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LEXICAL DECISION AND SEMANTIC RELATEDNESS JUDGMENT PROCESSING

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ABSTRACT

Numerous studies on semantic memory observed that monolinguals are faster and more accurate in processing concrete than abstract words. However, many aspects about bilingual semantic processing and lexical-semantic memory are not yet fully understood, including concreteness effects in second language (L2) processing. Furthermore, no study to date has compared unbalanced bilinguals and people with aphasia (PWA) on abstract and concrete word processing, although there is reason to suspect similar processing of the weaker language in bilinguals and the disrupted language in PWA. Both unbalanced bilinguals and monolingual English PWA may have weaker connections between the lexical form in English and the conceptual representation. This study involves Dutch-English bilinguals, neurologically healthy English monolinguals, and English monolinguals with aphasia and examines concreteness effects in lexical decision and semantic relatedness judgment tasks in English. Behavioral concreteness effects in L2 lexical decision were small and modulated by second language proficiency; furthermore, there was a stronger N400 for concrete than abstract words. Robust concreteness effects were found in the L2 semantic relationship judgment task, and for abstract words only, performance was better for associated than similar pairings. ERP data showed a larger N400 component in the concrete words for associated than similar pairings, and a reversed effect for abstract words. PWA did not show the expected concreteness effect in the lexical decision task but did show the same pattern as the bilinguals in the semantic relatedness task, though the results did not reach significance.

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Chapter 1

Introduction

Concreteness Effects

There are a number of features that can be used to describe and categorize words, which together make it possible to explain how these features of words affect the ways that they are processed. One of these features is concreteness. Concreteness refers to how directly a word refers to a tangible and imaginable entity which exists in the real world. Concrete words are those such as “table” or “dog” that have a direct imaginable referent. Abstract words, on the other hand, have no direct imaginable referent, such as “justice” or “love”.

The typical concreteness effect says that concrete words are processed more quickly and accurately than abstract words are. Additionally, the typical concreteness effect cites a stronger N400 for concrete as compared to abstract words (Holcomb, Kounios, Anderson, & West, 1999). The N400 is an ERP component associated with semantic integration, and will be discussed further in the next section.

Two main theories have been proposed to explain these concreteness effects: Dual-Coding theory and Context Availability theory. Dual-Coding theory states that people have two types of mental representations for words, verbal and image-based (Paivio, 1986). Concrete words, because they have a direct referent, are processed equally through both systems. Abstract words, on the other hand, cannot be processed through the image-based system (Jessen, Heun, Erb, Granath, Klose, Papassotiropoulos & Grodd, 2000). They can only be understood through their relationships with other words, which is the verbal system. Dual-Coding theory thus says that because concrete words can be processed through two codes simultaneously, they can be processed more quickly and accurately than abstract words. It can also account for the typical N400 effect by claiming that the N400 has a higher amplitude for concrete than abstract words because more information needs to be integrated in order to process concrete words (Holcomb et al., 1999).

In contrast with Dual-Coding theory, Context Availability theory claims that all words are processed through one system, regardless of concreteness. However, concrete and abstract words differ with respect to how sensitive the word meanings are to context. The meanings of concrete words tend to be fairly stable in any number of contexts, while the meanings of abstract words are more variable and context-dependent (Schwanenflugel, 1991). This theory can account for the typical concreteness effects by claiming that concrete words can be processed more quickly and accurately because there is no need to analyze the context to determine the intended meaning. Context availability also gains credence by the fact that when an abstract word is scaffolded by a conceptually constraining context, it is processed just as quickly and accurately as concrete words (Hoffman, Jefferies, & Ralph, 2010).

Although the standard concreteness effect claims that concrete words are processed more quickly, prior research has also shown that when word lists are controlled for lexical factors including context availability and imageability, abstract words actually show a faster response time (van Hell & de Groot, 1998; Barber, 2013). This finding supports and Context Availability theory—if the words are equally imageable regardless of concreteness, then concrete words have no advantage in the image-based coding system. Further, if the context availability is the same across concreteness, then the predicted effect of abstract words relying more on context to determine meaning does not apply, which also argues against dual coding theory.

ERPs and the N400

The N400 is a negative event-related potential component that typically peaks at 400ms post-stimulus onset. Event-related potential is a common methodology in language research that uses electroencephalography to measure participants' brain waves while processing language, and is used for its high temporal resolution. The N400 has been linked to semantic processing and integration, and in the traditional literature is found to be strongest when a word does not make sense in context (i.e. She takes her coffee with milk and DOG). The N400 has also been shown to be modulated by an individual's real-world knowledge, by the frequency and familiarity of the word, by the word's orthographic density, and by the degree to which the word make sense in context.

As previously mentioned, the typical N400 effect related to concreteness shows stronger negativity for concrete words as compared to abstract words (Holcomb, Kounios, Anderson, & West, 1999; Adorni & Proverbio, 2012).

Semantic Relationships

Semantic relationships are the qualitative relationships that exist between words that connect these words through meaning. That is, semantic relationships explain the types of ways that you can claim two words are "related" in meaning. There are a number of ways that these relationships can be categorized including (but not limited to): taxonomic, thematic, syntagmatic, paradigmatic, association, similarity, ad hoc, and rule-based/single-feature. These terms can be generally grouped into two categories: taxonomic-like and thematic-like. In this situation, taxonomic-like groupings are those which refer to features that are shared among word meanings that could create a hierarchical organization pattern, while thematic-like groupings are more concerned with word usage and relationships between words that lead them to be used together. Table 1 defines each relationship type and groups them into these broadly defined categories (Mirman, 2017).

Table 1. Semantic Relationship Groupings

	Taxonomic-like	**Thematic-like**
Taxonomic/thematic distinction	**Taxonomic:** Refers to shared features between words and a hierarchical system that organizes word meanings	**Thematic:** Refers to shared contexts between words
Syntagmatic/paradigmatic distinction	**Paradigmatic:** Refers to two words from the same grammatical class which share key semantic features and are conceptually similar	**Syntagmatic:** Refers to two words which could occur contiguously in a sentence
Association/similarity distinction	**Similarity:** Refers to words which belong to the same category and are the same type of object	**Association:** Refers to words which contribute to the same context **NOTE:** word association can also be used to refer to a task where a participant is told to "say the first word that comes to mind" when they are presented with a word. That type of relationship is not considered here.
Miscellaneous relationships	**Rule-based and Single-feature:** Refers to words which share a single, defined feature i.e. "things that are green" or "things you put in the toaster"	**Ad hoc:** Refers to words which can be placed in a contrived, context-specific, category i.e. "things to save from a burning house"

Much of the research to date regarding taxonomic and thematic relationships has focused on developmental trajectories related to a child's usage and understanding of these relationship types. Markman and Hutchinson (1984) found that children under age six prefer thematic relationships when asked to choose objects that go together. These children would use taxonomic relationships when specifically prompted to "find another *fep*," which cued them to consider the properties of words rather than just meaning. However, older children and adults show a general preference for taxonomic relationships whether or not they are given a verbal cue to focus on words.

Previous studies have explored the relationship between semantic relationships and concreteness and found an interaction. Crutch, Connell, and Warrington (2008) found that in an odd-one-out task, neurologically healthy English monolinguals were faster and more accurate for abstract words when the words that belonged were related by association than by similarity, but faster and more accurate for concrete words when the words that belonged were related by similarity than by association. Furthermore, in the associative condition abstract words were responded to more quickly and accurately than concrete words, thus showing a reversal of the concreteness effect in the associated context. This is in line with prior evidence in support of context availability theory, which has shown that when abstract words are presented in a constraining context the concreteness effect is diminished.

This interaction between relationship type and concreteness, in conjunction with prior studies finding the same patterns of preference in English monolinguals with aphasia, provides evidence for the different representational frameworks hypothesis. This theory proposes that abstract and concrete words are fundamentally different, and the semantic frameworks in which they are represented and processed point to that fundamental difference.

Bilinguals

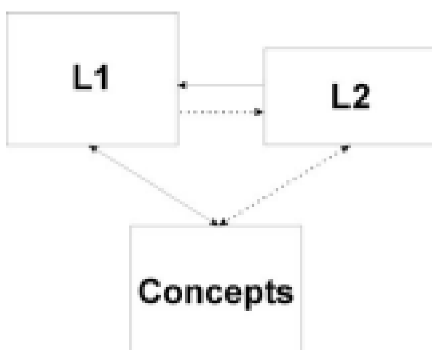
In this study, the term bilingual is used to refer to any individual who is fluent (or highly proficient) in two languages. Bilingualism is particularly important to study in language science because a majority of the world's population speaks multiple languages; thus, it is important to consider how people who are bilingual learn and process each of their languages in order to better support these individuals and to help monolinguals learn a second language.

There are generally considered to be two types of bilinguals, which must be considered separately as their methods of language development differ in significant ways. Simultaneous bilinguals, also known as crib bilinguals, are people who acquire multiple languages from birth. Simultaneous bilinguals can also be defined as children who begin to acquire their second language while still in the process of acquiring their first language, typically considered to be age three. Sequential bilinguals, on the other hand, do not begin to acquire their second language until after age 3, once they are beginning to speak in full phrases in the first language. Often sequential bilinguals do not learn their second language until school or even well into adulthood.

Children learning their first language must start from the very beginning and explore what language is and how sounds map to meanings and referents in their physical environment. This is perhaps the most important question when considering simultaneous bilinguals: how do children, who are still figuring out how language works as a concept, learn to distinguish between the languages to which they are exposed and map representations to referents in two different ways? Sequential bilinguals, on the other hand, have already developed a full linguistic system and understand how word meanings work (as well as the ways that words can be related to one another) before they begin to acquire their second language. Further, individuals learning a second language are often explicitly taught the language rather than learning through natural exposure the way a first language is acquired. Thus, the overarching consideration for sequential bilinguals is how people develop a second language system that is independent from the structure of their L1 (and indeed, whether the break from that L1 scaffold ever truly occurs).

There are a number of models to explain how bilinguals acquire their second language and the degree to which L1 knowledge scaffolds L2 learning. One such model is the Revised Hierarchical Model, pictured below (Kroll and Stewart, 1994). This model was originally proposed to explain differences in translation latency from L1 → L2 and L2 → L1. It claims that in emerging bilinguals, word meanings in L2 are understood via translation from L1, but as a person gains proficiency, direct connections between the concept and L2 word form are strengthened so L1 is no longer relied upon as a mediator.

Figure 1. Revised Hierarchical Model



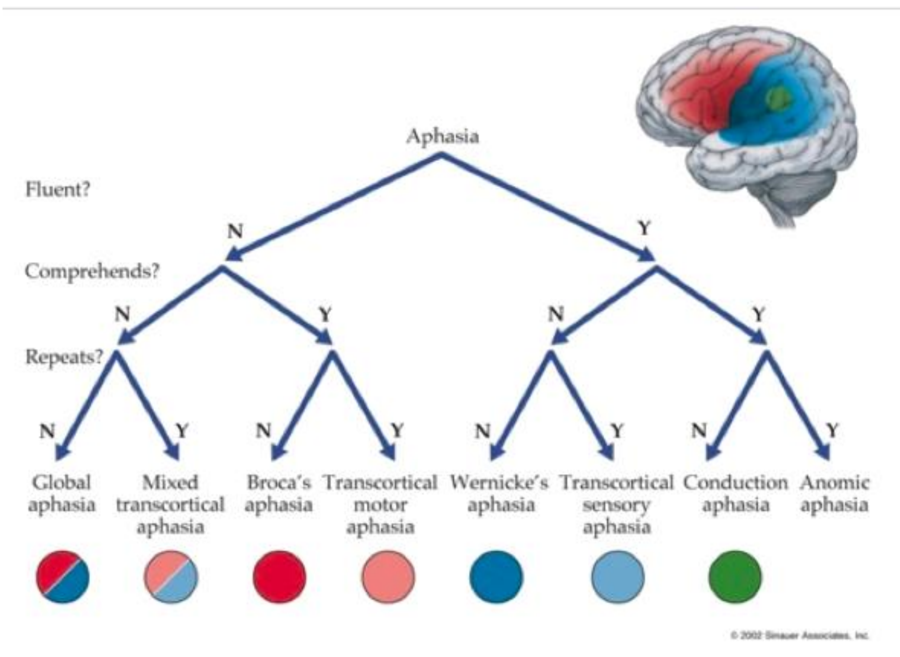
Recent criticism of the RHM has focused on evidence that bilinguals do not have separate lexicons for L1 and L2, and that there is not selective access of a particular lexicon (Brysbaert and Duyck, 2009). Models such as the Bilingual Interactive Activation (BIA) and BIA+ have been proposed in order to better address this natural interaction between L1 and L2 lexicons (Dijkstra and van Heuven, 2002).

This study will focus on sequential bilinguals in their L2, though considerations for simultaneous bilinguals and the L1 in simultaneous bilinguals will be discussed.

Aphasia

Aphasia is an acquired language disorder due to damage to the brain structures responsible for language. It is most common after a stroke, when the areas of the brain are deprived of blood (and therefore, oxygen). Aphasia can affect all language modalities (reading, writing, verbal, sign, etc.) and all aspects of language (production, comprehension, repetition). Although each person with aphasia differs with regard to their exact strengths and weaknesses in language, there are methods of characterizing aphasia based on common profiles.

Figure 2. Main characteristics of aphasia types



The image above highlights the differences between the eight most common classic aphasia types, based on the patient’s ability to produce, comprehend, and repeat language

(Sinauer Associates, 2002). The present study will focus only on four aphasia subtypes: Broca's, anomic, conduction, and transcortical motor. Patients with these four types of aphasia are all relatively unimpaired in language comprehension, though they do struggle with language production to varying degrees. The strongest deficits exhibited by people with anomic aphasia are in naming; otherwise their expressive language skills tend to be within normal limits. People with conduction aphasia often also struggle with naming, although their primary deficit is in repetition. This form of aphasia is due to an injury to the arcuate fasciculus, which forms the connection between Broca's area and Wernicke's area (the brain regions touted as responsible for language production and language comprehension, respectively). Thus, when the arcuate fasciculus is damaged, people have difficulty moving information directly from comprehension to production. Broca's aphasia is one of the most common and well-known forms of aphasia, and is due to damage to the left inferior frontal gyrus (Brodmann's areas 44 and 45). Broca's aphasia is a classic expressive aphasia, meaning that people with this disorder have deficits in all areas of language expression. Some hallmarks of the disorder include telegraphic speech, difficulty with naming, apraxia, short agrammatic phrases, and an inability to repeat. Despite these deficits in expression, patients with Broca's aphasia still tend to have intact comprehension. Transcortical motor aphasia is very similar to Broca's aphasia in terms of the brain region affected and the hallmark symptoms, though crucially repetition is relatively spared in transcortical motor aphasia.

Previous studies focusing on patients with aphasia have examined the ways that treatments for these patients can be structured to improve their word-finding abilities. As previously discussed, word-finding is most strongly associated with anomia, though anomia tends to be present (though not the strongest symptom) in most PWA, and tends to continue even after other language deficits have shown improvement. Sandberg and Kiran (2014) found that by training people with aphasia on abstract words, patients were able to generalize that training and knowledge to concrete words within the same category. Here, categories are determined by contexts in which the word may be used, such as “courthouse” or “hospital.”

The current study

The current study aims to further explore concreteness effects and different types of semantic relationships among both healthy bilinguals and monolinguals with aphasia, using neurologically healthy monolinguals as a control group. This study draws on prior research on concreteness effects both behaviorally and electrophysiologically, as well as research expressing evidence for differential semantic frameworks for abstract and concrete words. It will do this by examining behavioral responses such as accuracy and reaction time, as well as electrophysiological evidence for semantic processing. Furthermore, possible influences of fluency will be discussed, as well as the naturally following implications for second language education.

Chapter 2

Materials and Methods

Overview

The current study consists of two tasks, a lexical decision task and a semantic relatedness task. The order in which participants completed the two tasks was counterbalanced, to eliminate any fatigue effects resulting from consistently performing the same task at the end of the session. During each task, participants' brain waves were measured using event-related potentials and participants were asked to answer simple yes/no questions for each trial. Four separate groups of participants completed these two tasks: Dutch-English bilinguals, young adult English monolinguals, older adult English monolinguals, and English monolinguals with aphasia.

Lexical Decision Task

A lexical decision task is one in which participants are shown a string of letters and asked to decide whether the given letter string is a real word in the language of the task. The current task consisted of 232 letter strings. 116 letter strings were real words in English, while the other 116 letter strings were non-words. Of the 116 real English words, 58 were categorized as abstract and 58 were categorized as concrete.

The abstract and concrete words were taken from the MRC Psycholinguistics Database (Wilson, 1988) and values compared for cognate status, concreteness, familiarity, length, and log frequency in English. Two-sample equal variance t-tests were performed for each rating to ensure cognate status, familiarity, length, and log frequency were balanced across word types. See Appendix A for a complete list of lexical decision stimuli with lexicality ratings.

The non-words were retrieved from the ARC Nonword database (Rastle, Harrington, & Coltheart, 2002). 116 words were randomly selected, which all had a neighborhood size of 0-3 and were matched in number length to the real words previously described.

The task was run through Presentation, from Neurobehavioral Systems. Instructions and trials were presented on a gray background in white font centered on the screen. Participants were seated 3 feet away from the screen. Each trial consisted of a fixation cross for 700ms followed by a blank screen for 300ms, then the letter string for 500ms, then a question mark for up to 2000ms. Participants were instructed to wait to respond until they saw the question mark, at which point they should indicate either YES (real word) or NO (not a real word) via a button press. The YES button was situated under the participants' left index finger and the NO button was situated under the participants' left middle finger. Once the participant responded, the question mark was replaced by a blank screen for 750ms before the next trial began.

All participants started by completing a practice session which consisted of 10 trials. After the practice session, the researcher checked to ensure the participants understood the directions before the full session began. All stimuli were completely randomized for each participant and then split into four blocks of 58 trials each. Participants were given the opportunity to stretch, yawn, cough, and drink water between blocks.

Semantic Relatedness Task

A semantic relatedness task is one in which participants are asked to judge whether the meanings of two words are related. The present task consisted of 320 pairs of real words in English. These 320 pairs of words were balanced across abstract and concrete, related and unrelated, and type of relationship (within the related words). Table 1 shows the breakdown of how many pairs of words were presented for each category and gives an example for each category.

Table 2. Semantic Relatedness Stimuli Examples

	Associated	Similar	Unrelated
Abstract	(n=40) NUMBER-SUM	(n=40) AID-HELP	(n=80) DIVERSITY-ROMANCE
Concrete	(n=40) SHIP-SEA	(n=40) CORN-PEA	(n=80) BEETLE-SLEIGH

Here, similar pairs are words which are related taxonomically. This means that the words are the same type of thing and belong to the same category. For abstract words, similar pairs were defined as synonyms or near-synonyms. Associated pairs are words which are related thematically. This means that the words contribute to the same context or whose usage is functionally related. Pairs such as “bread—butter”, which contribute to the same context but are also used together frequently as a combination, were not used.

The relationship types were separated into blocks, such that participants completed two blocks when all the related words were related by similarity, and two blocks when all the related words were related by association. Relationship types were defined for the participants at the beginning of the study, and participants were told at the beginning of each block which relationship type to expect. Each block consisted of 80 word pairs, equally split across related/unrelated and abstract/concrete. Four such lists were devised, and each participant was pre-assigned to a stimuli list. Like in the Lexical Decision task, each participant also completed a practice session before beginning the full task. The practice session included 12 trials split into two blocks (one association block and one similarity block). After the practice session, participants were given the opportunity to ask any questions about the task and to receive feedback regarding their performance before the full task began.

In addition to the semantic features already noted, lexical ratings such as those balanced for in the lexical decision task were also tracked. See Appendix 2 for a complete list of semantic relatedness stimuli and their lexical ratings.

The task was run through Presentation, from Neurobehavioral Systems. Instructions and trials were presented on a gray background in white font centered on the screen. Participants were seated 3 feet away from the screen. Each trial consisted of a fixation cross for 700ms, followed by a blank screen for 300ms, then the first word for 500ms, then the second word for 500ms, then a question mark for up to 2000ms. Participants were instructed to wait to respond until they saw the question mark, at which point they should indicate either YES (meanings are related) or NO (meanings are not related) via a button press. The YES button was situated under the participants' left index finger and the NO button was situated under the participants' left middle finger. Once the participant responded, the question mark was replaced by a blank screen for 750ms before the next trial began.

Participants

Four groups of participants completed this study, with different language backgrounds. The groups were as follows: Dutch-English bilinguals, young adult neurologically healthy English monolinguals, older adult neurologically healthy English monolinguals, adult English monolinguals with aphasia (PWA). All participants completed a language history questionnaire before participating in the study to collect information on their language learning and usage experience, as well as other potentially relevant information such as handedness. We will focus only on the bilingual and PWA groups here.

25 Dutch-English bilinguals participated in this study. All were recruited and tested at the Donders Center for Cognition at Radboud University, Nijmegen, The Netherlands, in May-June 2016. They all received an IRIS check for 20 Euros (10 Euros/hour) at the end of the study. The participants had an age range of 18-30, with an average age of 21.6. All were highly proficient in English, though some had more exposure to English and used the language more in their daily lives and were thus more proficient than others. All participants were right-handed, and only one reported a left-handed immediate family member. For a complete list of responses, see Appendix C.

11 English monolinguals with aphasia participated in this study. All were recruited through Central Pennsylvania organizations and databases, as well as the Penn State Hershey Medical Center. They were tested using a portable EEG system at Penn State Hershey Medical Center. All participants were right handed and had at least a high school education. Their ages ranged from 51-82, with an average age of 62.3. Their Aphasia Quotients ranged from 40.3-96.6 with an average AQ of 76.2. Patients had anomic aphasia, Broca's aphasia, transcortical motor aphasia, and conduction aphasia. For a complete list of responses, see Appendix C.

EEG acquisition and analysis

All Dutch-English bilinguals were recruited and tested at Radboud University, Nijmegen, The Netherlands. Data was gathered using a 32-channel ActiCap system, which used active Ag/AgCl electrodes placed on 28 locations on the scalp (including Ground and Reference electrodes), one electrode on each mastoid bone, and electrodes to the outside of each eye and above and below the left eye to monitor ocular artifacts. Impedances were kept below 5 kΩ.

Scalp electrodes were rereferenced offline using BrainVision to the average activity recorded over the right and left mastoids and was filtered offline using a low cutoff of 1.59 Hz and high cutoff of 30 Hz. Independent Component Analysis was used to identify and correct for eyeblinks, and manual inspection was used to identify and discard any trials with other artifacts.

Only correct trials were considered, and electrodes Fz, Cz, and Pz were pooled and averaged for analysis. ERP analysis was conducted on one time window, 300-500ms post-stimulus, as this time window is representative of the N400, our neural pattern of interest. ANOVA for the

Chapter 3

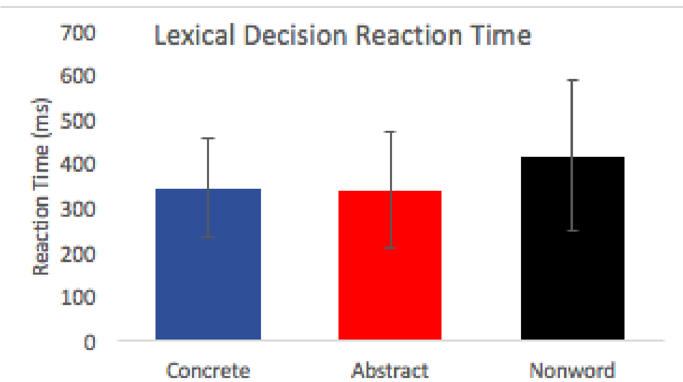
Results

Bilinguals

Lexical Decision

Reaction time and accuracy data was collected for the lexical decision task. Participants responded to each trial via button press, and were instructed to wait to respond until after the word on the screen was replaced with a question mark.

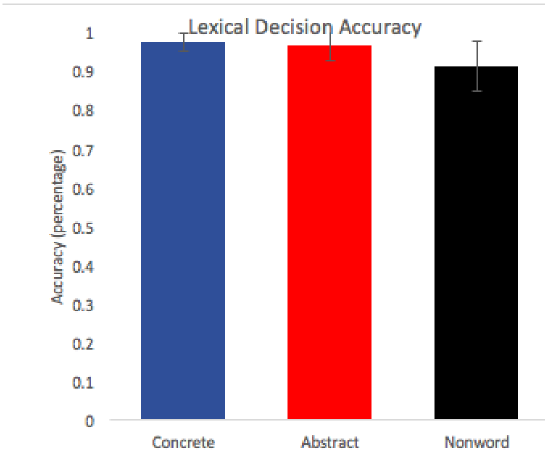
Figure 3. Lexical Decision Reaction Times --Bilinguals



Here, reaction time was only considered for correct trials—trials with an incorrect response or no response were not included in the reaction time data analysis. Furthermore, trials with a RT more than 2.5 standard deviations away from the average RT were not included in further analysis. Paired t-tests were performed between concrete and abstract words, and between words and non-words. Concrete and abstract reaction times were not statistically different (p >

0.05), but reaction time for non-words was significantly slower than reaction time for words ($p <$ .01).

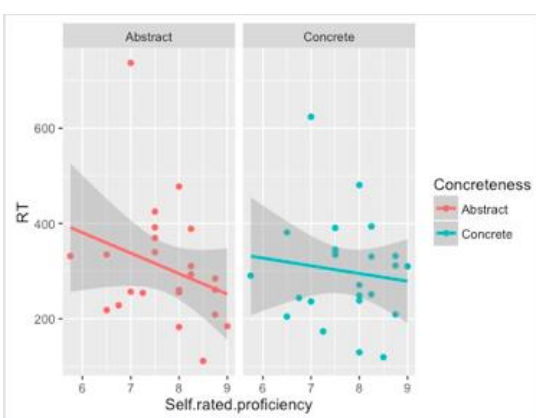
Figure 4. **Lexical Decision Accuracy--Bilinguals**

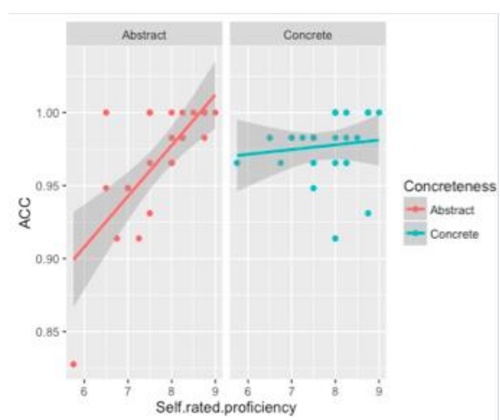


All trials were included in determining a participants' accuracy; trials with no response were coded as incorrect. Paired t-tests were performed for concrete and abstract words, and for words and non-words. Accuracy for concrete and abstract words was not significantly different ($p > 0.05$), but real words were significantly more accurate than non-words ($p < .001$, $|t| = 4.392$, df = 24). Note that participants were close to ceiling (M = .94, SD = .036 across all conditions).

Figure 5. RT as a function of proficiency--Bilinguals (left)

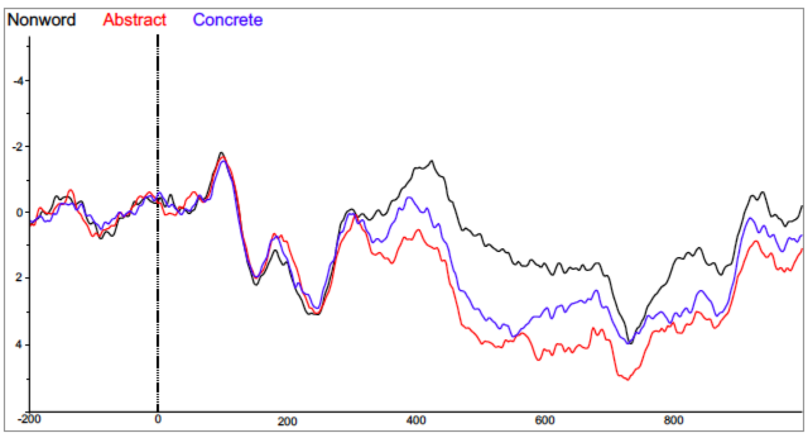
Figure 6. Accuracy as a function of proficiency--Bilinguals (right)





When further considering proficiency, we can see that a participant's self-rated proficiency predicted both reaction time and accuracy for abstract words only. Self-rated proficiency was averaged across speaking, reading, writing, and listening for each participant. The figures above show linear regression models as a function of self-rated proficiency and concreteness and show an interaction between proficiency and concreteness, where Accuracy changes as proficiency increases for abstract words only ($p < 0.001$, $F(3,44) = 10.02$).

Figure 7. Lexical Decision ERP--Bilinguals



For the ERP data here, electrodes Fz, Cz, and Pz were pooled and averaged. Information regarding strength of N400 was computed by finding the area from 300-500ms for each condition and comparing these areas.

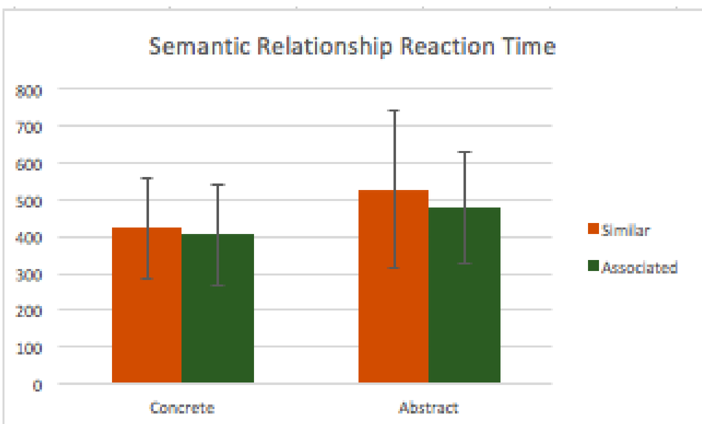
Paired t-tests were performed between concrete and abstract words, and between words and non-words. Non-words were more negative than real words ($p < 0.05$; $|t| = 5.1002$). Concrete words were more negative than abstract words ($p < 0.05$; $|t| = 3.4568$).

Semantic Relatedness

Reaction time and accuracy data were also collected for each trial of the semantic relatedness task. Note that as in the lexical decision task, participants were instructed to wait to respond until the second word in the pair had been replaced with a question mark.

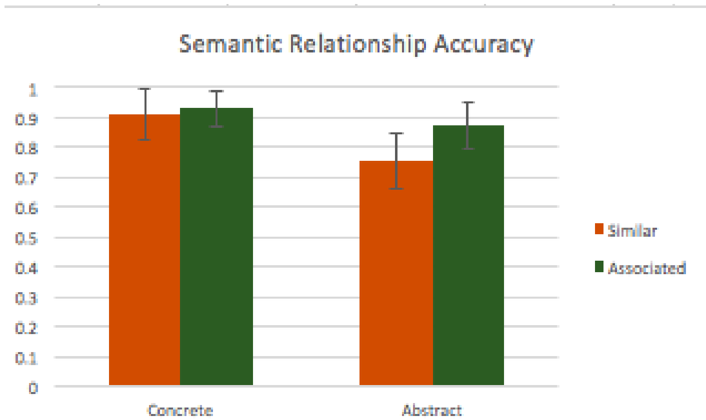
As in the lexical decision task, incorrect trials and trials with no response were not included in determining reaction time, and trials with a reaction time more than 2.5 standard deviations from the mean were also excluded.

Figure 8. Semantic Relatedness Reaction Times--Bilinguals



An ANOVA was performed using concreteness and relationship as within-subjects factors to determine the interaction between concreteness and relationship type, and a main effect of concreteness on reaction time was found ($p < .01$; F = 7.21, df = 1). No other effects were significant in reaction time.

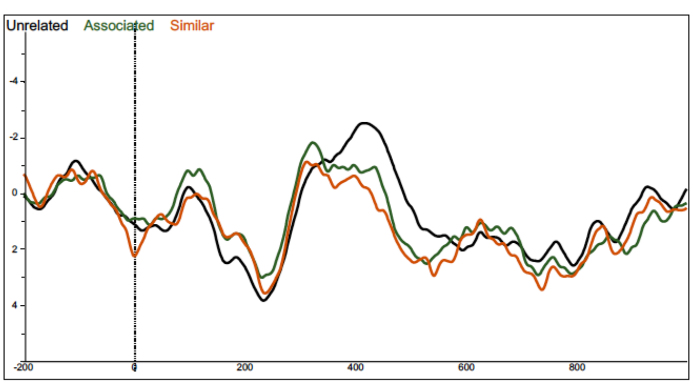
Figure 9. Semantic Relatedness Accuracy--Bilinguals

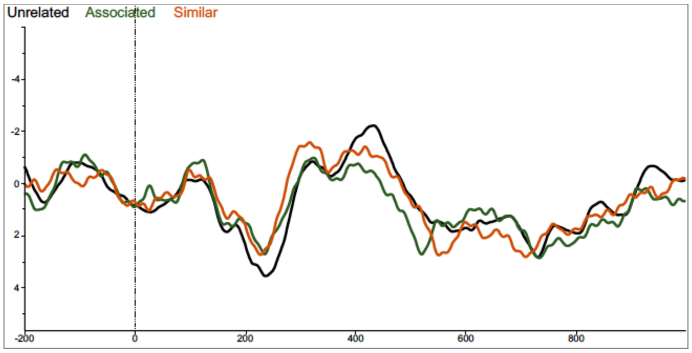


An ANOVA was performed using concreteness and relationship type as within-subjects factors to determine the interaction between concreteness and relationship type, and main effects of concreteness ($p < .001$; $F = 43.662$), relationship type ($p < .001$; $F = 17.731$), and interaction ($p < .01$; $F = 9.669$) on accuracy were found. However, the main effect of relationship type was driven by the abstract words, as accuracy for concrete associated and concrete similar were nearly identical. The main effect of concreteness was driven primarily by the similar pairings, although concrete associated compared to abstract associated was approaching significance ($p = .07$).

Figure 10. Bilingual Semantic Relationship ERP--Concrete Words (above)

Figure 11. Bilingual Semantic Relationship ERP--Abstract Words (below)





As in the lexical decision task, electrodes Fz, Cz, and Pz were pooled and averaged for the purposes of this analysis. Further, only correct trials are considered, and information regarding the size of the N400 was taken from the area from 300-500ms.

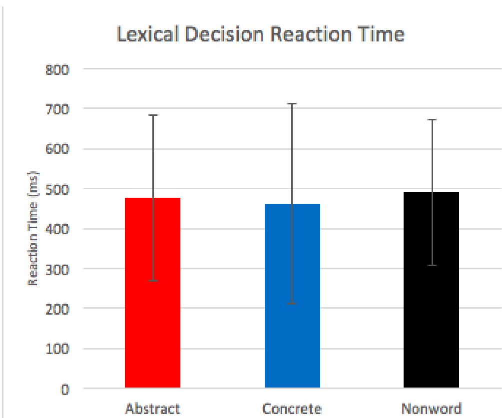
An ANOVA was performed to determine whether there is an interaction between concreteness and relationship type. There was no main effect of concreteness and there was a main effect of relationship, though that effect was only for the related pairs compared to the unrelated pairs ($p < 0.001$; $F = 21.707$). Associated compared to similar across concreteness was not significant. However, there was an effect of interaction in some of the predicted comparisons. Namely, abstract similar was significantly more negative than abstract associated ($p < .01$), and abstract similar was significantly more negative than concrete similar ($p < 0.001$). Concrete similar compared to concrete associated was approaching significance ($p = 0.08$).

People with Aphasia

Lexical Decision

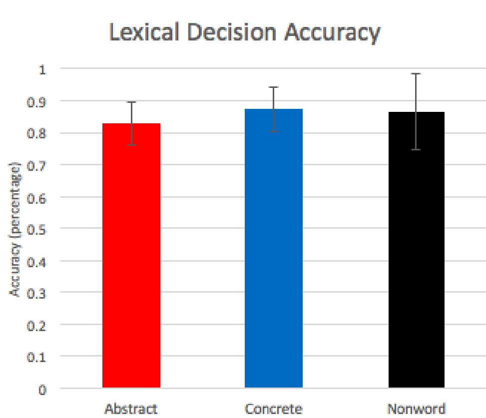
Reaction time data for the people with aphasia was analyzed using the same process as for the bilingual participants. Paired t-tests were performed to compare abstract to concrete words and words to non-words, and neither was significant ($p > 0.05$).

Figure 12. Lexical Decision Reaction Times--PWA



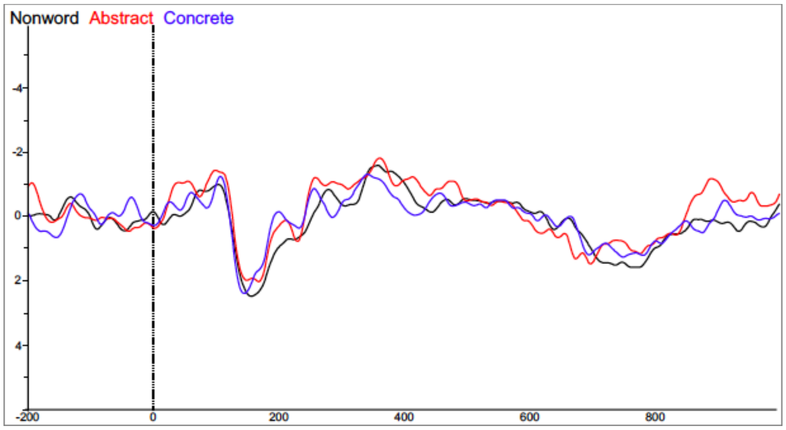
Similarly, t-tests were done to compare accuracy across the concrete/abstract and word/non-word domains, and neither were significant. However, the difference between abstract and concrete accuracy was approaching significance ($p < 0.1$).

Figure 13. Lexical Decision Accuracy--PWA



Again, electrodes Fz, Cz, and Pz are pooled and averaged when considering the ERP data, and only correct trials are included. There were no significant differences regarding the area from 300-500ms, but the difference between abstract and concrete was approaching significance ($p = 0.06$). Here, abstract words were more negative than concrete words.

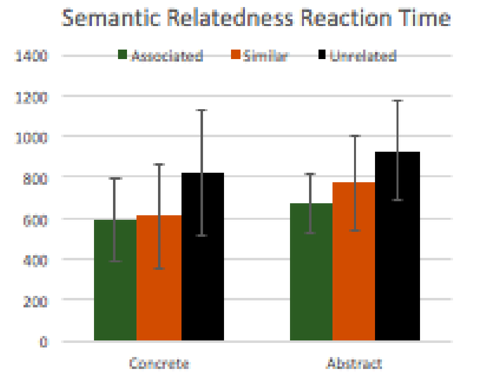
Figure 14. Lexical Decision ERP--PWA



Semantic Relationship

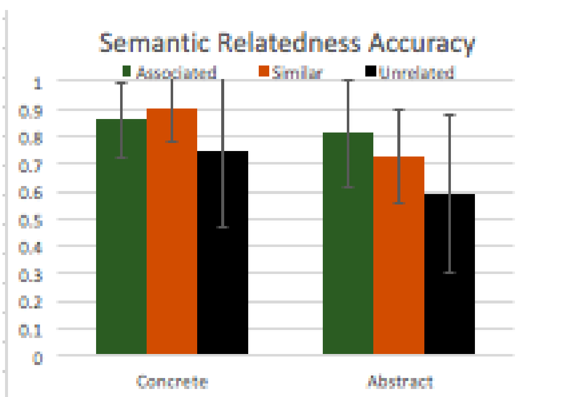
As previously, trials with an incorrect response, no response, or a reaction time greater than 2.5 standard deviations from the average RT were excluded for the purposes of this analysis. An ANOVA to determine interaction between concreteness and relationship type showed a main effect of relationship ($p < 0.05$; $F = 5.68$), which was driven by the difference between related and unrelated pairs. The difference between similar and associated pairs regardless of concreteness was not significant. The effect of concreteness was approaching significance ($p < 0.1$; $F = 3.783$). There was no effect of interaction.

Figure 15. Semantic Relatedness Reaction Times--PWA



An ANOVA was performed to determine interaction between concreteness and relationship type for accuracy and showed main effects of both concreteness ($p < 0.05$; $F = 5.344$) and relationship ($p < 0.05$; $F = 3.95$). Once again, the main effect of relationship was driven by the difference between related and unrelated pairs; the difference between associated and similar was not significant across concreteness. Furthermore, there was no effect of interaction.

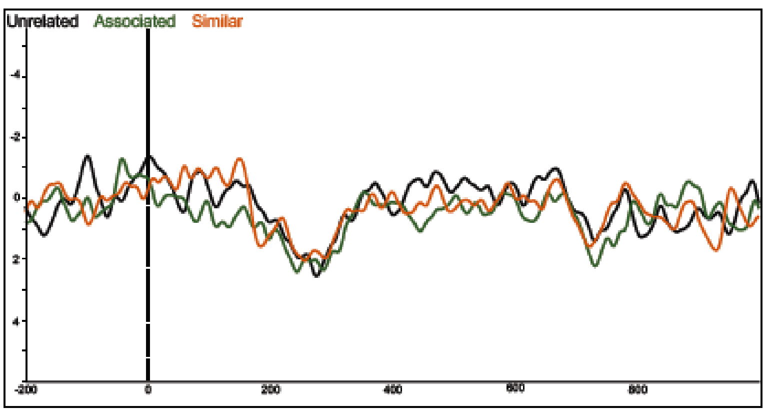
Figure 16. Semantic Relatedness Accuracy--PWA



When considering the area from 300-500ms, there were no significant differences for the concrete or the abstract words. However, there were trending differences for the abstract words in the same pattern as was found for the bilinguals in the abstract words. Additionally, for the concrete words there was an effect of relationship type on peak latency. The unrelated words have a later peak than the related pairs ($p < 0.05$). The peak latency between associated and similar pairs is not significantly different, although associated pairs are later than similar pairs.

Figure 17. PWA Semantic Relatedness--Concrete

Figure 18. PWA Semantic Relatedness—Abstract



Chapter 4

Discussion

Bilinguals

This study expected to find evidence for the typical concreteness effect in the bilingual participants, as these are highly proficient bilinguals and concreteness effects have been found in English in Dutch-English bilinguals previously (van Hell & de Groot, 1998). Although no concreteness effects were found behaviorally in the lexical decision task, there was an expected N400 concreteness effect where concrete words are more negative than abstract words. However, it is worth highlighting that participants were instructed to wait to respond until after they had seen the stimulus for 500ms. Thus, they were given additional time to consider their response. If participants had been allowed to respond immediately upon stimulus onset, it would be easier to evaluate clear differences between different word types. Alternatively, this finding potentially points to the robustness of ERPs in picking up underlying neural mechanisms that cannot be evaluated by considering behavior alone.

Furthermore, concreteness effects were found both behaviorally and using ERPs in the semantic relatedness judgment task. This was a significantly harder task than the Lexical Decision task, though participants were still highly proficient (M = .85), and a task which required more semantic activation than the lexical decision task. While the latter simply requires recognition of a letter string as an English word, the former relies on the participant's knowledge of two words in English and their ability to determine the relationship between the meanings of the two words. Thus, if there are concreteness effects in bilinguals they should be stronger in the semantic relatedness task due to the increased engagement of semantics in this task. Indeed, concrete words were faster and more accurate than abstract words as a whole for the semantic relatedness task, and there was an N400 effect when comparing concrete to abstract words.

However, when looking at the individual relationship types we see differences in concrete and abstract words in the behavioral data. Crucially the abstract words show a preference for associated pairings, while there are no significant differences for the concrete words. Although this preference for associated pairings over similar pairings is only significant for accuracy, it is approaching significance in the reaction time data. This pattern holds for the ERP findings as well. For the abstract words, there is an N400 effect where similar pairings are more negative than associated findings. While an opposite pattern was found for concrete words (associated pairings are more negative than similar pairings), the difference did not reach significance.

Additionally, when we take a given relationship type and compare concrete and abstract words, we find significant differences in accuracy and ERP negativity in the similarity condition, but not in the association condition. Thus, when the word pairs are related by association the concreteness effect is effectively nullified by the fact that abstract words strongly prefer this relationship type.

The initial finding that there is an interaction between concreteness and relationship type is clear evidence for the differential frameworks hypothesis (Crutch et al., 2008). This hypothesis, which claims that abstract and concrete words are processed through different frameworks, predicts that abstract words would be processed more easily in an associative context than in a similarity context and that the reverse would be true for concrete words. Indeed, we find higher negativity for abstract words in the similarity context, showing that there is greater effort needed for the semantic integration of the word pair than is needed in the associative context. An alternate way of viewing this finding is that it shows a decreased negativity for words in their preferred relationship context as opposed to in unrelated pairs or the dis-preferred relationship type.

Further considering the pattern that this relationship preference only reaches significance for the abstract words provides additional evidence that abstract and concrete words are processed in fundamentally different ways. Although these differences in semantic relatedness are not traditionally considered to be an aspect of the "concreteness effect", they do point to effects of concreteness on wider aspects of semantic processing. Furthermore, the fact that it is only abstract words which show a difference between associated and similar pairings shows that these two types of words are processed in different ways.

As previously mentioned, the two most prominent theories to explain concreteness effects are Dual-Coding and Context Availability theories. The finding explained above, where abstract words are processed preferentially through semantic associations while concrete words show no preference regarding association compared to similarity, will be discussed in the context of both theories. Dual Coding theory claims that concrete words are processed through both an image-based system and a verbal-based system while abstract words can only be processed through the verbal-based system due to their lack of a physical referent and general low imageability as compared to concrete words. It is these two codes that allow concrete words to be processed faster and more accurately than abstract words, but which also require greater semantic integration for processing to take place resulting in the N400 effect. Here, we find that abstract and concrete words are processed with roughly the same speed, accuracy, and strength of negativity when they are related by association, but that the concreteness effect is enhanced when the word pairs are related by similarity.

Based on these findings, this can be related to Dual-Coding theory by comparing association to the verbal system and similarity to the image-based system. Indeed, these comparisons are based on the way these relationship types are defined. As previously explained, words that are related by association are words which contribute to the same context in some way. These are words such as “ship” and “sea”, whose referents do not perform the same function or belong to the same taxonomic category, but whose meanings belong to the same schema—a ship is typically found at sea. This type of meaning relationship is based in the way the words are used, and is thus far more verbal-based than image-based. On the other hand, words which are related by similarity such as “corn” and “pea” do belong to the same taxonomic category or perform the same function—they are the same “type of thing”. Thus, they have many semantic and physical features in common, so this type of relationship could be said to be processed through an image-based system. However, due to the meanings of these words they are often also used in conjunction with one another, as referents which share semantic features are by nature members of the similar potential schemas. Thus, the similarity relationship is also processed through the verbal-based system.

As previously explained, Dual-Coding theory proposes that abstract words are processed only through the verbal system and concrete words are processed through both the verbal and image-based systems, and here we propose that associations are processed only through the verbal system and similarity is processed through both the verbal and image-based systems. Using this framing system, abstract words are processed quickly and more accurately when they are related by association than when they are related by similarity because both abstract words and associative relationships rely solely on the verbal-based system. However, concrete words are either processed preferentially when they are related by similarity or show no preference between similarity and association because concrete words can be processed through the verbal-based or the image-based system.

People with Aphasia

In evaluating the behavioral and ERP data from the people with aphasia, there were very few significant findings. However, there are only 11 participants in this group, and ERP studies typically need at least 20 participants to find reliable, significant effects due to the averaging of data points required to adequately analyze the results. Furthermore, data from patients with aphasia tends to be noisy and have a low signal-to-noise ratio as compared to neurologically healthy participants. Given these considerations, it is difficult to say whether the lack of significant differences in the ERP data is due to a true lack of differential processing between abstract and concrete words or if it should simply be attributed to the low signal-to-noise ratio in this sample.

Language experience and fluency: bilinguals compared to people with aphasia

It is highly uncommon for a study to compare a pair of language populations such as people with aphasia and bilinguals. However, we know that both of these groups of people, while competent in English, do not have the same English language ability or fluency as typically developing, neurologically healthy English monolinguals. The bilinguals tested in this study are late-learners of L2 who built their L2 knowledge onto their native knowledge of Dutch. Moreover, they are not embedded in an English-speaking environment. So, related to their L2 learning history and L2 language exposure they have not reached the degree of proficiency of the monolingual English speakers tested in this study. People with aphasia once had the language abilities of healthy monolinguals, but due to injury they are now functioning with an impaired L1. Thus, our purpose in this comparison is to determine if the quality of a person's language (i.e. the reason for their relative lack of proficiency as compared to a healthy monolingual) or the quantity of a person's language (their language ability irrespective of the language history leading to that ability) plays a role in their processing of concrete and abstract words (Braunstein, Ischebeck, Brunner, Grabner, Stamenov, & Neuper, 2012).

The most obvious difference between these participant groups is that the bilinguals performed better on the tasks than the people with aphasia—they were faster and more accurate across tasks. However, this is not surprising as neurologically healthy young adults can be expected to perform better than neurologically impaired older adults. Additionally, as previously discussed in the People with Aphasia section, it is at present difficult to truly analyze the ERP data for the individuals with aphasia due to the small number of participants.

The most interesting finding is that the participants with aphasia continue the pattern that dissociated abstract and concrete words behaviorally. Abstract words showed a preference for associated pairings, while there was no significant difference for concrete words. The fact that this pattern holds true across participant groups adds evidence to the theory using Dual Coding to explain the Differential Frameworks hypothesis. However, it remains unclear if that pattern is true only because both bilinguals and people with aphasia are less strong in English than healthy English monolinguals or if the pattern will persist for the healthy English monolinguals.

If this pattern only holds for bilinguals performing in their L2 and individuals with aphasia with an impaired L1, it suggests that people who are functioning in a weaker language rely more on functional semantic relationships that focus more heavily on contexts in which the words are used.

Chapter 5

Relevance

Second language education

This study holds potential relevance to methods in second language education and acquisition. Findings suggest that proficient bilinguals process abstract words better when presented with words that are related by association rather than by similarity. That is, when abstract words are presented in a more functionally relevant context, they are processed better. This suggests that abstract words should also be taught in contexts which will be functionally relevant for speakers. Doing so will allow learners to acquire the new vocabulary both in the context that they are most likely to use it in the future and the context that experienced L2 speakers have been shown to process the vocabulary.

People with Aphasia

This study holds clinical relevance regarding the semantic organization of people with aphasia. As previously discussed, studies have shown that training people with aphasia on abstract concepts can result in generalization to untrained concrete concepts within the same functional category (Sandberg & Kiran, 2014). This study adds to this clinical finding by providing evidence for differential semantic processing of abstract and concrete words in people with aphasia. Although there are no significant differences in the size of the N400 effect, data is trending in the same direction as the neurologically healthy bilinguals and this trend may become significant as more participants are included in the study.

If abstract words are preferentially processed in associative contexts but concrete words are preferentially processed in similar contexts, that would point to new methods of training to promote generalization in PWA. More specifically, it encourages the careful creation of contexts that takes into account the ways that words are best processed. Further work to explore whether training words in their preferred relationship type or dis-preferred relationship type leads to further generalization may help to advance this line of clinical relevance.

However, because this study was not designed to be immediately clinically relevant, it allows us to examine the effects of aphasia on concreteness effects and semantic processing alongside neurologically healthy populations. This is a unique perspective, as most studies involving people with aphasia do not compare participant groups in this way to look for larger trends in semantic processing and organization.

Chapter 6

Further Work

Ongoing studies

Immediate future plans include continuing to test people with aphasia. Data for this language population remains unclear due to a small participant sample, and we are hopeful that adding participants to this study will add clarity to the current results and increase the signal-to-noise ratio. We also plan to gather data from neurologically healthy English monolinguals in order to better compare across language populations. Doing so will allow us to determine whether English proficiency plays a role in the patterns presented in this study or if these patterns are consistent regardless of experience with the testing language. Presently, it is difficult to accurately compare young, neurologically healthy bilinguals and older monolinguals with aphasia because of the number of differing demographic features, but we are hopeful that including neurologically healthy monolinguals will help to bridge that divide.

Additionally, future analysis will center on the effect of fluency/proficiency on performance on these tasks. Analysis of behavioral results for the bilinguals shows that proficiency has an effect on accuracy and reaction times in the lexical decision task, although such analysis has not yet been conducted for the ERP data. Furthermore, we would like to use the performance of the people with aphasia on the CLQT screening in a similar method in order to determine the effect of their language abilities on their performance on these tasks.

Additional ratings

Presently, we did not include measures regarding the degree of relatedness between word pairs, only the nature of the relationship type. However, we recognize that some of the word pairs included in the semantic relationship task may be considered more closely related than others, and that this degree of relationship may affect performance. Additionally, it may be that some of the word pairs considered as concrete similar may also contribute to the same context, and therefore also be related by association. Although we attempted to avoid such word pairs, it was impossible to eliminate them entirely due to the nature of the semantic system. This difficulty should be accounted for in order to better clarify the role of relationship types. However, it should also be considered that if pairings which completely dissociate similarity from association cannot be found, that may point to greater patterns of semantic association across the semantic system.

Further information

This study only addressed sequential bilinguals in L2, and furthermore only addressed English. Additionally, Dutch and English are both Germanic languages and linguistically similar. Thus, it is unclear whether the semantic patterns found here are language-specific or if they are indicative of the lexical-semantic system as a whole. Future studies should consider both of a bilingual's languages in order to address whether the same patterns hold in L1 and L2 within a given person, and should include speakers of languages which are linguistically unrelated to one another in order to better determine cross-linguistic and cross-cultural effects.

Appendix A

Lexical Decision Stimuli

Concrete and Abstract Words

Table 3. Lexical Decision Stimuli—Concrete and Abstract words

WORD	Concreteness	Familiarity	Imageability	Frequency	Number of Letters
EGO	261	497	334	13	3
BETTERMENT	270	293	310	3	10
FALSEHOOD	260	348	326	2	9
SUFFRAGE	283	371	317	5	8
ATROCITY	296	371	404	-	8
JEOPARDY	266	352	344	4	8
ROTE	295	249	264	-	4
DISQUIET	270	304	305	1	8
JOY	300	545	533	40	3
TRUISM	276	398	292	3	6
FALLACY	258	379	287	1	7
PHILOSOPHY	257	491	348	86	10
DECEIT	257	440	338	2	6
SYMPATHY	278	501	402	36	8
INCURSION	275	277	164	1	9
SANCTITY	293	338	330	3	8
COWARDICE	263	431	344	2	9
GAIETY	275	464	546	8	6
IMMENSITY	262	388	402	2	9
FANTASY	295	499	455	14	7
INSTANCE	284	501	250	82	8
REPRISAL	282	395	294	3	8
ANTAGONISM	288	417	378	9	10
UPKEEP	299	395	347	6	6
OPTIMISM	240	500	418	15	8
SECURITY	290	513	391	91	8
ALLEGORY	283	314	244	3	8
DEFIANCE	275	432	383	7	8
INACTION	297	327	270	6	8
ETIQUETTE	252	332	388	3	9
PROTOCOL	264	306	258	3	8

INDUCEMENT	288	323	336	2	10
NICETY	242	302	221	-	6
DISHONESTY	255	475	362	2	10
WILL	275	584	322	2244	4
TENDENCY	243	507	261	49	8
ESSENCE	243	384	289	15	7
ASPECT	217	482	233	47	6
DISGRACE	278	488	386	3	8
INSISTENCE	262	411	324	19	10
DENIAL	272	407	364	18	6
SPITE	262	459	405	56	5
EXCISE	271	356	287	4	6
INDICATION	282	500	340	20	10
KINGDOM	392	513	494	26	7
STRAIN	338	533	402	31	6
PHRASE	321	521	342	34	6
DEFINITION	262	519	224	38	10
GRUDGE	313	510	373	7	6
OBEDIENCE	238	500	394	9	9
GHOST	379	505	552	11	5
BLAME	293	541	356	34	5
CALM	360	547	439	35	4
PLOT	379	515	420	37	4
ANGER	315	541	488	48	5
PAIR	377	544	480	50	4
TRUST	300	548	356	52	5
SIN	273	501	441	53	3
RISK	290	517	405	54	4
REPUTATION	232	492	343	27	10
CELLAR	572	467	572	26	6
PRODUCT	516	562	435	87	7
COLONY	511	445	481	28	6
CHINCHILLA	558	393	530	-	10
ZOOLOGIST	525	472	470	2	9
CONVENT	537	458	559	4	7
PACKAGE	580	497	529	20	7
DORMITORY	576	369	575	2	9
OFFICER	550	549	593	101	7
WARRIOR	525	368	553	5	7
NOODLE	588	499	530	-	6
ENAMEL	533	476	451	1	6
AVENUE	539	529	564	46	6

MONEY	574	631	604	265	5
INHABITANT	508	469	431	-	10
GINGHAM	540	203	523	2	7
GASKET	525	428	487	4	6
ICICLE	569	485	526	1	6
CHASSIS	561	327	386	1	7
ACCORDION	586	394	576	1	9
BODY	568	610	614	276	4
PORTAL	545	252	505	3	6
PROJECTOR	548	477	584	1	9
NEPHEW	541	452	443	9	6
METROPOLIS	504	398	572	8	10
NUTMEG	586	354	526	4	6
MORTAR	548	368	449	11	6
BENZENE	535	318	418	2	7
CHLORIDE	547	391	435	5	8
DETECTIVE	505	509	524	52	9
ARMADILLO	558	181	401	2	9
PISTON	586	409	526	7	6
GOBLET	592	306	577	-	6
POLLEN	584	488	526	11	6
CORNET	527	364	436	-	6
ROSARY	535	410	464	-	6
RACKET	562	486	530	5	6
MANURE	644	458	534	6	6
DANDELION	558	513	579	1	9
OUTFIT	515	489	487	16	6
CUSTOMER	505	549	488	27	8
LANCER	504	357	413	-	6
PASSAGE	558	525	525	49	7
ALBATROSS	621	309	583	-	9
WARBLER	570	273	541	-	7
URCHIN	568	332	529	-	6
CARRIAGE	576	436	529	11	8
MATERIAL	539	559	490	174	8
STUDENT	549	632	603	131	7
MACHINE	578	549	575	103	7
BROTHER	585	598	589	73	7

COLUMN	520	519	491	71	6
DISEASE	504	580	487	53	7
CROWD	546	523	548	53	5
SPEAKER	537	554	549	49	7
MISSILE	597	504	602	48	7
LIQUID	555	578	589	48	6
GUARD	517	504	530	48	5
DOLLAR	575	611	611	46	6
POCKET	578	590	558	46	6

Nonwords

Table 4. Lexical Decision Stimuli—Nonwords

Word	Number of Letters	Number of Neighbors	# of Phonological Neighbors
SKRYMBS	7	0	4
YARKES	6	0	12
PRYLFS	6	0	0
THROUGHND	9	0	0
TWARKED	7	0	1
BRALDS	6	2	1
WAUGHG	6	0	16
SKOAGNTH	8	0	0
VOLMS	5	2	0
SPRERLES	8	0	1
KRIRLED	7	0	1
SPREUVVS	8	0	0
SHOOMMTH	8	0	0
KWEAKS	6	1	8
SMOOFFED	8	0	0
THEUPPTH	8	0	0
CEV	3	1	12
KNAICH	6	0	9
REKSTS	6	0	1
SMAMFS	6	0	0
SKWEUMBTH	9	0	0
GRERNES	7	0	4
THWAGG	6	0	2
SULM	4	1	1
SQUOURTHS	9	0	1
GHREIGHVED	10	0	6
SKRERZED	8	0	0
HOOSSED	7	0	10
SKROARNTHS	10	0	0
SCWOUZZED	9	0	1
PHLIME	6	0	7
WRYLMS	6	0	2
FROLNS	6	1	0
CLETT	5	2	4
SCKROARPHS	10	0	0
KNAITH	6	0	9
WHOURGNTH	9	0	3
PSUIFS	6	0	9

GHLAUGNED	9	0	2
GHLUIGUE	8	0	3
SCKWAWSHED	10	0	2
PSEEGG	6	0	21
SCACED	6	3	1
SCWOUZZ	7	0	3
KNOUGHMBTH	10	0	2
KNEULLS	7	0	10
SKRULVED	8	0	0
GLUILE	6	0	3
DRORTS	6	0	1
ZIGHPHTHS	9	0	0
SCKWAWPTH	9	0	0
PSOUDES	7	0	6
CWYFTHS	7	0	0
SHRUTE	6	0	4
KNURDGE	7	0	9
SCKRARPHTH	10	0	0
WUFT	4	3	9
SMOIGNS	7	0	0
HOURCHED	8	0	5
SCWEIGHQUE	10	0	2
SCROARMBTH	10	0	0
GHLIRTHED	9	0	0
GHWOONTE	8	0	0
SWAUGHT	7	0	14
SLYCHE	6	0	10
POPHED	6	1	7
GNARTS	6	0	20
RHAWSH	6	0	6
KUGNS	5	0	28
SCKRALSED	9	0	0
SCKAIMTHS	9	0	0
KNEANS	6	0	15
SQUOOKED	8	0	2
SCKWOARPHS	10	0	1
SCKWAWNDS	9	0	0
CROURN	6	0	9
PLORCKED	8	0	1
WHERFE	6	0	20
FRARCH	6	0	0
USCKED	6	0	1
GWOUGHPHTH	10	0	0
GNYLDGED	8	0	0

SCKRORPH	8	0	2
SHROUND	7	0	5
RULM	4	1	1
PYZZ	4	0	32
TRIRBS	6	0	1
FEMFED	6	0	0
SPLIGHCKS	9	0	0
STEAVES	7	1	8
HYLMB	5	0	4
SCOWTHED	8	0	0
FRURTHE	7	0	0
KWUIMMTH	8	0	0
GHOUGHMTHS	10	0	0
SCKWOADGED	10	0	0
PHREUZE	7	0	15
YEIGHMTHS	9	0	0
STRAUZZED	9	0	0
TWAMPTE	7	0	1
SNEUST	6	0	2
TWAUSSED	8	0	1
GHLALKED	8	0	0
DYZ	3	1	24
BREWGN	6	0	14
GUZZED	6	1	4
GWEITT	6	0	2
GHEANN	6	0	18
PHRAUNDE	8	0	3
GHLIGH	6	0	7
RYLCKS	6	0	4
SNAUGHGED	9	0	0
THWIRNTS	8	0	0
SCROUGHP	8	0	4
STRENCKED	9	0	0
KNIRNDE	7	0	6
PREIGHDGED	10	0	1
TOWLDE	6	0	11
SCKROLDGED	10	0	0
KRIRK	5	0	9

Appendix B

Semantic Relatedness Stimuli

Abstract Associated

Table 5. Stimuli for abstract associated condition

English	Dutch	Concrete?	CNC	FAM	IMG	KFFRQ	NLET
chance	kans	yes	254	563	354	131	6
bet	weddenschap	no	403	527	453	20	3
conscience	geweten	no	255	536	386	40	10
guilt	schuldgevoel	no	299	559	381	33	5
noun	zelfstandig naamwoord	no	387	518	368	1	4
verb	werkwoord	no	337	534	357	4	4
solution	oplossing	no	388	548	391	59	8
problem	probleem	yes	360	596	411	313	7
death	dood	nah	365	581	498	277	5
birth	geboorte	no	471	527	532	66	5
motive	motief	yes	255	540	275	22	6
crime	misdaad	no	387	537	471	34	5
luxury	luxe	yes	346	506	507	21	6
wealth	weelde	yes	370	557	500	22	6
professional	professional	yes	379	520	383	105	12
amateur	amateur	yes	388	502	397	25	7
month	maand	nah	345	598	448	130	5
week	week	yes	383	577	481	275	4
size	maat	no	354	566	415	138	4
length	lengte	yes	365	591	395	116	6
weight	gewicht	nah	462	578	521	91	6
height	hoogte	nah	376	590	472	35	6
poetry	poezie	yes	425	512	486	88	6
literature	literatuur	yes	462	529	487	133	10
heaven	hemel	no	305	536	448	43	6
god	god	yes	365	567	461	318	3
democracy	democratie	yes	298	566	364	24	9
freedom	vrijheid	no	277	568	437	128	7
discovery	ontdekking	no	332	513	401	45	9
science	wetenschap	no	366	577	423	131	7
drama	drama	yes	375	534	482	43	5

comedy	komedie	yes	365	588	489	39	6
west	westen	yes	355	563	426	235	4
east	oosten	yes	363	574	497	183	4
engagement	verloving	no	362	535	474	22	10
marriage	huwelijk	no	398	559	556	95	8
welfare	welzijn	nah	309	509	362	53	7
poverty	armoede	no	343	529	502	20	7
clue	clue	yes	380	533	375	15	4
mystery	mysterie	yes	256	548	472	39	7
protection	bescherming	no	308	519	410	68	10
safety	veiligheid	no	323	556	397	47	6
biology	biologie	yes	400	526	441	7	7
chemistry	scheikunde	no	374	533	458	16	9
knowledge	kennis	no	278	575	348	145	9
education	onderwijs	no	320	585	416	214	9
wisdom	wijsheid	yes	275	510	381	44	6
age	leeftijd	no	390	582	468	227	3
expression	uitdrukking	no	297	527	386	79	10
feeling	gevoel	no	262	612	370	172	7
whole	geheel	no	324	592	377	309	5
half	half	yes	389	610	458	275	4
failure	gebrek	no	282	542	437	89	7
success	succes	yes	295	568	443	93	7
culture	cultuur	yes	351	523	339	58	7
society	maatschappij	no	335	601	440	237	7
management	management	yes	381	518	415	91	10
business	onderneming	no (but business is used too)	389	563	441	392	8
title	titel	yes	384	523	413	77	5
name	naam	yes	405	573	475	294	4
honour	eer	no	258	523	363	2	6
honesty	eerlijkheid	no	278	578	386	10	7
quantity	hoeveelheid	no	340	557	349	33	8
quality	kwaliteit	yes	274	560	349	114	7
topic	onderwerp	no	366	539	364	9	5
discussion	discussie	yes	341	541	381	94	10
division	onderdeel	no	332	518	404	107	8
addition	toevoeging	no	339	535	347	142	8
memory	geheugen	no	284	573	391	76	6
mind	denkvermogen	no	333	591	373	325	4
capacity	capaciteit	yes	293	512	373	83	8
zero	nul	no	341	569	483	24	4
budget	budget	yes	366	517	394	59	6

economy	economie	yes	284	580	357	79	7
attitude	houding	no	265	553	321	107	8
behaviour	gedrag	no	295	573	351	3	9
question	vraag	no	387	588	398	257	8
answer	antwoord	no	397	605	368	152	6
law	wet	no	349	562	409	299	3
justice	gerechtigheid	no	307	522	379	114	7

Abstract Similar

Table 6. Stimuli for abstract similar condition

English	Dutch	Cognate?	CNC	FAM	IMG	KFFRQ	NLET
profession	beroep	no	374	543	406	37	10
career	carriere	yes	373	589	418	67	6
ache	pijn	no	443	523	443	4	4
pain	pijn	yes	426	569	502	88	4
judgement	oordeel	no	260	506	333	1	9
opinion	mening	no	285	550	359	96	7
reality	realiteit	yes	296	551	315	79	7
truth	waarheid	no	261	581	374	126	5
cost	kosten	yes	348	589	401	229	4
fee	honorarium	no	441	515	440	16	3
sensation	gevoel	no	265	503	394	14	9
perception	perceptie	yes	287	558	355	29	10
direction	richting	no	336	562	399	134	9
route	route	yes	440	515	447	43	5
grief	verdriet	no	303	505	480	10	5
depression	depressie	yes	303	541	453	24	10
enthusiasm	enthousiasme	yes	266	506	464	28	10
excitement	opwinding	no	282	535	452	32	10
mixture	mengsel	no	356	588	433	30	7
variety	verscheidenheid	no	297	533	372	85	7
reduction	reductie	yes	313	509	332	42	9
loss	verlies	no	313	558	409	86	4
crisis	crisis	yes	319	521	375	82	6
tragedy	tragedie	yes	331	521	478	49	7
phase	fase	yes	360	516	319	72	5
period	periode	yes	358	573	429	265	6
skill	vaardigheid	no	346	549	366	42	5

ability	vaardigheid	no	273	563	327	74	7
manner	manier	yes	297	546	342	124	6
method	methode	yes	303	556	304	142	6
threat	bedreiging	no	335	524	408	42	6
danger	gevaar	no	338	557	505	70	6
tradition	traditie	yes	291	526	354	94	9
custom	gewoonte	no	323	538	364	14	6
harmony	harmonie	yes	372	534	423	33	7
peace	vrede	no	309	571	446	198	5
origin	oorsprong	no	319	537	306	44	6
beginning	begin	yes	318	593	359	164	9
role	rol	yes	335	524	385	104	4
duty	plicht	no	322	543	346	61	4
arrival	aankomst	no	328	548	419	23	7
appearance	verschijning	no	358	578	425	57	10
expansion	uitbreiding	no	325	515	417	47	9
growth	groei	nah	381	560	426	155	6
generation	generatie	yes	320	520	362	55	10
production	productie	yes	318	545	347	148	10
impression	indruk	no	288	554	313	45	10
sense	gevoel	no	316	583	368	311	5
bargain	koopje	no	399	552	505	7	7
value	waarde	no	260	552	289	200	5
site	plek	no	408	507	406	64	4
scene	plek / scene	yes	408	526	432	106	5
comparison	vergelijking	no	311	560	336	48	10
relation	relatie	yes	383	585	451	63	8
assistance	assistentie	yes	288	534	348	87	10
relief	opluchting	no	303	551	432	66	6
conclusion	conclusie	yes	278	577	345	59	10
decision	beslissing	no	297	601	340	119	8
theory	theorie	yes	287	534	317	129	6
belief	geloof	no	270	554	328	64	6
trick	truuk	yes	391	531	459	15	5
joke	grap	no	388	580	483	22	4
background	achtergrond	no	383	540	427	67	10
history	geschiedenis / historie	yes	328	564	405	286	7
pleasure	plezier	yes	302	583	511	62	8
fun	plezier	yes	295	621	515	44	3
spirit	geest	no	296	518	450	182	6
soul	ziel	yes	289	544	366	47	4
reason	reden	nah	332	601	285	241	6
purpose	doel	no	280	572	280	149	7

evidence	bewijs	no	340	504	356	204	8
proof	bewijs	no	328	546	339	40	5
team	team	yes	492	538	565	83	4
unit	eenheid	no	389	513	334	103	4
salary	salaris	yes	456	527	452	43	6
wage	salaris	no	451	539	466	56	4
passion	passie	yes	300	502	467	28	7
ambition	ambitie	yes	281	517	346	19	8
partner	partner	yes	500	555	513	32	7
friend	vriend	yes	450	603	587	133	6

Concrete Associated

Table 7. Stimuli for concrete associated condition

English	Dutch	Cognate?	CNC	FAM	IMG	KFFRQ	NLET
jury	jury	yes	540	498	580	67	4
court	rechtbank	no	509	549	552	230	5
instrument	instrument	yes	543	553	521	47	10
piano	piano	yes	615	545	630	38	5
music	muziek	yes	512	599	549	216	5
record	record	yes	558	609	591	137	6
moon	maan	yes	581	585	585	60	4
rocket	raket	yes	645	525	612	7	6
hospital	ziekenhuis	no	584	548	602	110	8
ambulance	ambulance	yes	595	499	627	6	9
secretary	secretaresse	yes	576	528	563	191	9
typewriter	typemachine	nah	611	524	615	10	10
flower	bloem	no	584	566	618	23	6
garden	tuin	no	602	567	635	60	6
camp	kamp	yes	571	541	588	75	4
tent	tent	yes	608	521	593	20	4
paint	verf	no	577	551	567	37	5
brush	borstel	no	589	579	570	44	5
breakfast	ontbijt	no	576	657	586	53	9
cereal	muesli	no	637	543	576	17	6
farm	boerderij	no	565	564	560	125	4
tractor	tractor	yes	590	518	585	24	7
professor	professor	yes	549	583	587	57	9

college	college	yes	554	620	590	267	7
tobacco	tabak	nah	609	558	601	19	7
cigarette	sigaret	yes	607	573	645	25	9
driver	bestuurder	no	553	593	567	49	6
limousine	limousine	yes	624	505	595	4	9
tree	boom	no	604	613	622	59	4
forest	bos	no	609	513	633	66	6
umbrella	paraplu	no	606	511	592	8	8
rain	regen	nah	600	604	618	70	4
teacher	onderwijzer	no	569	599	575	80	7
school	school	yes	573	582	599	492	6
rubber	rubber	yes	596	547	599	15	6
tire	band	no	563	546	511	22	4
wood	hout	no	606	574	577	55	4
fireplace	haard	no	592	529	639	6	9
cinnamon	kaneel	no	599	515	571	-	8
spice	kruiden	no	590	518	592	4	5
choir	koor	yes	567	526	567	8	5
church	kerk	no	587	560	616	348	6
camera	camera	yes	627	550	576	36	6
photograph	foto	yes	590	551	618	18	10
cauliflower	bloemkool	no	642	462	567	1	11
vegetable	groente	no	602	591	598	10	9
weapon	wapen	yes	560	517	546	42	6
bullet	kogel	no	595	517	611	28	6
cancer	kanker	yes	615	556	567	25	6
lung	long	yes	569	546	576	16	4
candle	kaars	no	565	544	594	18	6
flame	vlam	yes	582	551	598	17	5
violin	viool	yes	626	468	606	11	6
orchestra	orkest	yes	578	533	619	60	9
insect	insekt	yes	593	542	586	14	6
grasshopper	sprinkhaan	no	660	507	630	-	11
office	kantoor	no	569	566	518	255	6
desk	bureau	no	583	583	574	65	4
railroad	spoorweg	no	579	493	596	58	8
station	station	yes	572	548	554	105	7
mattress	matras	yes	640	524	601	-	8
bed	bed	yes	635	636	635	127	3
baby	baby	yes	589	597	608	62	4
bottle	fles	no	591	591	619	76	6
morning	ochtend	no	515	605	579	211	7
coffee	koffie	yes	613	625	618	78	6
envelope	envelop	yes	579	542	554	21	8

letter	brief	no	577	610	595	145	6
ocean	oceaan	yes	593	526	623	34	5
beach	strand	no	612	553	667	61	5
banana	banaan	yes	633	576	644	4	6
monkey	aap	no	566	531	588	9	6
branch	tak	no	583	529	548	33	6
leaf	blad	no	593	556	608	12	4
belt	riem	no	602	550	494	29	4
leather	leer	no	575	571	586	24	7
stadium	stadium	yes	569	526	586	25	7
football	voetbal	yes	584	565	597	36	8
cookie	koekje	yes	634	585	600	1	6
milk	melk	yes	670	588	638	49	4

Concrete Similar

Table 8. Stimuli for concrete similar condition

English	Dutch	Cognate?	CNC	FAM	IMG	KFFRQ	NLET
butterfly	vlinder	no	593	481	624	2	9
caterpillar	rups	no	586	457	626	1	11
beer	bier	yes	587	604	598	34	4
wine	wijn	yes	621	570	624	72	4
wool	wol	yes	608	540	586	10	4
cotton	katoen	nah	608	521	562	38	6
machinery	machine	yes	545	528	526	60	9
equipment	instrumentarium	no	532	543	410	167	9
rose	roos	yes	608	556	623	86	4
daisy	madeliefje	no	613	519	573		5
brandy	brandewijn	yes	595	542	590	7	6
vodka	wodka	yes	576	573	613	-	5
moose	eland	no	616	518	604	-	5
deer	hert	no	631	509	624	13	4
man	man	yes	618	623	567	1207	3
woman	vrouw	no	580	623	626	224	5
jacket	jas	nah	635	596	611	33	6
coat	jas	no	601	610	572	43	4
boot	laars	no (but boot is false	595	566	604	13	4

		friend with boat)					
shoe	schoen	yes	600	569	601	14	4
bay	baai	yes	580	474	570	57	3
harbor	haven	no	603	512	597	-	6
lemon	citroen	no	608	518	632	18	5
orange	sinaasappel	no	601	567	626	23	6
doorway	deuropening	nah	578	532	548	15	7
window	raam	no	609	621	602	119	6
ceiling	plafond	no	606	531	557	31	7
roof	dak	no	586	552	604	59	4
apartment	appartement	yes	575	491	556	81	9
house	huis	yes	608	600	606	591	5
mouth	mond	yes	568	572	613	103	5
nose	neus	yes	628	584	605	60	4
doctor	dokter	yes	575	573	600	100	6
nurse	verpleegster	no	588	537	617	17	5
sparrow	mus	no	629	523	583	-	7
nightingale	nachtegaal	nah	621	375	551	4	11
king	koning	nah	559	522	585	88	4
queen	koningin	no	537	527	612	41	5
pencil	potlood	no	617	598	607	34	6
pen	pen	yes	571	554	576	18	3
magazine	tijdschrift	no	588	585	588	39	8
newspaper	krant	no	576	641	616	65	9
maple	esdoorn	no	534	518	511	7	5
oak	eik	yes	588	515	590	15	3
apple	appel	yes	620	598	637	9	5
strawberry	aardbei	no	610	539	631	-	10
dinner	diner	yes	542	621	570	91	6
lunch	lunch	yes	552	616	602	33	5
cow	koe	nah	621	529	632	29	3
horse	paard	no	613	560	624	117	5
screwdriver	schroevendraaier	no	574	544	617	-	11
hammer	hamer	yes	605	515	618	9	6
lettuce	sla	no	579	565	608	-	7
cucumber	komkommer	nah	653	536	623	-	8
knife	mes	no	612	573	633	76	5
fork	vork	yes	592	584	598	14	4
plate	bord	no	595	556	527	22	5
bowl	kom	no	575	557	579	23	4
pillow	kussen	no	613	602	624	8	6
blanket	deken	no	622	563	582	30	7

hand	hand	yes	604	601	598	431	4
foot	voet	yes	558	583	597	70	4
corridor	gang	no	568	579	553	17	8
hall	hal	yes	565	592	559	152	4
couch	bank	no	578	521	536	12	5
chair	stoel	no	606	617	610	66	5
gentleman	heer	no	516	537	559	28	9
lady	dame	no	564	573	571	80	4
valley	vallei	yes	575	515	600	73	6
mountain	berg	no	616	574	629	33	8
garlic	knoflook	no	636	509	565	4	6
onion	ui	no	632	550	617	15	5
chestnut	kastanje	no	600	523	602	5	8
walnut	walnoot	yes	642	538	590	11	6
refrigerator	koelkast	no	574	545	612	23	12
oven	oven	yes	593	577	599	7	4
rug	kleed (rug is false friend with back)	611	557	591	13	3	
carpet	kleed	no	581	508	538	13	6
city	stad	no	554	616	605	393	4
town	dorp	no	556	589	553	212	4

Appendix C

Bilinguals LHQ/Demographic Information

Table 9. Demographic Information for Bilinguals

Participant Number	Gender	Age	What is your native language(s)?	At what age did you become FLUENT in English?	List what percentage of time you are exposed to English and Dutch	On a scale from 1 (very low) to 10 (perfect), rate your level of proficiency SPEAKING English	On a scale from 1 (very low) to 10 (perfect), rate your level of proficiency UNDERSTANDING English	On a scale from 1 (very low) to 10 (perfect), rate your level of proficiency READING English	On a scale from 1 (very low) to 10 (perfect), rate your level of proficiency WRITING English
rubn01	Female	24	Dutch	20	English: 20, Dutch 75%,	6	7	8	7
rubn02	Female	25	Dutch	16	Dutch - 70, English - 30	8	9	8	7
rubn03	Female	20	Dutch	25	96% Dutch and 5% English	4	4	3	4
rubn04	Male	18	Dutch	nvt	80dutch 20english	6	7	6	4
rubn05	Female	19	Dutch	15	Dutch 80%, English 20%	8	9	7	6
rubn06	Male	22	Dutch	16	English 20%, dutch 80%	8	9	9	9
rubn07	Male	23	Dutch	not	English10, Dutch 90	5	8	8	6
rubn08	Male	18	Dutch	15	Dutch 80%, English 20%	8	9	8	7
rubn09	Female	19	Dutch	13	English 35% Dutch 65%	7	8	9	8
rubn10	Female	23	Dutch	19	60% Dutch, 40% English	8	10	9	8
rubn11	Male	19	Dutch	13	Dutch 65%,	6	8	9	6

					English 35%				
rubn12	Female	19	Dutch	18	Dutch-75%, English-25%	8	9	9	8
rubn13	Female	19	Dutch	16	English 40% - Dutch 60%	8	9	8	7
rubn14	Female	27	Dutch	14	Dutch 60%, English 40%	7	9	9	8
rubn15	Female	21	Dutch	16	dutch: 80% english: 20%	6	7	8	5
rubn16	Female	19	Dutch	n/a	Dutch 75%, English 25%	6	9	9	6
rubn17	Male	28	Dutch	20	Dutch 70% English 30%	8	9	8	8
rubn18	Female	24	Dutch	21	English 25%, Dutch 75%	7	8	7	6
rubn19	Female	19	Dutch	14	English 20%- Dutch 80%	7	8	8	7
rubn20	Male	30	Dutch	15	English-20%, Dutch-80%	9	9	9	9
rubn21	Female	20	Dutch	16	Dutch 75%, English 25%	7	9	9	7
rubn22	Female	22	Dutch	8	English - 50%, Dutch - 50%	9	9	9	8
rubn23	Female	24	Dutch	19	60% English, 40%	8	8	9	8
rubn24	Female	22	Dutch	20 years	English-30%,Dutch-70%	7	8	8	7
rubn25	Female	20	Dutch	16	dutch 95% 5% english	6	8	6	6

People with Aphasia LHQ/Demographic Information

Table 10. Demographic Information for People with Aphasia

Participant #		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Age		67	46	56	61	67	51	73	76	82	53	53
Sex		M	M	F	F	M	M	M	M	M	M	M
Education							HS	BS				
Native Language		English	English	English	English	English	English	English	English	English	English	English
Ethnicity		black	white	white	white	white	white	white	white	white	white	white
Handedness		right	right	right	right	right	right	right	right	right	right	right
Composite	raw (4)	3.2	3.4	4	3.8	3.6	3.4	3.2	2.2	3.6	3.6	1.6
	rating	Mild	mild	WNL	WNL	WNL	mild	mild	moderate	WNL	WNL	moderate
Attention	raw (215)	177	199	193	194	187	181	162	138	170	184	122
	rating	Mild	WNL	WNL	WNL	WNL	WNL	WNL	mild	WNL	WNL	moderate
Memory	raw (185)	134	134	162	170	145	134	109	60	139	142	44
	rating	Moderate	moderate	WNL	WNL	Mild	MOD	moderate	severe	mild	mild	severe
EF	raw (40)	25	37	25	25	25	28	20	10	24	25	10
	rating	WNL	WNL	WNL	WNL	WNL	WNL	WNL	moderate	WNL	WNL	severe
Language	raw (37)	25.5	26	29	22.5	26.5	26	19	3	26	25	4.5
	rating	Mild	mild	WNL	moderate	Mild	MILD	moderate	severe	mild	mild	severe
Visuo-spatial	raw (105)	85	105	91	96	90	94	77	67	84	92	55
	rating	WNL	WNL	WNL	WNL	WNL	WNL	WNL	WNL	WNL	WNL	mild
Clock	raw (13)	4	13	13	10	10	13	5	1	11	13	5
	rating	Severe	WNL	WNL	mild	Mild	WNL	severe	severe	WNL	WNL	severe
AQ		81.2	91.2	93.2	78.5	74.3	93.3	63.3	40.3	96.6	95.4	30.6
Type		conduction	anomic	anomic	transcortical motor	conduction	anomic	transcortical motor	Broca's	anomic	anomic	Broca's

BIBLIOGRAPHY

Adorni, R., & Proverbio, A. M. (2012). The neural manifestation of the word concreteness effect: An electrical neuroimaging study. *Neuropsychologia*, *50*(5), 880–891.

Barber, H.A., Otten, L.J., Kousta, S.T., Vigliocco, G. (2013). Concreteness in word processing: ERP and behavioral effects in a lexical decision task. *Brain & Language*, *125,* 47-53.

Braunstein, V., Ischebeck, A., Brunner, C., Grabner, R. H., Stamenov, M., & Neuper, C. (2012). Investigating the influence of proficiency on semantic processing in bilinguals: An ERP and ERD / S analysis, 421–438.

Brysbaert, M., & Duyck, W. (2010). Is it time to leave behind the Revised Hierarchical Model of bilingual language processing after fifteen years of service? *Bilingualism*, *13*(3), 359–371.

Crutch, S. J., Connell, S., & Warrington, E. K. (2008). The different representational frameworks underpinning abstract and concrete knowledge: Evidence from odd-one-out judgements. *The Quarterly Journal of Experimental Psychology*, *62*(7), 1377–1390.

Dijkstra, T., & van Heuven, W. J. B. (2002). The Architecture of the Bilingual Word Recognition System: From Identification to Decision. *Bilingualism: Language and Cognition, 5,* 175-197.

Ghio, M., Maria, M., Vaghi, S., & Tettamanti, M. (2013). Fine-Grained Semantic Categorization across the Abstract and Concrete Domains, *8*(6).

Hoffman, P., Jefferies, E., & Ralph, M. A. L. (2010). Ventrolateral Prefrontal Cortex Plays an Executive Regulation Role in Comprehension of Abstract Words: Convergent Neuropsychological and Repetitive TMS Evidence. *The Journal of Neuroscience, 30*(46), 15450–15456.

Holcomb, P. J., Kounios, J., Anderson, J. E., & West, W. C. (1999). Dual-coding, context-availability, and concreteness effects in sentence comprehension: An electrophysiological investigation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *25*(3), 721–742.

Jessen, F., Heun, R., Erb, M., Granath, D., Klose, U., Papassotiropoulos, A., & Grodd, W. (2000). The Concreteness Effect: Evidence for Dual Coding and Context Availability. *Brain and Language*, *112,* 103–112.

Khateb, A., Pegna, A. J., Michel, C. M., Mouthon, M., & Annoni, J.-M. (2016). Semantic relatedness and first-second language effects in the bilingual brain: a brain mapping study . *Bilingualism: Language and Cognition*, *19*(2), 311–330.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connection between bilingual memory representations. *Journal of Memory and Language, 33*(2), 149-174.

Mirman, D., Landrigan, J., & Britt, A. E. (2017). Taxonomic and Thematic Semantic Systems. *Psychological Bulletin*, *143*(5), 499–520.

Paivio, A. (1986). *Mental Representations.* New York: Oxford University Press.

Paivio, A. (2013). Dual Coding Theory, Word Abstractness, and Emotion: A Critical Review of Kousta et al. (2011). *Journal of Experimental Psychology: General*, *142*(1), 282–287.

Rastle, K., Harrington, J., & Coltheart, M. (2002). 358,534 nonwords: The ARC Nonword Database. *Quarterly Journal of Experimental Psychology, 55A,* 1339-1362.

Sabourin, L., Brien, C., & Burkholder, M. (2013). The effect of age of L2 acquisition on the organization of the bilingual lexicon: Evidence from masked priming. *Bilingualism: Language and Cognition*, (September 2016).

Sandberg, C., & Kiran, S. (2014). How Justice Can Affect Jury Training Abstract Words Promotes Generalization to Concrete Words in Patients with Aphasia. *Neuropsychological Rehabilitation*, *24*(5), 738–769.

Sanford, A. J., Leuthold, H., Bohan, J., & Sanford, A. J. S. (2010). Anomalies at the Borderline of Awareness: An ERP Study. *Journal of Cognitive Neuroscience*, *23*(3), 514–523.

Schwanenflugel, P. J. (l991). Why are abstract concepts hard to understand? In P. J. Schwanenflugel (Ed.), The psychology of word meanings (pp. 223-250). Hillsdale, NJ: Erlbaum. Schwanenflugel, P. J., Harnishfeger, K. K., '" S

Schwanenflugel, P.J., Akin, C., & Luh, W-M. (1992). Context Availability and the recall of abstract and concrete words. *Memory & Cognition, 20*(1), 96-104.

van Hell, J. G., & de Groot, A. M. B. (1998). Conceptual representation in bilingual memory: Effects of concreteness and cognate status in word association. *Bilingualism: Language and Cognition, 1*(3), 193–211.

Wilson, M. (1988). MRC psycholinguistic database: Machine-usable dictionary, version 2.00. *Behavior Research Methods, Instruments & Computers, 20*(1), 6-10.

ACADEMIC VITA

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Academic Information

The Pennsylvania State University
B.A. Linguistics | B.S. Communication Sciences and Disorders | Mathematics (minor)
Thesis Supervisor: Janet van Hell
Honors Advisors: Carol Miller and Lisa Reed
College of Health and Human Development commencement student marshal Spring 2018
Expected date of graduation Spring 2018
GRE scores: 164 Verbal; 170 Quantitative; 5.5 Analytic Writing August 2017
The Penn State University Presidential Leadership Academy April 2015 – present

Awards and Scholarships

The President's Freshman Award April 2015
Presented to all freshmen with a 4.00 GPA
The Sparks Award April 2016
Presented to all sophomores with a 4.00 GPA
The Evan Pugh Award April 2017
Presented to all juniors and seniors whose GPA is in the top .5% of their class
Communication Disorders Award Fall 2016
Presented to an excellent scholar majoring in Communication Sciences and Disorders
Academic Excellence Award Fall 2014 – Spring 2018
Presented to all students who enter the Schreyer Honors College as a freshman
The Ruth B. Wodock Scholarship Fall 2015 – Spring 2018
Presented to excellent scholars in the college of Health and Human Development

Research Experiences

Bilingualism and Language Development Lab | Penn State University
Undergraduate research assistant September 2014 - present
Work under the supervision of Dr. Janet van Hell with post-doctoral student Dr. Sarah Grey and graduate student Dr. Kaitlyn Litcofsky on ERP experiments related to sentence comprehension. Responsibilities include independently capping participants for ERP studies and collecting data, recording and preparing auditory stimuli, recruiting participants, updating tasks in E-Prime.

Adult Neuroplasticity Laboratory | Penn State University
Undergraduate research assistant November 2015 - present
Work under the supervision of Dr. Chaleece Sandberg on experiment related to abstract and concrete word processing. Responsibilities include identifying semantic features for use in future experiments, developing ERP analysis protocol, training new research assistants on ERP data collection protocol.

PIRE Undergraduate Fellow | Radboud University, Nijmegen, Netherlands | Penn State CLS
Visiting researcher Summer 2016
Visited Dr. James McQueen's lab at Radboud University, Nijmegen to conduct research supported by NSF grant OISE-0968369. Conducted independent ERP research on concreteness

effects in lexical decision and semantic judgment processing in Dutch-English bilinguals. Responsibilities included preparing stimulus materials, designing the task in Presentation, independently capping and collecting ERP data from participants.

Presentations

Annual Meeting of the Cognitive Neuroscience Society March 2018

ERP exploration of semantic organization of abstract and concrete words in bilinguals and persons with aphasia

Poster presentation at annual meeting of the Cognitive Neuroscience Society in Boston, MA

Annual Meeting of the Psychonomic Society November 2017

Bilingual semantic memory: concreteness effects in second language lexical decision and semantic relationship judgment tasks

Poster presentation at annual meeting of the Psychonomic Society in Vancouver, BC, Canada

Center for Language Science at Penn State University November 2016

Concreteness effects in lexical decision and semantic judgment processing in bilinguals

Presented at the weekly Center for Language Science meeting in front of undergraduates, graduate students, post-docs, and faculty members within language science at Penn State.

Spanish department research luncheon November 2016

Concreteness effects in lexical decision and semantic judgment processing in bilinguals

One of six undergraduates invited to present research at a Spanish department luncheon attended by the president of the university.

PSUxLING3 October 2016

Concreteness effects in lexical decision and semantic judgment processing in bilingual healthy adults

Poster presentation at Penn State's annual undergraduate linguistics research exhibition.

Relevant Coursework

CSD 497 Neural Foundations of Communication Fall 2017

Course focusing on the cognitive neuroscience of language and communication with an emphasis on understanding fMRI studies and using data from patients to inform neural underpinnings of language.

LING 497 Introduction to Data Analysis in R for Language Scientists Fall 2016

Course taken almost exclusively by graduate students; designed to train language scientists in the use of R for data analysis with a focus on applying statistical concepts and R functions to our own data sets.

Extracurricular Activities and Leadership

Springfield benefiting THON

President March 2017 - March 2018

Manage a board of ten leaders; coordinate all aspects of fundraising, family relations, community, and alumni relations for a 150+ member organization; determine the future direction of the organization; serve as the face of the organization to the rest of the THON community (16,500 students), university, and donors

Family Relations Chair March 2016 - March 2017

Worked closely with a co-chair to facilitate relationships between three families affected by pediatric cancer and members of Springfield; applied for and received the opportunity to introduce another family to Springfield members; planned and coordinated visits with and care packages for four families; leader for an organization that raised nearly $193,000 in five months

Summer Fundraising Captain — Summer 2015

Organized and advertised fundraising activities in the Philadelphia area for the organization

Member — August 2014 - present

Active participant in a 150+ member student organization whose main purpose is to fundraise for the Penn State Dance Marathon (THON) in the fight against pediatric cancer and support families who have a child affected by pediatric cancer

Honors Leadership Jumpstart

Teaching Assistant — Fall 2015, 2016, 2017

Served as a three-time teaching assistant for an honors freshman leadership course. Designed and facilitated activities to promote leadership development; provided feedback on assignments; supervised teams of six freshmen while they designed and implemented a service project

State College Area High School North American Computational Linguistics Olympiad

Coach/mentor to high school team — Fall 2015

Assisted in preparing high school students for their first NACLO competition by giving guidance on practice exercises

Schreyer Honors College Freshman Orientation (SHO Time)

Group Mentor — August 2015

Served as a mentor to a group of 10 first-year honors students to introduce them to the university and honors college

THON Rules and Regulations Volunteer Safety Committee

Member — September 2014 - February 2015

Worked in a team of 35 individuals to help ensure the safety of all 15,000 attendees of THON Weekend 2015, an annual dance marathon to benefit pediatric cancer research

Employment

Penn State University Mathematics Department

Grader — August 2017 - present

Grade quizzes for 80 students in upper level undergraduate math classes given a solutions guide (6 hr/week)

Proctor — August 2017 - present

Proctor evening undergraduate math exams to ensure all exams are conducted fairly and eliminate academic integrity violations (3 hr/week)

Relevant Skills

Acoustic analysis using Praat: Beginner
EEG capping using ActiCap: Intermediate
Data analysis using R: Intermediate
ERP experiment editing using E-Prime: Beginner
EEG recording using BrainVision: Beginner to intermediate
ERP analysis using BrainVision: Intermediate
ERP experiment design using Presentation: Beginner to intermediate