshen*	FRESH
		step	wood	short	game	*wooden*	WOOD
		blame	urge	voice	pole	*blameless*	BLAME
		gang	fast	heart	worth	*worthless*	WORTH
		rate	fault	run	bid	*faultless*	FAULT
		wise	ghost	home	hate	*homeless*	HOME
		new	numb	guest	child	*childless*	CHILD
Unrelated	No	ill	guess	edge	sand	*gas*	HAND
		seat	glow	oil	golf	*gift*	HEAT

		slow	hat	gross	long	*meat*	STRONG
		shed	sold	ramp	month	*hip*	LAMP
		head	pig	blow	height	*road*	BIG
		smooth	square	rock	born	*route*	LOCK
		groom	mouth	group	bright	*health*	GLOOM
		week	stale	risk	bang	*hard*	BANK
		glass	port	faith	sour	*grave*	PART
		mat	odd	kiss	right	*cheap*	LIGHT
		sell	hour	toe	poor	*hang*	SHELL
		glaze	mess	harsh	loose	*broad*	MESH
		wheat	crown	vine	noise	*south*	WINE
		youth	rain	thing	nose	*quote*	THIN
		job	melt	neck	check	*bat*	CHICK
		air	desk	cake	nurse	*rail*	DISK
		tent	play	hide	wet	*male*	DENT
		goat	hold	van	tongue	*bread*	COAT
		kick	ride	pear	print	*bend*	BEAR
		beat	wild	house	lawn	*vain*	YAWN
	Yes	need	first	snake	milk	*rage*	FIRST
		fresh	read	rule	grade	*strong*	READ
		rude	end	flash	sound	*day*	FLASH
		wall	reign	act	aid	*egg*	WALL
		kid	whale	kind	owe	*hill*	OWE
		rank	mind	use	grain	*note*	GRAIN
		time	soul	mode	north	*mud*	TIME
		hall	pen	knee	rich	*base*	PEN
		raid	life	corn	roast	*guard*	CORN
		map	ball	clear	mourn	*sick*	MAP
		tall	inn	knit	green	*role*	KNIT
		tree	mad	move	gasp	*sun*	MAD
		hire	earth	greed	range	*quick*	RANGE
		net	pure	tame	half	*isle*	NET

		inch	scene	sat	stress	*joke*	SAT
		plain	jump	neat	sad	*huge*	SAD
		brave	myth	church	reach	*gate*	MYTH
		knock	plot	tough	blonde	*ripe*	TOUGH
		dumb	void	arch	rise	*merge*	DUMB
		cat	cook	best	hit	*weak*	COOK

7.2 Appendix 2

Dear participant,

You will be taking part in the Does Priming Improve Verbal Item Short-Term Memory? research project conducted by Issy Davison – Student, under supervision of Titia Benders – Assistant Professor, at the University of Amsterdam Linguistics Department. Before the research project can begin, it is important that you read about the procedures we will be applying. Make sure to read this brochure carefully.

Purpose of the research project:
In this research dyslexics and non-dyslexics will take part in a short-term memory task. The findings of the dyslexic participants will then be compared with the non-dyslexic participants.

Who can take part in this research?:
Dyslexics and non-dyslexic adults who are either native English speakers or who speak English as their second language are invited to take part in this research. To take part in this study you must attend university or have attended university in the past. Additionally the language of your university education must be or have been in English. To take part you must be able to read text on a computer screen. If you are a non-dyslexic participant, you must, to the best of your knowledge, not have any language problems. If you are a dyslexic participant, you must, to the best of your knowledge, not have any additional language problems, and will also have received a formal dyslexia diagnosis.

Instructions and procedure:
Initially you will be asked a few personal questions and you will either tick a box with your response or select your response from a list. The questions will ask your age, if you have a formal diagnosis for dyslexia or if you are a non-dyslexic participant. You will then be asked if you have any other language problems. Additionally you will be asked if English is your native language or your second language. Finally you will also be asked if you currently are attending university or if you did in the past, and if your university education is/was in English. After answering a few questions you will click a button to start the practice phase of the test. You will take part in a few practice trials before the test phase begins so you can become familiar with the procedure and after the practice trials you will take part in the test trials. You

will be notified when the practice trials are finished, and the test trials are starting. For a trial you will see a series of items on the computer screen, some items are words, and some are not words. The first screen you will see will contain a few words, and there will be a word on the final screen and your task is to decide if this word was on the first screen or not. You must press a button that either says yes or no. The total time to complete the experiment, including questions at the start will be maximum an hour.

Voluntary participation:

You will be participating in this research project on a voluntary basis. This means you are free to stop taking part at any stage. This will not have any consequences and you will not be obliged to finish the procedures described above. You can always decide to withdraw your consent later on. If you decide to stop or withdraw your consent, all the information gathered up until then will be permanently deleted.

Discomfort, Risks & Insurance:

The risks of participating in this research are no greater than in everyday situations at home. Previous experience in similar research has shown that no or hardly any discomfort is to be expected for participants. For all research at the University of Amsterdam, a standard liability insurance applies.

Confidential treatment of your details:

The information gathered over the course of this research will be used for further analysis and publication in scientific journals only. Your personal details will not be used in these publications, and we guarantee that you will remain anonymous under all circumstances.

The data gathered during the research will be encrypted and stored separately from the personal details. These personal details and the encryption key are only accessible to members of the research staff. Anonymous data will be stored for a period of 10 years. The personal data will only be stored as long as is necessary for the research and will be deleted as soon as possible.

Reimbursement:

If you wish, we can send you a summary of the general research results at a later stage.

Further information:

For further information on the research project, please contact Titia Benders (email: a.t.benders@uva.nl; Spuistraat 134, 1012VB Amsterdam).

If you have any complaints regarding this research project, you can contact the secretary of the Ethics Committee of the Faculty of Humanities of the University of Amsterdam, commissie-ethiek-fgw@uva.nl, phone number: +31 20 – 525 3054; Kloveniersburgwal 48, 1012 CX Amsterdam.

7.3 Appendix 3

‘I hereby declare that I have been clearly informed about the research project Does Priming Improve Verbal Item Short-Term Memory? at the University of Amsterdam, Linguistics department, conducted by Issy Davison – Student, under supervision of Titia Benders – Assistant Professor, as described in the information brochure. My questions have been answered to my satisfaction.

I realise that participation in this research is on an entirely voluntary basis. I retain the right to revoke this consent without having to provide any reasons for my decision. I am aware that I am entitled to discontinue the research at any time, and that I can always withdraw my consent after the research has ended. If I decide to stop or withdraw my consent, all the information gathered up until then will be permanently deleted.

If my research results are used in scientific publications or made public in any other way, they will be fully anonymised. My personal information may not be viewed by third parties without my express permission.

If I need any further information on the research, now or in the future, I can contact Titia Benders (e-mail: a.t.benders@uva.nl; Spuistraat 134, 1012 VB Amsterdam.

If I have any complaints regarding this research, I can contact the secretary of the Ethics Committee of the Faculty of Humanities of the University of Amsterdam; email: commissie-ethiek-fgw@uva.nl; phone number: +31 20 – 525 3054; Kloveniersburgwal 48, 1012 CX Amsterdam.

I consent to:

- personal information being stored for as long as required for the study	yes ☐	no ☐
- participate in this research	yes ☐	no ☐