EFFECTS OF WITHIN- AND CROSS-LANGUAGE SEMANTIC AMBIGUITY ON LEARNING AND PROCESSING

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Most words in English are semantically ambiguous. Cross-language translation ambiguity occurs when a word in one language has multiple translations in another language. Both within and cross-language ambiguity affect the learning and processing of words in the first language (L1) and the second language (L2) (e.g., Armstrong & Plaut, 2008; Degani & Tokowicz, 2010). This dissertation examined how semantic similarity between ambiguous words' meanings/senses affects learning and processing. Experiment 1 examined how semantic similarity impacts the learning of novel meanings for known words by teaching participants novel meanings that were related or unrelated to the known meaning of the vocabulary word. Participants recalled more meanings for vocabulary words with novel related meanings than unrelated meanings but no differences were found between related and unrelated meanings on a primed lexical decision task. In Experiment 2 we trained participants on a set of translation-ambiguous words that varied in semantic similarity between the multiple translations of the English word. Participants were slower and less accurate at recalling and translating words that had less related translations (e.g., Trunk – Rüssel (elephant), Kofferraum (car)) than words with more related translations (e.g., Sheet – Laken (bed), Blatt (paper)). Experiment 3 examined how L2 learners mapped meanings from ambiguous English words to L2 vocabulary by teaching participants only one translation that corresponded to one meaning of a semantically-ambiguous word (e.g., Trunk – Rüssel (elephant)). Using a translation-recognition task in which the critical “no” response items were semantic distractors (e.g., responding “no” that Nose is not a translation of Rüssel (trunk)) we examined how the trained (e.g., elephant) and untrained (e.g., car) meanings interfered with semantic processing of the L2 vocabulary. Participants extended the trained and untrained meanings to words with related meanings (e.g., wrapping vs. academic paper) but only the trained meaning for words with unrelated meanings (e.g., elephant vs. car trunk). Overall, this dissertation sheds light on the interplay between meaning similarity and context and how these factors influence how meanings and words are connected, provides a better understanding of how monolinguals and L2 learners process and learn semantically-ambiguous words, and informs models of monolingual and bilingual semantic memory.

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PREFACE

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1.0 INTRODUCTION

Mappings between word forms and word meanings within a language and across multiple languages often involve one-to-many mappings. One-to-many mapping between words and meanings within a language is called *semantic ambiguity* (e.g., river bank, money bank). One-to-many mapping between a word in one language and multiple translations in another language is called *translation ambiguity* (e.g., Shy – scheu and schüchtern in German). This dissertation examined the interconnections between concepts and words through a series of training studies in which we trained participants vocabulary words and word meanings within a first language (L1) and in a second language (L2). We used semantically-ambiguous words as our critical training materials to understand how the mappings between concepts/meanings and word forms within a language and across languages develop and change through experience (i.e., training). Critically, semantic ambiguity can occur because of homonymy, when a word has more than one unrelated meaning (e.g., car trunk vs. tree trunk) or because of polysemy, when a word has more than one related sense (e.g., wrapping paper vs. academic paper). We examined how different types of semantically ambiguous words are learned to understand how meaning similarity influences how connections are formed between words and meanings.

Additionally, translation ambiguity can be due to different sources. For example translation ambiguity can be due to within language homonymy, polysemy, noun/verb ambiguity (e.g., lexical ambiguity), and near-synonymy in the target language. For example, *trunk* is a translation-ambiguous word from English to German because of homonymy in the source language (English) and it can be translated into multiple translations in German that map to each specific meaning (e.g., car trunk – Kofferraum, tree trunk- Baumstamm, elephant's trunk – Rüssel). *Shy* is a translation-ambiguous word from English to German because of near-synonymy in the target language (German) and can be translated into multiple near-synonymous translations (e.g., shy – scheu and schüchtern). We investigated how these different types of translation-ambiguous words affect learning L2 vocabulary and how learners process these words in L1 and L2 (Experiments 2 and 3).

Semantic ambiguity has been extensively studied for decades. However, earlier psycholinguistic research focused primarily on homonymy (e.g., Duffy, Morris, & Rayner, 1988; Hogaboam & Perfetti, 1975; Simpson, 1984). Previous research noted that factors such as meaning dominance/frequency and context affect how homonyms are processed such that dominant meanings are more strongly activated than subordinate meanings but strong contexts can increase subordinate meaning activation (Duffy et al., 1988). More recent research has also examined polysemy and the differences in how homonymous and polysemous words are processed, learned, and represented in the mind (Rodd, Gaskell, & Marslen-Wilson, 2002). The distinct meanings of homonymous words are hypothesized to be represented *separately* whereas the senses of polysemous words are thought to be represented *together* (e.g., Rodd, Gaskell, & Marslen-Wilson, 2004). However, not all researchers agree that polysemous senses are represented together in a single lexical entry but alternatively hypothesize that the multiples senses are stored in separate lexical entries (see Eddington & Tokowicz, 2015 for a review)

Previous research suggests that there are differences between how polysemous and homonymous words are processed. For example, researchers have found processing advantages (i.e., faster and more accurate responses) for polysemous words in lexical decision over unambiguous and homonymous words and a processing *dis*advantage (i.e., slower and less accurate responses) for homonymous words in semantic-based tasks over unambiguous and polysemous words (e.g., Armstrong & Plaut, 2011; Hino, Lupker, & Pexman, 2002; Rodd et al., 2002). These processing differences in lexical decision and semantic decision based tasks have been used to support theories of polysemous sense representation and homonyms meaning representation (i.e., together vs. apart). However, these processing advantages and disadvantages are not always found, and some studies have found no processing advantages for polysemes or disadvantages for homonyms (e.g., Hino, Kusunose, & Lupker, 2010; Klein & Murphy, 2001).

Similar to the study of within language semantic ambiguity, researchers investigating translation ambiguity across languages have also found evidence for differences between various sources of translation-ambiguous words (e.g., Boada, Sanchez-Casas, Gavilán, García-Albea, & Tokowicz, 2013; Degani & Tokowicz, 2010; Degani, Tseng, & Tokowicz, 2014; Eddington & Tokowicz, 2013; Laxén & Lavaur, 2010). Prior research on translation ambiguity primarily focused on differences between *meaning* translation-ambiguous words, which collapsed homonyms and polysemous words, and *form* translation-ambiguous words, which were due to near-synonymy. This dissertation investigated the differences in processing and representation of homonymous and polysemous words within a language (Experiment 1) and different types of translation-ambiguous words (homonymous, polysemous and near-synonymous) across languages (Experiments 2 and 3). Before turning to the specific experiments, we review models of semantic ambiguity within a language and across languages.

1.1 MODELS OF SEMANTIC AMBIGUITY RESOLUTION

Several theories have been proposed to explain ambiguity effects reported in the literature. Prior models of semantic ambiguity resolution focused on how and when different meanings of ambiguous words become activated (Duffy et al., 1988; Hogaboam & Perfetti, 1975; Simpson, 1984). Recent models of semantic ambiguity resolution take into consideration the semantic similarity of the meaning/senses of ambiguous words, but emphasize context to a lesser extent (for a review, see Eddington & Tokowicz, 2015). Rodd et al. (2004) proposed a model of semantic ambiguity using a parallel distributed processing (PDP) network (See Figure 1). In their model, deep attractor basins develop as the network learns to differentiate the disparate meanings of homonyms. By contrast, the network develops shallow and wide attractor basins for the multiple related senses of polysemes. The deep attractor basins for homonyms correspond to different meanings, whereas the shallow attractor basins for polysemes map onto a "core meaning" that is shared among the multiple related senses. According to the model, advantages reported in the literature for polysemes are due to the shallow attractor basins that develop; during word recognition any feature associated with the word can facilitate the recognition process. For homonyms, initially there is a 'blend state' in which a specific semantic code has not been selected. There is a disadvantage for homonyms because the network must shift from the blend state to settling on a specific code before word recognition can be achieved.

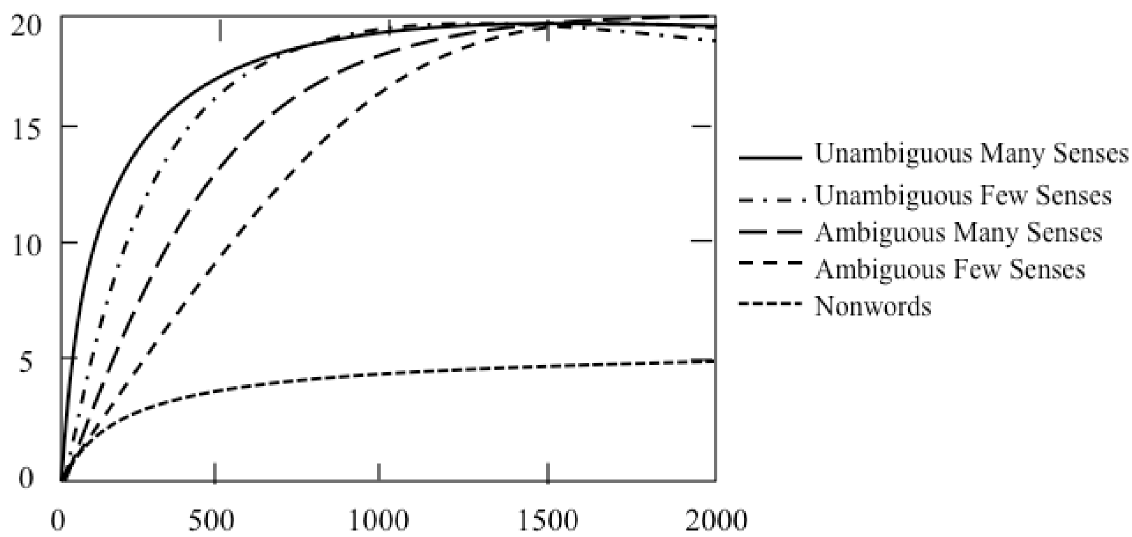


Figure 1. Model of Semantic Ambiguity Resolution adapted from Rodd et al., (2004). The y axis represents semantic activation units and the x axis represents the number of updates (time)

Another PDP account was proposed by Armstrong and Plaut (2008, 2011) and is called the *Semantics Settling Dynamics Account* (See Figure 2). This model takes into consideration different types of ambiguous words and how context influences semantic activation over time. Semantic activation for context-free and earlier processing is predominated by excitatory connections for polysemes and inhibitory connections for homonyms. During later stages in processing and in context-dependent tasks, both senses of a polyseme initially will be highly activated because they share features that would be consistent with the context and over time, the contextually-appropriate sense will become more active. For homonyms, the contextually-appropriate meaning will become more active and the semantic activation for the contextually-inappropriate word will slowly deactivate.

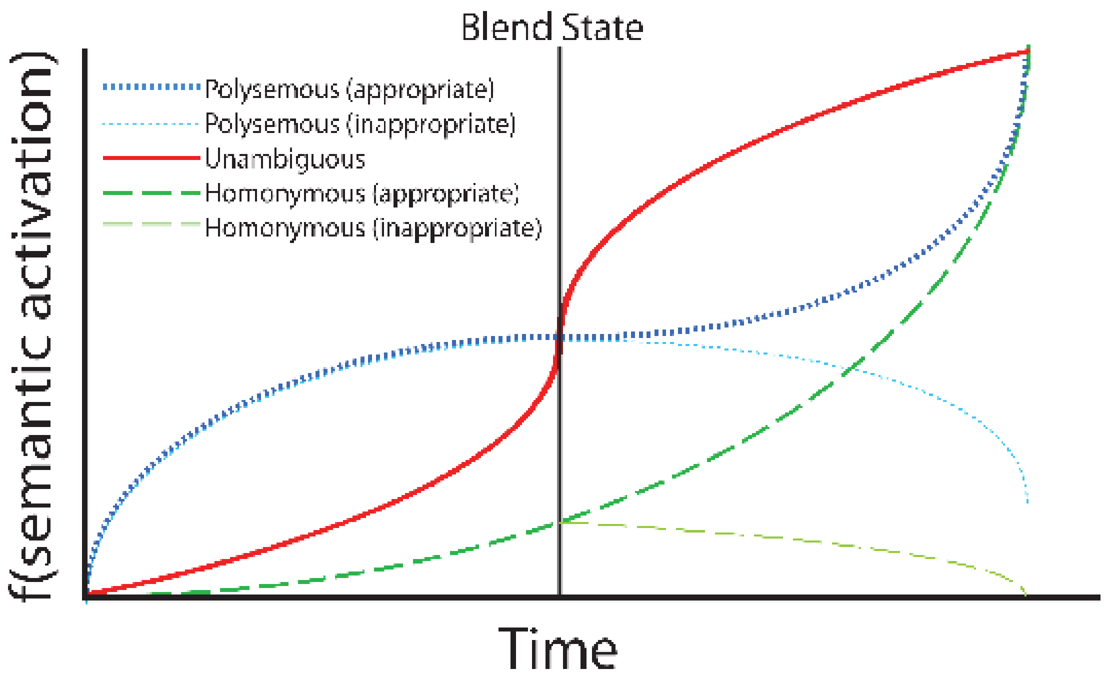


Figure 2. Semantics Settling Dynamics Account of Semantic Ambiguous, Armstrong (2012)

Ambiguous words often have meanings/senses that are more frequently encountered. Both accounts assume the meaning dominance/frequency and context will influence meaning/sense activation, however the accounts describe how meaning activation changes over time for balanced ambiguous words (i.e., words with meanings/senses that are equally frequent). Previous research on semantic ambiguity suggests that meaning dominance and context interact (Duffy et al., 1988), but meaning activation differs between polysemous and homonymous words (Klepousniotou, Pike, Steinhauer, & Gracco, 2012; Rodd et al., 2002). A comprehensive account of meaning ambiguity resolution would account for the effects of meaning dominance, meaning relatedness (homonyms vs. polysemes), and context (no context, biased context, unbiased context). Applying what we understand of how meaning dominance and context interact and differences in how polysemous vs. homonymous word meanings/senses are activated we can hypothesize the following:

1. Dominant polysemous senses will have the greatest level of activation, which will increase with a supporting context but decrease slowly over time with an incompatible context
2. Subordinate polysemous senses will have less activation relative to the dominant senses but will increase with a supporting context and will slowly decrease with an incompatible context.
3. Dominant homonymous meanings will have less activation relative to unambiguous words and polysemous words due to inhibitory connections with the alternative meanings but will quickly increase with a supportive context and slowly decrease with an incompatible context
4. Subordinate homonymous meanings will have relatively low activation compared to the dominant meaning but will gradually increase in activation with a supportive context but quickly decrease in activation with an incompatible context.

These hypotheses specify the meaning activation of ambiguous words with biased meanings/senses over time and with context, similar to the hypotheses laid out by Armstrong and Plaut (2008, 2011) for unbiased ambiguous words. In the next section we discuss models of bilingual memory representation and accounts of *translation-ambiguity*.

1.2 ACCOUNTS OF TRANSLATION-AMBIGUITY RESOLUTION

Bilingual models of production and meaning representation have also been adapted to explain and make predictions about translation ambiguity. The Distributed Conceptual Feature Model (DCFM, De Groot, 1992; van Hell & De Groot, 1998) is a bilingual model of semantic memory that was adapted by Laxén and Lavaur (2010) to explain translation ambiguity effects. In the original model, L1 and L2 lexical forms are connected to a shared conceptual store, which is composed of semantic nodes that represent conceptual features of a word. Translation production and recognition are facilitated by more overlapping features between L1 and L2 (e.g., De Groot, 1992). The adapted DCFM allows for more than one lexical form to be represented in L1 and L2, specifically allowing two forms to be associated with a single meaning, or a single form in one language to be associated with two forms in the other language. Laxén and Lavaur (2010) predicted that as the level of semantic similarity between multiple translations of an ambiguous word increases, there will be a greater number of shared semantic nodes, which will facilitate production and recognition. The Revised Hierarchical Model (RHM, Kroll & Stewart, 1994) of bilingual memory representation also has been adapted to explain translation ambiguity (Eddington & Tokowicz, 2013; Kroll & Tokowicz, 2001). Like the DCFM, the original RHM assumes a shared conceptual store between the L1 and L2 but separate lexical stores for each language. The RHM also assumes that as bilinguals become more proficient, L2 words will develop stronger links to their meanings (See Figure 3).

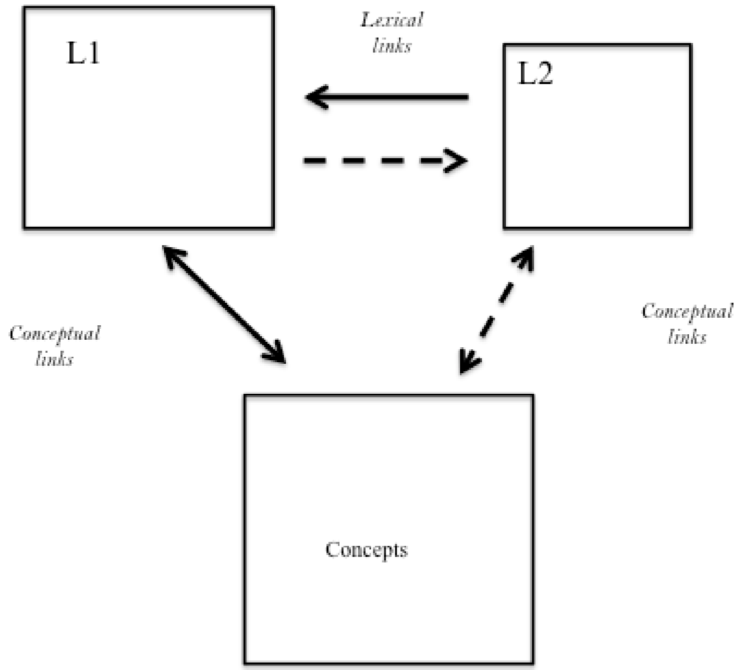
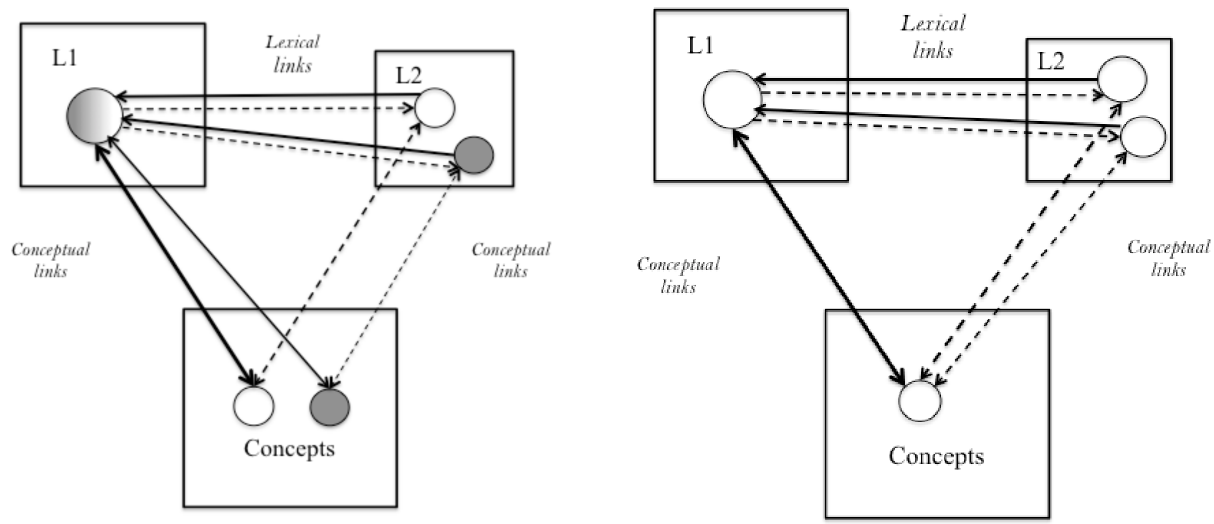


Figure 3. Revised Hierarchical Model. Adapted from Kroll & Stewart (1994)

The adapted RHM, the Revised Hierarchical Model of Translation Ambiguity (RHM-TA, Eddington & Tokowicz, 2013) makes the same assumptions as the original RHM, but makes specific predictions and assumptions for different types of translation-ambiguous words (see Figure 4). For synonym translation-ambiguous words (e.g., shy: schüchtern and scheu, in German), there is a strong conceptual link from the L1 word form to the concept and multiple links from the concept to the L2 word forms. For meaning translation-ambiguous words (e.g., number: odd – ungerade, strange odd – merkwürdig), there is one link from the L1 word to each concept, and each concept is connected to a different L2 word. Therefore, meaning translation-ambiguous words may benefit more from a prior context in production or recognition because the context may selectively activate the appropriate meaning, and therefore also the appropriate corresponding translation. For synonym translation-ambiguous words, a prior context would not alleviate competition between the multiple translations because both translations could be appropriate.



Homonym translation-ambiguous words

Polysemous translation-ambiguous words

Figure 4. Revised Hierarchal Model of Translation Ambiguity. Adapted from Eddington & Tokowicz (2013).

In sum, models of within language and cross language ambiguity point to context meaning/sense similarity and meaning/sense as important factors in ambiguity resolution. This dissertation examined the effects of semantic similarity between ambiguous words' meanings/senses and meaning/sense dominance on word learning and processing. The results from this dissertation will inform models of within language and cross language semantic ambiguity resolution.

1.3 OVERVIEW OF EXPERIMENTS

Experiment 1 examined how new meanings are mapped to known unambiguous English words where the new meaning is related or unrelated to he know word's meaning (e.g., related: learning that *hive* means a busy household; unrelated: learning that *hive* is a mythical monster). We examined how the relatedness between the new meaning and old meaning affects the learning of the new meaning to better understand the representation of ambiguous words. Using a primed lexical decision task with event related potentials (ERPs) we examined neural signatures of semantic processing of the new meanings.

Experiment 2 examined how known meanings are mapped to novel labels (L2 vocabulary) by training participants on a set of words that are ambiguous across languages. Specifically, we trained participants on a set of translation-ambiguous words from English to German that varied in the level of semantic similarity (low similarity: homonyms, moderate similarity: polysemes, high similarity: near-synonyms). We additionally examined how meaning dominance (dominant vs. subordinate meaning/sense) and translation dominance affected learning and processing of the L2 vocabulary (German) and how meaning similarity interacted with meaning/translation dominance. Critically, we examined how learners processed the L2 vocabulary words using a semantic relatedness task, which focuses on meaning level relationships.

In Experiment 3, we examined how learners differentially extend meanings/senses to L2 vocabulary. Similar to Experiment 2, participants learned a set of semantically-ambiguous words (homonyms and polysemes) from English to German but only learned one translation of the word. The translation corresponded to the dominant or subordinate meaning/sense of the word. We examined if the "untrained" meaning/sense was extended to the newly-learned L2 vocabulary with a translation recognition task using semantic distractors as the critical lures (e.g., trained on the elephant meaning of trunk but presented with a semantic distractor related to the car meaning of trunk).

2.0 EXPERIMENT 1

.New concepts and words are continuously being generated within a language. More recently, with social media and technological advances, new meanings to words and concepts can be shared at a rapid pace (Androutsopoulos, 2011). Words such as *friend*, *troll*, *feed*, *stumble, hacking*, *cloud*, *tweet*, *stream*, *share*, *follow, like*, *pin,* and *wall* all have new meanings. Many of these new word meanings are related to the original meaning of the word. How do we integrate these new meanings of familiar words so easily into our semantic networks, and how does the relatedness of the new and old meanings affect this process? This experiment investigated how easily learners acquire related and unrelated novel meanings to known unambiguous words and used ERPs to investigate neural and behavioral markers of semantic processing of these novel meanings.

Extensive research has been done on how people represent and process already known semantically-ambiguous words but less research has examined how new meanings are associated with known words (Clark & Gerrig, 1983; Rodd et al., 2012). The current study extends the small amount of work in this area done by Rodd et al. (2012) by teaching participants novel meanings that are related or unrelated to the original meanings gathering both behavioral and ERP data. This experiment further examined how newly learned ambiguous words are processed in comparison to known ambiguous words. We first discuss research relating to the acquisition of new meanings to known words and then review relevant literature of recent ERP investigations of semantically ambiguous words.

2.1 LEARNING NEW MEANINGS/SENSES TO OLD WORDS

There is a vast literature on how children acquire new words and word meanings but the focus of this dissertation is on how adults acquire new words and word meanings (e.g., Bloom, 2001; Miller & Gildea, 1987). We focus on adult vocabulary learning with respect to acquiring new meanings/senses to known words. One study by Clark and Gerrig (1983) examined how participants comprehended and interpreted novel meanings to known verb phrases using eponymous verb phrase structures. Eponymous words and verb phrases use a person or thing as a word or label of an action (e.g., Boycott, Arnold Palmer) In the first experiment participants read verb phrases using known eponyms ("She did a *Napoleon* for the camera") and unknown eponyms ("She did a *George Conklin* for the camera"). Napoleon is a familiar name and has familiar attributes, which participants could imagine such as posing like Napoleon. They also varied the level of context either restricting in which the context specified a specific action (e.g., restricting context: "Please do a George Conklin *for the camera*") or unrestricting in which the context did not specify a specific action (e.g., unrestricting context: "Please do a George Conklin for me"). Clark and Gerrig (1983) found that participants were more likely to interpret known than unknown eponyms and that a restricting context facilitated interpretability of the phrases. The results suggested that the participants were looking for eponym interpretations rather than restricting the interpretations to context alone.

In Experiment 2, participants were presented with vignettes that introduced a person for which an eponym could be created. The stories varied on coherence levels (coherent and incoherent) and the number of salient acts for use as an eponym (one vs. three). The vignettes began with “Imaging a friend told you about” and then continued to describe a character (e.g., a neighbor Harry Wilson who liked to carve his hedges into animal shapes). The last sentence of the paragraph ended either with an unrestricted eponym phrase (e.g., Your friend later told you “I plan to do a *Harry Wilson*”), a restricting eponym phrase (“I plan to do a *Harry Wilson* to the hedges”), or a extending eponym phrase (“I plan to do a *Harry Wilson* to a bar of soap”). Participants read the vignettes and were asked to rate how certain they were in interpreting the eponym and to clarify their answer in a short answer format. Participants comprehended the restricting completions more than the unrestricted and extending completions. Additionally, participants were more likely to produce interpretations that were related to a narrow meaning of the eponym than a broad meaning when the vignettes were coherent than incoherent. This study highlights how supportive context can facilitate new interpretations to familiar words and concepts and the ease with which comprehenders can interpret and accept novel meanings/senses.

Similar to eponym interpretation, learners easily comprehend novel metonymical interpretations. In an eye-tracking study, Frisson and Pickering (2007) examined how novel metonymical words were processed compared to familiar metonymical words (e.g., reading *Dickens* (familiar) vs. reading *Needham* (novel/unfamiliar)). They manipulated the context to be supportive of the literal interpretation, metonymical interpretation, or unsupportive to the metonymical interpretation for both the familiar and unfamiliar names. For unfamiliar metonyms participants read sentences such as “My great-grandmother has all the novels written by

Needham in her library. I heard that she often read *Needham* when she had the time." In this example *Needham* is an unfamiliar name but the context supports the metonymical use of *Needham* in the second sentence.

Overall, participants had more difficulty processing unfamiliar names (e.g., *Needham*) than familiar names (*Dickens*) and literal interpretations of the unfamiliar names were easier to process than metonymical interpretations for the unfamiliar names. No differences in processing were found between literal and metonymical supporting contexts for familiar names. Interestingly, no differences were found in processing times of familiar and unfamiliar metonyms when the prior context supported the metonymical interpretation. These results first demonstrate a lack of a sense dominance effect for metonyms and further that supporting contexts can diminish processing difficulties with the presentation of novel interpretations of words. These results provide online processing support that novel meanings/sense comprehension is done with few processing costs.

Prior research indicates that associating novel meanings/senses to names and people is done with ease, especially with a supportive prior context. How do learners associate and learn new meanings to known *words*? A recent study by Fang and Perfetti (2015) examined how learners acquired novel meanings to high and low frequency words and further examined how the new meaning of the word impacts processing of the old meaning of the word. They found an overall word frequency effect such that novel meanings for words with low frequency were recalled more initially than novel meanings for words with high frequency, but low frequency words were forgotten more quickly than high frequency words. They hypothesized that this difference in retention rates occurred due to interference from the old meaning and that this is especially prominent for high frequency words early in learning. Additionally, they found no evidence that learning a new meaning of a word impacted the old meaning of the word with a semantic relatedness task. These results demonstrated that characteristics of the old meaning of a word impact learning new meanings for known words. For these stimuli all novel meanings were unrelated to the old meaning. How does meaning relatedness of the old to new meaning influence learning?

Rodd et al. (2012) examined how meaning relatedness affected how easily new meanings to known words were learned. Rodd et al. (2012) further examined if the participants would demonstrate ambiguity (e.g., a polysemy advantage and homonym disadvantage) effects after training on a lexical decision task. In experiment 1, participants learned the new meanings of the words by reading paragraphs which instantiated the new meaning of the word. After a filler task participants completed a cued-recall task in which they were presented with the vocabulary word and were asked to recall features associated with the new meaning. Results showed that participants recalled more features for words with related meanings than unrelated meanings. However, because participants recalled so few features of the words associated with unrelated meanings they were unable to ensure that participants adequately learned the new meanings of the words and therefore could not assess meaning relatedness would affect their processing of the words.

In Experiment 2, Rodd et al. (2012) modified the training to include test booklets, which asked participants to complete questions that probed their learning of the new meanings. Participants completed one training session in the lab and then completed five training sessions outside of the lab. A week after the initial training session, participants returned to the lab and completed a post-training lexical decision task and cued-recall task. The lexical decision task contained the vocabulary words and words that matched on word characteristics. Again, they found that participants recalled more features for words with new related meanings than words with unrelated meanings. On the lexical decision task they expected that participants would be slower and less accurate at responding to the vocabulary words with unrelated novel meanings and faster and more accurate at responding to vocabulary words with related novel meanings. However, they only observed an effect of experience such that the vocabulary words were responded to more quickly and accurately than the control words. Rodd et al. hypothesized that this lack of effect was due to the novel meanings not sufficiently being integrated into the participants' semantic networks and that the training did not emphasize meaning enough for this to occur.

In Experiment 3, Rodd et al. (2012) modified the training paradigm further to include the original paragraphs and supplementary tasks that focused on meaning-level relationships (e.g., vocabulary-definition matching tasks and sentence generation/creative writing). The first training session occurred on first day in the lab and training sessions two through four occurred at home. The participants came back on the fifth day and completed the lexical decision task and the cued-recall task. They found overall greater accuracy on the meaning generation task compared to Experiment 1 and 2 suggesting that participants learned the new meanings of the words. Like in Experiment 2 and 3, they found greater recall of features for words with related novel meanings than words with unrelated novel meanings. The lexical decision task using a subset of items that participants correctly recalled during the meaning generation task, revealed an effect of relatedness. The related words were responded to more quickly than unrelated words; no differences were observed in the accuracy analysis.

Rodd et al. (2012) concluded from these results that semantic similarity facilitates the integration of novel meanings to known words and that semantic similarity even for newly acquired meanings to known words can lead to processing advantages similar to established polysemous words. This facilitation on learning novel related meanings is akin to prior research on similarity in associative learning paradigms (e.g., Underwood, Ekstrand, & Keppel, 1965) which demonstrated that greater semantic similarity between paired associates across exposures to different list versions (e.g., learning associates table – banana facilitates learning table – pear) facilitates learning.

The results from Rodd et al. (2012) also provide insight into the early stages of ambiguous word learning and highlights the importance of meaning similarity in the process of integrating new concepts in the mental lexicon. However, because comparisons were not made between the newly learned ambiguous words (i.e., the trained vocabulary) and established ambiguous words it is unknown if there are differences in how these types of words are processed. Additionally, it is unknown how learning novel meanings to known words affects the representation of the dominant meanings after training (but see Fang & Perfetti, 2015, for a similar paradigm).

In the current study, like Rodd et al.'s, (2012) study we asked how meaning similarity impacts the learning of novel meanings and further examined how the new and old meanings of the words are impacted by meaning similarity. Additionally, we asked how learners process the newly learned ambiguous words compared to known ambiguous words in the lexical decision tasks by included matched homonymous and polysemous words Participants completed an unprimed lexical decision task pre and post-training so we could examine differences from before training and after training. Critically, ERPs were collected while participants in this experiment performed a primed lexical decision task in which the primes included the trained vocabulary words with targets that were related to the dominant established meaning and the newly-learned meaning. Participants performed this task on the second session of the study (after one vocabulary training session) and again on the final testing session (after two vocabulary training sessions). Therefore, across training sessions we examined how the dominant meaning and newly-learned meaning influenced semantic processing and examined how meaning relatedness interacts with the differential priming effects. In the primed lexical decision task, we additionally included homonymous and polysemous primes with targets related to the dominant and subordinate meaning/sense in a separate analysis to further examine semantic processing for established ambiguous words within our sample. In sum, we evaluated the differences in meaning dominance for both the newly-learned ambiguous words and established ambiguous words and examined how meaning similarity impacts the effect of dominance in processing.

The effect of meaning dominance on meaning activation of semantically ambiguous words differs by the relatedness of the ambiguous words meanings/senses(Klepousniotou et al., 2012). Klepousniotou et al. (2012) examined differential priming effects in an ERP study on polysemous and homonymous words using a primed lexical decision task with a short inter-stimulus interval (ISI) between the prime and target (50 ms). Targets related to the dominant and subordinate meanings of polysemes led to similar mean N400 attenuations (indicative of priming), whereas only the targets related to dominant meanings led to a mean N400 attenuation for homonyms. In a follow up experiment, MacGregor, Bouwsema, and Klepousniotou (2015) used the same stimuli as Klepousniotou et al. (2012) but used a longer ISI between the prime and the target (750ms). They found similar results such that both the dominant and subordinate related target led to N400 priming for polysemes suggesting that both senses of polysemes remain active even after a longer delay. However, for homonyms no N400 priming was observed suggesting that both meanings of the homonym were no longer activated after the longer delay.

MacGregor et al. (2015) did observe a significant late positivity effect (P600) for homonyms such that related targets led to greater positivity relative to primes but no late positivity effects were observed for polysemes. These late effects in processing may indicate difficulty in processing specifically for homonymous words.

2.2 EXPERIMENT OVERVIEW

The current study examined how meaning relatedness impacts the learning of novel meanings for known words. Participants in the experiment learned new meanings to familiar words by reading paragraphs in which the new meaning was instantiated and were tested on their knowledge of the new meanings using a meaning generation task. This research builds on Rodd et al.'s (2012) work and examined how easily related vs. unrelated novel meanings are acquired and, how learning new meanings to known words impacts processing of the vocabulary word after training. Additionally, we examined how the vocabulary words after training, are processed compared to known (untrained) polysemous and homonymous words using primed and unprimed lexical decision tasks.

Based on previous research (Rodd et al., 2012) we predicted that participants would generate more associates for words with novel related meanings than novel unrelated meanings. For the lexical decision task we expected there to be a session by word type interaction such that the trained words and untrained ambiguous words would be responded to similarity on session 2 but not on session 1. After training, we hypothesized that the related trained words would be responded to more quickly than the unambiguous words and the unrelated meaning trained words would be responded to more slowly than the related meaning words and unambiguous words. Thus, after training we hypothesized that words with related novel meaning would yield a polysemy advantage effect and words with unrelated novel meanings would yield a homonym disadvantage effect.

For the primed lexical decision task we focused on the N400 component because it reflects semantic processing (e.g., Kutas, Federmeier, Coulson, King, & Münte, 2000). In particular, semantic priming leads to a reduction in the mean N400 amplitude. Therefore, we expected overall a reduction in the mean N400 amplitude in response to related primes compared to unrelated controls. We expected that the magnitude of the N400 reduction compared to controls would be modulated by the word type and word meaning. In particular, when compared to unrelated controls, we expected that associates related to old meanings would lead to a larger mean N400 reduction than new meanings compared to unrelated controls. Further we expected that related new meanings would lead to a larger reduction than unrelated new meanings compared to unrelated controls. Based on previous research (Klepousniotou et al., 2012) for homonyms, we expected a larger N400 reduction for targets related to the dominant meanings compared to targets related to the subordinate meaning, relative to controls, but a similar N400 reduction for both dominant and subordinate targets for polysemes.

For behavioral results, overall we expected a semantic priming effect such that related targets would be responded to more quickly and accurately than unrelated targets. We also expected a meaning relatedness effect such that words associated with related meanings/senses would be responded to more quickly and accurately than words associated with unrelated meanings/senses. We hypothesized that there would be a significant meaning dominance effect such that dominant related targets would be responded to faster than subordinate related targets. Additionally, based on previous research and models of semantic ambiguity (Klepousniotou et al., 2012) we expected that meaning relatedness and dominance would interact such that there would be equal levels of priming for the dominant and subordinate related meanings/senses for words with related meanings but greater priming for dominant related meanings/senses for words with unrelated meanings.

2.3 METHODS

2.3.1 General Methods for Experiments 1-3

2.3.1.1 Individual Difference Tasks

All participants in the three experiments completed five individual difference tasks (see Appendix A). These tasks served as (1) fillers between testing and training procedures; (2) a way of controlling for individual variability in our behavioral statistical models; and (3) variables that can be used in future work to examine how individual differences interacts with the different conditions. In this dissertation, we only used the individual differences as a means of accounting for individual variability and not examining any interactions with individual differences.

2.3.2 Participants

Twenty-two native English speakers participated in the experiment. All participants were at least 18 years of age or older, right-handed, had normal or corrected-to-normal visual and hearing. Participants were recruited from the community and through the Introduction to Psychology subject pool and received credits and were compensated for their time. One participant was excluded because they did not attend all three sessions of the experiment, one participant was excluded because he or she was not a native English speaker, one participant was excluded due to poor EEG recordings, and four participants were excluded due to missing data. Demographic information for the final set of 16 participants can be seen in Appendix B.

2.3.3 Stimuli

2.3.3.1 Vocabulary Training

There were 64 English vocabulary training words in this experiment. Thirty-six of the vocabulary words and corresponding novel meanings for the vocabulary were from Rodd et al. (2012). The additional 28 vocabulary words and novel meanings were selected and generated by the experimenter and research assistants (see Appendix C for the complete set of training stimuli). We followed the same procedures as Rodd et al. (2012) in creating the novel related meanings such that the novel meanings corresponded to the known word's functional properties, physical properties, to a more specific instance of a general meaning, or based on imagery that the word evoked. Paragraphs containing the vocabulary words with the new meanings were used as part of the training phase and within each paragraph the vocabulary word was used at least five times in each paragraph. We used the 36 paragraphs generated by Rodd et al. (2012) and generated paragraphs for the additional 28 vocabulary words. To create "unrelated" vocabulary-meaning pairings, each word was paired with another vocabulary word that matched on similar word characteristics (e.g., length and frequency) that had an unrelated novel meaning. Thus, across two counter-balanced list versions, each vocabulary word was paired with a "related" novel meaning and "unrelated" novel meaning.

2.3.3.2 Unprimed Lexical Decision Task

For the unprimed lexical decision task, 64 vocabulary words, 32 homonyms, 32 polysemes, and 128 unambiguous words were used as word stimuli. The homonyms and polysemes were selected from previous research (Bedny, McGill, & Thompson-Schill, 2008) and homonym and polyseme norms (Crossley, Salsbury, & McNamara, 2010; Twilley, Dixon, Taylor, & Clark, 1994). These different word types were matched on average length ($F(4,249) = .245$, $p = .91$), frequency ($F(4,249) = .72$, $p = .58$), and concreteness ($F(4,249) = .48$, $p = .74$) (see Table 1 for stimuli characteristics). The 256 pronounceable nonwords matched the relative frequency of the word length of the English words.

Table 1. Stimuli Characteristics for Unprimed Lexical Decision Task - Exp. 1

	Length		log Frequency		Concreteness	
Word Type	*M*	*SD*	*M*	*SD*	*M*	*SD*
Homonym	4.69	1.31	2.85	0.51	4.39	0.42
Polyseme	4.97	1.09	2.84	0.45	4.38	0.67
Related (V1) Unrelated (V2)	4.75	1.11	2.61	0.52	4.46	0.61
Unrelated (V1) Related (V2)	4.78	1.39	2.82	0.55	4.45	0.76
Unambiguous Filler	4.84	1.17	2.82	0.78	4.31	0.78

Note. V1 and V2 refer to the two different training list versions.

2.3.3.3 Primed Lexical Decision Task

The critical word primes for the primed lexical decision task consisted of 64 vocabulary words, 32 homonym, and 32 polysemes, the same as in the unprimed lexical decision task. Additionally, 256 unambiguous fillers paired with related and unrelated targets and 256 unambiguous fillers paired with nonwords were included in the stimulus list. The targets for the vocabulary words consisted of 64 targets related to each new meaning of the vocabulary words and corresponding 64 controls, 64 targets related to each old meaning of the vocabulary words and 64 corresponding controls. The target words for the homonyms consisted of 32 words related to the dominant meaning of each homonym and 32 corresponding controls, 32 words related to each subordinate meaning and 32 corresponding controls. The target words for the polysemes consisted of 32 word related to each dominant sense and 32 corresponding controls, 32 word related to each subordinate sense and 36 corresponding controls. Dominance of the homonyms and polysemes were determined from norms (Durkin & Manning, 1989; Twilley et al., 1994). There were 128 related targets for 128 of the filler unambiguous words, and 128 unrelated targets for the remaining filler unambiguous words. The related targets for the trained vocabulary words were selected by the researchers and the related targets for the untrained known ambiguous vocabulary words were selected from a previous priming experiment (Bedney et al., 2008). All unrelated controls were matched to the trained words on length ($F(1,382) = 1.89$, $p = .17$), and log frequency (SUBTL; Brysbaert and New (2009) ($F(1,382) = 1.09$, $p = .3$), but were not well matched on concreteness (Brysbaert, Warriner, & Kuperman, 2014) ($F(1,382) = 3.14$, $p = .08$), see Table 2 for a summary of target characteristics. Using Latent Semantic Analysis (Landauer, Foltz, & Laham, 1998) we confirmed that the related prime-target pairs have a greater level of semantic similarity ($M = .21$, $SD = .21$) than unrelated prime-target pairs ($M = .06$, $SD = .08$), $t(629) = 11.49$ $p < .001$. Four counterbalanced list versions were created for each training version so that each word was presented in each condition across the list versions. See Appendix D for the complete set of stimuli for the trained and untrained primes and corresponding related targets and unrelated controls.

Table 2. Target word characteristics

	English Word Length		English log Frequency		English Concreteness	
Word Type	M	SD	M	SD	M	SD
Trained	6.03	1.62	2.61	0.84	4.05	0.76
Untrained	5.82	1.71	2.72	0.74	4.22	0.83

2.3.4 Procedure

For a summary of the procedures see Table 3. On the first session, participants completed an unprimed lexical decision task that contained to-be-trained words and untrained words. Then participants completed the O-Span task (Turner & Engle, 1989). Next participants completed the first vocabulary training session (see below for details). Last, participants completed the PPVT-IV task (Dunn & Dunn, 2007).

On the second session (2 days after the session 1) participants completed a meaning generation task to test their memory of the novel meanings. Next, participants completed the primed lexical decision task while we recorded ERPs. Next, participants completed the Flankers test (Eriksen, 1995) and the Stroop task (Stroop, 1935). Last, participants completed the second session of the vocabulary training.

On the third session (1 week after session 2), participants completed the meaning generation task, the primed lexical decision task with ERPs, and the unprimed lexical decision task. Finally, participants completed the Raven's Matrices (Raven, 1965) and a language history questionnaire (Tokowicz, Michael, & Kroll, 2004).

Table 3. Summary of Exp. 1 Procedures

Session	Task	Task Order
1 (Day 1)	Pretest and Vocabulary Training	Unprimed Lexical Decision Task O-span Vocabulary Training PPVT
2 (Day 3)	Vocabulary Tests and Vocabulary Training	Meaning generation Test Primed Lexical Decision (with ERPs) Stroop Task Flankers Task Vocabulary Training
3 (Day 10)	Posttests and	Unprimed Lexical Decision Task

Vocabulary Tests	Meaning generation Test Primed Lexical Decision Task (with ERPs) Ravens Language History Questionnaire

2.3.4.1 Vocabulary Training

The formal training sessions involved participants reading paragraphs that instantiated the new meaning of the vocabulary word and used the vocabulary word at least five times. This training protocol was selected because it was effective in prior research (Rodd et al., 2012, Experiments 2 and 3), and because it explicitly draws attention to the new meanings. Participants were asked to read the paragraphs using the vocabulary word and to learn the new meanings of the words. Participants read the paragraphs at their own pace and pressed the space bar to continue to the next paragraph. Participants were exposed to $1/4^{th}$ of the vocabulary words within a block and were then tested on their knowledge of the vocabulary they were exposed to within a block with a vocabulary-definition matching task. During the vocabulary-definition matching task, participant typed in their response and pressed the ENTER key to record their answer. After participants were exposed to the training paragraphs and vocabulary-definition matching tests twice, they were asked to complete a final test in which they were tested on all vocabulary in a final vocabulary-definition test.

2.3.4.2 Unprimed Lexical Decision Task

During the unprimed lexical decision task participants were instructed that they would first be presented with a fixation cross at the center of the screen, which shortly would be replaced with a letter string. The participants were instructed to decide if the letter string was a real English word or not by pressing corresponding buttons on the button box. They were instructed to press the “yes” key (rightmost button on the button box) with their right index finger if the letter string was a real English word and to press the “no” key (leftmost button on the button box) with their left index finger if the letter string was not a real word in English. They were asked to make a decision as quickly and as accurately as possible and to guess if they were unsure. The fixation cross was displayed on the screen for 250 ms and the letter string was displayed on the screen until the participant made a response. The words and nonwords were randomly presented to the participants.

2.3.4.3 Meaning Generation Task

During the meaning generation task, participants were presented with the new vocabulary words on the screen and were asked to type in a word or short phrase that is related to the new meaning of the word. After they typed in a word or short phrase they were instructed to press the ENTER key to record their response and move on to the next word. They were asked to type in “I don’t know” if they were unable to recall the new meaning of the word. Words were presented in a random order.

2.3.4.4 Primed-Lexical Decision Task

After the ERP cap was set up, and impedances were lowered to below 10 kΩ, the participant was instructed to keep their feet flat against the floor and to place their left and right index fingers on the left and right keys of the button box for the duration of the experiment. Stimuli were presented on a black background in white ink at the center of the screen. They were instructed to move as little as possible and to blink only after they made a response and during the breaks. On each trial, participants were presented with a fixation cross for 1000 ms, which was followed by a 200 ms inter-stimulus interval (ISI). Next, the prime was displayed on the screen for 200 ms followed by a 200 ms ISI. The target was then displayed on the screen until the participant made a response or for 3000 ms, whichever came first. There was a 800 ms inter-trial interval before the next fixation cross appeared. The prime was always a real word and was presented in lowercase letters and the target was either a word or nonword and was presented in uppercase letters. The participants were instructed to read both letter strings but to only respond to the second letter string in uppercase letters. They pressed the “yes” key (rightmost button on the button box) with their right index finger if the letter string was a real English word and the “no” button (leftmost button on the button box) if the letter string was not a real word in English. Every 128 trials a break screen would appear to give the participants a break; the participants were instructed to press the “yes” key to end the break and continue with the task. Participants completed two list versions of the experiment during the first ERP session and two different list versions during the second ERP session. Therefore, across the two session participants were exposed to all list versions across all word types. Within a session, the critical primes were presented two times and no targets were repeated. Within each block, which was one of the four list versions, the stimuli were randomly displayed to the participant. Participants additionally completed a practice session to ensure they were comfortable with the task and to make certain they were blinking at the appropriate time. The vocabulary words were presented to participants in a pseudo-random order across four counter-balanced training list versions.

2.4 RESULTS

2.4.1 Statistical Approach for Experiments 1 -3

2.4.1.1 Behavioral Data

Behavioral data for all experiments were analyzed using linear mixed effects models (lmer) for reaction time (RT) data and general linear mixed effects models (glmer) for accuracy data using the lme4 package (Bates, Maechler, Bolker, & Walker, 2015) with R software (Team, 2015). We also included the following fixed factors in all models: Individual difference scores (Flankers difference, Stroop score, PPVT standard score, Ravens score, o-span total span); word characteristics (English length, English log word frequency, English concreteness, English orthographic neighborhood size, German length (Exp. 2 and 3)). For all RT analyses we only included correct responses and removed responses that were 2.5 times above the standard deviation of each participants mean RT or below 200 ms.

2.4.1.2 ERP Data

A Dell PC and E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) were used to display stimuli. To record ERPs, we used a 64 electrode cap with Ag/AgCl electrodes (QuikCap, Compumedics, NeuroScan Inc., El Paso, TX), which were connected to Neuroscan SynAmps2 amplifiers with 24-bit analog-to-digital conversion. The sampling rate was 1000 Hz using DC and no online filter. Impedances were kept at 10 kΩ. Electrodes were placed over the right and left mastoids, as well as below and above the left eye to monitor blinks, and at the outer canthi of both eyes to monitor eye movements. Ocular artifacts were corrected with standardized algorithms. All electrodes were re-referenced offline to averaged mastoids and low-pass filtered at 30 Hz with a slope of 24 dB per octave.

Separate repeated measures ANOVAs were conducted for the "new" ambiguous words (vocabulary words) and the known ambiguous words. For the "new" ambiguous words model, session (session 1 vs. 2), relatedness (related vs. unrelated), target type (related vs. control), dominance (related to old meaning vs. related to new meaning), region (frontal, central, parietal), and laterality (left, midline, right) were included as factors. For the "old" ambiguous words model, session (session 1 vs. 2), meaning relatedness (homonym vs. polyseme), target type (related prime vs. control), dominance (dominant vs. subordinate), region (frontal, central, posterior), and laterality (left, midline, right) were included as factors. For both models the representative electrodes included in the analyses were F3, Fz, F4, C3, Cz, C4, P3, Pz, and P4. The component of interest is the N400, which reflects semantic and integrative processes (Kutas & Federmeier, 2011). A reduction in the mean peak amplitude for related targets relative to controls is indicative of N400 priming. We chose the 300-500 ms range for the mean peak amplitudes. Because we are interested in differential N400 priming effects we focused on the main effect of target type (related targets vs. controls) and the interactions with target type and only reported these effects (Elston-Güttler & Friederici, 2005). A summary of all main effects and interactions can be seen in Appendix E. The grand average ERPs for the vocabulary words and ambiguous words can be seen in Figures 12 and 13 for session 1 and Figures 14 and 15 for session 2.

2.4.1.3 Model specifics and contrasts for behavioral reaction time and accuracy models

We included participant and the word stimuli (targets and primes) as random effects for each model. The critical fixed effects for the unprimed lexical decision task included the following factors: testing session (session 1 vs. 2), relatedness of meanings (related vs. unrelated), and training (trained vs. untrained). Polysemes and “new” polysemes were the related meaning words and homonyms and “new” homonyms were the unrelated meaning words. The critical fixed effects for the meaning generation task included testing session and relatedness of meanings. The critical fixed effects for the primed lexical decision task included testing session, relatedness of meanings, training, meaning dominance (dominant vs. subordinate), and target type (related target vs. unrelated control). We used effects coding for these contrasts.

2.4.1.4 Unprimed Lexical Decision Task

In the reaction time and accuracy models we included testing session (session 1 vs. 2), meaning relatedness (related vs. unrelated), and training (trained vs. untrained) as critical factors.

Reaction Time

Only a significant effect of testing session was observed, such that participants were faster responding to targets on testing session 2 than testing session 1. A marginal effect of relatedness was observed such that unrelated targets (i.e., “new” homonyms and known homonyms) were responded to more slowly than related targets (i.e., “new” polysemes and known polysemes). A marginal training by session interaction was also observed such that participants were especially slow at responding to untrained target words during session 2 (See Figure 5). Put another way, participant were especially faster at responding to the trained words ("new" homonyms and polysemes) compared to the untrained words (i.e., known homonyms and polysemes) after two sessions of training. See Table 4 for the model results.

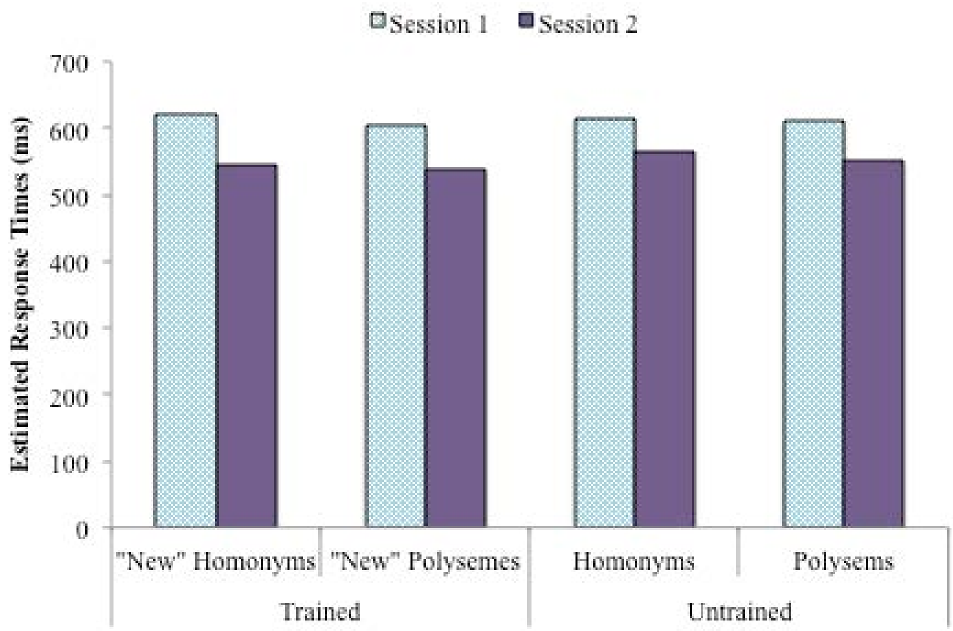


Figure 5. Unprimed Lexical Decision – Estimated RTs -_Word type by session

Table 4. Lexical Decision Task - RT - Model Results

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	6.36	0.04	10.00	143.48	0.00	***
Flankers Dif.	0.00	0.00	10.00	-0.56	0.59	
PPVT Standard	0.00	0.01	10.00	0.53	0.61	
Stroop	0.06	0.43	10.00	0.14	0.89	
Ravens	-0.02	0.02	10.00	-0.88	0.40	
O-span Total	0.00	0.01	10.00	-0.46	0.65	
English word length	0.00	0.01	116.00	-0.51	0.61	
English word log frequency	-0.05	0.01	118.00	-4.65	0.00	***
English word concreteness	0.00	0.01	118.00	0.34	0.74	
English word orthographic N.	0.00	0.00	118.00	-0.14	0.89	
Trial Number	0.00	0.00	3806.00	-4.03	0.00	***
Previous RT	0.00	0.00	3821.00	11.62	0.00	***
Related vs. Unrelated	0.02	0.01	251.00	1.69	0.09	.
Trained vs. Untrained	0.01	0.01	117.00	1.18	0.24	
Session 1 vs. Session 2	-0.11	0.01	3731.00	-13.08	0.00	***
Related vs. Unrelated * Trained	0.00	0.02	253.00	-0.09	0.93	

vs. Untrained						
Related vs. Unrelated * Session 1 vs. Session 2	0.01	0.02	3728.00	0.34	0.74	
Trained vs. Untrained * Session 1 vs. Session 2	0.03	0.02	3728.00	1.69	0.09	.
Related vs. Unrelated * Trained vs. Untrained * Session 1 vs. Session 2	0.03	0.03	3728.00	0.84	0.40	

Random Effects	Variance	Std. Dev.
Target	0.00	0.05
Participant	0.03	0.16

Note: All effects above the vertical line in the middle of the table refer to fixed effects. The effects below the line are the critical factors of interest. *** refers to p-values at <.001, ** refers to p-values at <.01, * refers to p-values at <.05, and . refers to p-values at <.1.

Accuracy

Only a marginal effect of testing session was observed in which participants were less accurate at responding during testing session 2 than testing session 1 (See Figure 6). See Table 5 for the model results.

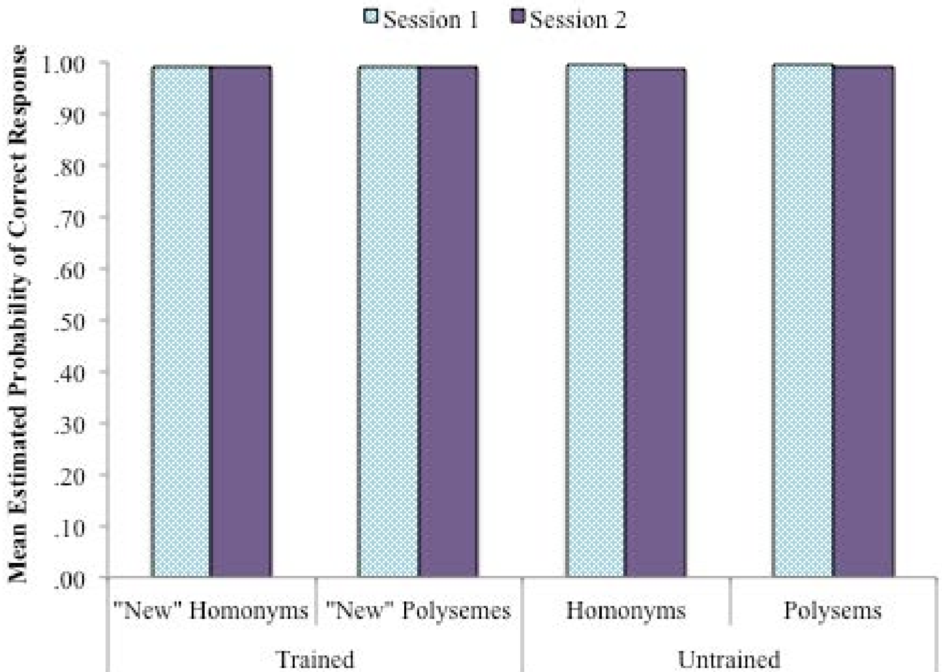


Figure 6. Unprimed Lexical Decision – Estimated Accuracy -_Word type by session

Table 5. Lexical Decision Task - Accuracy - Model Results

	β	Std. Error	z-value	p-value	Sig.
(Intercept)	4.81	0.29	16.81	0.00	***
Flankers Dif.	0.01	0.00	1.71	0.09	.
PPVT Standard	0.04	0.03	1.17	0.24	
Stroop	-5.73	2.05	-2.80	0.01	**
Ravens	-0.03	0.11	-0.23	0.82	
O-span Total	0.03	0.04	0.76	0.45	
English word length	0.62	0.22	2.83	0.00	**
English word log frequency	0.94	0.31	3.04	0.00	**
English word concreteness	0.52	0.23	2.25	0.02	*
English word orthographic N.	0.02	0.04	0.44	0.66	
Trial Number	0.00	0.00	-1.94	0.05	.
Related vs. Unrelated	-0.19	0.31	-0.61	0.54	
Trained vs. Untrained	0.36	0.33	1.09	0.28	
Session 1 vs. Session 2	-0.50	0.27	-1.86	0.06	.
Related vs. Unrelated * Trained vs. Untrained	-0.48	0.61	-0.79	0.43	
Related vs. Unrelated * Session 1 vs. Session 2	0.02	0.54	0.03	0.98	
Trained vs. Untrained * Session 1 vs. Session 2	-0.82	0.54	-1.52	0.13	
Related vs. Unrelated * Trained vs. Untrained * Session 1 vs. Session 2	0.92	1.07	0.86	0.39	

Random Effects	Variance	Std. Dev.
Target	0.58	0.76
Participant	0.17	0.41

2.4.1.5 Meaning Generation Task

Accuracy coding. Two independent coders determined the accuracy of the participants' responses. The coders had a high amount of agreement, Kappa = .84, $p < .0001$. A third coder resolved any inconsistencies between scores.

Accuracy. See Figure 7 for the converted model estimates. Model estimates were converted from log odds to probability of correct response for ease of interpreting the effects. Participants were more accurate in generating correct associates on testing session 2 than testing session 1. Additionally, participants were more accurate generating correct associates when the novel meanings were related to known meaning than when the novel meanings were unrelated to the known meanings suggesting that the relatedness of the meanings facilitated generation of associates. A testing session by relatedness interaction was not observed. See Table 6 for a summary of the model results.

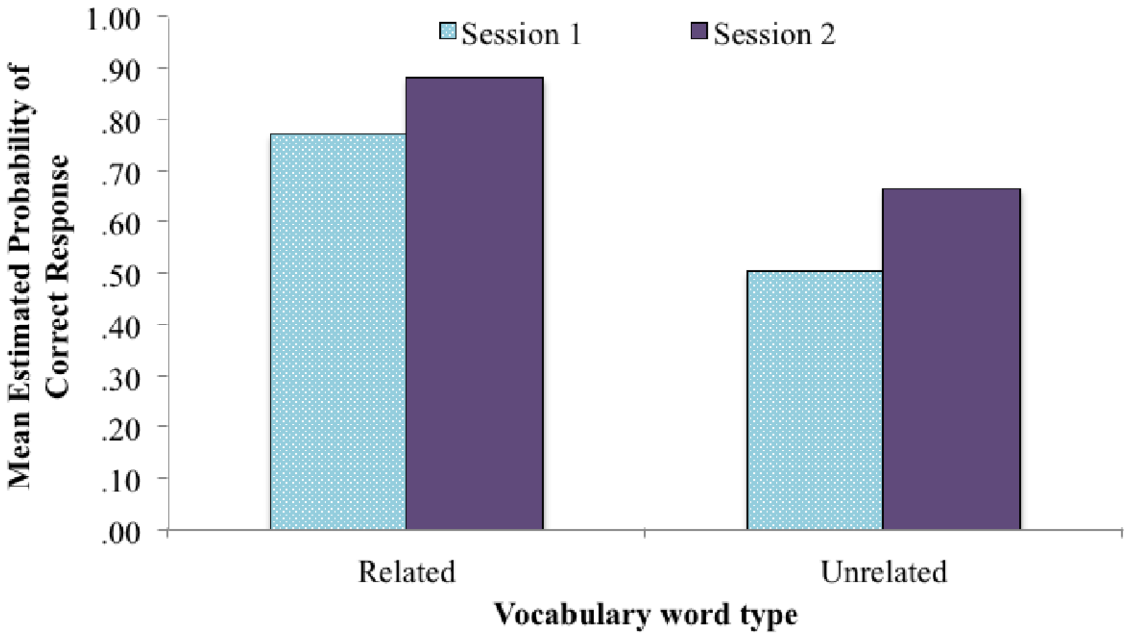


Figure 7. Meaning Generation Task - Estimated Accuracy

Table 6. Meaning Generation Task - Model Results

	β	Std. Error	*z*-value	p-value	Sig.
(Intercept)	0.98	0.15	6.62	0.00	***
Flankers Dif.	0.00	0.00	0.79	0.43	
PPVT Standard	0.01	0.02	0.31	0.76	
Stroop	0.08	1.34	0.06	0.95	
Ravens	-0.05	0.08	-0.68	0.49	
O-span Total	-0.15	0.03	-4.37	0.00	***
English word length	0.13	0.09	1.45	0.15	
English word log frequency	0.12	0.16	0.73	0.46	
English word concreteness	0.25	0.12	2.00	0.05	*
English word orthographic N.	-0.01	0.02	-0.26	0.79	
Relatedness: Related vs. Unrelated	-1.26	0.12	-10.70	0.00	***
Session: Session 1 vs. 2	0.73	0.12	6.24	0.00	***
Relatedness x Session	-0.13	0.23	-0.55	0.58	
Random Effects		Variance	Std. Dev.		
Vocabulary Word		0.22	0.47		

Participant	0.21	0.46	

2.4.1.6 Primed Lexical Decision Task - Behavioral Results

Reaction Time

A significant testing session by dominance by target relatedness interaction was observed such that there was greater priming for dominant targets on session 2. This interaction qualified main effects of session and relatedness. A significant session by meaning relatedness by training by dominance by target relatedness interaction was observed. To interpret this five-way interaction additional post-hoc tests were conducted. We first ran separate models for trained vocabulary and untrained ambiguous stimuli (See Figures 8 and 9). The trained vocabulary model revealed a significant effect of priming ($\beta = 0.04$, $t(234) = 3.94$, $p < .001$) and a significant priming by dominance by session interaction ($\beta = -0.07$, $t(3539) = -2.48$, $p = .01$). Further post-hoc analyses for the trained vocabulary revealed that on testing session 1 there was a significant effect of priming ($\beta = 0.04$, $t(212) = 2.71$, $p = .01$) such that related targets were responded to faster than unrelated targets. On session 2, there was a significant priming effect ($\beta = 0.05$, $t(207) = 4.01$ $p < .001$) but the priming effect interacted with dominance ($\beta = -0.07$, $t(208) = -2.94$, $p = <.001$) such that there was greater priming for dominant (old) meanings than subordinate (novel) meanings. This result suggests that the meaning activation for the subordinate (new) meanings decayed from testing session 1 to testing session 2. Testing session 2 occurred one week after testing session 1 in which they would have more exposure to the dominant (old) meanings). The untrained ambiguous stimuli model revealed a significant effect of priming ($\beta = 0.02$, $t(216) = 2.02$, $p = .04$) and a significant priming by dominance by session interaction (β = 0.12, $t(3647) = -2.14$, $p = .03$). Further post-hoc tests by session revealed that on testing session 1 only a marginal effect of priming was observed (β = 0.02, $t(212) = 1.54$, $p = .13$), but on testing session 2 a significant effect of priming was observed (β = 0.02, $t(163) = 1.97$, $p = .05$).

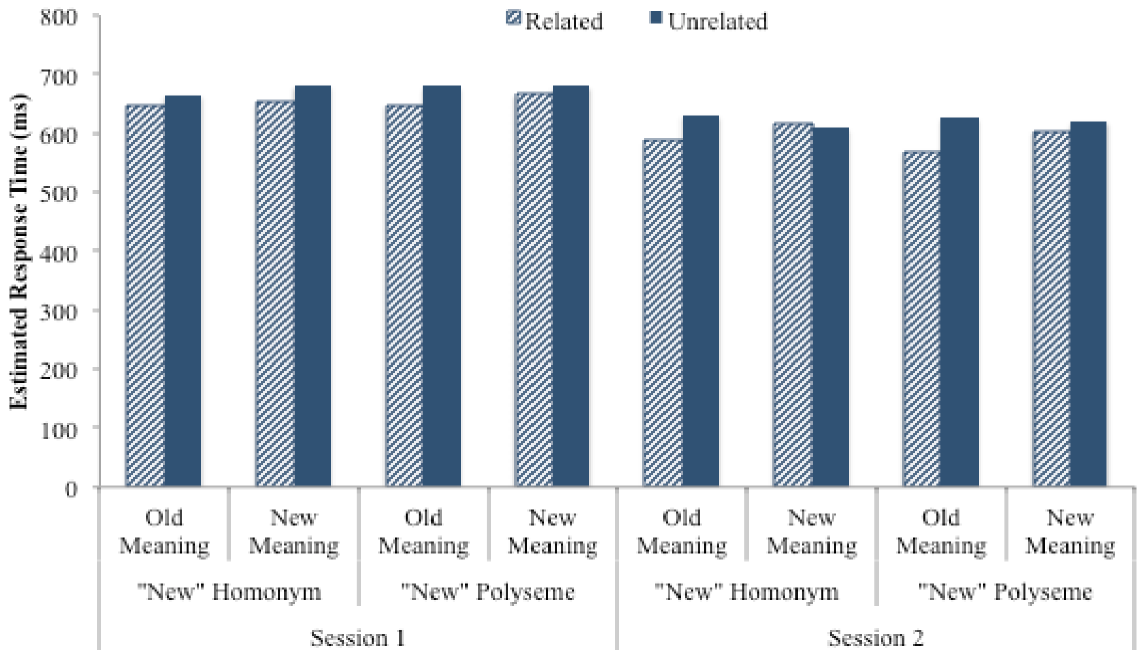


Figure 8. Primed Lexical Decision - RT -_Vocabulary Words - Priming effect by Session and Meaning

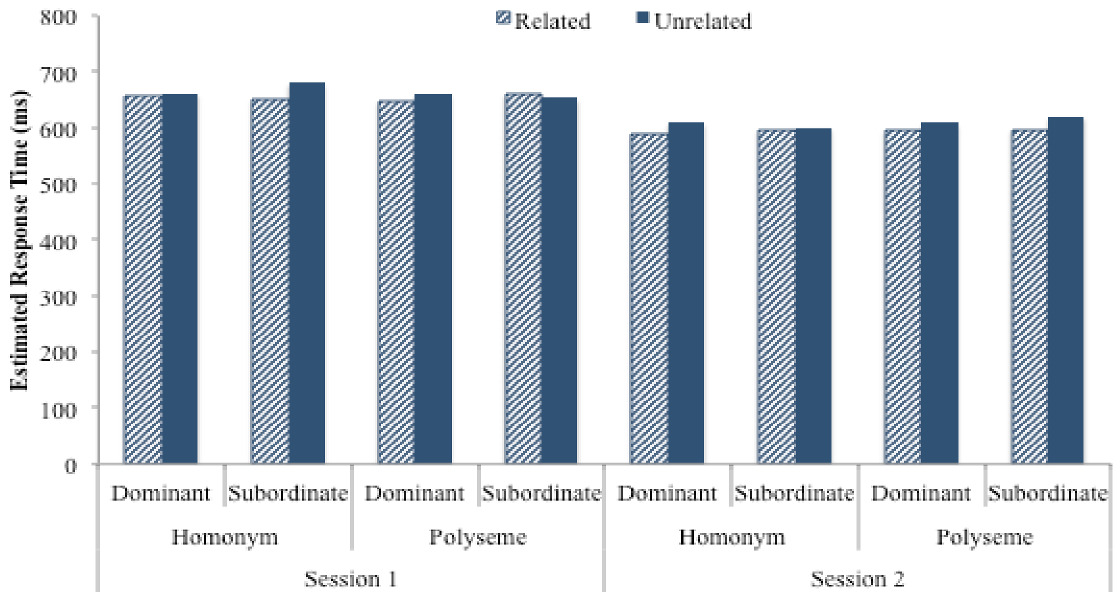


Figure 9. Primed Lexical Decision Task - RT – Untrained Ambiguous Words - Priming effect by Session and Dominance

Table 7. Primed Lexical Decision Task - RT - Model Results

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	6.45	0.03	11.00	217.76	0.00	***
Flankers Dif.	0.00	0.00	10.00	-1.63	0.13	
PPVT Standard	0.00	0.01	10.00	-0.04	0.97	
Stroop	0.31	0.29	10.00	1.08	0.30	
Ravens	-0.03	0.02	10.00	-1.71	0.12	
O-span Total	0.00	0.01	10.00	-0.12	0.91	
Prime word length	-0.01	0.00	853.00	-1.70	0.09	.
Prime word log frequency	0.00	0.00	902.00	-0.92	0.36	
Prime word concreteness	0.00	0.00	794.00	-1.44	0.15	
Prime word orthographic N.	0.00	0.00	964.00	-1.99	0.05	*
Target word length	0.00	0.00	449.00	-0.17	0.86	
Target word log frequency	0.00	0.00	478.00	-16.70	0.00	***
Target word concreteness	0.00	0.00	463.00	-4.05	0.00	***
Target word orthographic N.	0.00	0.00	445.00	-0.53	0.60	
Trail Number	0.00	0.00	7187.00	-1.65	0.10	.
Previous RT	0.00	0.00	7269.00	11.20	0.00	***
Session 1 vs. 2	-0.09	0.01	7227.00	-17.32	0.00	***

Rel. vs. Unrel. meanings	0.00	0.01	1022.00	0.79	0.43	
Dom vs. Sub	0.01	0.01	526.00	1.63	0.10	
Trained vs. Untrained	-0.01	0.01	591.00	-1.87	0.06	.
Rel. vs. Unrel. target	0.03	0.01	472.00	4.07	0.00	***
Session 1 vs. 2 * Rel. vs. Unrel. meanings	0.02	0.01	7236.00	1.63	0.10	
Session 1 vs. 2 *Dom vs. Sub	0.00	0.01	7211.00	0.36	0.72	
Rel. vs. Unrel. meanings * Dom vs. Sub	0.00	0.01	1015.00	0.30	0.76	
Session 1 vs. 2 * Trained vs. Untrained	0.00	0.01	7215.00	0.28	0.78	
Rel. vs. Unrel. meanings * Trained vs. Untrained	0.00	0.01	1017.00	-0.16	0.88	
Dom vs. Sub * Trained vs. Untrained	-0.01	0.02	490.00	-0.43	0.67	
Session 1 vs. 2 * Rel. vs. Unrel. target	0.01	0.01	7219.00	0.81	0.42	
Rel. vs. Unrel. meanings * Rel. vs. Unrel. target	-0.01	0.01	1023.00	-0.44	0.66	
Dom vs. Sub * Rel. vs. Unrel target	-0.02	0.01	555.00	-1.06	0.29	
Trained vs. Untrained * Rel. vs. Unrel. target	-0.02	0.01	542.00	-1.13	0.26	
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Dom vs. Sub	-0.01	0.02	7230.00	-0.32	0.75	
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Trained vs. Untrained	0.00	0.02	7236.00	-0.19	0.85	
Session 1 vs. 2 * Dom vs. Sub * Trained vs. Untrained	0.00	0.02	7215.00	-0.03	0.98	
Rel. vs. Unrel. meanings * Dom vs. Sub * Trained vs. Untrained	0.01	0.03	1017.00	0.34	0.74	
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Rel. vs. Unrel. target	0.00	0.02	7234.00	-0.18	0.86	
Session 1 vs. 2 * Dom vs. Sub * Rel. vs. Unrel target	-0.04	0.02	7214.00	-2.00	0.05	*
Rel. vs. Unrel. meanings * Dom vs. Sub * Rel. vs. Unrel. target	0.00	0.03	1016.00	-0.09	0.93	
Session 1 vs. 2 * Trained vs. Untrained * Rel. vs. Unrel. target	0.00	0.02	7218.00	-0.20	0.84	
Related vs. Unrelated * Trained vs. Untrained * Rel. vs. Unrel. targetl	0.01	0.03	1021.00	0.23	0.82	
Dom vs. Sub * Trained vs. Untrained * Rel. vs. Unrel. target	0.04	0.03	462.00	1.38	0.17	
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Dom vs. Sub * Trained vs. Untrained	0.04	0.04	7233.00	0.95	0.34	
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Dom vs. Sub * Rel. vs. Unrel. target	0.03	0.04	7231.00	0.76	0.45	
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Trained vs. Untrained * Rel. vs. Unrel. target	0.06	0.04	7235.00	1.53	0.13	
Session 1 vs. 2 * Dom vs. Sub* Trained vs. Untrained * Rel. vs. Unrel. target	0.06	0.04	7210.00	1.49	0.14	
Rel. vs. Unrel. meanings* Dom vs. Sub* Trained vs. Untrained * Rel. vs. Unrel. target	-0.03	0.05	1016.00	-0.63	0.53	
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Dom vs. Sub * Trained vs. Untrained * Rel. vs. Unrel. target	0.17	0.08	7233.00	2.17	0.03	*

Random Effects	Variance	Std.Dev.

Target	0.00	0.07
Prime	0.00	0.00
Participant	0.01	0.11

Accuracy

A significant testing session by training interaction was observed such that untrained words showed a decrease in accuracy from testing session 1 to testing session 2 but no change was observed for trained words (See Figure 10). This may be due to the repeated exposure of the trained vocabulary such that the there was not a decrease in accuracy for trained vocabulary because they had more exposure to those words during training than the untrained words. A significant training by target relatedness interaction was also observed such that there was a greater priming effect for targets associated with the trained word primes than untrained word primes (See Figure 11). Overall, a significant priming effect was observed such that related targets were responded to more accurately than unrelated controls. Participants were less accurate on testing session 1 than testing session 2. Targets related to the subordinate meaning of the prime were responded to less accurately than targets related to the dominant meaning of the prime. See Table 8 for the estimated means from the trained vocabulary words and Table 9 for the estimated means from the untrained ambiguous words.

Table 8. Primed Lexical Decision – Estimated Accuracy -_Trained Vocabulary Words -

		Target Type	
Relatedness	Meaning Dominance	Related	Unrelated

Session 1	"New" Homonym	Old Meaning	0.95	0.90
		New Meaning	0.93	0.86
	"New" Polyseme	Old Meaning	0.95	0.89
		New Meaning	0.96	0.90
Session 2	"New" Homonym	Old Meaning	0.95	0.83
		New Meaning	0.94	0.86
	"New" Polyseme	Old Meaning	0.97	0.88
		New Meaning	0.94	0.92

Table 9. Primed Lexical Decision Task – Estimated Accuracy- Untrained Ambiguous Words -

			Target Type	
	Relatedness	Meaning Dominance	Related	Unrelated
Session 1	Homonym	Dominant	0.98	0.94
		Subordinate	0.94	0.90
	Polyseme	Dominant	0.94	0.98
		Subordinate	0.95	0.94
Session 2	Homonym	Dominant	0.93	0.93
		Subordinate	0.92	0.89
	Polyseme	Dominant	0.92	0.95
		Subordinate	0.90	0.82

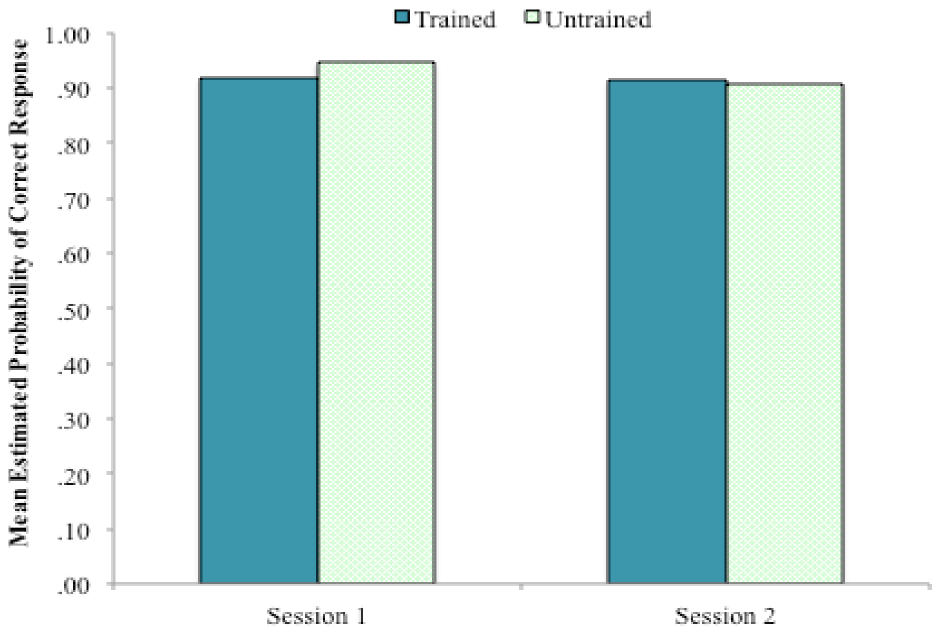


Figure 10. Primed Lexical Decision - Estimated Accuracy - Session by Word Type

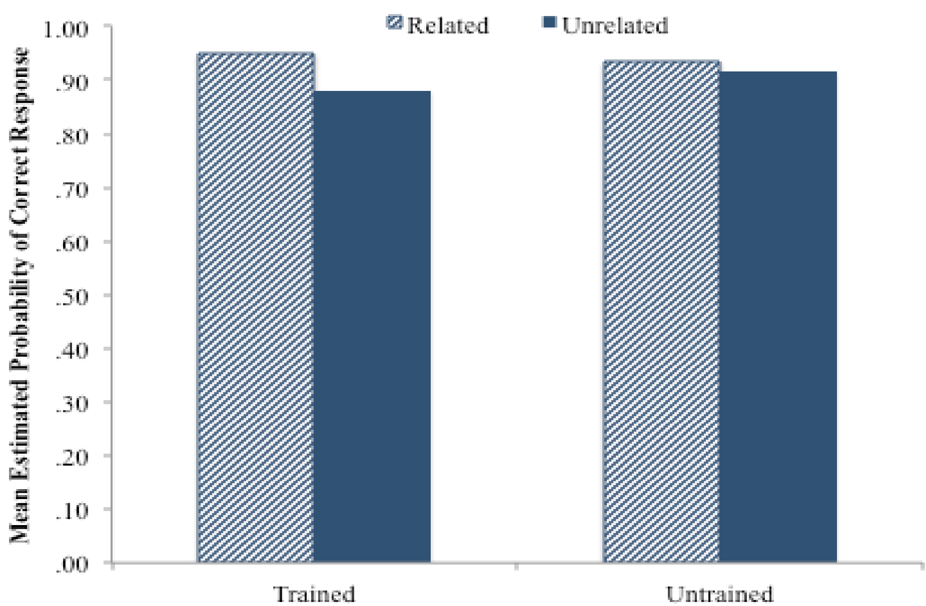


Figure 11. Primed Lexical Decision - Estimated Accuracy - Priming effect by Word Type

Table 10. Primed Lexical Decision Task - Accuracy - Model Results

	β	Std. Error	z-value	p-value	Sig.
(Intercept)	2.58	0.21	12.37	0.00	***
Flankers Dif.	0.00	0.00	0.30	0.77	
PPVT Standard	0.01	0.02	0.23	0.82	
Stroop	-5.01	1.34	-3.75	0.00	***
Ravens	0.10	0.08	1.34	0.18	
O-span Total	0.06	0.03	1.80	0.07	.
Prime word length	0.01	0.07	0.08	0.94	
Prime word log frequency	0.00	0.00	-0.92	0.36	
Prime word concreteness	0.00	0.00	0.26	0.79	
Prime word orthographic N.	0.01	0.01	0.96	0.34	
Target word length	0.29	0.06	4.56	0.00	***
Target word log frequency	0.02	0.00	12.10	0.00	***
Target word concreteness	0.00	0.00	2.21	0.03	*
Target word orthographic N.	0.00	0.01	-0.13	0.89	
Trail Number	0.00	0.00	0.25	0.80	
Previous RT	0.00	0.00	4.02	0.00	***
Session 1 vs. 2	-0.31	0.12	-2.53	0.01	*
Rel. vs. Unrel. meanings	-0.14	0.15	-0.88	0.38	
Dom vs. Sub	-0.37	0.18	-2.03	0.04	*
Trained vs. Untrained	0.15	0.18	0.84	0.40	
Rel. vs. Unrel. target	-0.57	0.18	-3.20	0.00	**
Session 1 vs. 2 * Rel. vs. Unrel. meanings	-0.35	0.24	-1.45	0.15	
Session 1 vs. 2 *Dom vs. Sub	0.07	0.24	0.28	0.78	
Rel. vs. Unrel. meanings * Dom vs. Sub	-0.28	0.31	-0.92	0.36	
Session 1 vs. 2 * Trained vs. Untrained	-0.63	0.24	-2.61	0.01	**
Rel. vs. Unrel. meanings * Trained vs. Untrained	0.29	0.31	0.95	0.34	
Dom vs. Sub * Trained vs. Untrained	-0.48	0.36	-1.34	0.18	
Session 1 vs. 2 * Rel. vs. Unrel. target	-0.08	0.24	-0.33	0.74	
Rel. vs. Unrel. meanings * Rel. vs. Unrel. target	0.26	0.31	0.87	0.39	
Dom vs. Sub * Rel. vs. Unrel target	-0.13	0.35	-0.38	0.70	
Trained vs. Untrained * Rel. vs. Unrel. target	0.79	0.35	2.24	0.03	*
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Dom vs. Sub	0.89	0.48	1.85	0.06	.
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Trained vs. Untrained	-0.16	0.48	-0.33	0.74	
Session 1 vs. 2 * Dom vs. Sub * Trained vs. Untrained	0.06	0.48	0.12	0.90	
Rel. vs. Unrel. meanings * Dom vs. Sub * Trained vs. Untrained	0.04	0.62	0.06	0.95	

Session 1 vs. 2 * Rel. vs. Unrel. meanings * Rel. vs. Unrel. target	-0.60	0.48	-1.25	0.21
Session 1 vs. 2 * Dom vs. Sub * Rel. vs. Unrel target	0.29	0.48	0.61	0.54
Rel. vs. Unrel. meanings * Dom vs. Sub * Rel. vs. Unrel. target	-0.75	0.61	-1.23	0.22
Session 1 vs. 2 * Trained vs. Untrained * Rel. vs. Unrel. target	0.24	0.48	0.49	0.62
Related vs. Unrelated * Trained vs. Untrained * Rel. vs. Unrel. target	0.64	0.61	1.04	0.30
Dom vs. Sub * Trained vs. Untrained * Rel. vs. Unrel. target	-1.04	0.71	-1.46	0.15
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Dom vs. Sub * Trained vs. Untrained	-1.47	0.96	-1.52	0.13
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Dom vs. Sub * Rel. vs. Unrel. target	-0.01	0.97	-0.01	0.99
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Trained vs. Untrained * Rel. vs. Unrel. target	-0.81	0.97	-0.84	0.40
Session 1 vs. 2 * Dom vs. Sub* Trained vs. Untrained * Rel. vs. Unrel. target	-1.19	0.96	-1.24	0.22
Rel. vs. Unrel. meanings* Dom vs. Sub* Trained vs. Untrained * Rel. vs. Unrel. target	-0.78	1.23	-0.63	0.53
Session 1 vs. 2 * Rel. vs. Unrel. meanings * Dom vs. Sub * Trained vs. Untrained * Rel. vs. Unrel. target	1.89	1.93	0.98	0.33
Random Effects		Variance	Std.Dev.	
Target		1.41	1.19	
Prime		0.00	0.00	
Participant		0.20	0.44	

2.4.1.7 Primed Lexical Decision Task - ERP Results

Effects of training – "new" ambiguous words

A significant target type main effect was not observed, however a significant relatedness by target type interaction was observed, in which N400 priming was observed for vocabulary with related novel meanings but the opposite effect was observed for vocabulary with unrelated novel meanings, F (1,15) = 9.039, $p < .01$. This reversal of the N400 priming (more positive mean amplitudes for related targets relative to controls) may be due to inhibitory connections from the unrelated meanings. This effect was qualified by a marginal target type by relatedness by lobe interaction in which the N400 priming effect for the related words was the strongest over the frontal and central electrodes, $F(1,15) = 4.062$, $p = .052$ (see Figure 16). However, Duncan's new multiple range test post-hoc analyses on these interactions did not yield significant pair-wise comparisons, therefore these conclusions must be taken as suggestive rather than definitive. Additionally, a testing session by dominance by relatedness effect was also observed, $F(1,15) = 4.881$, $p = .043$ (see Figure 17). Again, the post-hoc analyses on this interaction did not yield any significant pair-wise comparisons, so it must be interpreted cautiously, but it seems to reflect that on session 1 there was a N400 priming effect for targets related to the new meaning, which reversed on session 2. Despite the participants having been exposed to more training on testing session 2 than testing session 1, the one week separation may have led to a decay in the meaning activation of the new meanings and therefore a reversal or lack of N400 priming.

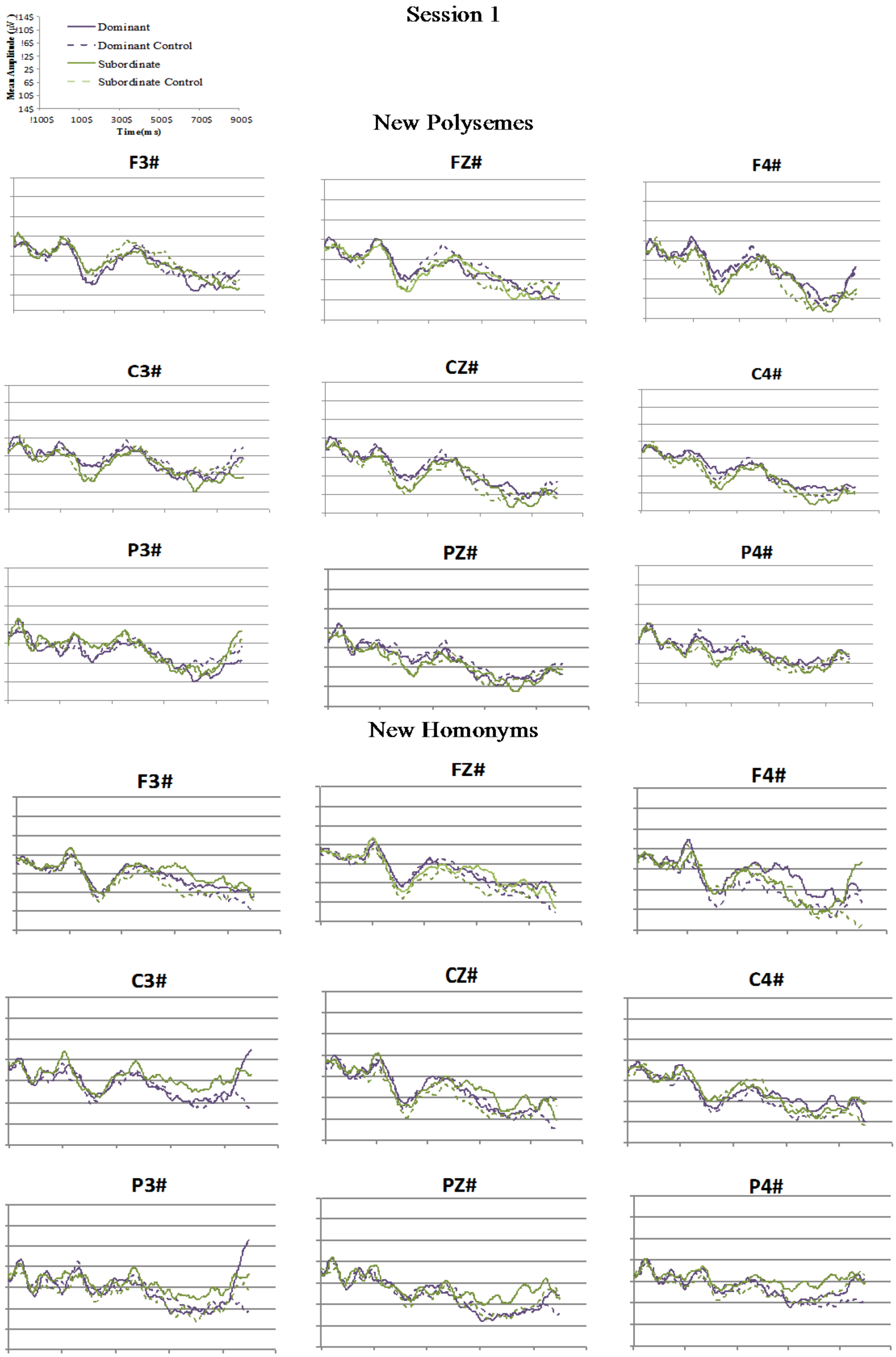


Figure 12. Grand average ERPs for vocabulary words on session 1 across nine electrode sites

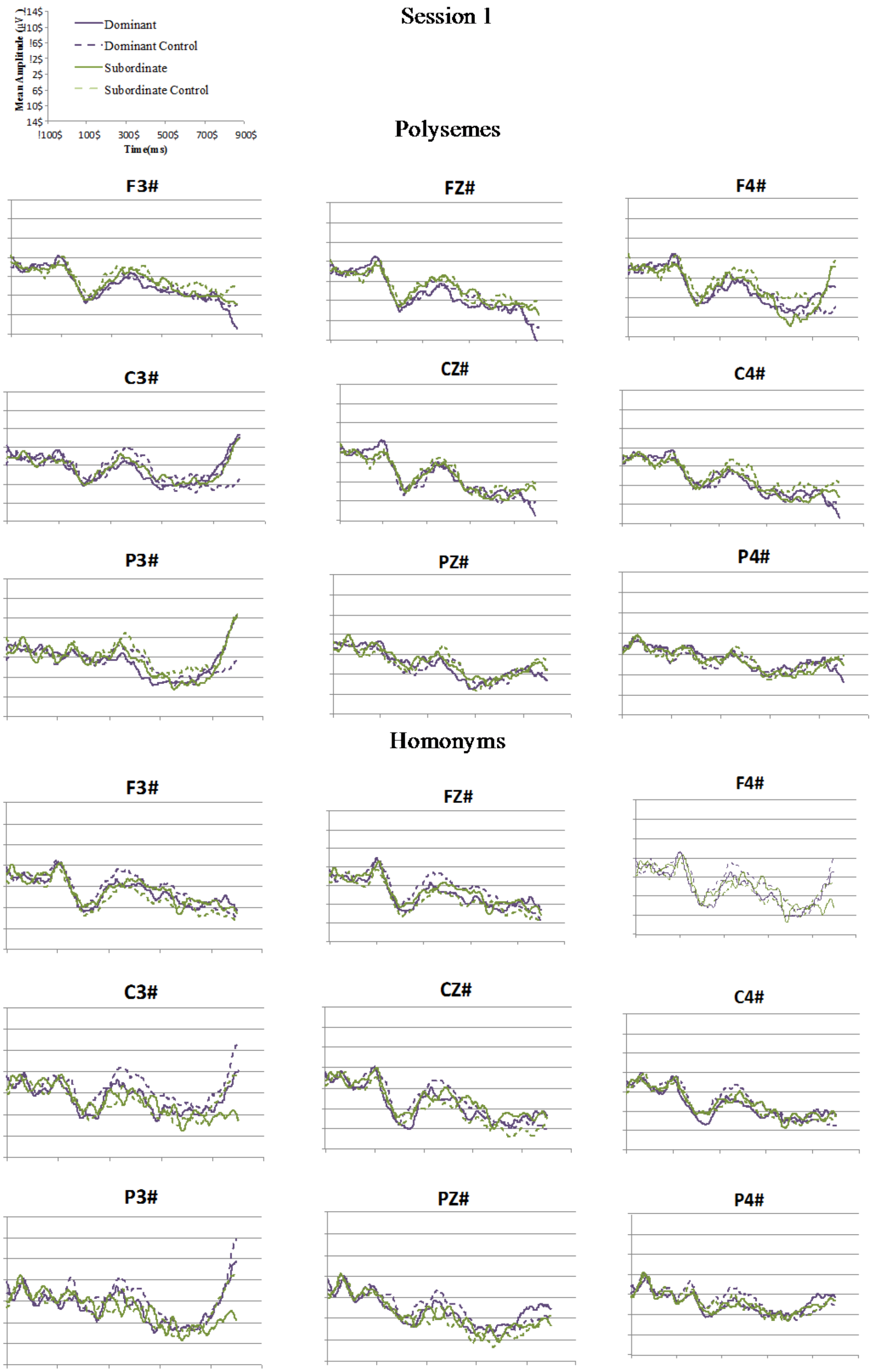


Figure 13. Grand average ERPs for ambiguous words on session 1 across nine electrode sites

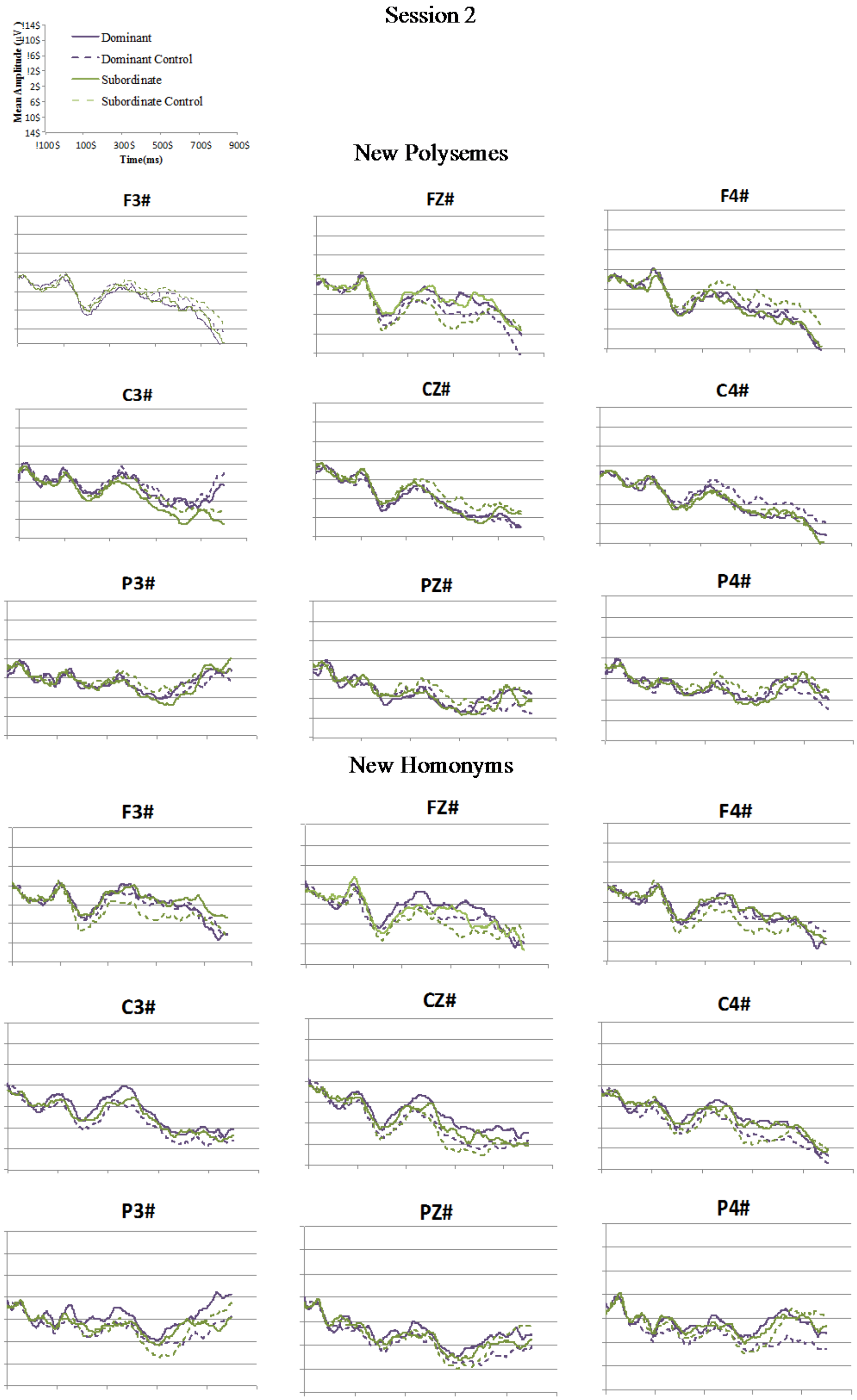


Figure 14. Grand average ERPs for vocabulary words on session 2 across nine electrode sites

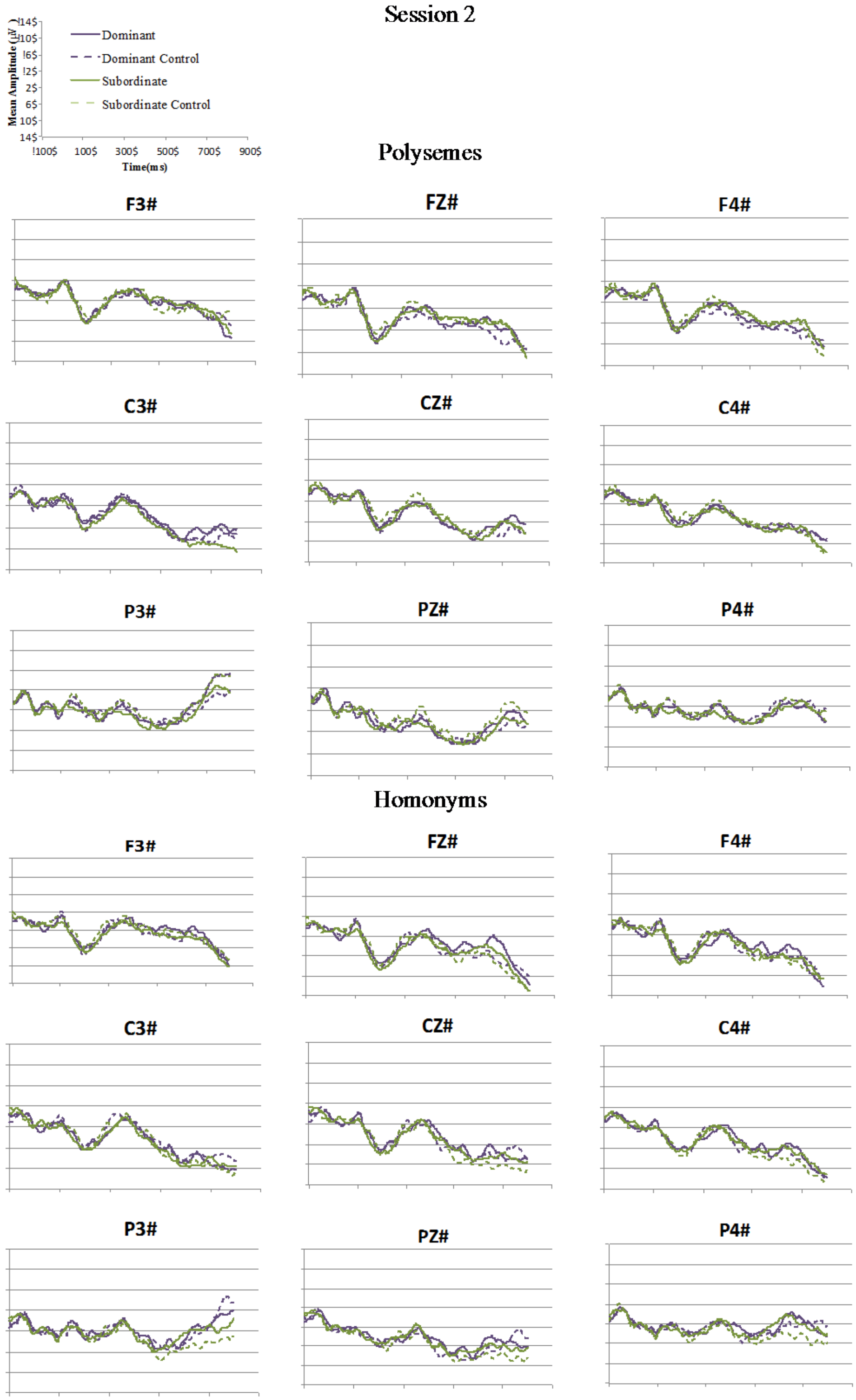


Figure 15. Grand average ERPs for ambiguous words on session 2 across nine electrode sites

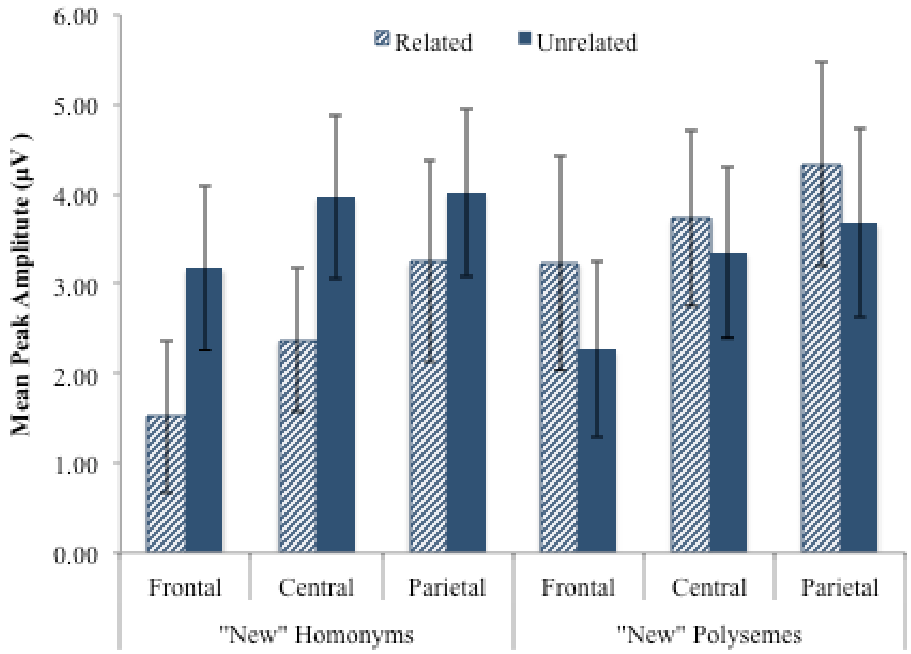


Figure 16. Mean Peak Amplitudes – Trained Words- Priming Effect by Word Type and Lobe

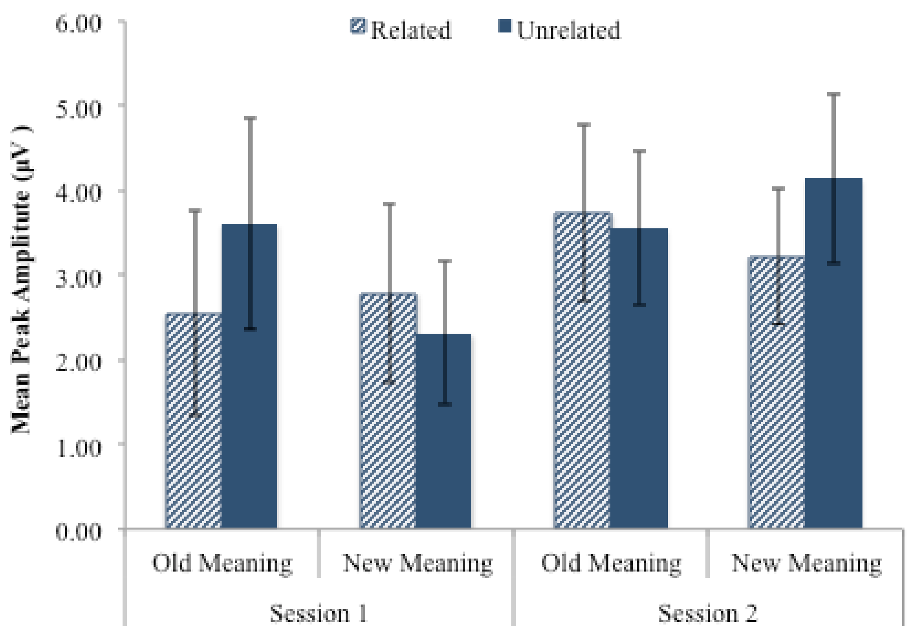


Figure 17. Mean Peak Amplitudes – Trained Words - Priming Effect by Session and Meaning Dominance

Effects of semantic ambiguity – control ambiguous words

No overall main effect of relatedness was observed. However, a significant prime type (homonym vs. polyseme) by dominance by target type interaction was observed. Again, the post-hoc analyses did not reveal significant pair-wise comparisons, but this interaction seems to suggest that N400 priming was observed for dominant and subordinate related targets for polysemes but only dominant related targets yielded N400 priming and the subordinate related targets yielded a reverse effect, $F(1,15) = 4.638$, $p = .048$ (See Figure 18). This result may suggest that for homonyms the activation of only the dominant meaning is sufficient to lead to N400 priming. Thus, on viewing a homonym prime (e.g., Scale) the dominant meaning (e.g., weight) would be more strongly activated and therefore when the participant is presented with a subordinate related prime (e.g., fish), the activation for the subordinate meaning is not sufficient to lead to N400 priming. Further, on viewing the subordinate prime, the dominant meaning would need to be inhibited to establish semantic cohesiveness, which may also influence this lack of N400 priming for subordinate targets. On the other hand, for polysemes the activation of both the dominant and subordinate senses are sufficient to lead to N400 priming possibly due to the shared conceptual features between the dominant and subordinate senses. Additionally, there would be a lack of inhibitory connections between the dominant and subordinate senses because they have overlapping features. A relatedness by lobe interaction was also observed such that greater N400 priming was observed over the parietal lobes, $F(1,15) = 4.404$, $p = .022$ (see Figure 19) but these results did not reach significance in the post-hoc analysis.

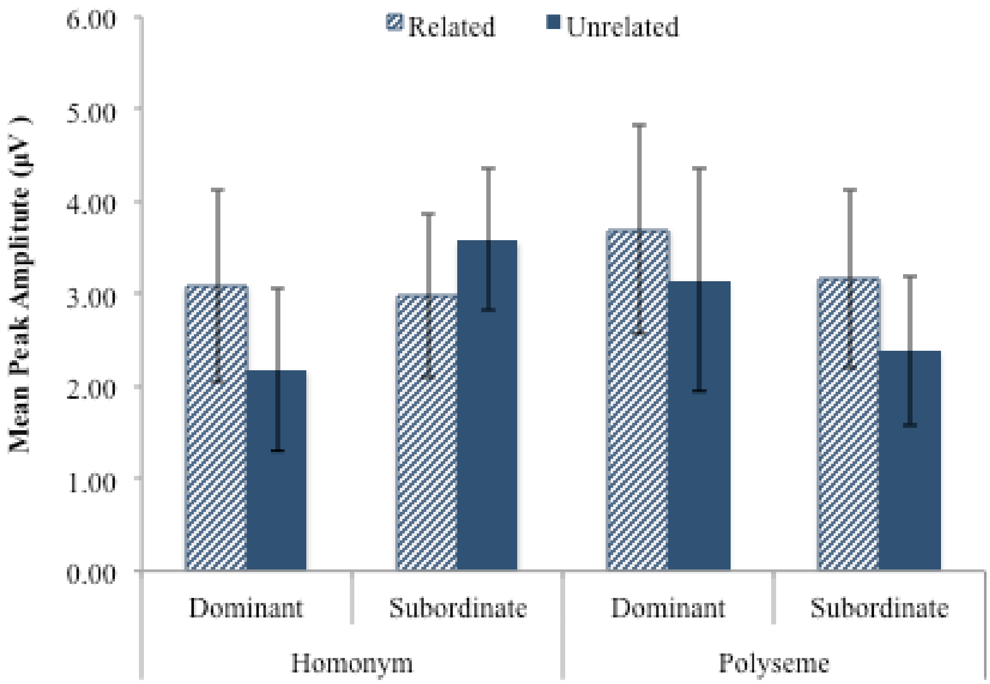


Figure 18. Mean Peak Amplitudes – Untrained Words - Priming Effect by Word Type and Dominance

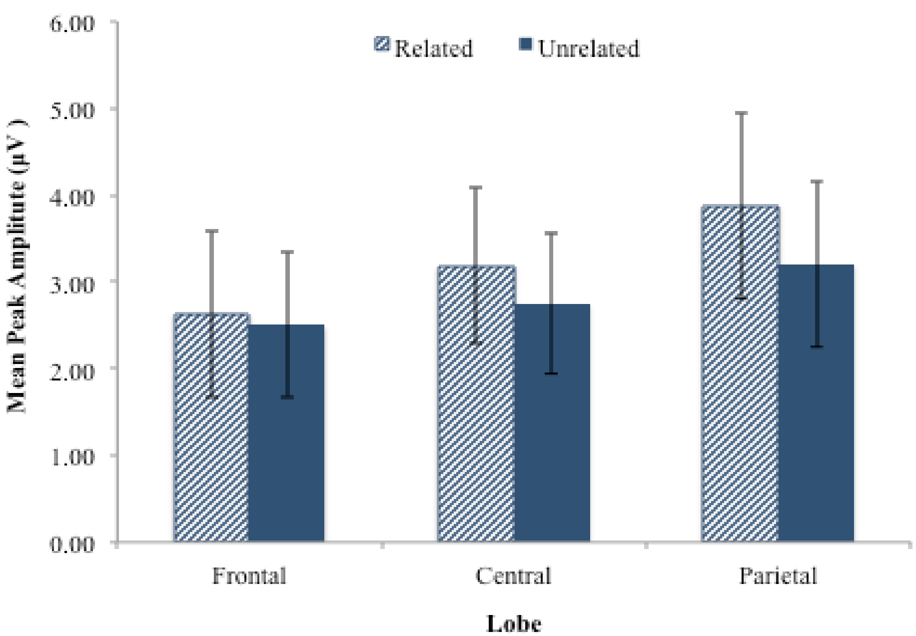


Figure 19. Mean peak amplitudes – Untrained Words - Priming Effect by Lobe

2.5 DISCUSSION

This experiment examined how novel meanings are associated with known words and how meaning relatedness affects this process. We had hypothesized that novel meanings that were related to the known meanings of the vocabulary words would be better learned than novel meanings that were unrelated to the known meanings. Additionally, we expected there to be differences in processing between the related and unrelated novel meanings using an unprimed lexical decision task and a primed lexical decision task with ERPs. Further, we compared the "new" ambiguous words with known semantically-ambiguous words to examine if words with novel related meanings and words with novel unrelated meanings would yield analogous processing effects to polysemous and homonymous words respectively.

Results for the meaning generation task showed that words with novel related meanings were learned better than words with novel unrelated meanings. This result suggest that it is easier to acquire novel meanings that are related to the known meaning than those that are unrelated to the known meaning which is consistent with previous work on feature and semantic similarity in associative learning (e.g., Morgan & Underwood, 1950; Underwood, 1951; Underwood et al., 1965). For related novel meanings there are similarities across a wide variety of features between the new and old meanings of the word. Thus, when viewing the vocabulary word, similar features would be activated between the old and new meanings allowing the participant to more easily produce an associate or phrase related to the new meaning. Little to no overlap would be found between the novel unrelated meanings between the old and new meaning of the word, which would reduce the probability of the participant correctly producing an associate or phrase related to the new meaning of the vocabulary word. Further, the acquisition of polysemous senses is more common than homonymous meanings (Srinivasan & Rabagliati, 2015). Learning, for example that a hive is a busy household may be easier to accept as a new meaning than learning that hive is a mythical monster. Acquiring new senses to words is a common occurrence and can be created and understood on the fly (Clark & Gerrig, 1983; Frisson & Pickering, 2007; Srinivasan & Rabagliati, 2015).

The unprimed lexical decision data did not yield any significant theoretical results and only a significant effect of testing session was observed, such that participants were faster on testing session 2 than testing session 1. This result is likely due to practice effects. These results are similar to the results found by Rodd et al. (2012) in Experiment 2 in which they found a null effect of relatedness. However, Rodd et al. did find an effect of relatedness in Experiment 3, which they attributed to their training procedures. Our lack of a relatedness by testing session interaction could be due to the type of training procedure used, which may not have emphasized meaning as well as the training used by Rodd et al. in Experiment 3.

Significant priming occurred for both the known dominant meanings and the novel meanings, indicating that the novel meanings were integrated into the learners' semantic networks. The reduced priming effect on testing session 2 may correspond to a decay in meaning activation of the novel meaning relative to the dominant meaning of the vocabulary word.

Despite there being differences between related and unrelated novel meanings on the meaning generation test, there were no significant differences between related and unrelated trained vocabulary words on the unprimed lexical decision task. This difference between the tasks could be due to differences between productive (meaning generation) and receptive (primed lexical decision) knowledge of the words' meanings. As stated previously, correctly producing an associate is facilitated for related novel meanings due to shared features between the new and old meaning. This facilitation would be absent for novel unrelated meanings.

Further, there may be greater competition between the new and old meanings for unrelated novel meanings, which would inhibit recall. In the primed lexical decision task, participants are not required to generate a specific meaning. Although recall was worse for unrelated novel meanings, no differences were observed in priming for related and unrelated suggesting that both types of meanings were learned and integrated into semantic memory.

Interestingly, there were no significant differences found between the trained vocabulary words and the untrained ambiguous words, although participants were significantly faster at responding to targets associated with untrained ambiguous words than trained vocabulary on session 2. Further, there were no differences between the untrained polysemous words and homonymous words, which is consistent with some previous research (e.g., Klein & Murphy, 2001). However, several studies have demonstrated differences between polysemous and homonymous words in lexical decision tasks (e.g.,Armstrong & Plaut, 2011; Beretta, Fiorentino, & Poeppel, 2005; Rodd et al., 2002). The lack of effects may also relate to the setting such that the ambiguous words were intermixed with trained vocabulary words, which may have changed how the words were processed.

Unlike the behavioral results, the ERP results for the primed lexical decision task did not yield any significant effects based on the post-hoc pair-wise comparisons. The results from the trained vocabulary words did reveal an interaction with relatedness and target type such that N400 priming occurred for the novel related meanings (both old and new related targets relative to controls) but a reverse N400 effect for the novel unrelated meanings (both for old and new related targets relative to controls). The fact that there was N400 priming for novel related meanings but the reverse pattern for unrelated novel meanings (based on the means) may suggest facilitation for related trained meanings but inhibitory processes for unrelated trained meanings.

This result is in contrast to what the behavioral evidence demonstrated, in which there was similar priming effects for both related and unrelated novel meanings. Despite the fact that the behavioral evidence suggests little difference in processing novel related vs. unrelated meanings the ERP record suggests early processing differences.

The results from the untrained ambiguous words revealed a significant prime type (homonym vs. polyseme) by dominance by target type interaction such that N400 priming occurred for dominant but not subordinate related targets for homonyms but N400 priming was numerically found for both dominant and subordinate related targets for polysemous words. Because these results did not reach significance after the post-hoc comparisons any conclusions must be considered tentative. The three-way interaction found for the untrained ambiguous words is consistent with previous research (Klepousniotou et al., 2012). Differences in priming for dominant and subordinate related targets for homonyms and polysemes are hypothesized to be due to representational differences such that polysemous senses are stored in a single lexical entry whereas homonymous meanings are stored in separate lexical entries (Klepousniotou et al., 2012). However, these differences may also reflect facilitation from related polysemous senses and inhibition from unrelated homonym meanings.

In sum, the current study demonstrates the effects of relatedness on learning new meanings to known words forms. Behavioral differences were observed between related novel meanings and unrelated novel meaning on the meaning generation task, but were not observed on the unprimed lexical decision task or the primed lexical decision task.

2.5.1 Study Limitations and future research

The present study has several limitations that could be addressed in future research. Unlike previous research by Rodd et al. (2012, Experiment 3) we did not observe a relatedness effect in the unprimed lexical decision task. This may have been due to the training procedures used. In addition to participants completing a vocabulary-definition task during training, it may be beneficial to include a meaning production task during the training sessions and not just as a learning measure to elicit more productive knowledge of the new meanings. The current study only had two formal training sessions, which may have also reduced the level of meaning acquisition for the vocabulary words. Including more training sessions and/or delayed testing sessions may be added to examine the learning curves of the novel meanings. Additionally, manipulating the ISI of the prime and target may be of interest in future research to examine the time course of meaning activation of the new and old meanings of the vocabulary words. Lastly, the current study had a small sample size, which may have impacted the ability to sufficiently detect differences in the N400 analyses.

2.5.2 Conclusions

Overall we found an effect of meaning similarity in novel word learning such that learners were better at recalling novel meanings when the meanings were related to the old meaning of the known word than when the meanings were unrelated to the old meaing of the known word. This result is consistent with the original experiment by Rodd et al., (2012) and with previous associative learning paradigms (e.g., Morgan & Underwood, 1950; Underwood et al., 1965). This experiment further dxamined the vocabulary words would be influenced by the acquisition of the novel meanings using unprimed and primed lexical decision task. Unlike Rodd et al., (2012), we found no differences on processing of the vocabulary words after learning the new meanings of the unprimed lexical decision task. However, we did observe priming for both the old and new meanings on the primed lexical decision task for both related and unrelated vocabulary words despite their being a benefit on the meaning generation task for related vocabulary words. This suggests that the learners had incorporated the new meanings into their semantic memory. Overall, this experiment provides insight into how meaning relatedness influences the learning of meanings and how semantic similarity impacts processing.

2.5.3 Motivation for Experiment 2

The first experiment examined the process of mapping *new meanings* to *known words* and how that affects processing and representation. How does the learning *novel labels* that map to *known meanings* affect processing and representation? To answer this question, in the next two experiments we examined the process mapping novel labels (L2 vocabulary) onto known meanings of semantically-ambiguous words.

3.0 EXPERIMENT 2

Semantic ambiguity within a language and across languages affects monolingual and multilingual processing. In this experiment, we examined how different types of translation-ambiguous words affect how early L2 learners map word meanings/senses to L2 word forms. Participants in this experiment learned a set of German words that are translation ambiguous due to homonymy and polysemy in the source language (i.e., English), and near-synonymy in the target language (i.e., German) as well as a set of translation-unambiguous words as a comparison group. We examined how meaning similarity (i.e., similarity between the ambiguous words meanings and the German translations) and dominance (i.e., dominant vs. subordinate meaning and translation) influenced participants' learning and semantic processing of the words. The translation-ambiguous words we used differed in how semantically similar the translations are to each other. Homonym translation-ambiguous words have distinct and different meanings (e.g., car trunk – Kofferraum vs. elephant's trunk – Rüssel), polysemous translation-ambiguous words have distinct but similar senses (e.g., earth's atmosphere – Lufthülle vs. mood atmosphere – Stimmung), and near-synonymous translation-ambiguous words have nearly identical meanings/senses (e.g., fruit – Frucht and Obst).

Previous research has investigated how different types of translation-ambiguous words are learned and processed (Bracken, Degani, Eddington, & Tokowicz, 2015; Degani & Tokowicz, 2010; Degani et al., 2014; Eddington & Tokowicz, 2013). However, previous research has not specifically tested differences between homonyms and polysemous translation-ambiguous words compared to near-synonymous and unambiguous words. Experiment 2 specifically examined how meaning/sense similarity affects the learning and processing of translation-ambiguous words by making the distinction between polysemous, homonymous, and near-synonymous translation-ambiguous words and how meaning/translation dominance interacts with meaning/sense similarity. Additionally, this study focused on early L2 vocabulary learning with an emphasis on acquiring meaningful connections to the L2 vocabulary word. First, we review the literature relating to the effects of translation ambiguity on processing in bilinguals and learners and then discuss how L2 vocabulary training strategies affect the meaningful encoding and learning of L2 vocabulary.

3.1 EFFECTS OF TRANSLATION AMBIGUITY ON LEARNING AND PROCESSING

Overall, translation-ambiguous words are associated with slower and less accurate responses on a variety of bilingual tasks (Tokowicz, 2014; Tokowicz & Degani, 2010). Tokowicz and Kroll (2007) found that English-Spanish and Spanish-English bilinguals were slower and less accurate in producing translations for translation-ambiguous words than translation-unambiguous words. Similarly, Prior, Kroll, and Macwhinney (2013) found that Spanish-English bilinguals were slower and less accurate at a translation production task for translation-ambiguous words than translation-unambiguous words. This disadvantage in translation production for translation-ambiguous words may be due to competition in selecting a correct translation equivalent. Thus, when a bilingual is presented with a word that has more than one possible translation, they require more time to make this selection and produce a response due to competition from the multiple translations. However, bilinguals are also slower and less accurate at recognizing correct translation pairs when the words are translation-ambiguous vs. translation-unambiguous (Boada et al., 2013; Laxén & Lavaur, 2010). Thus, even when bilinguals are presented with a correct translation in a task in which there would be no need to select a specific translation, there is still a cost in processing. This may be due to the automatic activation of all possible translations, leading to competition and a delay in a responding. Additionally, because there is a one-to-many mapping between the L1 to L2 words (or L2 to L1) the associative strength between the L1 word and each translation would be weaker compared to words with one-to-one mappings (Tokowicz, Kroll, De Groot, & Van Hell, 2002). These interpretations provide an understanding to why dominate translations produce faster and more accurate responses in translation recognition. The association strength between a word and the dominant translations would be much greater than the subordinate translation and therefore would facilitate processing.

Translation-ambiguity also impacts L2 learning. Degani and Tokowicz (2010) examined how native English-speaking learners acquired Dutch vocabulary words that were translation-ambiguous or unambiguous. The translation-ambiguous words were either meaning ambiguous in that the English word had two or more meanings and the Dutch translations corresponded to each of the distinct meanings (e.g., iron, metal iron – ijzer vs. clothing iron - strijken) or they were form ambiguous in that the English word had a single meaning but had two Dutch translations that were near-synonyms (e.g., boot – laars and schoen). For the vocabulary training, participants were presented with each English and Dutch word along with a definition. Each English-Dutch vocabulary word pair exposure lasted 8 seconds and participants completed three training cycles across two days (with four exposures per cycle). Participants were exposed to the different translations for the form and meaning ambiguous words on separate trials. Degani and Tokowicz (2010) found that translation-ambiguous words were more difficult to learn than translation-unambiguous words.

Additionally, they found that form-ambiguous words showed a learning disadvantage relative to meaning-ambiguous words in terms of a greater decline in retention. These differences in learning form vs. meaning ambiguous words may be due to how participants mapped the meaning to the L2 word. For meaning-ambiguous words there is a distinct meaning-to-L2 label mapping. For form-ambiguous words there remains a one-to-many mapping between the single meaning and the L2-labels. This one-to-many mapping between a meaning and the multiple word forms may have led to the decline in retention for the learners.

In a related study, Bracken et al. (2015) examined how learners acquired L2 translations that corresponded to two English translations that varied in semantic similarity. Unlike the Degani & Tokowicz (2010) and Degani et al. (2014) studies, the direction of ambiguity was from L2 to L1. Further, they examined the degree of semantic similarity between the multiple translations of the translation-ambiguous words using a continuous measure, called the Translation Semantic Variability (TSV) score. The TSV is the average semantic similarity scores across all pairwise comparisons of the multiple translations of an ambiguous word. It is calculated on a 1 to 7 scale in which a 1 would indicate the word has two or more completely unrelated translations, and a score of 7 would indicate the word has two or more completely related translations. Participants learned a set of German words that had multiple English translations. In the training, participants were presented with the German and English word simultaneously on the screen for 800 ms. For the translation ambiguous words the second translation was presented on the trial immediately following the first translation. After training and a filler task participants were tested on their knowledge of the vocabulary using a translation recognition task on which they were asked to correctly identify if the English and German words were correct translations or not. They were tested again on their knowledge one week after the first training session. Bracken et al. (2015) found significant negative correlations with TSV and reaction time such that participants were faster at correctly identifying words that had translations that were semantically similar than words with translations that were semantically dissimilar. In this study, form translation-ambiguous words (higher TSV) showed an advantage in learning and processing unlike previous training studies (e.g., Degani & Tokowicz, 2010). In Bracken et al. (2015) participants learned German words that had multiple English translations. Thus for form translation-ambiguous words (high TSV) (e.g., Tüte – sack and bag) there was a one-to-one mapping between form and meaning. For meaning translation-ambiguous words (low TSV) (e.g., Kiefer – jaw and pine) there was a one-to-many mapping between words and meanings. Participants were native English speakers and did not need to learn the L1 words. Therefore the results from Bracken et al. are consistent with prior training studies (Degani & Tokowicz, 2010; Degani et al., 2014) in that the difficulty in processing was with words with one-to-many mappings (either from form to meaning (L2-L1 direction) or meaning to form (L1-L2 direction) (see Tokowicz, 2014 for a review). This study further highlights the influence of semantic similarity on translation-ambiguity. These results also parallel within language semantic ambiguity effects (e.g., Rodd et al., 2002).

The differences between the translation ambiguous words with varying levels of meaning similarity found for L2 learners has also been found for bilingual and advanced L2 speakers as well (Boada et al., 2013; Eddington & Tokowicz, 2013; Laxén & Lavaur, 2010). Laxén and

Lavaur (2010) conducted a translation recognition task with French-English bilinguals. In Experiment 3, they examined how meaning similarity affected translation recognition speed and accuracy. For ease of comparison across studies, we refer to the semantically similar translations as form translation-ambiguous words and the semantically dissimilar translation-ambiguous words as meaning translation-ambiguous. They found that participants were faster and more accurate to respond to form translation-ambiguous words than meaning-translation words. Additionally, they found that dominant translations were responded to faster than subordinate translations and that this effect was larger for meaning ambiguous words than form ambiguous words.

Eddington and Tokowicz (2013) found a similar pattern of results with highly proficient English-German bilinguals using a primed translation-recognition task. In this experiment participants were presented with a related or unrelated prime and then presented with the English-German word pairs. For meaning translation-ambiguous words there were different related primes for the dominant meaning/translation and the subordinate meaning/translations. For near-synonymous or form translation-ambiguous words there was only a single related prime. Eddington and Tokowicz (2013) found that participants were significantly faster at responding to translation pairs when they were preceded by a related prime than an unrelated prime, and that there were differences in the priming effects for meaning vs. near-synonymous translation-ambiguous words. In particular, meaning-ambiguous words had a greater priming effect than form/near-synonymous ambiguous words. Similar to Laxén and Lavaur (2010), Degani et al. (2014) also found a dominance effect in which participants were more accurate in responding to the dominant translation than the subordinate translations.

Boada et al. (2013) also found an effect of translation dominance on translation recognition speed and accuracy for Catalan-Spanish bilinguals. The effect of translation dominance on translation recognition is akin to the meaning dominance effects found in within-language semantic ambiguity studies in which participants are faster when presented with a target related to the dominant meaning of the semantically ambiguous word than when presented with a target related to the subordinate meaning of the semantically ambiguous word (Klepousniotou et al., 2012). In translation recognition, the word presented first in the L1 serves as the prime and the word presented in L2 serves as the target. Using a more continuous measure of dominance called translation probability, Prior et al. (2013) also found that translations were more likely to be produced based on the translation probabilities (Prior, MacWhinney, & Kroll, 2007). Additionally, they found that translations with higher translation probabilities were associated with faster and more accurate responses in production and recognition. Therefore, the more likely or dominant a translation is used/produced from one language to another, the easier it is to produce a translation in another language and recognize the translation pairs.

In the current experiment we examine how translation dominance and sense/meaning dominance affect the learning and processing of translation-ambiguous words and how the different types of translation-ambiguous interact with dominance. Bracken et al. (2015) demonstrated that greater semantic similarity between multiple translations led to facilitation in processing L2 vocabulary. Bracken et al. examined translation ambiguity in the L2 to L1 direction and used continuous variables in their analysis. In the current experiment we specifically compared polysemous and homonymous translation-ambiguous words in L1 to L2 vocabulary-training paradigm using categorical approaches. Several studies have examined L2 processing of homonyms but there are very few studies examining L2 processing of polysemes (e.g., Crossley et al., 2010; Elston-Güttler & Friederici, 2005). We now discuss how strategies in L2 vocabulary learning impact meaningful encoding of L2 vocabulary.

3.2 L2 VOCABULARY TRAINING STRATEGIES

The L2 vocabulary training strategies commonly used in previous studies had participants primarily use the repetition method. With this method, participants are asked to repeat L1-L2 word pairs multiple times. This method is effective in learning L2 vocabulary (Lawson & Hogben, 1996) however, these methods are associated with shallow, form level processing. Thus, the learners are forming mainly orthographic and/or phonological associations from L1 to L2 but not forming associations with meaning with the L2 directly. Based on the RHM (Kroll & Stewart, 1994) bilinguals' L1 and L2 lexical representations are asymmetrically connected to conceptual representations. Bilinguals are hypothesized to have stronger conceptual connections from L1 lexical representations to concepts than from L2 lexical representations to concepts. Further, conceptual representations are hypothesized to be accessed via L1 connections. The RHM additionally postulates that as L2 learners and bilinguals become more proficient, the stronger the L2 to concepts connections become. It is possible that the common training strategies (e.g., repetition), which focused on form level representations in L2 lead to the weaker connections from L2 to concepts. Because we are interested in semantic processing and representation, we wanted to ensure that the learners were engaging with the L2 vocabulary in a meaningful way. Therefore, we are attempting facilitate learners' mappings between the L2 vocabulary directly to meanings in their semantic networks.

We chose to use a training paradigm that is effective at meaning-based learning called the Sentence Generation method. The training is based on the "Generation Effect" (Slamecka & Graf, 1978). The generation effect is a phenomenon in which learners retain information better when they actively generate a solution than when they are provided the information. For example, learners are more likely to remember the solution to a problem when they actually attempt to solve a problem (e.g., a math problem) than when they are shown the problem with the solution. This effect has been applied to L2 learning with the sentence generation effect. Webb (2005) found that advanced learners of Spanish better learned new L2 vocabulary when they created sentences using the new vocabulary than when they were provided with sentences using the new L2 vocabulary words. Bolger, Balass, Landen, and Perfetti (2008) used a similar method with L1 vocabulary acquisition with native English speakers.

This method has also been applied to early/naïve L2 learners and forms the basis of the training procedure used in the current experiment. Tokowicz and Jarbo (2015) examined whether the generation effect could be applied to naïve learners of Dutch. Participants in the study learned English-Dutch word pairs by repeating the vocabulary words aloud or generating English sentences using the Dutch word in place of the English vocabulary (e.g., I pressed my clothes with the strijken (iron)). They found that participants learned more words with the sentence generation method than the repetition method.

In a related study Eddington, Martin, and Tokowicz (2012) examined how learners acquired German vocabulary using four training methods. In this fully crossed design, participants learned the L2 vocabulary words by generating a sentence, generating a definition, reading a sentence, and reading a definition. Eddington et al. (2012) found that overall words paired with the sentence training (either generating or reading) were learned better than words paired with the definition training (either generating or reading). Critically, there was an added benefit for words learned by generating a sentence specifically in the meaning-based L2 vocabulary test. This study further supports the sentence generating method as an effective training strategy that focuses on meaning level connections with the L2 vocabulary words.

Additionally, we also wanted to ensure that the learners were able to learn both translations of the translation-ambiguous words. In a follow up study to Degani and Tokowicz (2010), Degani et al. (2014) found that when participants were exposed to translations of the translation-ambiguous words sequentially they learned the words better than when the translation ambiguous words were trained on separate training days . Therefore, in the training, participants were exposed to the translations for translation-ambiguous words on consecutive trials rather than across separate training sessions to maximize their learning of these words.

3.3 EXPERIMENT OVERVIEW

In this experiment we examined how factors such as meaning/sense similarity of translation-ambiguous words and meaning/sense dominance affect the learning and processing of L2 vocabulary. Further this experiment examined how acquiring new labels (i.e., L2 vocabulary) that map to ambiguous word meanings affects processing in L1. To examine these issues we trained native English speakers on English-German vocabulary words that were translation-ambiguous. The translation-ambiguous words included homonymous, polysemous, and near-synonymous translation-ambiguous words. Critically, using the sentence generation method, the L2 vocabulary training emphasized mapping L2 vocabulary to each meaning. Thus, emphasizing that the German words have a one-to-one mapping between the German word form and the meaning but the English words have a one-to-many mapping between the English word form and the multiple meanings. Participants' learning was evaluated using productive measures (free recall, and L2-L1 translation production) and a receptive measure (semantic relatedness task). For the free-recall task, participants were asked to type in as many of the L2-L1 word pairs they could recall. For the L2-L1 translation task participants were presented with the German word and were asked to produce the English translation. In the semantic relatedness task, participants were presented with the German word and an English word that was the direct translation, was related in meaning to the German word, or was unrelated to the translation. Participants were asked to decide if the English word is related or unrelated to the German word by pressing corresponding "yes" and "no" buttons on a button box. Participants must know the meaning of the L2 vocabulary word to perform well on this task rather than just recognizing the correct translations. Therefore, this task taps into semantic processing of the L2 vocabulary words by asking participants to make relatedness judgments on the L2 words.

Additionally, participants completed a lexical decision task before and after training. The words in the lexical decision task were the English vocabulary training words (homonymous, polysemous, near-synonymous, and unambiguous words), and additional homonymous, polysemous, near-synonymous, and unambiguous words that were matched on item level characteristics to the training words. This task allowed us to examine if changes occur in how participants process these different word types in their L1 after learning L2 labels associated with their meanings/senses.

Based on previous research (Degani & Tokowicz, 2010; Degani et al., 2014), we expected that participants would have more difficulty learning the translation-ambiguous words than the translation-unambiguous words. Additionally, we expected there to be differences between the three types of translation-ambiguous words. The RHM-TA predicts that there would be an advantage for learning meaning translation-ambiguous words over form (near-synonyms) translation-ambiguous words because the is a one-to-one mapping between meaning and L2 labels for meaning translation-ambiguous words (e.g., mapping tree trunk to the German word Kofferraum) but a one-to-many mapping from between meaning and L2 labels (e.g., mapping fruit to both Obst and Frucht). Based on the RHM-TA (Eddington & Tokowicz, 2013) and previous research by Degani & Tokowicz (2010) we expected that participants would learn the homonym translation-ambiguous words better than the near-synonym translation-ambiguous words based on the free-recall and L2-L1 translation production tasks. Alternatively, participants may show a disadvantage for homonymous translation-ambiguous words due to the emphasis on meaning during the training, which may lead to greater semantic interference between the multiple unrelated meanings.

We also hypothesized that there would be an interaction between the different types of translation-ambiguous words and the two types of 'yes' responses (semantic associate vs. correct translation) during the semantic relatedness test. Overall, we expected that participants would respond more slowly and less accurately on semantic trials vs. translation trials and that this difference would be reduced for near-synonymous and polysemous translation-ambiguous words due to the related senses facilitating recognition. For the semantic associate "yes" response, we hypothesized that synonym translation-ambiguous words would be responded to more quickly and accurately than the homonymous translation-ambiguous words and that polysemous translation-ambiguous words would elicit accuracy and response times in the middle of the two types. We expected these results because the semantic relatedness decision explicitly emphasizes semantic relationships between words, which may lead to disadvantages in processing of homonyms (Hino et al., 2002; Pexman, Hino, & Lupker, 2004). Based on previous research (Boada et al., 2013) we hypothesized that there would be a dominance effect for the translation-ambiguous words in which dominant translations would be responded to more quickly and accurately than subordinate translations. Additionally, we hypothesized that translation dominance would interact with ambiguity type such that there would be a greater dominance effect for homonyms than polysemous and near-synonymous translation-ambiguous words.

For the lexical decision task, we expected participants to have faster and more accurate response times on the second test session. We hypothesized that after the vocabulary training sessions; participants would be slower to respond to the translation-ambiguous words compared to the translation-unambiguous words. We also hypothesized that the untrained semantically-ambiguous words would show typical ambiguity effects such that polysemes would be responded to more quickly and accurately than unambiguous words and homonyms would be responded to more slowly than unambiguous words (e.g., Armstrong & Plaut, 2011; Rodd et al., 2002).

3.4 METHODS

3.4.1 Participants

Seventy-one native English speakers participated in the experiment, however only 46 were included in the final analyses of the experiment. Participants were recruited form the community and from the Introduction to Psychology subject pool and receive credits and were compensated for their time. All participants included in the final analyses were at least 18 years of age or older, had not previously learned German or Dutch, had not been exposed to a language other than English prior to age 12, and were right handed. Fourteen participants were excluded from analyses because they did not complete all three sessions of the experiment and 11 participants were excluded because they had exposure to German or were exposed to another language before age 12. The participants' demographic information obtained from the Language History Questionnaire can be seen in Appendix B.

3.4.2 Design

This study used a 4 word type (homonym, polyseme, near-synonym, unambiguous) x 2 test session (session 1, session 2) within subjects design.

3.4.3 Stimuli

3.4.3.1 L2 Vocabulary stimuli

Participants were trained on set of 60 English and 90 German vocabulary words (see Appendix F for the complete stimulus list). Half of the English words were translation-ambiguous and had two German translations and half of the English words were translation-unambiguous and had a single German translation. Of the translation-ambiguous words, 10 were classified as homonymous (e.g., Bark – tree (Baumrinde) – dog (Bellen)), 10 were classified as polysemous (e.g., Sheet – bedding (Laken) – paper (Blatt)), and 10 were classified as near-synonymous (e.g., joke – Witz and Schertz). The dominance of the translations were determined by from published norms (Durkin & Manning, 1989; Twilley et al., 1994) and the English-German translation norms (Eddington, Degani, & Tokowicz, 2015). An abbreviated definition obtained from online dictionaries (e.g., dictionary.com, wordnet) was provided for each vocabulary word (2 definitions for polysemous and homonymous translation-ambiguous words to map to each distinct sense/meaning). The stimuli were matched on word length ($F(3,56) = .43$, $p = .73$) log frequency (SUBTL; Brysbaert & New, 2009) ($F(3,56) = 1.22$, $p = .31$), concreteness (Brysbaert et al., 2014) ($F(3,56)$ 1.79, $p = .16$) , and German length ($F(3,56) = 1.62$, $p = .19$) (see Table 11 for stimulus characteristics). Because these characteristics were not perfectly matched, we included these factors in the model to control for any differences across word types.

Table 11. Vocabulary Word Characteristics - Experiment 2

	English Word Length		English log Frequency		English Concreteness		German Word Length	
Word Type	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Homonym	5.20	1.03	2.83	0.50	4.46	0.46	7.65	2.01
Polyseme	5.50	1.78	3.10	0.48	4.68	0.59	6.75	1.83
Near-synonym	4.90	1.37	3.11	0.55	3.87	1.29	5.90	1.55
Unambiguous	5.03	1.19	3.17	0.44	4.41	0.78	6.03	1.53

3.4.3.2 Testing stimuli

Lexical Decision Task.

The lexical decision task included the 60 English words from the German training as well as 60 English words not included in the training as comparison words. The control "untrained" words included 10 homonyms, 10 polysemes, 10 near-synonyms (selected from the German-English translation norms, Eddington et al., 2015), and 30 unambiguous words. An additional 120 pronounceable non-words were included. The added trained stimuli matched the untrained stimuli in word length ($F(1,232) = .51$, $p = .48$), log frequency (SUBLT; Brysbaert & New,

2009) (F(1,232) = .17, p = .68), and concreteness (Brysbaert et al., 2014) (F(1,232) = .78, p = .38). See Table 12 for item level characteristics.

Table 12. "Untrained" Stimuli Characteristics - Lexical Decision Task

	English Word Length		English log Frequency		English Concreteness	
Word Type	M	SD	M	SD	M	SD
Homonym	5.2	1.01	2.83	0.47	4.31	0.55
Polyseme	5.1	1.17	3.19	0.59	4.34	0.69
Near-synonym	5.0	1.21	3.11	0.47	4.17	0.48
Unambiguous	4.9	1.36	3.08	0.44	4.63	0.55

Semantic Relatedness Task

For the semantic relatedness task, each German vocabulary word was paired with an English word that was either the direct translation, a semantic associate, or an unrelated word. The 90 semantic associates were generated by the researchers or selected from published free association norms (Nelson, McEvoy, & Schreiber, 2004) and free association norms collected by the researchers (See Appendix F for associates and Appendix G for the free association norms details). For the translation-ambiguous words there were two semantic associates, which related to each distinct meaning/sense. The unrelated pairings were created by re-pairing the translations and semantic associates with different vocabulary words. The semantic associates across word types were matched on word length (F(3,116) 1.01, p = .39) and log word frequency (SUBLT; Brysbaert & New, 2009) (F(3,116) = .37, p = .77) but not on concreteness (Brysbaert et al., 2014) (F(3,116) 2.96, p = .035). Because the stimuli were not matched on all word characteristics we included these factors in the model to control for any differences. The stimulus characteristics can be seen in Table 13.

Four counterbalanced list versions were created for each training list version so that each German word appeared in each condition. Within each testing list version there were two blocks in which the participants were exposed to the vocabulary words twice. Half of the words received a "yes" response and half received a "no" response. Sub-lists for each list version were created so that across blocks the "yes" and "no" responses were not predictive from one block to the next. Participants were randomly assigned to a list version. On the first testing session participants completed one list version and they completed a different list version on the second session.

Table 13. Word Characteristics of Semantic Associates - Experiment 2

	English Word Length		English log Frequency		English Concreteness	
Word Type	M	SD	M	SD	M	SD
Homonym	5.55	2.09	3.12	0.89	4.00	1.15
Polyseme	4.80	1.51	2.87	0.78	4.28	0.95
Near-synonym	5.70	1.89	2.99	0.77	3.57	1.23
Unambiguous	5.58	1.94	2.93	0.82	4.27	0.77

3.4.4 Procedure

3.4.4.1 Procedure Overview by Session

See Table 14 for a timeline of the procedures. On session one, participants performed a pre-test lexical decision task that contained the training vocabulary words and the untrained filler words. Next, participants completed the first German vocabulary training session, and completed a free recall task (see details below). Next, participants completed the Flankers task (Eriksen, 1995) and finally the Stroop task (Stroop, 1935).

On session 2 (two days after session 1), participants performed the free recall task, a L2-L1 translation production task, and a semantic relatedness task (see details below). Next, participants completed a computerized adapted version of the Ravens progressive matrices task (Raven, 1965). Lastly, the participants completed the German vocabulary training for a second time.

On session 3 (one week after session 2), participants completed the free recall task, L2-L1 translation production task, and semantic relatedness task, a post-test lexical decision task, the O-span task (Turner & Engle, 1989), and PPVT test (Dunn & Dunn, 2007). Lastly, participants completed the language history questionnaire (Tokowicz et al., 2004), were debriefed, and compensated for their time.

Table 14. Summary of Exp. 2 Procedures

Session	Task	Task Order
1 (Day 1)	Pretest and Vocabulary Training	Lexical Decision Task Vocabulary Training Free Recall Stroop Flankers
2 (Day 3)	Vocabulary Tests and Vocabulary Training	Free Recall L2-L1 Translation Semantic Relatedness Ravens Matrices Vocabulary Training
3 (Day 10)	Posttests and Vocabulary Tests	Lexical Decision Free Recall L2-L1 Translation Semantic Relatedness PPVT O-span Language History Questionnaire

3.4.4.2 German Vocabulary Training.

The training paradigm was adapted from prior L2 word learning studies (Bracken et al., 2015; Degani & Tokowicz, 2010; Eddington et al., 2012). On a computer screen, participants saw the English word and the German translation (e.g., bread-Brot). They were asked to repeat the word pair out loud two times. Below the word pair there was the definition of the vocabulary word (e.g., bread – Brot = "a kind of food made from dough") and the participants were asked to read the definition aloud. The English-German word pair and definition were presented on the screen until they pressed the space bar to move on to the next screen. On the next screen, participants were presented with the English-German word pair and were instructed to use the German word in an English sentence substituting the German word for the English word (e.g., "I spread butter on my Brot (bread)."). Participants were instructed to create meaningful sentences that used the vocabulary word in context. Participants were instructed to press the space bar to continue to the next trial. For the translation-ambiguous words, participants were exposed to the two translations of the translation-ambiguous words on sequential trials during training. We matched the exposure of the German word across word types, thus participants saw the German words an equal number of times across word types but saw the English translation twice as often for translation-ambiguous words than translation-unambiguous words. Participants ran through the training program three times within a session and their utterances were recorded with a digital recorder.

3.4.4.3 Testing Procedures

The unprimed lexical decision task procedure was the same as in Experiment 1. In the free recall test, participants were asked to recall as many of the vocabulary word pairs they could remember. Participants typed their responses in an Excel spreadsheet.

In the L2 to L1 production task, participants were presented with the German word on the screen and they were asked produce the English equivalent as quickly and accurately as possible. Stimuli were presented using E-prime and responses were recorded with a digital recorder to code for accuracy of their responses. Response times were recorded using a microphone connected to a button box.

In the semantic relatedness task, the German vocabulary words were paired with a semantically-related associate, an unrelated word, or the English translation. Participants first saw a fixation cross for 1000 ms and then the German and English words were presented on the screen until the participant made a response on a button box. The German word was located on the left side a hyphen and then the English word was presented on the right side of the hyphen. Participants were instructed to respond 'yes' (rightmost button on the button box) with their right index finger if the word pairs were semantically related (e.g., Rüssel – Trunk) or translation equivalents (Rüssel – Nose), and 'no' (leftmost button on the button box) with their left index finger if the word pairs were unrelated (e.g., Rüssel – Art). Every 45 trials participants could take a break. Stimuli were presented using E-prime and accuracy and response times were collected.

3.5 RESULTS

3.5.1 Statistical approach

We included a random factor of participants for the free recall and L2-L1 translation production models and random factors of participants and items for the semantic relatedness models. The fixed factors of interest are word type (homonym, polyseme, near-synonym, unambiguous), testing session (session 1, session 2) and translation dominance (dominant, subordinate). For the semantic relatedness task, an additional factor of relation (translation vs. semantic associate) was included. These factors were coded using effect coding in which the intercept of the model represents the grand mean and the slopes indicate the difference between the contrasted conditions. We ran models containing all word types (e.g., homonym, polyseme, near-synonym, unambiguous) to examine differences between translation-ambiguous and translation-unambiguous words and models with only translation-ambiguous words to examine the effect of translation dominance. Because the models containing just translation-ambiguous words have the same contrasts as the models examining all word types we only reported the significant findings that are unique to the models with just translation-ambiguous words.

Word type: All word types

C1: homonyms vs. polysemes

C2: homonyms and polysemes vs. near-synonyms

C3: translation ambiguous vs. translation-unambiguous

Word type: Ambiguous words only

C1: homonyms and polysemes vs. near-synonyms

C2: homonyms vs. polysemes

Testing Session

C1: Session 1 vs. Session 2

Translation Dominance

C1: Dominant vs. Subordinate

Relation – For Semantic Relatedness Task

C1: Semantic Associate vs. Translation

Training – For Lexical Decision Task

C1: Trained vs. Untrained

3.5.2 Lexical Decision Task

3.5.2.1 RT model

We observed a significant interaction with testing session, trained vs. untrained words, and word type. This three-way interaction qualified a main effect of testing session. For ease of interpretation post-test models were conducted for Session 1 and Session 2 separately to examine the interaction between word type and training on the separate days. The post-tests revealed that before training (Session 1), no significant interactions were observed between trained vs. untrained words and word types (β = -0.0012, $t(109)$ = -.11, p = .71). After training (Session 2) there was a significant interaction between trained vs. untrained words and the word types such that trained homonymous words were responded to significantly faster than untrained homonymous words (β = -0.07, $t(113)$ = -2.23, p = .03) (See Figure 20). This effect cannot be solely due to repeated exposure to the trained words because no other differences were observed between the trained and untrained polysemous, near-synonymous, and unambiguous words. Thus, this was a special effect for homonymous words after the L2 vocabulary training. The full results of the model can be seen in Table 15.

Table 15. Lexical Decision Model Results – RT

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	6.36	0.02	42.00	285.16	0.00	***
Flankers Dif.	0.00	0.00	40.00	-1.04	0.31	

PPVT Standard	0.00	0.00	40.00	1.33	0.19	
Stroop	0.00	0.00	40.00	0.19	0.85	
Ravens	0.01	0.01	40.00	0.62	0.54	
O-span Total	0.00	0.01	40.00	-0.03	0.98	
English word length	0.01	0.00	108.00	2.30	0.02	*
English word log frequency	-0.05	0.01	107.00	-5.71	0.00	***
English word concreteness	-0.02	0.01	108.00	-3.73	0.00	***
English word orthographic N.	0.00	0.00	107.00	2.47	0.02	*
Trial Number	0.00	0.00	10590.00	-6.39	0.00	***
Previous RT	0.00	0.00	10580.00	-0.67	0.50	
Type C1: H vs. P	0.02	0.01	114.00	1.52	0.13	
Type C2: H & P vs. N-S	0.02	0.01	109.00	1.41	0.16	
Type C2: Ambig. vs. Unambig.	0.00	0.01	115.00	0.36	0.72	
Session 1 vs. 2	-0.08	0.01	10520.00	-15.35	0.00	***
Training: Trained vs. Untrained	-0.01	0.01	109.00	-1.14	0.26	
Type C1: H vs. P * Session 1 vs. 2	0.00	0.02	10520.00	0.16	0.88	
Type C2: H & P vs. N-S * Session 1 vs. 2	0.01	0.01	10520.00	0.69	0.49	
Type C3: Ambig. vs. Unambig. * Session 1 vs. 2	-0.01	0.01	10520.00	-0.67	0.50	
Type C1: H vs. P * Trained vs. Untrained	-0.03	0.03	114.00	-0.99	0.32	
Type C2 : H & P vs. N-S * Trained vs. Untrained	0.00	0.02	110.00	0.13	0.90	
Type C3: Ambig. vs. Unambig. * Trained vs. Untrained	0.00	0.02	116.00	-0.14	0.89	
Session 1 vs. 2 * Trained vs. Untrained	-0.01	0.01	10520.00	-1.25	0.21	
Type C1: H vs. P * Session 1 vs. 2 * Trained vs. Untrained	-0.08	0.03	10520.00	-2.25	0.02	*
Type C2: H & P vs. N-S * Session 1 vs. 2 * Trained vs. Untrained	0.00	0.03	10520.00	0.01	0.99	
Type C3: Ambig. vs. Unambig. * Session 1 vs. 2 * Trained vs. Untrained	-0.03	0.02	10520.00	-1.66	0.10	.
Random Effects	Variance	St. Dev.				
Participant	0.02	0.15				
Item	0.00	0.03				

Note: H & P vs. N-S = homonyms and polysemes vs. near-synonyms, H vs. P = homonyms vs. polysemes, and Dom vs. Sub = dominant vs. subordinate.

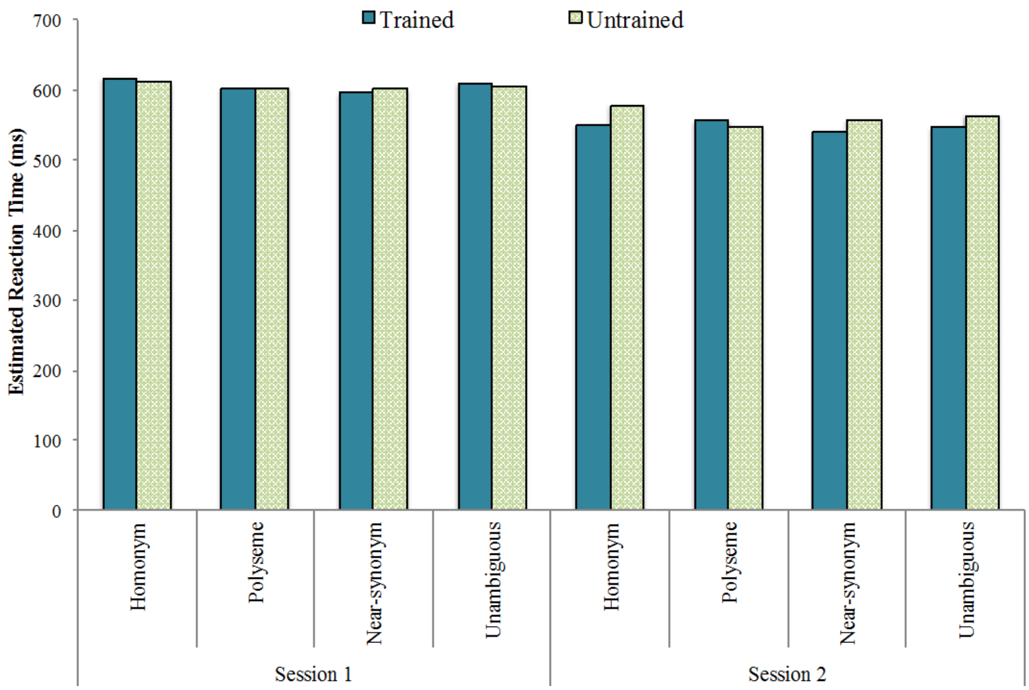


Figure 20. Mean Estimated RTs - Lexical Decision

3.5.2.2 Accuracy model

We observed an interaction with word type and session such that participants responded less accurately to homonymous than polysemous words on Session 2 (see Figure 21). These interactions qualified a main effect of testing session. The results from the full model can be seen in Table 16.

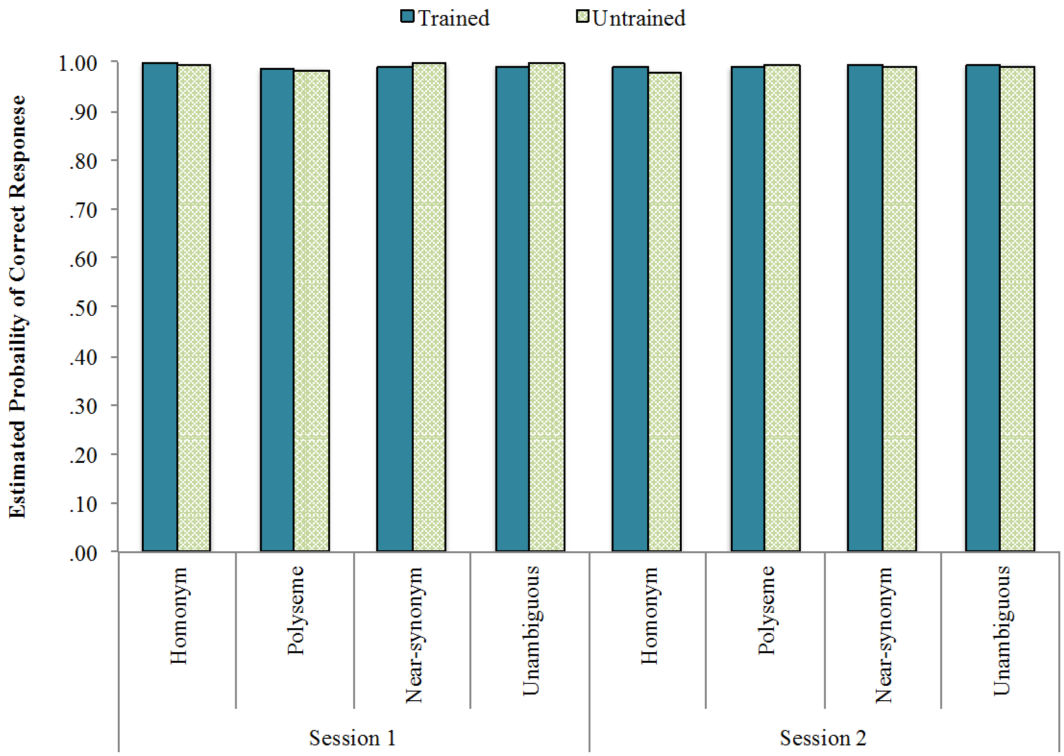


Figure 21. Lexical Decision Accuracy Estimates

Table 16. Lexical Decision Model Results - Accuracy

	β	Std.Error	t-value	p-value	Sig.
Intercept	4.45	0.27	16.41	0.00	***
Flankers Dif.	0.00	0.01	-0.12	0.90	
PPVT Standard	-0.02	0.02	-1.12	0.26	
Stroop	0.00	0.01	0.29	0.77	
Ravens	0.17	0.09	1.81	0.07	.
O-span Total	0.00	0.04	0.00	1.00	
English word length	0.20	0.12	1.66	0.10	.
English word log frequency	0.67	0.21	3.11	0.00	**
English word concreteness	0.34	0.15	2.30	0.02	*
English word orthographic N.	-0.03	0.02	-1.46	0.14	
Trial Number	0.00	0.00	-3.13	0.00	**
Type C1: H vs. P	0.48	0.35	1.38	0.17	

Type C2: H & P vs. N-S	0.56	0.27	2.09	0.04	*
Type C2: Ambig. vs. Unambig.	0.52	0.35	1.47	0.14	
Session 1 vs. 2	0.59	0.37	1.58	0.11	
Training: Trained vs. Untrained	-0.07	0.45	-0.15	0.88	
Type C1: H vs. P * Session 1 vs. 2	-1.85	0.60	-3.08	0.00	**
Type C2: H & P vs. N-S * Session 1 vs. 2	-0.89	0.46	-1.95	0.05	.
Type C3: Ambig. vs. Unambig. * Session 1 vs. 2	-1.06	0.56	-1.89	0.06	.
Type C1: H vs. P * Trained vs. Untrained	1.04	0.69	1.51	0.13	
Type C2 : H & P vs. N-S * Trained vs. Untrained	-0.31	0.54	-0.57	0.57	
Type C3: Ambig. vs. Unambig. * Trained vs. Untrained	-0.12	0.67	-0.18	0.86	
Type C1: H vs. P * Session 1 vs. 2 * Trained vs. Untrained	-0.31	0.74	-0.41	0.68	
Type C2: H & P vs. N-S * Session 1 vs. 2 * Trained vs. Untrained	-0.09	1.20	-0.08	0.94	
Type C3: Ambig. vs. Unambig. * Session 1 vs. 2 * Trained vs. Untrained	1.26	0.91	1.38	0.17	

Random Effects	Variance	St. Dev.
Participant	0.21	0.46
Item	0.66	0.81

3.5.3 Free Recall

3.5.3.1 Accuracy model – All word types

Overall, translation-unambiguous words were correctly recalled more often than translation-ambiguous words. To further test the effect of ambiguity we ran an additional model comparing each translation-ambiguous word type to the unambiguous words. We found that homonyms (β = -3.86, z = 2.62, p < .001) were recalled less than unambiguous words but no differences were observed between near-synonyms and polysemes with unambiguous words (ps > .3). Near-synonym translation ambiguous words were correctly recalled more often than homonymous and polysemous translation-ambiguous words, and polysemous translation-ambiguous words were correctly recalled more often than homonymous translation ambiguous words. Participants were more accurate on testing session 2 than session 1 (See Figure 22). No other significant effects were found. See Table 17 for the results of the model.

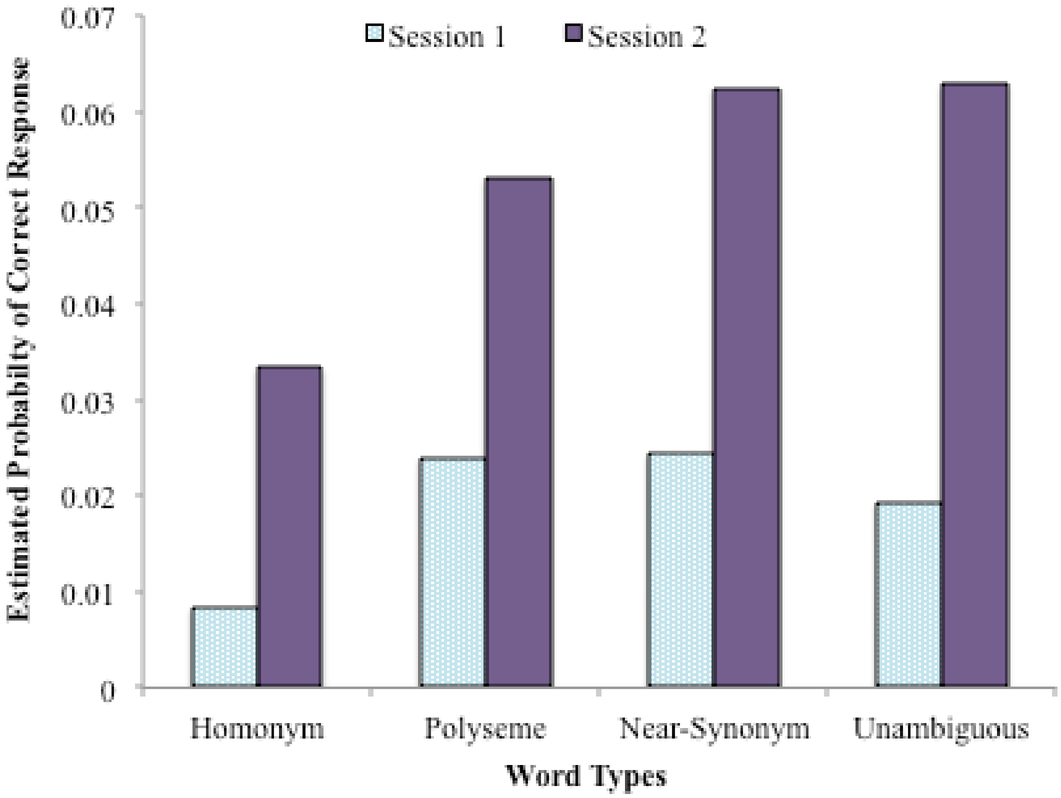


Figure 22. Free Recall Accuracy Estimates- All word types

Table 17. Free Recall Accuracy - All word types model results

	β	Std. Error	z-value	p-value	Sig.
(Intercept)	-3.47	0.13	-26.57	.00	**
Flankers Dif.	0.00	0.00	0.05	.96	
PPVT Standard	0.02	0.01	1.77	.07	
Stroop	-0.02	0.01	-1.83	.07	
Ravens	-0.02	0.07	-0.29	.77	
O-span Total	0.02	0.03	0.67	.50	

English word length	-0.03	0.06	-0.46	.64	
English word log frequency	0.39	0.11	3.48	.00	**
English word concreteness	0.29	0.08	3.63	.00	**
English word orthographic N.	-0.03	0.01	-2.35	.02	**
German word length	-0.27	0.04	-7.39	.00	**
Type C1: H vs. P	-0.78	0.23	-3.34	.00	**
Type C2: H & P vs. N-S	-0.36	0.17	-2.11	.03	*
Type C3: Ambig. vs. Unambig.	-0.37	0.12	-2.99	.00	**
Session 1 vs. 2	1.11	0.13	8.39	.00	**
Type C1: H vs. P * Session 1 vs. 2	0.58	0.45	1.29	.19	
Type C2: H & P vs. N-S * Session 1 vs. 2	-0.13	0.31	-0.39	.69	
Type C3: Ambig. vs. Unambig. * Session 1 vs. 2	0.18	0.24	0.77	.44	

Random Effects	Variance	St. Dev.
Participant	0.47	0.68

Note: H & P vs. N-S = homonyms and polysemes vs. near-synonyms, H vs. P = homonyms vs. polysemes.

3.5.3.2 Accuracy model – Ambiguous word types

This model examines only ambiguous words and thus permits testing of the effect of translation dominance and how it interacts with different word types. There was a significant dominance by word type interaction such that the effect of dominance (higher accuracy on dominant translations than subordinate translations) was greater for polysemous words than homonymous words (see Figure 23). This effect qualifies a main effect of dominance. The full results of the model can be seen in Table 18.

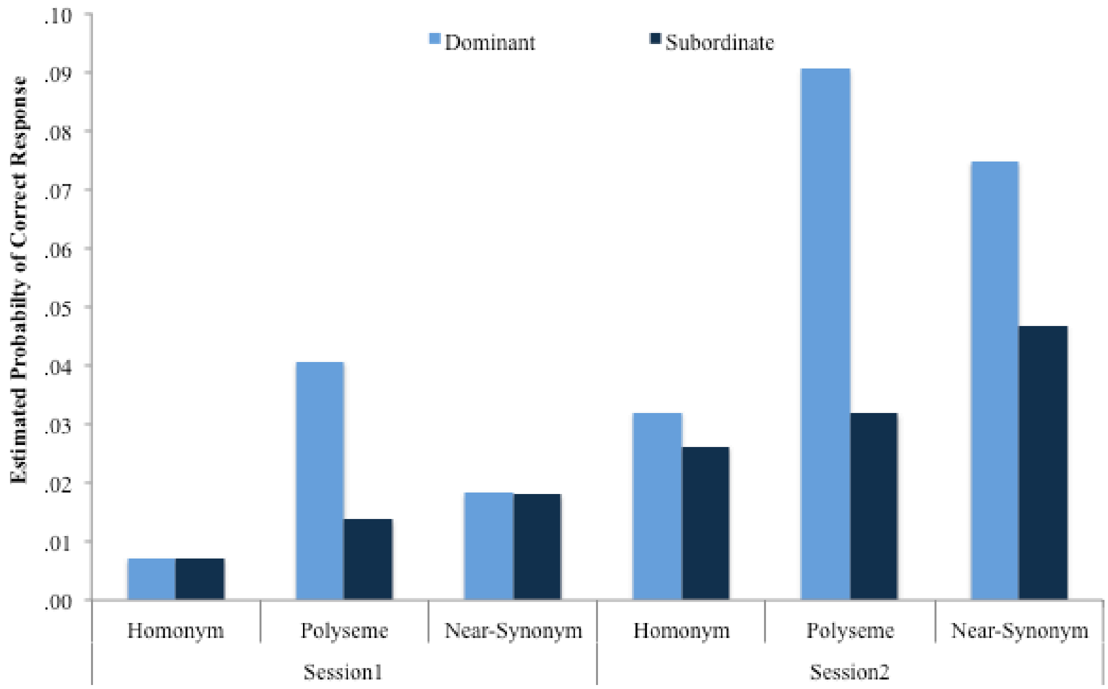


Figure 23. Free Recall Accuracy Estimates- Ambiguous word types

Table 18. Free Recall Accuracy - Ambiguous word types model results

	β	Std. Error	z-value	p-value	Sig.
(Intercept)	-3.63	0.15	-24.17	.00	**
Flankers Dif.	0.00	0.00	0.83	.40	
PPVT Standard	0.02	0.02	1.41	.16	
Stroop	-0.01	0.01	-0.84	.40	
Ravens	0.00	0.08	0.04	.97	
O-span Total	0.08	0.04	1.94	.05	
English word length	0.19	0.08	2.53	.01	*
English word log frequency	0.30	0.15	2.00	.05	
English word concreteness	0.23	0.09	2.28	.02	*
English word orthographic N.	0.09	0.02	4.13	.00	**
German word length	-0.23	0.05	-4.96	.00	**
Type C1: H & P vs. N-S	-0.37	0.19	-1.98	.05	
Type C2: H vs. P	-0.92	0.25	-3.76	.00	**
Dom vs. Sub	-0.49	0.18	-2.79	.00	**
Session 1 vs. 2	1.16	0.18	6.64	.00	**
Type C1: H & P vs. N-S * Dom vs. Sub	-0.35	0.34	-1.02	.31	
Type C2: H vs. P * Dom vs. Sub	1.01	0.46	2.17	.03	*

Type C1: H & P vs. N-S * Session 1 vs. 2	-0.10	0.34	-0.29	.78
Type C2: H vs. P * Session 1 vs. 2	0.56	0.46	1.20	.23
Dom vs. Sub * Session 1 vs. 2	-0.23	0.35	-0.64	.52
Type C1: H & P vs. N-S * Dom vs. Sub * Session 1 vs. 2	0.37	0.68	0.55	.58
Type C2: H vs. P * Dom vs. Sub * Session 1 vs. 2	-0.21	0.93	-0.23	.81
Random Effects	Variance	St. Dev.		
Participant	0.49	0.70		

Note: H & P vs. N-S = homonyms and polysemes vs. near-synonyms, H vs. P = homonyms vs. polysemes, and Dom vs. Sub = dominant vs. subordinate.

3.5.4 L2-L1 Translation Production

3.5.4.1 RT model – All word types

We observed an overall ambiguity effect such that translation-ambiguous words were translated more slowly than translation-unambiguous words. To further test the effect of ambiguity we ran an additional model comparing each translation-ambiguous word type to the unambiguous-words. We found that homonyms ($\beta = 0.14$, $t(1897) = 2.62$, $p < .01$) and near-synonyms ($\beta = 0.10$, $t(1903) = 3.94$, $p < .001$) were translated more slowly compared to unambiguous words, but no differences were observed between polysemes and unambiguous words ($\beta = 0.03$, $t(1897) = .68$, $p = .50$), thus the effect was driven by the homonyms and near-synonyms. Additionally, homonyms were translated more slowly than polysemes and participants translated words more slowly on testing session 1 than testing session 2 (See Figure 24). See Table 19 for the model results.

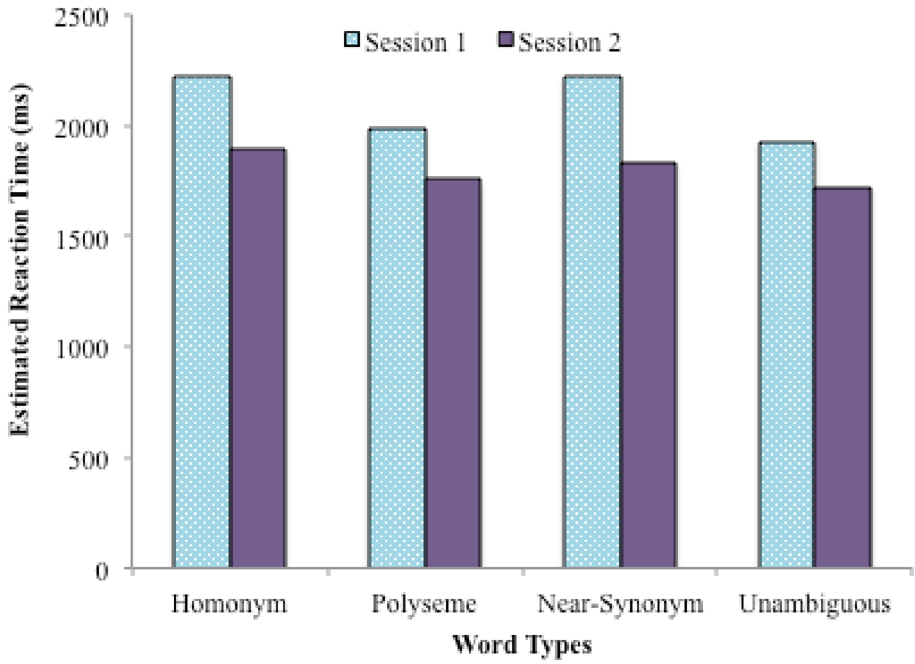


Figure 24. L2 L1 Translation Production RT Estimates - All Word Types

Table 19. L2-L1 RT - All word types model results

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	7.57	0.04	42.20	211.32	.00	***
Flankers Dif.	0.00	0.00	35.90	-1.13	.27	
PPVT Standard	0.00	0.00	41.40	-0.82	.42	
Stroop	0.00	0.00	37.60	0.35	.73	
Ravens	0.06	0.02	36.90	2.89	.01	**
O-span Total	-0.02	0.01	40.80	-1.58	.12	
English word length	0.03	0.02	1898.00	1.73	.08	.
English word log frequency	-0.11	0.03	1897.00	-3.42	.00	***
English word concreteness	0.03	0.02	1893.00	1.67	.10	.
English word orthographic N.	0.01	0.00	1899.00	2.95	.00	**
German word length	0.04	0.01	1904.00	4.53	.00	***
Type C1: H vs. P	0.10	0.05	1896.00	2.08	.04	*
Type C2: H & P vs. N-S	-0.03	0.04	1899.00	-0.72	.47	
Type C2: Ambig. vs. Unambig.	0.08	0.03	1900.00	2.71	.01	**
Session 1 vs. 2	-0.15	0.03	1900.00	-5.03	.00	***
Type: H vs. P * Session 1 vs. 2	-0.04	0.09	1891.00	-0.47	.64	

Type: H & P vs. N-S * Session 1 vs. 2	0.05	0.07	1891.00	0.70	.48
Type C2: Ambig. vs. Unambig. * Session 1 vs. 2	-0.04	0.06	1887.00	-0.77	.44
Random Effects	Variance	St. Dev			
Participant	0.05	0.21			

3.5.4.2 Accuracy model – All word types

There was no overall ambiguity effect in the L2-L1 translation production data, however homonymous and polysemous translation-ambiguous words were translated marginally less accurately than near-synonymous translation ambiguous words. Homonymous translation-ambiguous words were translated significantly less accurately than polysemous translation-ambiguous words. Overall, participants were more accurate on testing session 2 than testing session 1 (See Figure 25). No other significant effects or interactions were found. See Table 20 for the full results of the model.

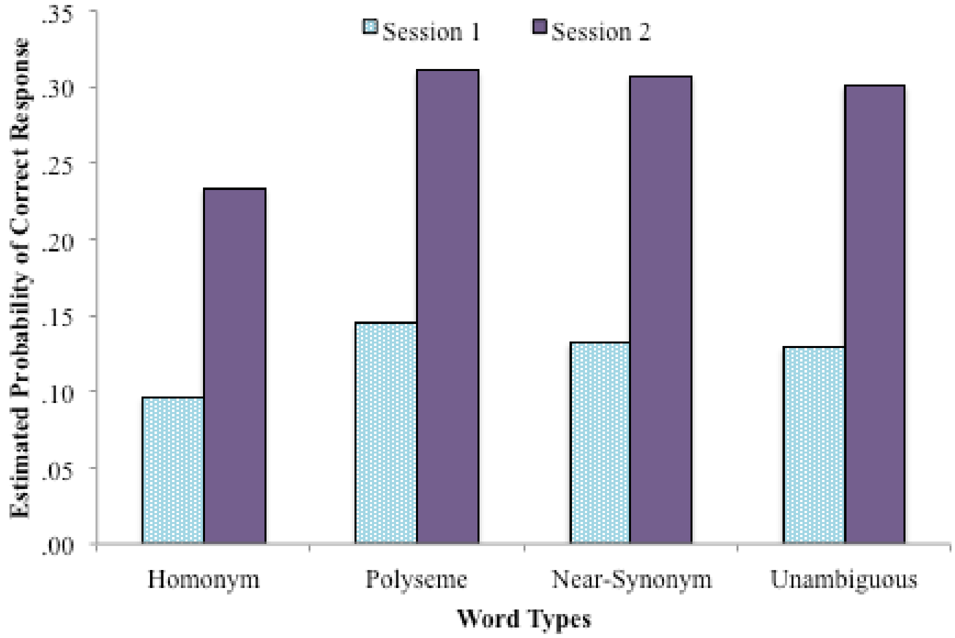


Figure 25. L2 L1 Translation Production Accuracy Estimates - All Word Types

Table 20. L2-L1 Accuracy - All word types model results

	β	Std. Error	t-value	p-value	Sig.
(Intercept)	-1.43	0.09	-15.38	.00	**
Flankers Dif.	0.00	0.00	-0.23	.82	
PPVT Standard	0.05	0.01	4.65	.00	**
Stroop	0.01	0.01	1.03	.31	
Ravens	0.02	0.05	0.39	.69	
O-span Total	0.04	0.03	1.57	.12	-
English word length	0.06	0.03	1.91	.06	
English word log frequency	0.32	0.06	5.13	.00	**
English word concreteness	0.29	0.04	6.78	.00	**
English word orthographic N.	-0.01	0.01	-1.20	.23	
German word length	-0.06	0.02	-3.23	.00	**
Type C1: H vs. P	-0.43	0.09	-4.62	.00	**
Type C2: H & P vs. N-S	-0.15	0.09	-1.79	.07	-
Type C2: Ambig. vs. Unambig.	-0.07	0.06	-1.15	.25	
Session 1 vs. 2	1.04	0.06	17.40	.00	**
Type: H vs. P * Session 1 vs. 2	0.08	0.18	0.44	.66	
Type: H & P vs. N-S * Session 1 vs. 2	-0.05	0.15	-0.35	.72	

Type C2: Ambig. vs. Unambig. * Session 1 vs. 2	-0.04	0.12	-0.30	.77

Random Effects	Variance	St. Dev.
Participant	0.3511	0.5925

3.5.4.3 RT model- Ambiguous word types

We observed a marginal testing session by dominance interaction such that the dominance effect was greater on testing session 1 than testing session 2 (see Figure 26). This interaction qualified the main effects of testing session and dominance. See Table 21 for the model results.

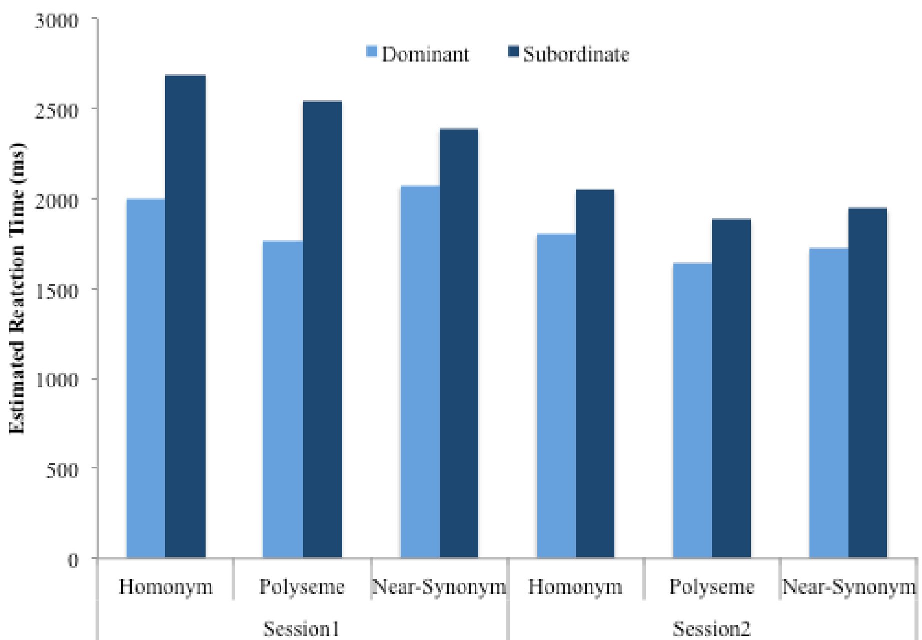


Figure 26. L2 L1 Translation Production RT Estimates - Ambiguous word types

Table 21. L2-L1 RT - Ambiguous word types model results

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	7.61	0.04	44.70	192.63	.00	***
Flankers Dif.	0.00	0.00	34.90	-0.79	.43	
PPVT Standard	0.00	0.00	41.20	-0.59	.56	
Stroop	0.00	0.00	37.80	-0.01	.99	
Ravens	0.06	0.02	36.20	2.80	.01	**
O-span Total	-0.02	0.01	41.30	-1.41	.17	
English word length	0.01	0.02	1184.00	0.49	.62	
English word log frequency	-0.11	0.04	1186.00	-2.95	.00	**
English word concreteness	0.06	0.02	1182.00	2.34	.02	*
English word orthographic N.	0.00	0.00	1190.00	0.62	.53	
German word length	0.02	0.01	1194.00	2.22	.03	*
Type: H&P vs. N-S	0.00	0.05	1189.00	0.04	.97	
Type: H vs. P	0.09	0.05	1183.00	1.77	.08	.
Dom vs. Sub	0.20	0.04	1178.00	5.28	.00	***
Session 1 vs. 2	-0.19	0.04	1185.00	-5.10	.00	***
Type: H&P vs. N-S * Dom vs. Sub	0.10	0.08	1184.00	1.23	.22	
Type: H vs. P * Dom vs. Sub	-0.04	0.09	1183.00	-0.44	.66	
Type: H & P vs. N-S * Session 1 vs. 2	0.01	0.08	1178.00	0.11	.92	
Type: H vs. P * Session 1 vs. 2	0.00	0.09	1179.00	-0.03	.98	
Dom vs. Sub * Session 1 vs. 2	-0.14	0.07	1175.00	-1.94	.05	.
Type: H & P vs. N-S * Dom vs. Sub * Session 1 vs. 2	-0.18	0.15	1175.00	-1.15	.25	
Type: H vs. P * Dom vs. Sub * Session 1 vs. 2	0.06	0.18	1178.00	0.34	.74	
Random Effects	Variance	St. Dev.				
Participant	0.05	0.22				

3.5.4.4 Accuracy model – Ambiguous word types

Again, there was a significant dominance by word type interaction such that the effect of dominance was greater for polysemous words than homonymous words (see Figure 27). This interaction qualified a main effect of dominance. No other significant effects were present. See Table 22 for the results of this model.

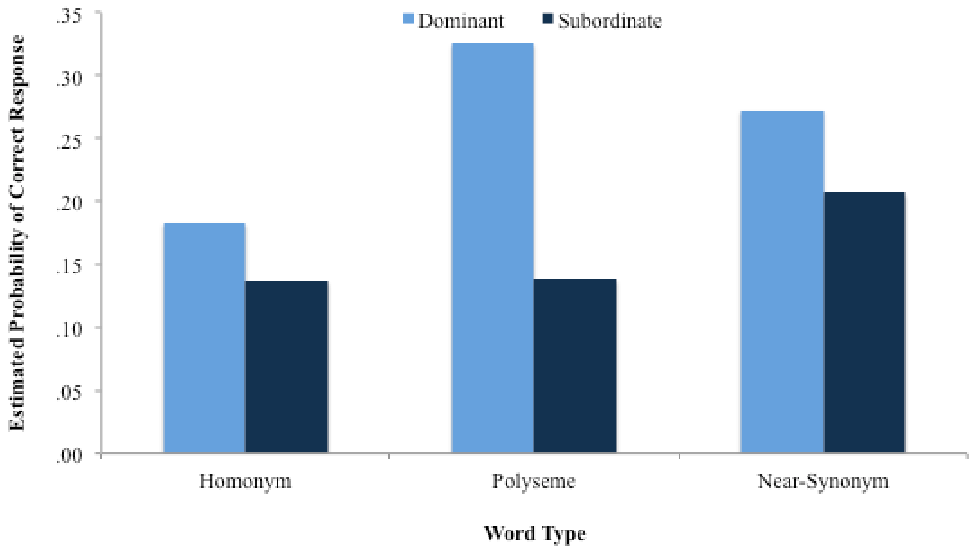


Figure 27. L2 L1 Translation Accuracy Estimates - Ambiguous word types

Table 22. L2-L1 Accuracy - Ambiguous word types model results

	β	Std. Error	t-value	p-value	Sig.
(Intercept)	-1.50	0.10	-14.90	.00	***
Flankers Dif.	0.00	0.00	0.10	.92	
PPVT Standard	0.05	0.01	4.27	.00	***
Stroop	0.01	0.01	0.87	.38	
Ravens	0.04	0.06	0.70	.48	
O-span Total	0.05	0.03	1.70	.09	.
English word length	0.07	0.04	1.84	.07	.
English word log frequency	0.28	0.08	3.76	.00	***
English word concreteness	0.36	0.05	6.99	.00	***
English word orthographic N.	0.01	0.01	0.96	.34	
German word length	-0.06	0.02	-2.59	.01	**
Type: H&P vs. N-S	-0.20	0.09	-2.14	.03	*
Type: H vs. P	-0.41	0.10	-4.09	.00	***
Dom vs. Sub	-0.74	0.08	-9.64	.00	***
Session 1 vs. 2	1.10	0.08	14.31	.00	***
Type: H&P vs. N-S * Dom vs. Sub	-0.19	0.16	-1.18	.24	
Type: H vs. P * Dom vs. Sub	0.78	0.19	4.20	.00	***
Type: H & P vs. N-S * Session 1 vs. 2	-0.06	0.16	-0.35	.72	
Type: H vs. P * Session 1 vs. 2	0.02	0.19	0.11	.91	
Dom vs. Sub * Session 1 vs. 2	0.13	0.15	0.86	.39	

Type: H & P vs. N-S * Dom vs. Sub * Session 1 vs. 2	0.34	0.32	1.07	.29
Type: H vs. P * Dom vs. Sub * Session 1 vs. 2	0.04	0.37	0.10	.92
Random Effects	Variance	St. Dev.		
Participant	0.39	0.62		

3.5.5 Interim summary of learning measures (free recall and L2-L1 translation production)

Overall, participants were more accurate at recalling L1-L2 vocabulary word pairs on the free recall task and were also faster and more accurate at producing translations in the L2-L1 translation production task on testing session 2 than on testing session 1. This suggests that after additional vocabulary training participants were retaining more L2 vocabulary and were able to access the vocabulary more quickly. We also observed differences on these measure between different word types. In particular homonym translation-ambiguous words were recalled than other word types and were also translated more slowly and less accurately than other word types suggesting that the unrelated meanings of homonyms led to a learning “disadvantage” of these L2 vocabulary words. Conversely, near-synonymous translation ambiguous words were recalled more than other word types on the free recall task suggesting that the similarity between the translations facilitated learning of the L2 words. On the L2-L1 translation production task participants were marginally more accurate translating near-synonymous translation ambiguous words than polysemous and homonymous translation ambiguous words. However, participants were significantly slower at translation near-synonymous translation-ambiguous words than unambiguous words and polysemous translation-ambiguous words suggesting weaker cue strength from the L2 vocabulary to the correct L1 translation (see Discussion). Last, we found that participants were faster and more accurate producing dominant meanings/senses and translations than subordinate translations suggesting that the learners were associating the L2 word forms with the specific meaning and therefore meaning dominance. Further, meaning dominance interacted with word type such that the effect of meaning dominance was greater for polysemous translation-ambiguous words than other word types.

3.5.6 Semantic Relatedness Task

3.5.6.1 Reaction time model – All word types

There was a significant interaction of word type by relation in which translation-ambiguous words were responded to faster than translation-unambiguous words for "yes" responses with semantic associates but translation-ambiguous words were responded to more slowly than translation-unambiguous words for "yes" response with translations (see Figure 28). There was also a main effect of word type in which homonymous and polysemous translation-ambiguous words were responded to more slowly than near-synonymous translation-ambiguous words, and homonymous translation-ambiguous words were responded to more slowly than polysemous translation-ambiguous words. Overall, semantic associates were responded to more slowly than direct translations. There was a marginal interaction between session and relation such that participants became faster at responding to semantic associates from session 1 to session 2, but not significantly faster at responding to translation responses from session 1 to session 2 (see Figure 29). This interaction qualified a main effect of testing session. No other significant effects were found. See Table 23 for all mean estimated response times across conditions. The model results can be found in Table 24.

Table 23. Mean Estimated RTs - Semantic Relatedness- All word types

		Word Type			
	Response Type	Homonym	Polyseme	Near-Synonym	Unambiguous
Session 1	Translation	1808.52	1812.89	1316.11	1553.06
	Semantic Associated	2365.14	2004.90	1507.86	2064.38
Session 2	Translation	1608.22	1521.39	1058.24	1282.44
	Semantic Associated	1807.09	1677.61	1236.47	1555.75

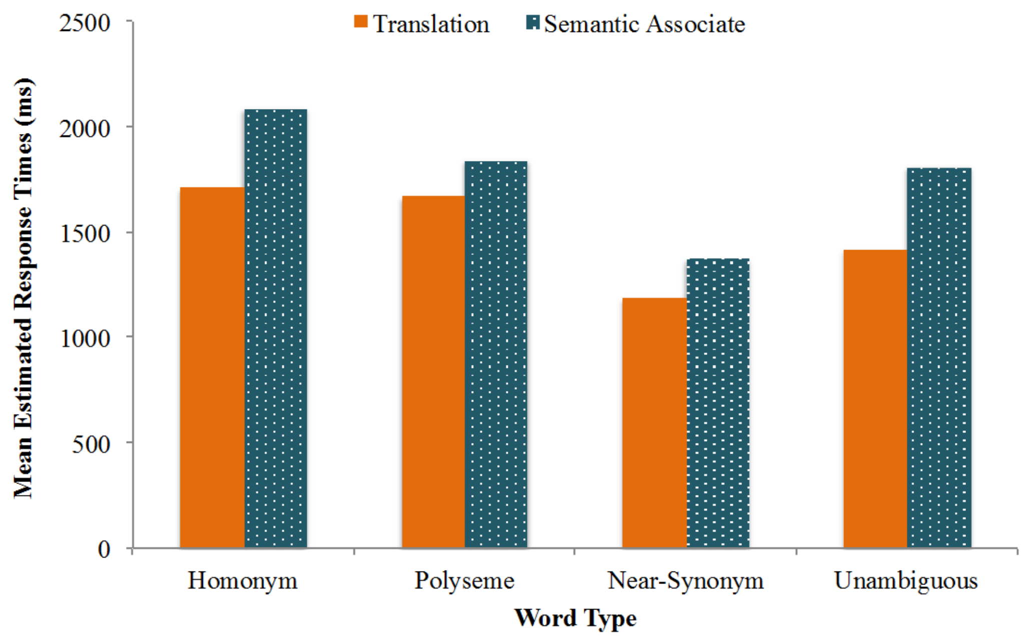


Figure 28. Semantic Relatedness Task Estimated RTs- All word types – Word Type by Response Type

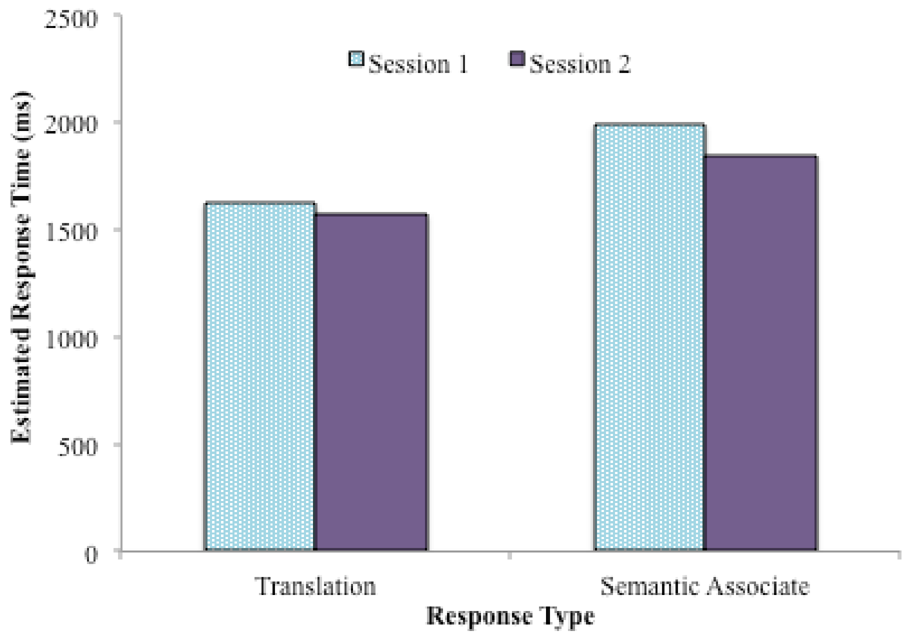


Figure 29. Semantic Relatedness Estimated RTs - All word types - Session by Response Type

Table 24. Semantic Relatedness RT - all word types model results

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	7.38	0.03	46.30	249.60	.00	***
Flankers Dif.	0.00	0.00	39.70	-2.02	.05	*
PPVT Standard	0.00	0.00	40.20	0.10	.92	
Stroop	0.00	0.00	40.00	0.95	.35	
Ravens	0.04	0.02	40.20	2.03	.05	*
O-span Total	0.01	0.03	40.00	0.22	.82	
English word length	-0.01	0.01	107.60	-0.85	.40	
English word log frequency	0.00	0.00	104.40	-2.17	.03	*
English word concreteness	-0.03	0.01	114.60	-2.10	.04	*
English word orthographic N.	0.00	0.00	105.00	0.35	.73	
German word length	0.02	0.01	179.60	3.47	.00	***
Trial Number	0.00	0.00	2811.00	-3.88	.00	***
Type C1: H vs. P	0.07	0.03	103.80	2.18	.03	*
Type C2: H & P vs. N-S	0.10	0.03	91.60	3.12	.00	**
Type C2: Ambig. vs. Unambig.	0.01	0.02	126.20	0.56	.57	
SA vs. T	0.24	0.02	96.70	10.91	.00	***
Session 1 vs. 2	-0.20	0.02	2785.00	-12.86	.00	***
Type C1: H vs. P * SA vs. T	0.09	0.07	102.20	1.39	.17	

Type C2: H&P vs. N-S * SA vs. T	-0.07	0.06	80.90	-1.26	.21	
Type C3 Ambig vs. Unambig * SA vs. T	-0.09	0.04	123.00	-2.16	.03	*
Type C1: H vs. P * Session 1 vs. 2	-0.02	0.05	2798.00	-0.34	.73	
Type C2: H & P vs. N-S * Session 1 vs. 2	0.02	0.04	2771.00	0.59	.56	
Type C3 Ambig vs. Unambig * Session 1 vs. 2	0.04	0.03	2776.00	1.36	.17	
SA vs. T * Session 1 vs. 2	-0.06	0.03	2786.00	-1.79	.07	.
Type C1: H vs. P * SA vs. T * Session 1 vs. 2	-0.15	0.10	2796.00	-1.55	.12	
Type C2: H&P vs. N-S * SA vs. T * Session 1 vs. 2	-0.10	0.08	2770.00	-1.23	.22	
Type C3 Ambig vs. Unambig * SA vs. T * Session 1 vs. 2	0.05	0.07	2776.00	0.71	.48	
Random Effects	Varia nce	St. Dev.				
Participant	0.03	0.19				
Item	0.01	0.08				

3.5.6.2 Accuracy Model– All word types

Homonym and polysemous translation-ambiguous words were responded to less accurately than near-synonymous translations-ambiguous words, and there were no significant differences between homonymous and polysemous words. Participants were more accurate on testing session 2 than on testing session 1. Again, there was a significant word type by response interaction such that translation-ambiguous words were responded to more accurately than translation-unambiguous words on the translation responses, which qualified main effects of ambiguity and response type (e.g., “yes” translation vs. “yes” semantic associate) (see Figure 30). We also observed a marginal relation by session interaction in which semantic associates were responded to marginally more accurately in session 1 than session 2 but participants were not significantly more accurate at responding to translations from session 1 to session 2 (see Figure 30). No other significant effects were observed. See Table 25 for the results of the model.

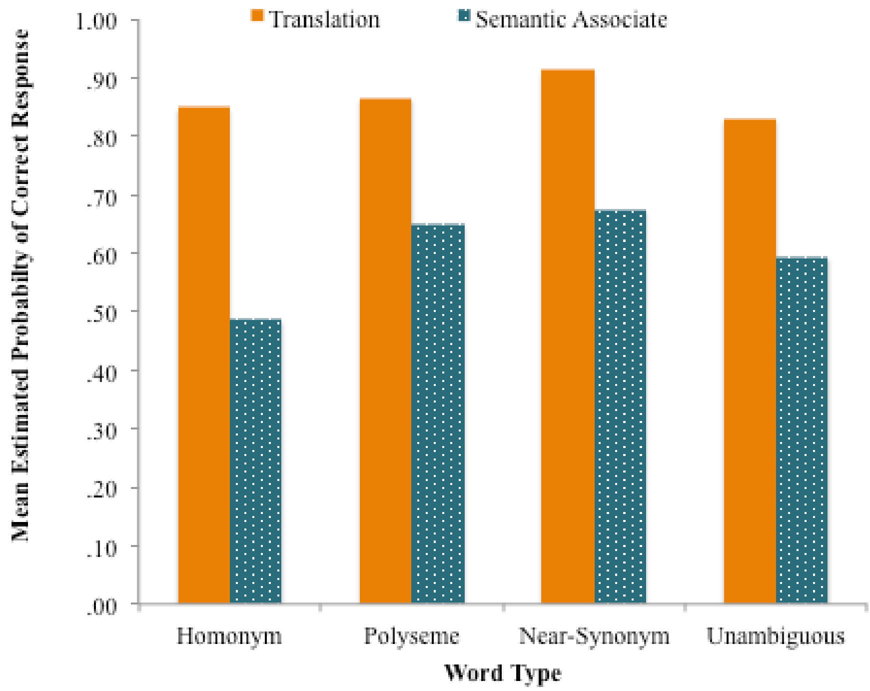


Figure 30. Semantic Relatedness Task Estimated Accuracy - All word types - Word type by Response type

Table 25. Semantic Relatedness Accuracy - All word types model results

	β	Std. Error	t-value	p-value	Sig.
(Intercept)	1.27	0.11	11.24	.00	***
Flankers Dif.	0.00	0.00	0.14	.89	
PPVT Standard	0.01	0.01	1.05	.30	
Stroop	0.00	0.01	0.24	.81	
Ravens	0.08	0.05	1.63	.10	
O-span Total	0.03	0.08	0.38	.70	
English word length	0.00	0.06	0.02	.98	
English word log frequency	0.00	0.00	-0.09	.93	
English word concreteness	0.03	0.09	0.37	.71	
English word orthographic N.	0.00	0.01	-0.40	.69	
German word length	0.00	0.04	0.06	.95	

Trial Number	0.00	0.00	-2.81	.01	**
Type C1: H vs. P	-0.30	0.26	-1.18	.24	
Type C2: H & P vs. N-S	-0.54	0.25	-2.15	.03	*
Type C2: Ambig. vs. Unambig.	-0.38	0.17	-2.19	.03	*
SA vs. T	-1.89	0.18	-10.65	.00	***
Session 1 vs. 2	0.29	0.09	3.33	.00	***
Type C1: H vs. P * SA vs. T	-0.34	0.51	-0.67	.50	
Type C2: H&P vs. N-S * SA vs. T	0.06	0.48	0.12	.91	
Type C3 Ambig vs. Unambig * SA vs. T	0.85	0.34	2.49	.01	*
Type C1: H vs. P * Session 1 vs. 2	-0.25	0.24	-1.04	.30	
Type C2: H & P vs. N-S * Session 1 vs. 2	-0.17	0.22	-0.74	.46	
Type C3 Ambig vs. Unambig * Session 1 vs. 2	-0.12	0.20	-0.62	.53	
SA vs. T * Session 1 vs. 2	0.33	0.17	1.90	.06	.
Type C1: H vs. P * SA vs. T * Session 1 vs. 2	0.55	0.48	1.14	.25	
Type C2: H&P vs. N-S * SA vs. T * Session 1 vs. 2	0.20	0.45	0.44	.66	
Type C3 Ambig vs. Unambig * SA vs. T * Session 1 vs. 2	0.38	0.39	0.96	.34	
Random Effects	Variance	St. Dev.			
Participant	0.23	0.48			
Item	0.60	0.77			

3.5.6.3 Reaction time model – Ambiguous word types

Participants were especially slow on semantic associate responses when the items were subordinate homonymous or polysemous translation-ambiguous words (see Figure 31). This interaction qualified a main effect of dominance. Additionally, a significant word type by relation by session interaction was also observed, such that participants became significantly faster at responding to semantic associates from session 1 to session 2 for homonym-translation ambiguous words but not for polysemous translation-ambiguous words (see Figure 32). We also observed a significant type by dominance by session interaction such that participants became significantly faster at responding to subordinate homonym-translation ambiguous words from session 1 to session 2 but this was not the case for subordinate polysemous translation-ambiguous words (see Figure 33). A marginal type by response by dominance by session interaction was also observed, such that participants showed a significant decrease in response time from testing session 1 to 2 when responding to semantic associates for subordinate homonymous translation-ambiguous words. No other significant effects were observed. See Table 26 for all mean estimated response times across conditions. See Table 27 for the results of the model.

Table 26. Mean Estimated RTs - Semantic Relatedness - Ambiguous word types

		Dominant		Subordinate	
		Translation	Semantic Associate	Translation	Semantic Associate
Session1	Homonym	1597.24	1924.52	1620.98	2555.40
	Polyseme	1573.63	1871.25	1650.01	1921.64
	Near-Synonym	1445.24	1903.43	1538.15	1910.75
Session2	Homonym	1442.51	1643.24	1433.58	1745.47
	Polyseme	1294.60	1483.65	1397.85	1843.01
	Near-Synonym	1069.76	1531.70	1342.83	1660.18

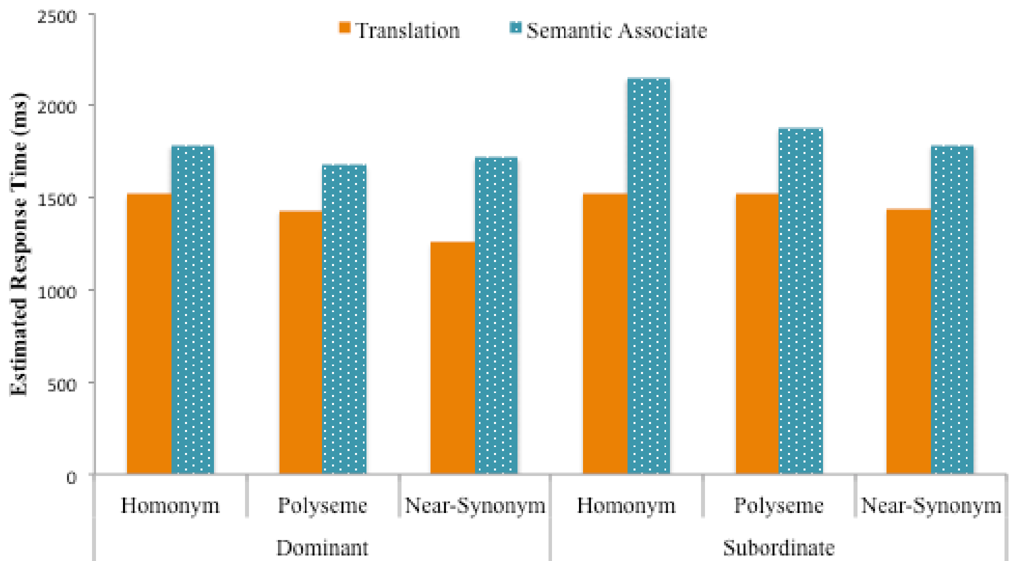


Figure 31 Semantic Relatedness Task Estimated RTs - Ambiguous word types - Word type by Dominance by Response type

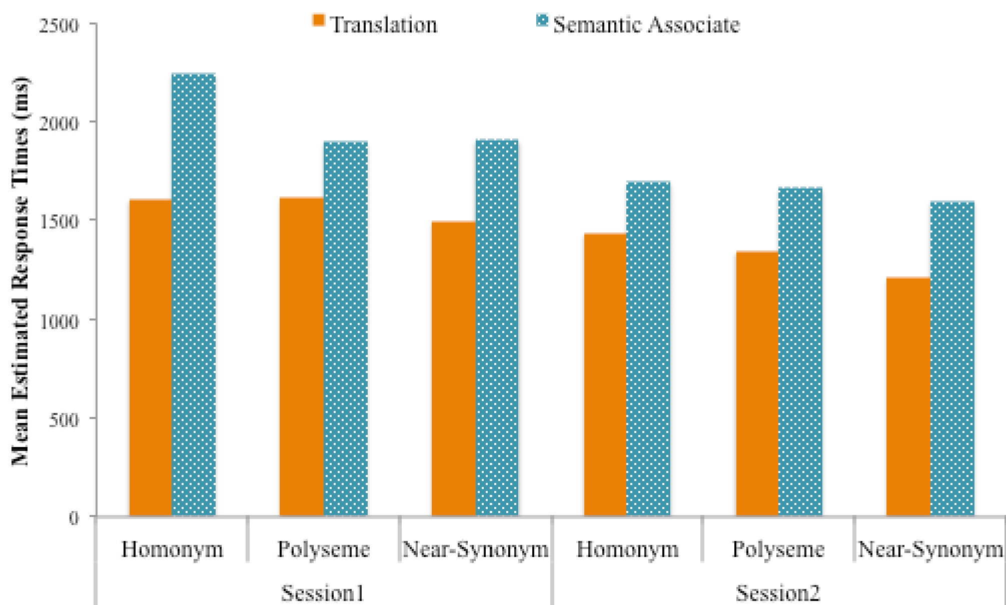


Figure 32. Semantic Relatedness Task Estimated RTs - Ambiguous word types - Word type by response type

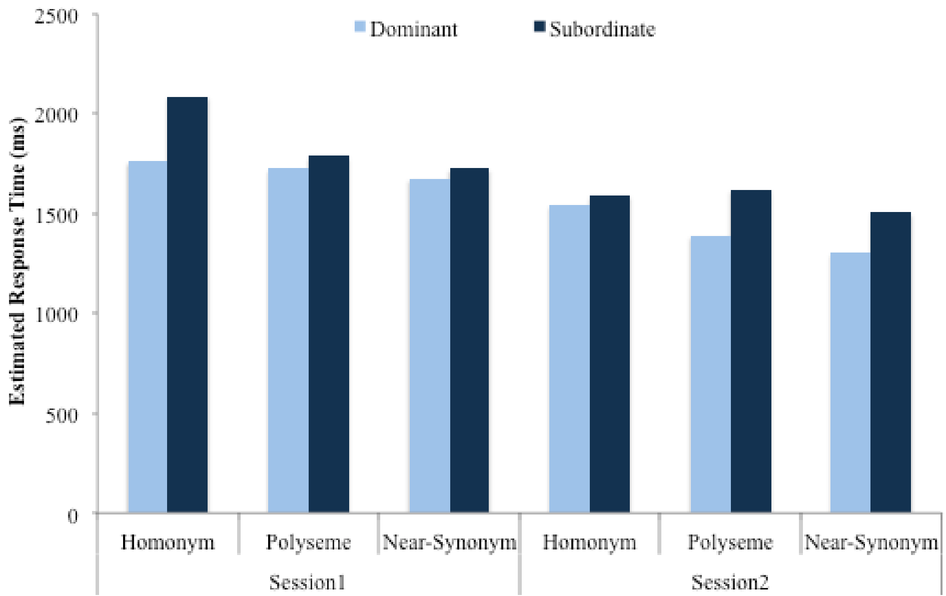


Figure 33. Semantic Relatedness Task Estimated RTs- Ambiguous word types - Word type by dominance by session

Table 27. Semantic Relatedness RT - Ambiguous word type model results

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	7.39	0.03	50.70	227.26	.00	***
Flankers Dif.	0.00	0.00	39.70	-2.00	.05	.
PPVT Standard	0.00	0.00	40.30	0.36	.72	
Stroop	0.00	0.00	40.20	1.03	.31	
Ravens	0.04	0.02	40.70	2.04	.05	*
O-span Total	0.00	0.01	40.00	-0.27	.79	
English word length	0.00	0.01	53.00	-0.22	.82	
English word log frequency	0.00	0.00	48.30	-2.09	.04	*
English word concreteness	-0.02	0.02	60.50	-1.03	.31	
English word orthographic N.	0.00	0.00	47.80	0.27	.79	
German word length	0.02	0.01	113.90	2.84	.01	**
Trial Number	0.00	0.00	1783.00	-2.75	.01	**
Type: H&P vs. N-S	0.09	0.04	53.00	2.40	.02	*
Type: H vs. P	0.06	0.04	57.00	1.63	.11	
SA vs. T	0.23	0.03	49.90	7.57	.00	***
Dom vs. Sub	0.09	0.02	318.00	3.72	.00	***
Session 1 vs. 2	-0.18	0.02	1778.00	-9.10	.00	***

Type: H&P vs. N-S * SA vs. T	-0.05	0.07	45.60	-0.79	.44	
Type: H vs. P * SA vs. T	0.06	0.07	55.10	0.77	.45	
Type: H&P vs. N-S * Dom vs. Sub	0.00	0.05	535.50	-0.07	.94	
Type: H vs. P * Dom vs. Sub	0.00	0.06	241.10	-0.06	.95	
SA vs. T * Dom vs. Sub	0.04	0.05	294.00	0.88	.38	
Type: H & P vs. N-S * Session 1 vs. 2	0.02	0.04	1763.00	0.57	.57	
Type: H vs. P * Session 1 vs. 2	-0.03	0.05	1783.00	-0.64	.52	
SA vs. T * Session 1 vs. 2	-0.03	0.04	1778.00	-0.62	.53	
Dom vs. Sub * Session 1 vs. 2	0.04	0.04	1774.00	0.89	.37	
Type: H&P vs. N-S * SA vs. T * Dom vs. Sub	0.22	0.10	493.50	2.20	.03	*
Type: H vs. P * SA vs. T * Dom vs. Sub	0.11	0.12	221.10	0.89	.38	
Type: H&P vs. N-S * SA vs. T * Session 1 vs. 2	-0.10	0.08	1762.00	-1.16	.25	
Type: H vs. P * SA vs. T * Session 1 vs. 2	-0.20	0.10	1784.00	-2.00	.05	*
Type: H&P vs. N-S * Dom vs. Sub * Session 1 vs. 2	-0.13	0.08	1762.00	-1.53	.13	
Type: H vs. P * Dom vs. Sub * Session 1 vs. 2	-0.23	0.10	1801.00	-2.26	.02	*
SA vs. T * Dom vs. Sub * Session 1 vs. 2	-0.04	0.08	1777.00	-0.53	.60	
Type: H&P vs. N-S * SA vs. T * Dom vs. Sub * Session 1 s. 2	0.07	0.17	1761.00	0.41	.68	
Type: H vs. P * SA vs. T * Dom vs. Sub * Session 1 s. 2	-0.36	0.20	1783.00	-1.80	.07	.
Random Effects	Variance	St. Dev.				
Participant	0.19	0.44				
Item	0.46	0.68				

3.5.6.4 Accuracy model – Ambiguous word types

Participants became significantly more accurate at responding to semantic associates from testing session 1 to 2 but not for translations (see Figure 34). There also was a marginal type by relation by dominance interaction in which dominant homonym translation-ambiguous words were responded to significantly less accurately than dominant polysemous translation-ambiguous words on semantic associate decisions but not on translation decisions. This interaction qualified a main effect of dominance. No other significant effects were observed. See Table 28 for all mean estimated response times across conditions. The results of the full model can be seen in Table 29.

Table 28. Mean Estimated Probability of Correct Response - Semantic Relatedness - Ambiguous word types

		Dominant		Subordinate	
		Translation	Semantic Associate	Translation	Semantic Associate
Session1	Homonym	0.91	0.46	0.82	0.40
	Polyseme	0.89	0.62	0.83	0.44
	Near-Synonym	0.94	0.64	0.88	0.58
Session2	Homonym	0.90	0.59	0.75	0.50
	Polyseme	0.87	0.73	0.88	0.52
	Near-Synonym	0.93	0.81	0.91	0.60

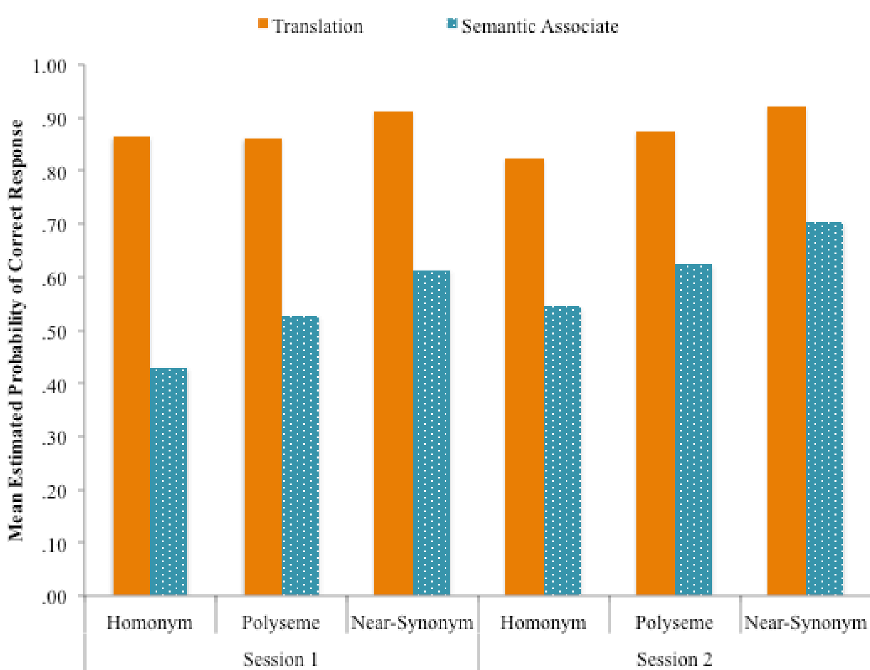


Figure 34. Semantic Relatedness Task Estimated Accuracy - Ambiguous word types - Word type by session by response type

Table 29. Semantic Relatedness Accuracy - Ambiguous word types model results

	β	Std. Error	t-value	p-value	Sig.
(Intercept)	0.32	0.14	2.28	.02	*
Flankers Dif.	0.00	0.00	0.69	.49	
PPVT Standard	0.00	0.01	0.29	.77	
Stroop	-0.01	0.01	-0.77	.44	
Ravens	0.08	0.05	1.59	.11	
O-span Total	-0.01	0.02	-0.57	.57	
English word length	-0.01	0.07	-0.10	.92	
English word log frequency	0.00	0.00	-0.47	.64	
English word concreteness	0.06	0.11	0.58	.56	
English word orthographic N.	-0.01	0.01	-0.59	.56	
German word length	0.01	0.05	0.30	.76	
Trial Number	0.00	0.00	-2.31	.02	*
Type: H&P vs. N-S	-0.74	0.39	-1.88	.06	.
Type: H vs. P	-0.38	0.29	-1.30	.19	
SA vs. T	1.71	0.20	8.53	.00	***
Dom vs. Sub	-0.59	0.20	-2.91	.00	**
Session 1 vs. 2	0.45	0.13	3.54	.00	
Type: H&P vs. N-S * SA vs. T	-0.06	0.60	-0.10	.92	
Type: H vs. P * SA vs. T	0.24	0.48	0.51	.61	
Type: H&P vs. N-S * Dom vs. Sub	0.13	0.51	0.26	.79	
Type: H vs. P * Dom vs. Sub	0.53	0.52	1.01	.31	
SA vs. T * Dom vs. Sub	0.04	0.28	0.13	.90	
Type: H & P vs. N-S * Session 1 vs. 2	-0.02	0.36	-0.06	.95	
Type: H vs. P * Session 1 vs. 2	0.05	0.31	0.15	.88	
SA vs. T * Session 1 vs. 2	-0.49	0.22	-2.27	.02	*
Dom vs. Sub * Session 1 vs. 2	-0.35	0.26	-1.37	.17	
Type: H&P vs. N-S * SA vs. T * Dom vs. Sub	-0.22	0.79	-0.28	.78	
Type: H vs. P * SA vs. T * Dom vs. Sub	-1.22	0.69	-1.77	.08	.
Type: H&P vs. N-S * SA vs. T * Session 1 vs. 2	-0.17	0.63	-0.28	.78	
Type: H vs. P * SA vs. T * Session 1 vs. 2	-0.42	0.51	-0.83	.41	
Type: H&P vs. N-S * Dom vs. Sub * Session 1 vs. 2	0.93	0.72	1.29	.20	
Type: H vs. P * Dom vs. Sub * Session 1 vs. 2	0.09	0.63	0.14	.89	
SA vs. T * Dom vs. Sub * Session 1 vs. 2	0.61	0.44	1.39	.16	
Type: H&P vs. N-S * SA vs. T * Dom vs. Sub * Session 1 s. 2	-1.46	1.27	-1.15	.25	

Type: H vs. P * SA vs. T * Dom vs. Sub * Session 1 vs. 2	-0.94	1.02	-0.92	.36
Random Effects	Variance	St. Dev.		
Participant	0.19	0.44		
Item	0.46	0.68		

3.6 DISCUSSION

The present experiment investigated how semantic similarity between ambiguous words' meanings/senses and L2 translations affects the learning and processing of L2 vocabulary. We additionally examined how meaning/translation semantic similarity interacted with meaning/sense dominance (for homonyms and polysemes) and translation dominance (for near-synonyms). Further, this experiment examined how learning L2 labels that map to specific meanings/senses of semantically-ambiguous words influences processing in the L1.

Unlike previous studies (Degani & Tokowicz, 2010; Degani et al., 2014) we did not find an *overall* disadvantage on learning measures for translation-ambiguous words compared to translation-unambiguous words but rather only a disadvantage for "meaning" translation-ambiguous words (homonyms and polysemes) that was mainly driven by homonyms. The results for polysemous translations were often in between homonymous and near-synonymous translations. The lack of an over-all ambiguity disadvantage was also driven by the learning advantage we observed for near-synonymous translation-ambiguous words, in which participants showed little differences on learning and processing measure between synonym translation-ambiguous words and translation-unambiguous words across tasks.

The lack of an overall translation-ambiguity disadvantage may be due to the differences in training procedures used in the current experiment that differed previous studies. The present study used a combination of the repetition method and the sentence generation method, which contextualizes the L2 vocabulary and emphasizes meaning. Additionally, the presentation of the translation-ambiguous words were presented sequentially rather than presented on separate days throughout the training. The sequential presentation of the multiple translations in conjunction with the meaning-based training maybe have further highlighted the differences between the translation-ambiguous words meanings/senses for homonyms and polysemes and emphasized the fact that the near-synonym translations had the same meaning.

3.6.1 Semantic Similarity

Results indicated that translation-ambiguous words with semantically similar meanings/senses are better learned than translation-ambiguous words with semantically-dissimilar meanings/senses. Based on the RHM-TA (Eddington & Tokowicz, 2013) and prior research (Degani & Tokowicz, 2010), we hypothesized that learners would show learning advantages for homonymous-translation ambiguous words because there would be a one-to-one mapping between a specific meaning of the homonym with a specific L2 label. Near-synonymous words have a one-to-many mapping between meaning and L2 labels, which we hypothesized would lead to greater difficulties in learning (Eddington & Tokowicz, 2013). However, results indicated that learners showed the reverse pattern of results, such that the near-synonymous translation-ambiguous words were recalled more often than homonymous translation-ambiguous words.

The learning and processing advantage for semantically similar translations are consistent with Bracken et al.'s (2015) findings in which there were processing advantages for words with semantically similar translations relative to words with dissimilar translations. However, the direction of ambiguity in Bracken et al., (2015) was opposite to the direction of ambiguity in the current experiment. Bracken et al. argued that the learning advantages arose because there was a *one-to-one* mapping between words and concepts for words with related meanings/senses because learners mapped single German words to multiple English words. However we found similar learning advantages in the current experiment when there was a *one-to-many* mapping between concepts and words in which learners mapped an English word to multiple German words. Why do we find results that are inconsistent with those of previous studies (e.g., Degani & Tokowicz) that trained participants on translation-ambiguous words in the same direction as the current study (L1-to-L2 and one-to-many mapping between concepts and words) but consistent results with previous research (e.g., Bracken et al., 2015) that trained participants on translation-ambiguous words in the opposite direction as the current study (L2-to-L1 and one-to-one mapping between words and concepts)?

The differences in how learners acquired different types of translation-ambiguous words between the current training experiment and previous training experiments (e.g., Bracken et al., 2015; Degani & Tokowicz, 2010) may be due to the training procedures used in the current experiment, in which meaning and context was highly emphasized in during the training. For near-synonyms the training may have emphasized that the German translations mapped to the exact same meaning and therefore facilitated performance. For homonyms and polysemes the training may have emphasized that the German translations mapped to different meanings/senses and therefore inhibited performance. Specifically, participants showed greater difficulties on some of the learning measures for homonyms, which may have been due to inhibition from the multiple unrelated meanings. Thus, when participants were required to recall the vocabulary they showed a learning disadvantage. However, participants showed no differences in accuracy on the semantic relatedness task on the translation “yes” responses, suggesting that they had learned the words sufficiently to identify the correct translations. The slower and less accurate responses only on the semantic associate “yes” responses compared to other word types may also suggest inhibitory processes from the unrelated meanings.

Previous research comparing “meaning” translation-ambiguous words to form/synonym translation-ambiguous words also did not distinguish homonymous and polysemous words, which may also contributed to differences in the findings between previous work and the current experiment (Degani & Tokowicz, 2010; Degani et al., 2014). In the current study polysemous words showed responses that were in between homonyms and near-synonyms suggesting that meaning/sense differences and similarities impacted performance. Prior training studies may not have emphasized differences in the meanings/senses of the polysemous words for the participant and the participants may have emphasized similarities, which may have led to advantages in learning measures for “meaning” translation-ambiguous words.

The only “disadvantage” for near-synonymous (form) translation-ambiguous words was found on the L2-L1 translation production RTs, in which participants were significantly slower to produce near-synonymous translations than unambiguous translations. This slowing down in translation production cannot be due to competition in lexical selection because the direction is from L2 to L1 in which the ambiguous word in English is being produced so there is only one option to select and produce. There also was not a speed accuracy trade-off because accuracy for near-synonyms was as high as unambiguous words. The slow down specifically on a production task may reflect automatic activation of the alternative translation, which slowed down the production. This is similar to a synonym disadvantage found in lexical decision and picture naming within a language in which words with more synonyms are responded to more slowly than words with fewer synonyms (Hino et al., 2002).

3.6.2 Meaning Dominance

Similar to within language and cross language studies on ambiguity processing, the learners showed typical dominance effects such that participants were slower and less accurate on subordinate translations than dominate translations (Klepousniotou et al., 2012; Laxén & Lavaur, 2010). Learners were particularly slow when making semantic relatedness judgments on subordinate translations for homonymous words. These effects also interacted with testing session such that learners were overall faster and more accurate on the second testing session as expected, but the effects of dominance was different for the various word types from testing session 1 to session 2. The meaning dominance effect was stronger for homonyms on session 1 than session 2. This change from session 1 to session 2 can be explained by repeated exposure of both meanings of the ambiguous words during the training. Thus, the dominant meaning was experienced as many times as the subordinate meaning during the training, making the frequency of each meaning relatively equal during this time period. This is consistent with recent research by Rodd, Lopez Cutrin, Kirsch, Millar, and Davis (2013) in which a single exposure to one meaning of an ambiguous word led to long term priming of that specific meaning. Each meaning of a homonym is not encountered frequently and typically both meanings are not experienced at similar time points. The L2 vocabulary training created a context in which both meanings were experienced together, which may have led to changes in the meaning representations of each meaning (i.e., relative meaning frequency and access to each meaning).

The effects of dominance on translation production and recognition provide further evidence that the learners are meaningfully encoding the L2 vocabulary words. During free-recall, participants recall as many of the vocabulary word pairs as best as they could. When recalling a word that was ambiguous, the dominant meaning is more likely to be activated. If participants did not correctly associate the specific meanings to the L2 vocabulary then there would be no differences between dominant associated translations and subordinate associated translations in recalling the L2 vocabulary. The fact that there is a dominance effect suggests that participants correctly associated specific meanings to the L2 vocabulary. For L2-L1 translation production, participants are cued with the German word and are asked produce the English translation. Thus, even though the correct translation is the same for the dominant and subordinate German translations we still observed a dominance effect. That is, participants are faster and more accurate producing a translation when cued with a German word that is associated with the dominant meaning than when cued with a German word that is associated with the subordinate meaning.

3.6.3 Implications for the Revised Hierarchal Model

The RHM (Kroll & Stewart) would predict that for learners with few exposures to L2 vocabulary would show weaker connections between concepts to L2 lexicon. However, the results from the current experiment provide evidence that the L2 learners had acquired meaningful associations with the L2 vocabulary and further were automatically activating the alternative meanings/senses associated with the L1 translation. That is, when learners are making semantic relatedness judgments (e.g., deciding that *nose* is related to *Rüssel*, which means trunk) the German word activates the L1 translation (e.g., trunk), which in turn automatically activates alternative meanings such as car trunk. However, because we also observed an interaction with response type (saying yes to semantic associate vs. translation) with word type and translation dominance suggests that accessing meaning either from the L2 directly or through the L1 is influenced by the semantic relationships between the multiple translations of the ambiguous words. Therefore, unlike what the RHM (Kroll & Stewart, 1994) would predict learners were associating the L2 vocabulary not only with L1 word form but also the specific meaning. As stated previously, the training highly emphasized meaning and contextualized the L2 using sentence generation. The developmental model of the RHM (Kroll & Stewart, 1994) postulates that as learners become more proficient in the L2 the connections between concepts and the L2 vocabulary become strong. The training used in the current experiment may have facilitated the associations between concepts and L2 leading to semantic effects on the L2.

3.6.4 Effects of L2 Learning on L1

A second goal of this experiment was to examine how learning L2 vocabulary words that map to specific meanings/senses of semantically-ambiguous words affect the processing of the L1 vocabulary. To examine this, participants completed a lexical decision before training and after training. Results indicated that the experience of training does affect lexical processing of homonymous words. After training, homonyms that were included in the L2 vocabulary training were responded to more quickly than homonyms that were not included in the study. This change in response times on the trained homonymous words may be due to greater semantic activation from the multiple meanings after repeated exposure of the multiple meanings during the training.

Alternatively, because specific L2 labels are associated with each distinct meaning, the training may have disambiguated the homonym. Prior to training, each meaning mapped to the same word, whereas after training each meaning of the ambiguous word was associated with a new label. Polysemous word senses do not necessarily need to be disambiguated in order to be comprehended and, therefore, may not have led to this effect after training.

3.6.5 Limitations of study

The present study has several limitations, which could be improved on in future work. The stimuli used included a small set of items per condition and therefore did not permit testing of different types of polysemous words. Recent research suggests that there are differences in how metonymical vs. metaphorical polysemous words are processed, which may also impact L2 vocabulary learning and processing. And, the participants were naïve learners of German and therefore these results may only reflect early exposure of L2 vocabulary and not advanced bilingual processing or proficient L2 speakers.

3.6.6 Conclusions

The current experiment examined how naïve learners of German acquired different types of translation-ambiguous words and further how learning new L2 labels to semantically-ambiguous words in the L1 affected L1 processing. Results indicated the meaning similarity and meaning/translation dominance are important factors in the acquisition of translation ambiguous words and their corresponding translations such that homonymous words led to an overall disadvantage in learning compared to polysemous and near-synonymous translation-ambiguous words. German translations associated with the dominant meaning/sense of the word were recalled more accurately than German translations associated with the subordinate meaning/sense of the words. The training method (sentence generation) was effective at developing meaningful connections between the L2 vocabulary and the specific meanings of the ambiguous words. Overall, these results provide insights into the first exposure of L2 vocabulary that correspond to ambiguous words in L1 and how L1 meaning representations impact L2 word acquisition.

3.6.7 Motivation for Experiment 3

In Experiment 2, learners acquired some translation-ambiguous words that were also semantically ambiguous (i.e., homonyms and polysemes). However, if there are processing costs for multiple meanings as well as multiple translations, then the source of these processing disadvantages are difficult to isolate. The present study included near-synonymous translations, which are semantically unambiguous but translation-ambiguous. These word types showed no learning disadvantages in contrast to what was found in previous research (e.g., Degani & Tokowicz, 2010). However, for homonymous and polysemous translation-ambiguous words which are both meaning ambiguous and translation ambiguous there are multiple sources of ambiguity present. The motivation for Experiment 3 was to examine how semantically-ambiguous words are learned and processed when only one translation is taught to the learner. Therefore, the vocabulary words within the training paradigm are translation-unambiguous for the participant allowing us to examine the unique contribution of semantic ambiguity on L2 vocabulary learning.

4.0 EXPERIMENT 3

Like experiment 2, the current experiment examined how learners acquired L2 vocabulary words that correspond to polysemous and homonymous senses/meanings. However, in this experiment participants only learned one German translation that corresponded to a specific meaning or sense of a semantically ambiguous English word and therefore the we could examine the effect of semantic ambiguity on L2 word learning without the influence of translation ambiguity. This study allowed us to examine how L2 learners map polysemous and homonymous word meanings/senses to L2 labels differently, and how meaning/sense dominance influences the learning and processing of the words. Further, we investigated how the untrained meaning/senses differentially extended to the L2 vocabulary. For example, do both meanings of the word *trunk* get association with the L2 translation *Kofferraum* despite being explicitly told that Kofferraum means car trunk.

In Experiment 2, both meanings were trained in sequential order, therefore participants could make comparisons between the meaning of one word and the other. That is, participants could distinguish that Kofferraum maps specifically to car trunk, whereas *Baumstamm* corresponds to tree trunk. By training participants on only one meaning/translation we could test how the untrained meaning/sense affected semantic processing of the L2 vocabulary. We assessed learners' semantic processing of the words using a translation recognition task in which the critical trials were the "no" trials. Critically, we compared learners' responses to incorrect

English translations that are semantically related to the trained meaning, semantically related to untrained meanings, and to unrelated controls (e.g., Talamas, Kroll, & Dufour, 1999)

In Experiment 2, we demonstrated learning and processing differences between homonymous and polysemous translation-ambiguous words. In the current experiment, we further examined how homonymous and polysemous words are represented in the mind by examining how the untrained meanings interfere with semantic processing on the trained L2 vocabulary. In a related study, Srinivasan and Snedeker (2011) investigated how young children represent ambiguous word meanings. They taught children new labels to familiar concepts that mapped onto homonymous meanings or polysemous senses. For example, the children learned that the new word "blicket" corresponded to the content sense of book but not the physical sense of book, or they learned that "devo" corresponded to the baseball meaning of bat but not the animal meaning. Srinivasan and Snedeker (2011) hypothesized that if the children represented polysemous word senses together in a single lexical entry then they would be more likely to apply the new label of book to both the content and the physical sense of the word. However, if the children represented each sense in separate lexical entries they would be less likely to apply the new label to both senses. They found that young children extended all polysemous senses onto a novel label for a polysemous word (e.g., polyseme: blicket –book – content or object), even when only one sense was emphasized during the training of the novel label. However, children did not extend all meanings of homonyms onto a novel label (e.g., homonym: devo – baseball bat) and made the distinction that only the taught meaning corresponded to the new label of the homonym. Srinivasan and Snedeker suggested that these results indicated that polysemous word senses are stored together rather than in separate lexical entries. However, these results also suggest that polysemous senses are highly interconnected and that homonym meanings are less interconnected, even for young children who have less experience with the words and their meanings and senses. This alternative explanation is based on more recent models of ambiguous word processing (Armstrong & Plaut, 2011; Rodd 2005), which suggest that facilitation from related meanings/senses and inhibitory connections between unrelated meanings/senses are responsible for differences between polysemes and homonyms.

In the current experiment, the critical task used to determine how naïve learners differentially extend homonymous and polysemous meanings/senses is the translation recognition task using semantic distractors (e.g., Talamas et al., 1999). In the translation recognition task participants are asked to decide if L1 - L2 word pairs are correct translation equivalents or not. Participants are presented with a word in their L1 or L2 and then presented with a word that is either the correct translation (requiring a yes response), a semantic distractor (word related in meaning to the correct translation), a form distractor (word similar in orthography or phonology to the correct translation), or a control word. L2 speakers typically respond more slowly and less accurately to semantic distractors than controls. The difference between semantic distractors and their controls is called the semantic interference effect. This effect is used to index the level of semantic processing on the L2 vocabulary such that the lack of a semantic interference effect suggests weak connections between L2 and conceptual representations of the words.

Talamas et al. (1999) examined how L2 proficiency impacted the semantic interference effect. They found that more proficient L2 speakers showed a greater semantic interference effect than less proficient L2 speakers. Less-proficient speakers additionally showed greater form-level interference than more-proficient speakers. The results support the developmental view of the RHM (Kroll & Stewart, 1994) such that early L2 speaker rely more on form level connections between L2 and L1 and have weaker connections between L2 and conceptual stores, but that the connections between L2 and concepts strengthen as proficiency increases. In an extension of Talamas et al. (1999), Ferré, Sánchez- Casas, and Guasch (2006) examined the form vs. semantic interference effect for proficient early L2 learners, proficient late L2 learners, and non-proficient late L2 learners. They found that proficiency and age of acquisition both influenced the magnitude of the semantic interference effect such that both early and late proficient L2 speakers showed form and semantic interference effects, whereas late non-proficient L2 speakers showed only a form interference effect and not a semantic interference effect. These results further support the developmental view of the RHM.

Although prior research would suggest that naïve L2 learners would not be influenced by semantic distractors during the translation recognition task, the vocabulary training procedure (sentence generation) used in the current study emphasizes meaning level connections to L2 vocabulary. Importantly, results from Experiment 2 and prior studies using the sentence generation effect have demonstrated that the training leads to meaning level processing of the L2 vocabulary (e.g., Eddington et al., 2015; Tokowicz & Jarbo, 2015).

4.1 EXPERIMENT OVERVIEW

The current experiment examined how adult naïve L2 learners map specific meanings/senses to L2 labels and how meaning/sense dominance affects the mapping between meanings to L2 labels. To investigate these issues we trained participants on a set of polysemous and homonymous translation-ambiguous words and taught participants German vocabulary words that mapped to the dominant meaning/sense or to the subordinate meaning/sense of the L1 ambiguous word. Thus, the words in the training were essentially translation-unambiguous from the participants' point of view. The vocabulary training was done in the same way as in Experiment 2 such that participants contextualized the L2 vocabulary in a sentence. Participants completed a free recall task and L2-L1 translation production task as in Experiment 2. We examined how meaning/sense dominance and ambiguity type (semantic similarity) affected how participants represented L2 vocabulary words in semantic memory using a translation recognition task with semantic distractors on the critical "no" trials. Because we are interested in how the L2 learners represent the meaning of the L2 vocabulary we presented semantic distractors and their controls but not form distractors. The semantic distractors were related to the dominant meaning/sense (e.g., Abfall (litter) – trash) or the subordinate meaning/sense (e.g., Wurf (litter) – puppy), and critically the "trained" meanings/senses (e.g., trained on Abfall (litter), presented with trash) and "untrained" (e.g., trained on Abfall (litter), presented with puppy) meanings/senses were presented. Thus, we can evaluate if the "untrained" meaning/sense is extended to the L2 vocabulary by examining the semantic interference effect. Further, this design tests whether the different ambiguous word types extend differentially and if meaning/sense frequency affects this process.

Based on previous research (Degani & Tokowicz, 2010), we expected that participants would show an ambiguity disadvantage on the overall learning measures. We also expected that participants would acquire more polysemous vocabulary than homonymous vocabulary. On the translation recognition task, we expected an overall semantic interference effect such that participants would be slower and less accurate to respond to semantic distractors than controls. We also expected that the type of distractor (e.g., trained vs. untrained meaning/sense) would modulate this effect such that trained semantic distractors would lead to a bigger semantic interference effect than untrained semantic distractors. Further we expected there to be a three-way interaction with distractor type (semantic vs. controls) by training (trained vs. untrained) by word type (homonym vs. polyseme) such that untrained semantic distractors would show a semantic interference effect for polysemes but not for homonyms. We expected this because the related senses of a polysemous word are likely to activate each other, thereby leading to semantic interference for both trained and untrained senses. Additionally, we expected dominance effects such that there would be a larger semantic interference effect for dominant meanings/senses than subordinate meanings/senses. We expected semantic interference to be larger for dominant translations because the dominant meaning should result in greater automatic semantic activation leading to greater interference. We expected the dominance effect to be modulated by word type and training (trained vs. untrained) such that dominance would be less influential for polysemous words and that untrained dominant would lead to semantic interference but untrained subordinate words would not. We expected these findings based on previous within language studies on ambiguity (e.g., Duffy et al., 1988).

4.2 METHODS

4.2.1 Participants

Thirty-six native English speakers participated in the experiment. Participants were recruited from the Introduction to Psychology subject pool and received four research credits for the first four hours of participation and additionally were compensated for the remaining time they participated in the study. Six participants were not included in the final analyses because of prior language exposure (N =3) or because they did not complete all three sessions of the experiment (N=3). All participants included in the final analyses had not learned German or Dutch, were at least 18 years of age of older, had not been exposed to another language other than English before the age of 12, and were right handed. See Appendix B for characteristics of the final set of participants.

4.2.2 Design

This study used a 3 word type (homonym, polyseme, unambiguous) x testing time (testing session 1 vs. testing session 2) x dominance (dominant, subordinate) mixed design.

4.2.3 Stimuli

4.2.3.1 L2 vocabulary stimuli

The stimuli included of 80 English words and 120 German vocabulary words. Twenty words were classified as homonymous, 20 were classified as polysemous, and 40 were classified as unambiguous. The homonymous and polysemous words were paired with either the translation corresponding to the dominant meaning/sense or with the translation corresponding to the subordinate meaning/sense. Two counterbalanced list versions were created so that all words were learned across participants and each participant learned dominant and subordinate translations. Therefore, although the stimulus list included 120 German words, each participant learned only 80 German words (40 unambiguous translations, 20 translations of the dominant meaning/sense and 20 translations of the subordinate meaning/sense). See Appendix H for the complete set of stimuli. Participants also learned a set of 8 filler English-German vocabulary words. These filler vocabulary words were included for counterbalancing purposes for the semantic relatedness task. The stimuli were matched on English word length ($F(2,115) = .55$, $p = .58$) and German word length ($F(2,115) = 2.10$, $p = .13$) but were not well matched on log frequency (SUBTL; Brysbaert & New, 2009) ($F(2,115) = 3.84$, $p = .02$), concreteness (Brysbaert et al., 2014) ($F(2,115)$ 2.77, $p = .07$). See Table 30 for item characteristics. Item characteristics were included in the statistical models to control for item level differences.

Table 30. Vocabulary word characteristics –Experiment 3

	English Word Length		English log Frequency		English Concreteness		German Word Length	
Word Type	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Homonym	5.05	1.13	2.75	0.57	4.35	0.46	6.70	2.20
Polyseme	5.20	1.45	2.99	0.54	4.61	0.56	6.88	1.95
Unambiguous	4.90	1.17	3.09	0.54	4.24	1.01	6.03	1.66

4.2.3.2 Translation recognition stimuli

For the translation recognition task, the German words were paired with the correct English translation or a distractor. The critical “no” trials consisted of four conditions: semantic distractor related to the trained meaning/sense, control for the trained meanings/sense semantic distractor, semantic distractor related to the untrained meaning/sense, and control for the untrained meaning/sense semantic distractors. Semantic distractors were selected from published free association norms (Nelson et al., 2004) and norms collected from Experiment 2. Control words were selected to match the semantic distractors in word length ($F(1,237) = .24$, $p = .67$), frequency (SUBTL; Brysbaert & New, 2009) ($F(1,237) = .01$, $p = .91$), concreteness (Brysbaert et al., 2014) ($F(1,237) = .65$, $p = .41$) (see Table 31 for stimuli characteristics). Relatedness ratings were collected to ensure that the semantic distractors were related and that the control words were unrelated (see Appendix I). The semantic distractors received significantly higher relatedness ratings (*M* = 4.89, *SD* = .84) than the unrelated controls (*M* = 1.83, *SD* = .46), *t* (94) = 31.99, *p* <.001. An additional 25 items were added to the stimulus list after the relatedness norms were collected. We used LSA (Landauer et al., 1998) to confirm the semantic similarity between the vocabulary words and the semantic associates and the controls. For the entire stimulus set the semantic distractors received significantly higher similarity scores (*M* = .30, *SD* = .19) than the unrelated controls (*M* = .06, *SD* = .07), *t*(119) = 12.58, *p* <.001. Four counterbalanced list versions were created for each training list version so that each German word appeared with all translation and distractors across participants, and each participant was exposed to each condition within a list version for each word type.

Table 31. Critical Distractors - Word Characteristics

		English Word Length		English log Frequency		English Concreteness	
	Word Type	*M*	*SD*	*M*	*SD*	*M*	*SD*
Semantic Distractors	Homonym	5.38	1.85	2.77	0.88	4.16	1.00
	Polyseme	5.80	2.02	2.74	0.78	4.20	0.91
	Unambiguous	5.50	1.72	3.00	0.76	4.22	0.94
Controls	Homonym	5.38	1.85	2.73	0.87	4.24	0.85
	Polyseme	5.67	1.85	2.74	0.77	4.06	0.87
	Unambiguous	5.30	1.49	3.00	0.68	3.99	1.00

4.2.4 Procedure

4.2.4.1 Procedure Overview by Session

See Table 32 for a timeline of the procedures by session. On Session 1, participants first completed the German vocabulary training (see below). Next, participants completed the Flankers (Eriksen, 1995) and Stroop (Stroop, 1935) individual difference tests.

On Session 2 (two days after session 1) participants completed the free recall task, L2-L1 translation task, and a translation recognition task and then completed the German vocabulary for a second time.

On Session 3 (one week after session 2), participants completed the free recall task, L2-L1 translation task, and translation recognition task. Next participants completed a computerized adapted version of the Ravens progressive matrices (Raven, 1965), the O-span task (Turner & Engle, 1989), the PPVT (Dunn & Dunn, 2007), and the language history questionnaire (Tokowicz et al., 2004). Last, participants were debriefed and compensated for their participation.

Table 32. Summary of Exp. 3 Procedures

Session	Task	Task Order
1 (Day 1)	Pretest and Vocabulary Training	Vocabulary Training Stroop Flankers
2 (Day 3)	Vocabulary Tests and Vocabulary Training	Free Recall L2-L1 Translation Translation Recognition Vocabulary Training
3 (Day 10)	Posttests and Vocabulary Tests	Free Recall L2-L1 Translation Semantic Relatedness Ravens PPVT

	O-span
	Language History Questionnaire

4.2.4.2 Training

The training paradigm was the same as in Experiment 2, with the exception that learners were exposed to only one translation for the translation-ambiguous words. Participants were first asked to repeat an English and German vocabulary word pair two times aloud. Next, participants were asked to read a definition of the word aloud. Last, participants were asked to generate a sentence in English using the German vocabulary word (e.g., “On Earth Day I volunteered to pick up Abfall (litter) in my neighborhood.”). For the ambiguous English vocabulary, participants were trained on the German translation that mapped to the dominant or the subordinate meaning/sense of the English word.

4.2.4.3 Testing

The vocabulary tests included a free-recall task, an L2-L1 translation production task, and a translation recognition task (see below for details on the translation recognition task and see Experiment 2 for details on free recall and L2-L1 translation production tasks).

Translation Recognition Task.

During the translation recognition task, participants were instructed that they would first see a fixation cross on the screen to indicate that the trial was about to begin. The fixation cross was on the screen for 2000 ms and was replaced with a German vocabulary word. The German vocabulary word was presented for 500 ms and then after an ISI of 250ms the English word appeared on the screen. The English word remained on the screen until a response was made.

After a response was made there was a 600ms delay before the next fixation cross appeared on the screen. Participant were instructed to press the “yes” key (rightmost button on the button box) with their right index finger if the English word was the correct translation they were exposed to during training of the previously presented German word and to press the “no” key (leftmost button on the button box) with their left index finger if the English word was not a correct translation of the previously presented German word. Participants were instructed to respond as quickly as possible while remaining accurate. Five counterbalanced list versions were created for each training list version so that each German word appeared in each condition. Participants completed two blocks of the task such that they were presented with all of the vocabulary words and fillers twice. Half of the words were to receive a “yes” response and half were to receive a “no” response. Sub-lists for each list version were created so that across blocks the “yes” and “no” responses were not predictive from one block to the next. Participants were randomly assigned to a list version. Participants completed different list versions on testing session 1 and testing session 2. Participants completed four practice trials before the experimental trials began.

4.3 RESULTS

4.3.1 Statistical approach

We included random factors of participants and English vocabulary and German translations for all tasks. The fixed factors of interest are word type (homonym, polyseme, unambiguous), testing session (session 1, session 2) and translation dominance (dominant, subordinate). For the translation recognition task an additional factor of distractor type was included (see contrasts below). These factors were coded using effect coding in which the intercept of the model represents the grand mean and the slopes indicate the difference between the contrasted conditions. As in Experiment 2, we ran models containing all word types (e.g., homonym, polyseme, unambiguous) to examine differences between translation-ambiguous words and translation-unambiguous words and models with only translation-ambiguous words to examine the effect of translation dominance.

Word type : All word types

C1: homonyms and polysemes vs. near-synonyms

C2: homonyms vs. polysemes

Word type : Ambiguous words only

C1: homonyms vs. polysemes

Testing Session

C1: Session 1 vs. Session 2

Translation Dominance

C1: Dominant vs. Subordinate

Distractor Type – For Semantic Relatedness Task

C1: Trained Semantic Distractor vs. Untrained Semantic Distractor

C2: Trained Semantic Distractor vs. Trained Semantic Distractor Control

C3: Untrained Semantic Distractor vs. Untrained Semantic Distractor Control

4.3.2 Free Recall

4.3.2.1 Accuracy – All word types

Overall, there was an effect of ambiguity such that homonymous and polysemous semantically-ambiguous words were recalled less often than unambiguous words. Although, the semantically-ambiguous words were not translation ambiguous in this training experiment, the multiple meanings/senses of the ambiguous words may have reduced the participants' ability to correctly recall of the English-German word pairs. Participants correctly recalled more words on testing session 2 than on testing session 1. No other effects were observed. See Table 33 for estimated means and Table 34 the results of the model.

Table 33. Free Recall - All word types - Mean Estimated Probability of Correct Response

	Session 1	Session 2
Homonym	0.01	0.03
Polyseme	0.02	0.04
Unambiguous	0.03	0.06

Table 34. Free Recall Accuracy - All word types model results

	β	Std. Error	*z-value*	*p-value*	*Sig.*
(Intercept)	-3.52	0.20	-17.92	.00	***
Flankers Dif.	0.00	0.00	0.45	.65	
PPVT Standard	0.02	0.02	0.73	.47	
Stroop	2.07	2.26	0.92	.36	
Ravens	-0.10	0.07	-1.39	.17	
O-span Total	0.05	0.04	1.34	.18	
English word length	0.02	0.14	0.12	.91	
English word log frequency	0.24	0.22	1.10	.27	
English word concreteness	0.26	0.17	1.49	.14	
English word orthographic N.	0.00	0.02	0.16	.88	
German word length	-0.17	0.07	-2.58	.01	**
Form overlap	-0.11	0.09	-1.17	.24	

Type: Ambig. vs. Unambig.	-0.57	0.25	-2.30	.02	*
Type: H vs. P	-0.30	0.34	-0.88	.38	
Session 1 vs. 2	0.77	0.15	5.07	.00	***
Type: Ambig. vs. Unambig. * Session 1 vs. 2	-0.25	0.27	-0.95	.34	
Type: H vs. P * Session 1 vs. 2	0.32	0.43	0.76	.45	
Random Effects	Variance	St. Dev			
Participant	0.55	0.74			
German Word	0.83	0.91			
English Word	0.00	0.07			

4.3.2.2 Accuracy – Ambiguous word types

Only testing session was a significant predictor of accuracy on these data such that the L1-L2 vocabulary word pairs were recalled more on session 2 than session 1. See Table 35 for the estimated means and Table 36 for the model results.

Table 35. Free Recall - Ambiguous word types - Mean Estimated Probability of Correct Response

		Dominant	Subordinate
Session 1	Homonym	0.02	0.01
	Polyseme	0.03	0.02
Session 2	Homonym	0.03	0.03
	Polyseme	0.04	0.04

Table 36. Free Recall Accuracy - Ambiguous word type model results

	β	Std. Error	*z-value*	*p-value*	*Sig.*
(Intercept)	-3.70	0.25	-15.03	.00	***
Flankers Dif.	0.00	0.00	0.32	.75	
PPVT Standard	0.01	0.02	0.65	.51	
Stroop	1.76	2.20	0.80	.42	
Ravens	-0.04	0.08	-0.56	.58	
O-span Total	0.03	0.04	0.78	.44	

English word length	0.04	0.19	0.20	.84	
English word log frequency	-0.14	0.32	-0.44	.66	
English word concreteness	0.24	0.39	0.61	.54	
English word orthographic N.	0.03	0.04	0.77	.44	
German word length	-0.23	0.08	-2.68	.01	**
Form overlap	-0.09	0.13	-0.72	.47	
H vs. P	0.54	0.39	1.40	.16	
Dom vs. Sub	-0.24	0.34	-0.70	.48	
Session 1 vs. 2	0.72	0.22	3.30	.00	***
H vs. P * Dom vs. Sub	0.23	0.66	0.34	.73	
H vs. P * Session 1 vs. 2	-0.34	0.44	-0.78	.44	
Dom vs. Sub * Session 1 vs. 2	0.52	0.44	1.19	.23	
H vs. P * Dom vs. Sub *Session 1 vs. 2	0.14	0.87	0.16	.87	
Random Effects	Variance	St. Dev.			
Participant	0.34422	0.58670			
German Word	0.95359	0.97652			
English Word	0.00155	0.03941			

4.3.3 L2-L1 Translation Production

4.3.3.1 RT – All word types

Only a significant main effect of testing session was observed in which participants were faster translation words on testing session 2 than testing session 1 (see Table 37). See Table 38 for the model results.

Table 37. L2-L1 Translation production - All word types – Estimated mean RTs

	Session 1	Session 2
Homonym	2717.33	1833.81
Polyseme	2811.08	1932.19
Unambiguous	2578.40	1838.78

Table 38. L2-L1 Translation Production RT- All word types model results

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	7.72	0.04	36.70	182.93	.00	***
Flankers Dif.	0.00	0.00	20.50	-2.26	.04	*
PPVT Standard	-0.01	0.01	24.10	-1.40	.17	
Stroop	-1.11	0.56	20.80	-1.98	.06	.
Ravens	0.00	0.02	23.90	-0.13	.90	
O-span Total	-0.01	0.01	26.40	-0.80	.43	
English word length	-0.01	0.03	97.40	-0.26	.79	
English word log frequency	0.00	0.04	81.10	-0.08	.94	
English word concreteness	-0.08	0.04	98.10	-1.95	.05	.
English word orthographic N.	0.00	0.01	74.90	0.81	.42	
German word length	0.03	0.01	79.90	2.41	.02	*
Form overlap	0.03	0.02	88.00	1.56	.12	
Type: Ambig. vs. Unambig.	0.05	0.05	75.00	0.90	.37	
Type: H vs. P	-0.04	0.07	106.80	-0.62	.54	
Session 1 vs. 2	-0.37	0.04	1238.00	-9.57	.00	***
Type: Ambig. vs. Unambig. * Session 1 vs. 2	-0.05	0.07	1236.00	-0.63	.53	
Type: H vs. P * Session 1 vs. 2	-0.02	0.10	1238.00	-0.18	.86	
Random Effects	Variance	St. Dev				
Participant	0.03	0.18				
German Word	267500.00	517.20				
English Word	0.00	0.00				

4.3.3.2 Accuracy – All word types

Overall, participants were more accurate translating vocabulary words on testing session 2 than on testing session 1. No other significant effects were found. See Table 39 for the estimated means and Table 40 the model results.

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Table 39. L2-L1 translation production - All word types - Mean Estimated Probability of Correct Response

	Session 1	Session 2
Homonym	0.10	0.27
Polyseme	0.15	0.33
Unambiguous	0.11	0.31

Table 40. L2-L1 Translation Production Accuracy- All word types model results

	β	Std. Error	t-value	p-value	Sig.
(Intercept)	-3.70	0.25	-15.03	.00	***
Flankers Dif.	0.00	0.00	0.32	.75	
PPVT Standard	0.01	0.02	0.65	.51	
Stroop	1.76	2.20	0.80	.42	
Ravens	-0.04	0.08	-0.56	.58	
O-span Total	0.03	0.04	0.78	.44	
English word length	0.04	0.19	0.20	.84	
English word log frequency	-0.14	0.32	-0.44	.66	
English word concreteness	0.24	0.39	0.61	.54	
English word orthographic N.	0.03	0.04	0.77	.44	
German word length	-0.23	0.08	-2.68	.01	**
Form overlap	-0.09	0.13	-0.72	.47	
Type: Ambig. vs. Unambig.	0.54	0.39	1.40	.16	
Type: H vs. P	-0.24	0.34	-0.70	.48	
Session 1 vs. 2	0.72	0.22	3.30	.00	***
Type: Ambig. vs. Unambig. * Session 1 vs. 2	0.23	0.66	0.34	.73	
Type: H vs. P * Session 1 vs. 2	-0.34	0.44	-0.78	.44	
Random Effects	Variance	St. Dev.			
Participant	0.34	0.59			
German Word	0.95	0.98			
English Word	0.00	0.04			

4.3.3.3 RT- Ambiguous word types

A marginal session by dominance interaction was observed in which there was a greater dominance effect on session 1 than session 2 (see Figure 35). This interaction qualified the main effects of session and dominance such that participants translated dominant meanings/senses translations faster than subordinate meaning/senses and were faster on testing session 2 than testing session 1. The reduced dominance effect on testing session 2 may be due to an increase in meaning activation of the subordinate meaning/sense after additional experience with the subordinate meaning/sense from the L2 vocabulary training. See Table 41 for the model results.

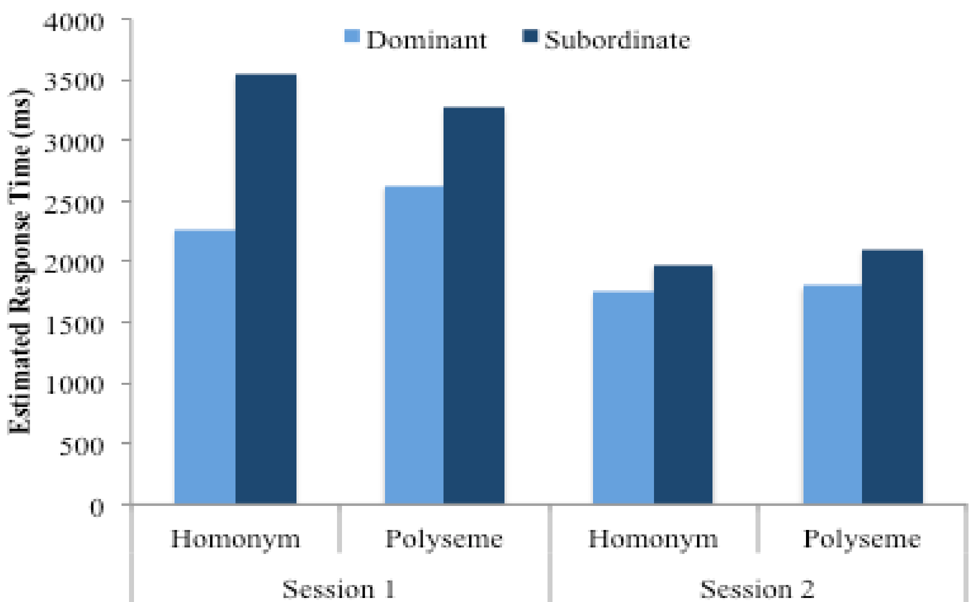

Figure 35. L2 L1 Translation Production- Ambiguous word types - Mean Estimated RTs

Table 41. L2-L1 Translation Production RT - Ambiguous word type model results

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	7.76	0.05	39.10	156.26	0.00	***
Flankers Dif.	0.00	0.00	20.40	-1.93	0.07	.
PPVT Standard	-0.01	0.01	25.40	-1.20	0.24	

Stroop	-0.26	0.63	20.70	-0.42	0.68	
Ravens	-0.03	0.02	25.80	-1.26	0.22	
O-span Total	0.00	0.01	29.40	-0.20	0.84	
English word length	0.02	0.04	71.10	0.62	0.54	
English word log frequency	0.04	0.06	53.90	0.75	0.46	
English word concreteness	-0.07	0.08	68.80	-0.91	0.37	
English word orthographic N.	0.00	0.01	53.00	0.34	0.73	
German word length	0.02	0.01	49.00	1.41	0.17	
Form overlap	0.04	0.02	56.50	1.60	0.11	
H vs. P	0.04	0.07	60.10	0.58	0.56	
Dom vs. Sub	0.24	0.06	67.00	3.66	0.00	***
Session 1 vs. 2	-0.42	0.05	594.30	-7.69	0.00	***
H vs. P * Dom vs. Sub	-0.10	0.13	58.80	-0.77	0.45	
H vs. P * Session 1 vs. 2	0.01	0.11	595.20	0.12	0.91	
Dom vs. Sub * Session 1 vs. 2	-0.19	0.11	592.00	-1.81	0.07	.
H vs. P * Dom vs. Sub *Session 1 vs. 2	0.27	0.22	593.90	1.23	0.22	
Random Effects	Variance	St. Dev				
Participant	0.03	0.19				
German Word	0.01	0.12				
English Word	0.00	0.00				

4.3.3.4 Accuracy – Ambiguous word types

Participants correctly produced dominant translations more than subordinate translations. No other significant effects were observed. See Table 42 for the mean estimated probability of correct responses. See Table 43 for a summary of the model.

Table 42. L2 L1 Translation Production- Ambiguous word types - Mean Estimated Probability of Correct Response

		Dominant	Subordinate
Session 1	Homonym	0.13	0.07

	Polyseme	0.27	0.07
Session 2	Homonym	0.32	0.20
	Polyseme	0.44	0.25

Table 43. L2-L1 Translation Production Accuracy - Ambiguous word type model results

	β	Std. Error	z-value	p-value	Sig.
(Intercept)	0.00	0.00	1.02	0.31	
Flankers Dif.	0.00	0.00	1.02	0.31	
PPVT Standard	0.01	0.02	0.22	0.83	
Stroop	2.15	2.72	0.79	0.43	
Ravens	-0.02	0.09	-0.17	0.87	
O-span Total	0.03	0.05	0.63	0.53	
English word length	0.09	0.15	0.58	0.57	
English word log frequency	-0.11	0.24	-0.47	0.64	
English word concreteness	0.58	0.31	1.86	0.06	.
English word orthographic N.	0.06	0.03	2.07	0.04	*
German word length	-0.15	0.07	-2.30	0.02	*
Form overlap	-0.11	0.10	-1.05	0.29	
H vs. P	0.41	0.29	1.42	0.16	
Dom vs. Sub	-0.91	0.26	-3.50	0.00	***
Session 1 vs. 2	1.14	0.12	9.72	0.00	***
H vs. P * Dom vs. Sub	-0.60	0.52	-1.14	0.25	
H vs. P * Session 1 vs. 2	-0.07	0.23	-0.32	0.75	
Dom vs. Sub * Session 1 vs. 2	0.32	0.23	1.38	0.17	
H vs. P * Dom vs. Sub *Session 1 vs. 2	0.70	0.46	1.52	0.13	
Random Effects	Variance	St. Dev.			
Participant	1.12	1.06			
German Word	0.00	0.00			
English Word	0.95	0.98			

4.3.4 Interim summary of learning measures (free recall and L2-L1 translation production)

Overall, participants were more accurate at recalling L1-L2 vocabulary words on testing session 2 than testing session 1. Participants were faster and more accurate at translating vocabulary on testing session 1 than testing session 2 on the L2-L1 transition production task. These results suggest that with additional training the participants had retained more vocabulary and were able to access the vocabulary more quickly. Additionally, we observed a significant ambiguity effect such that semantically-unambiguous words were recalled more than ambiguous words on the free recall task. This result suggest that even though both meanings/senses and corresponding translations were not taught to the participants, the untrained meaning/senses interfered with the acquisition of the L2 labels. No overall ambiguity effect was observed on the L2-L1 translation production task in RT and accuracy. However, we did observe a meaning dominance effect in which participant produced dominant meaning translations more quickly and accurately than subordinate translations suggesting that participants were associating the L2 vocabulary with the specific meaning. The lack of an overall ambiguity effect therefore was due to collapsing across meaning dominance.

4.3.5 Translation Recognition

We first present the “yes” (i.e., correct translation) responses and then present the results from the “no” (i.e., semantic distractor or control) responses for all word types and then for only ambiguous words.

4.3.5.1 RT All word types – "Yes" response

There was a marginal effect of ambiguity such that homonymous and polysemous words were responded to more slowly than unambiguous words. Participants responded to correct translations more quickly on testing session 2 than on testing session 1. No other significant effects were found. See Table 44 for the mean estimated response times and Table 45 for a summary of the results.

Table 44. Translation Recognition Estimated RTs - All word types

	Session 1	Session 2
Homonym	967.40	763.27
Polyseme	950.36	728.51
Unambiguous	900.20	703.53

Table 45 . Translation Recognition - Yes Responses - RT model of all word types

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	6.72	0.04	34.00	159.49	.00	***
Flankers Dif.	0.00	0.00	25.00	-1.07	.30	
PPVT Standard	0.00	0.01	25.00	0.40	.70	
Stroop	-0.45	0.60	25.00	-0.74	.47	
Ravens	0.03	0.02	25.00	1.50	.15	
O-span Total	-0.01	0.01	25.00	-0.57	.57	
English word length	-0.02	0.02	112.00	-0.94	.35	
English word log frequency	-0.03	0.03	101.00	-1.07	.29	
English word concreteness	-0.06	0.02	72.00	-2.44	.02	*
English word orthographic N.	-0.01	0.00	93.00	-1.94	.06	.
German word length	0.01	0.01	106.00	1.17	.24	
Form overlap	0.01	0.01	95.00	0.75	.46	
Trial Number	0.00	0.00	3908.00	-7.33	.00	***
Type: Ambig. vs. Unambig.	0.06	0.03	87.00	1.75	.08	.
Type: H vs. P	0.03	0.05	126.00	0.71	.48	
Session 1 vs. 2	-0.25	0.02	3854.00	-14.16	.00	***
Type: Ambig. vs. Unambig. * Session 1 vs. 2	0.00	0.03	3845.00	-0.16	.87	
Type: H vs. P * Session 1 vs. 2	0.03	0.05	3853.00	0.58	.56	

Random Effects	Variance	St. Dev.
Participant	0.05	0.21
German Word	0.02	0.14
English Word	0.00	0.00

4.3.5.2 Accuracy All word types – “Yes” response

No significant effects were observed for the accuracy data. This is most likely a ceiling effect, participants were highly accurate at correctly identifying translation equivalents. See Table 46 for the estimated means and Table 47 for the model results.

Table 46. Translation Recognition “Yes” Response Estimated Accuracy - All word types

	Session 1	Session 2
Homonym	0.96	0.96
Polyseme	0.96	0.97
Unambiguous	0.96	0.96

Table 47. Translation Recognition – “Yes” responses - Accuracy Model of all word types

	β	Std. Error	z-value	p-value	Sig.
(Intercept)	3.14	0.17	18.11	.00	***
Flankers Dif.	0.00	0.00	0.49	.63	
PPVT Standard	0.01	0.02	0.48	.63	
Stroop	-1.97	2.51	-0.79	.43	
Ravens	0.03	0.08	0.33	.74	
O-span Total	0.05	0.04	1.12	.26	
English word length	0.04	0.06	0.77	.44	
English word log frequency	-0.07	0.10	-0.71	.48	
English word concreteness	0.00	0.07	-0.05	.96	
English word orthographic N.	0.01	0.01	0.78	.44	
German word length	-0.08	0.03	-2.59	.01	**
Form overlap	0.04	0.04	0.92	.36	
Trial Number	0.00	0.00	2.16	.03	*
Type: Ambig. vs. Unambig.	0.09	0.14	0.63	.53	

Type: H vs. P	-0.17	0.17	-0.95	.34
Session 1 vs. 2	0.08	0.09	0.86	.39
Type: Ambig. vs. Unambig. * Session 1 vs. 2	0.18	0.16	1.09	.28
Type: H vs. P * Session 1 vs. 2	-0.19	0.23	-0.80	.42
Random Effects	Variance	St. Dev.		
Participant	0.73	0.86		
German Word	0.61	0.78		
English Word	0.00	0.00		

4.3.5.3 RT Ambiguous word types – "Yes" response

A significant dominance by word type by session interaction was observed such that the dominant translations were responded to more quickly than subordinate translation on session 1 for polysemes but this effect was reduced on session 2 (see Figure 36). This interaction qualified a main effect of dominance. No other significant effects were observed. See Table 48 for the model results.

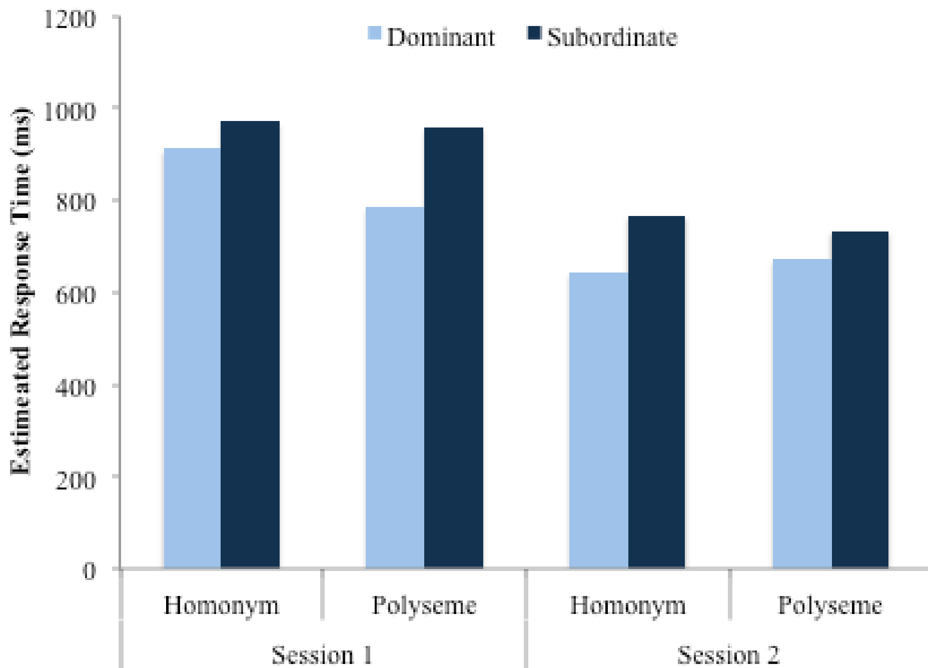

Figure 36. Translation Recognition "yes" responses Estimated RTs- Ambiguous word types

Table 48. Translation Recognition – "Yes" Response- RT model of ambiguous word types

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	6.68	0.05	53.20	123.58	.00	***
Flankers Dif.	0.00	0.00	25.20	-1.10	.28	
PPVT Standard	0.00	0.01	24.90	0.78	.44	
Stroop	-0.53	0.67	24.80	-0.79	.44	
Ravens	0.02	0.02	27.60	0.89	.38	
O-span Total	-0.01	0.01	25.20	-0.61	.55	
English word length	-0.03	0.03	76.90	-1.00	.32	
English word log frequency	-0.05	0.05	87.50	-1.02	.31	
English word concreteness	-0.10	0.05	59.00	-1.96	.06	.
English word orthographic N.	-0.01	0.01	75.00	-2.10	.04	*
German word length	0.02	0.01	72.10	1.32	.19	
Form overlap	0.03	0.02	93.90	1.41	.16	
Trial Number	0.00	0.00	1055.00	-2.01	.04	*
H vs. P	-0.04	0.07	64.10	-0.60	.55	
Dom vs. Sub	0.13	0.05	65.90	2.90	.01	**
Session 1 vs. 2	-0.25	0.03	1170.00	-7.29	.00	***
H vs. P * Dom vs. Sub	0.02	0.09	65.30	0.27	.79	

H vs. P * Session 1 vs. 2	0.08	0.07	1166.00	1.14	.25	
Dom vs. Sub * Session 1 vs. 2	0.00	0.05	1168.00	0.05	.96	
H vs. P * Dom vs. Sub *Session 1 vs. 2	-0.22	0.10	1167.00	-2.22	.03	*
Random Effects	Variance	St. Dev.				
Participant	0.05	0.23				
German Word	0.02	0.15				
English Word	0.00	0.00				

4.3.5.4 Accuracy Ambiguous word types – “Yes” response

There was a significant word type by dominance by session interaction such that the dominance effect (more accurate responses for dominant translations than subordinate translations) was greater for homonymous words on testing session 1 than testing session 2 (see Figure 37). A marginal dominance by session interaction was observed, such that the dominance effect was larger on testing session 1 than on testing session 2. These interactions qualified a main effect of dominance. See Table 49 for a summary of the model results.

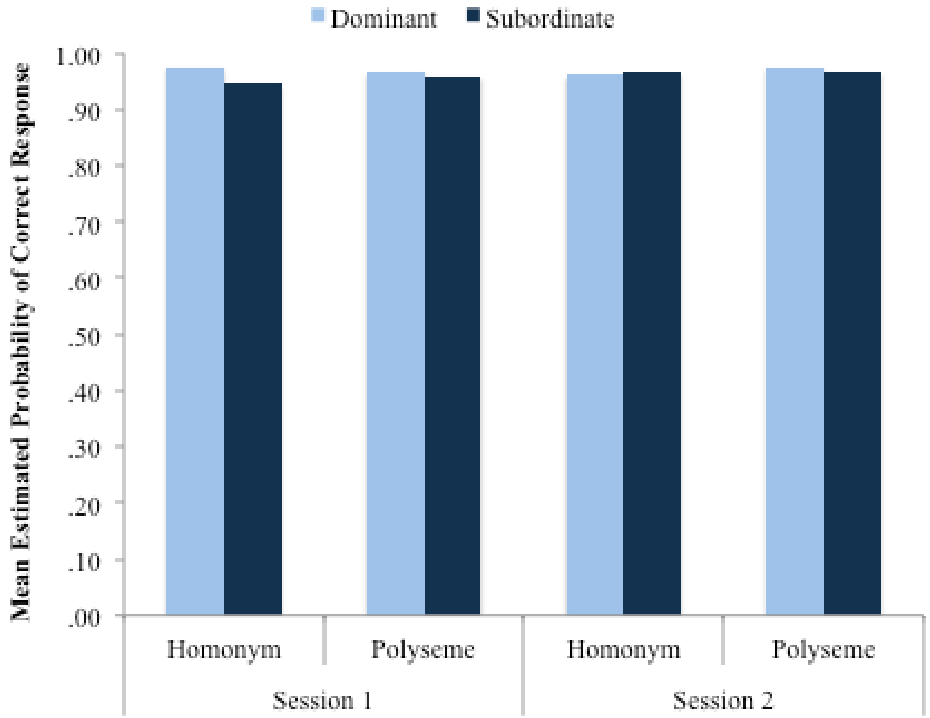

Figure 37. Translation Recognition "Yes" Response Estimated Accuracy - Ambiguous word types

Table 49. Translation Recognition - RT model of ambiguous word types "yes" response

	β	Std. Error	t-value	p-value	Sig.
(Intercept)	3.35	0.21	16.26	.00	***
Flankers Dif.	0.00	0.01	0.84	.40	
PPVT Standard	0.01	0.03	0.20	.84	
Stroop	0.36	2.79	0.13	.90	
Ravens	0.08	0.09	0.96	.34	
O-span Total	0.08	0.05	1.64	.10	
English word length	0.05	0.08	0.62	.54	
English word log frequency	-0.08	0.13	-0.59	.56	
English word concreteness	-0.07	0.12	-0.59	.56	
English word orthographic N.	0.02	0.02	0.97	.33	
German word length	-0.11	0.04	-2.85	.00	**
Form overlap	-0.02	0.06	-0.39	.70	
Trial Number	0.00	0.00	1.49	.14	
H vs. P	0.12	0.19	0.61	.54	
Dom vs. Sub	-0.32	0.12	-2.57	.01	*
Session 1 vs. 2	0.12	0.12	0.98	.33	

H vs. P * Dom vs. Sub	0.13	0.25	0.54	.59	
H vs. P * Session 1 vs. 2	0.24	0.24	0.99	.32	
Dom vs. Sub * Session 1 vs. 2	0.42	0.24	1.77	.08	.
H vs. P * Dom vs. Sub *Session 1 vs. 2	-1.06	0.48	-2.22	.03	*
Random Effects	Variance	St. Dev.			
Participant	0.84	0.92			
German Word	0.00	0.01			
English Word	0.82	0.91			

4.3.5.5 RT All word types – “No” response

Here we present the RT results from the critical “no” responses. For this analysis only the “trained” semantic distractors are included for the ambiguous word types so that there is an equivalent comparison between the semantic distractors and controls for the unambiguous words.

We observed a word type by testing session interaction such that ambiguous words were responded to more slowly than unambiguous words on testing session 1 but not on testing session 2. A significant semantic interference effect was observed such that participants were slower at responding to semantic distractors compared to controls. Participants were faster overall on testing session 2 than testing session 1. No other significant effects were found. See Table 51 for the mean estimated response times across all conditions. See Table 50 for a summary of the model results.

Table 50. Translation Recognition "No” Response Estimated RTs- all word types

		Semantic	Control
Session 1	Homonym	1023.98	935.07

	Polyseme	1044.63	907.93
	Unambiguous	1072.24	966.19
Session 2	Homonym	830.68	781.33
	Polyseme	895.96	772.32
	Unambiguous	823.89	788.73

Table 51. Translation Recognition “No” Responses - Results of RT model for all word types

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	6.80	0.04	27.60	168.53	.00	***
Flankers Dif.	0.00	0.00	25.00	-1.34	.19	
PPVT Standard	0.01	0.01	25.00	1.18	.25	
Stroop	-0.64	0.61	25.00	-1.04	.31	
Ravens	0.00	0.02	25.20	-0.12	.90	
O-span Total	-0.01	0.01	25.00	-0.54	.60	
English word length	0.01	0.01	149.00	0.67	.51	
English word log frequency	0.03	0.01	163.00	2.43	.02	*
English word concreteness	-0.01	0.01	158.20	-0.83	.41	
English word orthographic N.	0.00	0.00	162.40	0.62	.54	
German word length	0.02	0.01	119.90	3.49	.00	***
Form overlap	0.01	0.01	105.30	1.75	.08	.
Trial Number	0.00	0.00	3024.00	-5.16	.00	***
Type: Ambig. vs. Unambig.	-0.01	0.02	99.60	-0.59	.56	
Type: H vs. P	-0.01	0.03	146.10	-0.47	.64	
Semantic Distractor vs. Control	0.10	0.02	127.40	5.84	.00	***
Session 1 vs. 2	-0.19	0.02	3028.00	-12.89	.00	***
Type: Ambig. vs. Unambig. * Semantic Distractor vs. Control	0.04	0.03	90.10	1.15	.25	
Type: H vs. P * Semantic Distractor vs. Control	-0.07	0.05	170.90	-1.51	.13	
Type: Ambig. vs. Unambig. * Session 1 vs. 2	0.06	0.03	3017.00	2.08	.04	*
Type: H vs. P * Session 1 vs. 2	-0.04	0.04	3027.00	-0.90	.37	
Semantic Distractor vs. Control * Session 1 vs. 2	-0.03	0.03	3024.00	-0.90	.37	
Type: Ambig. vs. Unambig. * Semantic Distractor vs. Control * Session 1 vs. 2	0.05	0.06	3014.00	0.91	.36	
Type: H vs. P * Semantic Distractor vs. Control * Session 1 vs. 2	-0.04	0.08	3030.00	-0.46	.65	
Random Effects	Variance	St. Dev.				
Participant	0.84	0.92				
German Word	0.00	0.01				

English Word	0.82	0.91

4.3.5.6 Accuracy All word types "no" response

We present the accuracy results from the critical "no" trials. As in the RT analysis above we only include the "trained" semantic distractors for the ambiguous word types.

A significant semantic interference effect was found across all word types such that semantic distractors were responded to less accurately than controls. No other significant effects were observed. This is likely due again to a ceiling effect. See Table 52 for the mean estimated probability of correct responses across all conditions and Table 53 for a summary of the results.

Table 52. - Translation Recognition "No" Response Estimated Accuracy - All word types

		Semantic	Control
Session 1	Homonym	0.91	0.99
	Polyseme	0.92	0.98
	Unambiguous	0.92	0.99
Session 2	Homonym	0.94	0.99
	Polyseme	0.96	0.99
	Unambiguous	0.94	0.98

Table 53. Translation Recognition "No" Responses - Model results for all word types

	β	Std. Error	t-value	p-value	Sig.
(Intercept)	3.48	0.23	15.12	.00	***
Flankers Dif.	0.00	0.01	-0.06	.96	
PPVT Standard	-0.03	0.03	-0.96	.34	
Stroop	-2.50	2.97	-0.84	.40	
Ravens	0.14	0.09	1.45	.15	
O-span Total	0.07	0.05	1.38	.17	
English word length	0.04	0.08	0.58	.56	
English word log frequency	0.01	0.15	0.10	.92	
English word concreteness	0.07	0.11	0.66	.51	
English word orthographic N.	0.01	0.02	0.49	.62	
German word length	-0.03	0.05	-0.46	.64	

Form overlap	0.02	0.08	0.25	.80	
Trial Number	0.00	0.00	2.09	.04	*
Type: Ambig. vs. Unambig.	0.04	0.22	0.20	.84	
Type: H vs. P	0.01	0.31	0.03	.97	
Semantic Distractor vs. Control	-1.66	0.23	-7.20	.00	***
Session 1 vs. 2	0.17	0.19	0.93	.35	
Type: Ambig. vs. Unambig. * Semantic Distractor vs. Control	-0.16	0.42	-0.39	.70	
Type: H vs. P * Semantic Distractor vs. Control	-0.45	0.60	-0.75	.45	
Type: Ambig. vs. Unambig. * Session 1 vs. 2	0.38	0.34	1.13	.26	
Type: H vs. P * Session 1 vs. 2	-0.34	0.51	-0.67	.50	
Semantic Distractor vs. Control * Session 1 vs. 2	0.57	0.37	1.53	.13	
Type: Ambig. vs. Unambig. * Semantic Distractor vs. Control * Session 1 vs. 2	-0.36	0.68	-0.52	.60	
Type: H vs. P * Semantic Distractor vs. Control * Session 1 vs. 2	0.24	1.02	0.23	.82	

Random Effects	Variance	St. Dev.
Participant	0.91	0.96
German Word	0.71	0.84
English Word	0.82	0.91

4.3.5.7 RT Ambiguous word types –"No" response

We observed a marginal effect of distractor type in which "trained" distractors were responded to more slowly than "untrained" semantic distractors. Trained semantic distractors were responded to significantly more slowly than their controls, and untrained semantic distractors were responded to marginally more slowly than their controls. Dominant translations were responded to more slowly than subordinate translations. We also observed a significant word type by distractor type interaction such that polysemes have a semantic interference effect for both the "trained" and "untrained" semantic distractors but homonyms have a semantic interference effect only for "trained" semantic distractors (see Figure 38). A significant dominance by distractor type interaction also was observed such that subordinate translations have a semantic interference effect for both “trained” and “untrained” semantic distractors but dominant translations only have a semantic interference effect for “trained” semantic distractors (see Figure 39). Additionally, a dominance by session interaction was found such that the dominance effect was larger on testing session 2 than testing session 1. See Table 54 for the estimated RTs across conditions and Table 55 for a summary of the model results.

Table 54. Translation Recognition "No” Response - Estimated RTs - Ambiguous word types

			Trained Meaning		Untrained Meaning	
			Semantic Distractor	Control	Semantic Distractor	Control
Session 1	Homonym	Dominant	1001.37	928.11	942.12	1027.01
		Subordinate	1049.15	985.23	937.16	979.00
	Polyseme	Dominant	995.84	929.87	880.11	896.72
		Subordinate	1123.92	1021.62	960.83	910.73
Session 2	Homonym	Dominant	797.94	731.19	719.02	815.57
		Subordinate	872.29	881.13	835.68	774.26
	Polyseme	Dominant	819.28	811.63	737.64	745.54
		Subordinate	1005.68	894.45	821.21	777.11

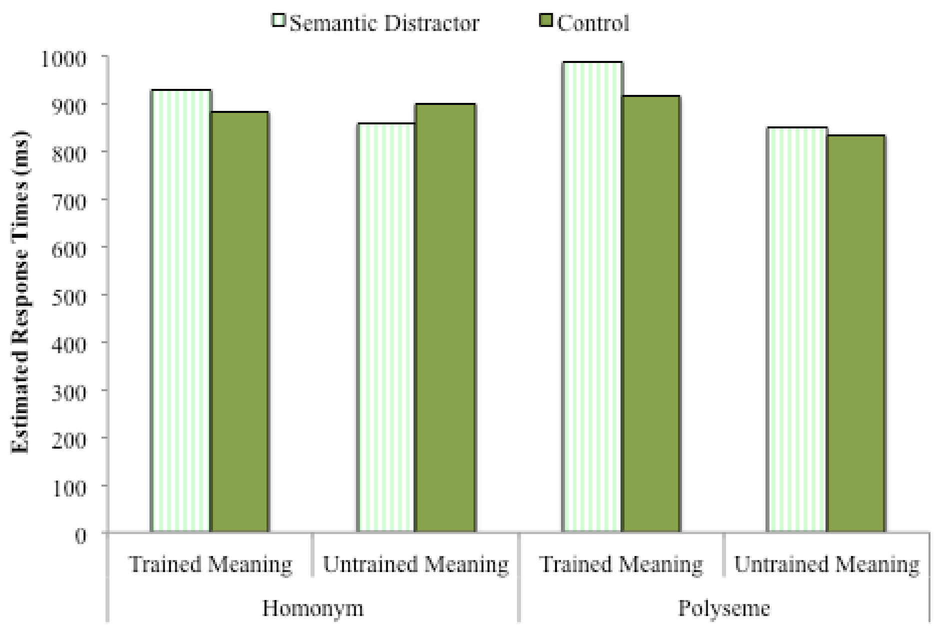

Figure 38. Translation Recognition "No" Reponses Estimated RTs- Word type by Distractor type

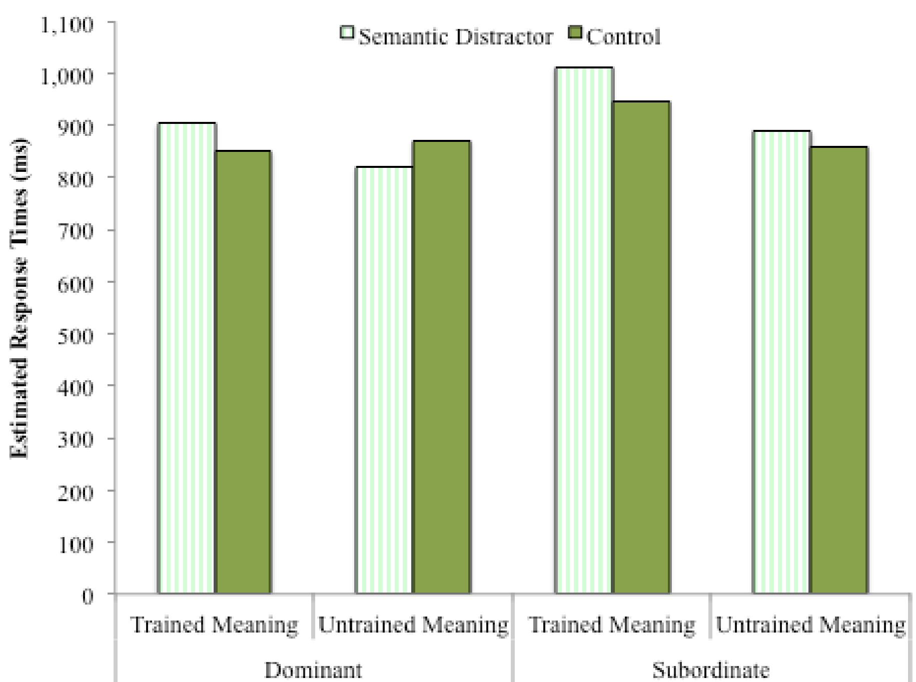

Figure 39. Translation Recognition "No" Responses Estimated RTs - Dominance by Distractor Type

Table 55. Translation Recognition "No" Reponses - RT Model Results for ambiguous word types

	β	Std. Error	df	t-value	p-value	Sig.
(Intercept)	6.79	0.04	28.60	157.59	.00	***
Flankers Dif.	0.00	0.00	25.20	-1.47	.15	
PPVT Standard	0.01	0.01	25.00	0.98	.34	
Stroop	-0.44	0.65	25.00	-0.68	.50	
Ravens	-0.01	0.02	25.90	-0.25	.80	
O-span Total	0.00	0.01	25.10	-0.38	.71	
English word length	0.00	0.01	106.10	0.22	.83	
English word log frequency	0.01	0.01	94.40	1.10	.28	
English word concreteness	0.00	0.01	95.30	0.19	.85	
English word orthographic N.	0.00	0.00	84.50	-0.27	.79	
German word length	0.02	0.01	69.10	3.00	.00	**
Form overlap	0.02	0.01	55.60	2.03	.05	*
Trial Number	0.00	0.00	2852.00	-3.44	.00	***
H vs. P	0.00	0.03	71.60	0.15	.88	
Distractor type: T vs. UT	0.05	0.03	2857.00	1.74	.08	.
Distractor type: T-SD vs. T-MC	0.11	0.02	212.30	5.07	.00	***
Distractor type: U-SD vs. U-MC	0.04	0.02	218.70	1.73	.09	.
Dom vs. Sub	0.07	0.02	50.90	3.08	.00	**
Session 1 vs. 2	-0.18	0.01	2749.00	-12.37	.00	***
H vs. P * Distractor type: T vs. UT	0.08	0.06	2858.00	1.43	.15	
H vs. P * Distractor type: T-SD vs. T-MC	0.07	0.04	212.20	1.49	.14	
H vs. P * Distractor type: U-SD vs. U-MC	0.11	0.04	218.90	2.58	.01	*
H vs. P * Dom vs. Sub	0.04	0.05	51.30	0.87	.39	
Distractor type: T vs. UT* Dom vs. Sub	0.10	0.07	86.70	1.43	.16	
Distractor type: T-SD vs. T-MC * Dom vs. Sub	0.03	0.05	224.90	0.67	.50	
Distractor type: U-SD vs. U-MC * Dom vs. Sub	0.12	0.04	231.50	2.72	.01	**
H vs. P * Session 1 vs. 2	0.04	0.03	2744.00	1.56	.12	
Distractor type: T vs. UT* Session 1 vs. 2	0.00	0.06	2745.00	-0.04	.97	
Distractor type: T-SD vs. T-MC * Session 1 vs. 2	0.00	0.04	2745.00	0.00	1.00	
Distractor type: U-SD vs. U-MC * Session 1 vs. 2	0.05	0.04	2741.00	1.18	.24	
Dom vs. Sub * Session 1 vs. 2	0.06	0.03	2738.00	1.97	.05	*
H vs. P * Distractor type: T vs. UT* Dom vs. Sub	0.07	0.14	85.60	0.48	.63	
H vs. P * Distractor type: T-SD vs. T-MC * Dom vs. Sub	0.07	0.09	213.50	0.78	.44	

H vs. P * Distractor type: U-SD vs. U-MC * Dom vs. Sub	-0.11	0.09	221.80	-1.21	.23
H vs. P * Distractor type: T vs. UT* Session 1 vs. 2	-0.02	0.12	2744.00	-0.20	.84
H vs. P * Distractor type: T-SD vs. T-MC * Session 1 vs. 2	0.03	0.08	2746.00	0.33	.74
H vs. P * Distractor type: U-SD vs. U-MC * Session 1 vs. 2	-0.02	0.08	2741.00	-0.25	.80
H vs. P * Dom vs. Sub * Session 1 vs. 2	-0.05	0.06	2739.00	-0.82	.41
Distractor type: T vs. UT* Dom vs. Sub * Session 1 vs. 2	0.07	0.12	2744.00	0.65	.51
Distractor type: T-SD vs. T-MC * Dom vs. Sub * Session 1 vs. 2	-0.02	0.08	2750.00	-0.30	.77
Distractor type: U-SD vs. U-MC * Dom vs. Sub * Session 1 vs. 2	0.05	0.08	2739.00	0.67	.50
H vs. P * Distractor type: T vs. UT* Dom vs. Sub * Session 1 vs. 2	0.00	0.23	2743.00	0.00	1.00
H vs. P * Distractor type: T-SD vs. T-MC * Dom vs. Sub * Session 1 vs. 2	0.18	0.16	2750.00	1.08	.28
H vs. P * Distractor type: U-SD vs. U-MC * Dom vs. Sub * Session 1 vs. 2	-0.15	0.16	2738.00	-0.96	.34

Random Effects	Variance	St. Dev.
Participant	0.05	0.23
German Word	0.01	0.08
English Word	0.00	0.05

4.3.5.8 Accuracy Ambiguous word types – “No” responses

Participants were highly accurate a correctly identifying incorrect translations. We only observed a significant effect of distractor type such that the “trained” semantic distractors were responded to less accurately compared to controls, but no differences were observed between “untrained” semantic distractors and their controls (See Figure 40). No other significant effects were found. See Table 56 for the mean estimated probability of correct responses across all conditions and Table 57 for a summary of the model results.

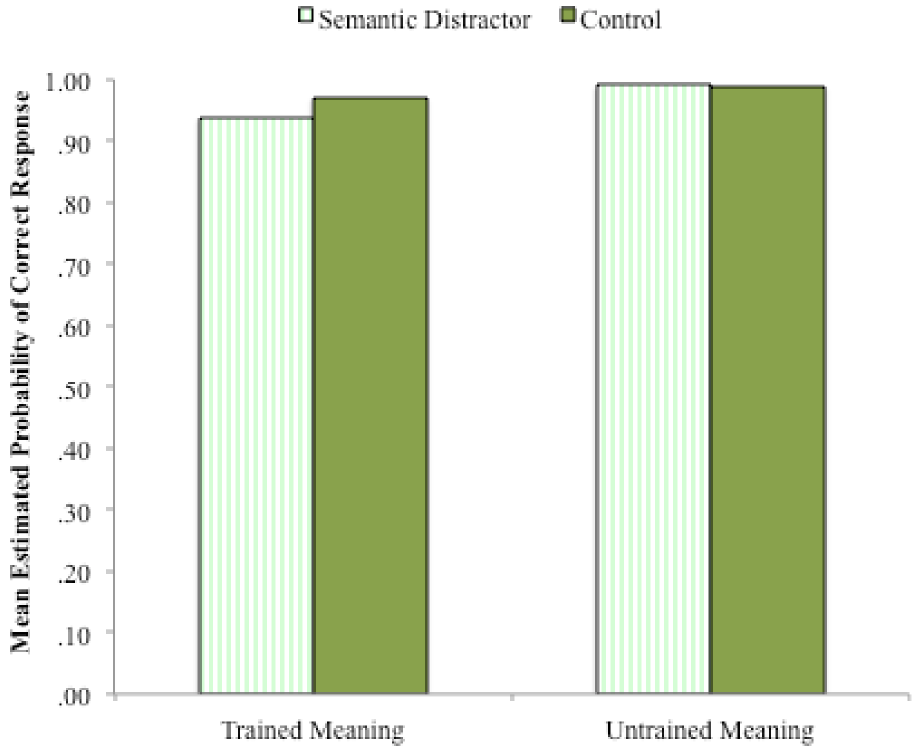

Figure 40. Translation Recognition "No" Responses Estimated Accuracy – Training by Distractor Type

Table 56. Translation Recognition "No" Responses Estimated Accuracy- Ambiguous word types

			Trained Meaning		Untrained Meaning	
			Semantic Distractor	Control	Semantic Distractor	Control
Session 1	Homonym	Dominant	0.92	1.00	0.99	0.99
		Subordinate	0.92	0.94	0.99	0.99
	Polyseme	Dominant	0.92	0.98	0.99	1.00
		Subordinate	0.94	0.94	0.99	1.00
Session 2	Homonym	Dominant	0.92	0.98	0.99	0.98
		Subordinate	0.97	0.99	0.99	0.98
	Polyseme	Dominant	0.96	0.98	0.99	0.99
		Subordinate	0.97	0.95	0.99	0.99

Table 57. Translation Recognition "No" Reponses - Accuracy Model Results for ambiguous word types

	β	Std. Error	t-value	p-value	Sig.
(Intercept)	4.50	2.26	1.99	.05	*
Flankers Dif.	0.00	0.01	0.31	.75	
PPVT Standard	-0.02	0.03	-0.51	.61	
Stroop	-0.13	3.53	-0.04	.97	
Ravens	0.20	0.11	1.80	.07	.
O-span Total	0.08	0.06	1.38	.17	
English word length	0.02	0.09	0.24	.81	
English word log frequency	-0.10	0.16	-0.64	.52	
English word concreteness	-0.05	0.14	-0.34	.73	
English word orthographic N.	0.00	0.02	0.04	.97	
German word length	-0.08	0.06	-1.52	.13	
Form overlap	-0.07	0.08	-0.93	.35	
Trial Number	0.00	0.00	2.19	.03	*
H vs. P	-0.91	4.50	-0.20	.84	
Distractor type: T vs. UT	-2.93	8.99	-0.33	.74	
Distractor type: T-SD vs. T-MC	-1.92	0.34	-5.71	.00	***
Distractor type: U-SD vs. U-MC	0.92	8.99	0.10	.92	
Dom vs. Sub	-1.38	4.50	-0.31	.76	
Session 1 vs. 2	-1.09	4.50	-0.24	.81	
H vs. P * Distractor type: T vs. UT	4.02	17.98	0.22	.82	
H vs. P * Distractor type: T-SD vs. T-MC	0.31	0.66	0.47	.64	
H vs. P * Distractor type: U-SD vs. U-MC	-5.29	17.98	-0.29	.77	
H vs. P * Dom vs. Sub	1.52	9.00	0.17	.87	
Distractor type: T vs. UT* Dom vs. Sub	4.91	17.99	0.27	.78	
Distractor type: T-SD vs. T-MC * Dom vs. Sub	1.07	0.66	1.62	.11	
Distractor type: U-SD vs. U-MC * Dom vs. Sub	-4.73	17.98	-0.26	.79	
H vs. P * Session 1 vs. 2	1.85	9.00	0.21	.84	
Distractor type: T vs. UT* Session 1 vs. 2	5.14	17.99	0.29	.78	
Distractor type: T-SD vs. T-MC * Session 1 vs. 2	0.74	0.59	1.26	.21	
Distractor type: U-SD vs. U-MC * Session 1 vs. 2	-2.93	17.98	-0.16	.87	
Dom vs. Sub * Session 1 vs. 2	2.74	8.99	0.31	.76	
H vs. P * Distractor type: T vs. UT* Dom vs. Sub	-9.23	35.99	-0.26	.80	
H vs. P * Distractor type: T-SD vs. T-MC * Dom vs. Sub	1.23	1.33	0.93	.35	
H vs. P * Distractor type: U-SD vs. U-MC * Dom vs. Sub	7.97	35.96	0.22	.82	
H vs. P * Distractor type: T vs. UT* Session	-6.97	35.93	-0.19	.85	

1 vs. 2				
H vs. P * Distractor type: T-SD vs. T-MC * Session 1 vs. 2	0.02	1.17	0.02	.99
H vs. P * Distractor type: U-SD vs. U-MC * Session 1 vs. 2	7.96	35.95	0.22	.82
H vs. P * Dom vs. Sub * Session 1 vs. 2	-4.01	18.01	-0.22	.82
Distractor type: T vs. UT* Dom vs. Sub * Session 1 vs. 2	-8.17	35.98	-0.23	.82
Distractor type: T-SD vs. T-MC * Dom vs. Sub * Session 1 vs. 2	-0.29	1.17	-0.25	.80
Distractor type: U-SD vs. U-MC * Dom vs. Sub * Session 1 vs. 2	9.13	35.95	0.25	.80
H vs. P * Distractor type: T vs. UT* Dom vs. Sub * Session 1 vs. 2	17.85	71.81	0.25	.80
H vs. P * Distractor type: T-SD vs. T-MC * Dom vs. Sub * Session 1 vs. 2	-2.71	2.36	-1.15	.25
H vs. P * Distractor type: U-SD vs. U-MC * Dom vs. Sub * Session 1 vs. 2	-17.98	71.88	-0.25	.80
Random Effects	Variance	St. Dev.		
Participant	1.25	1.12		
German Word	0.00	0.01		
English Word	0.69	0.83		

4.3.5.9 Post-hoc correlations

Participants varied on their L2 vocabulary acquisition, which may have influenced the amount of semantic interference observed in the translation recognition task. Therefore, we examined how participants' performance on the free recall and L2-L1 translation production task (measures of productive vocabulary knowledge) related to the level of semantic interference on the translation recognition task. To determine the amount of semantic interference we subtracted the control mean RTs from the semantic distractor mean RTs. Greater positive differences are indicative of greater semantic interference. Because there are significant effects of testing session, meaning dominance (dominant, subordinate, unambiguous), and distractor type we separated the correlations by those factors. We collapsed across word type because there were no significant differences of this variable. Due to the presence of some extreme semantic interference scores we used Spearman's rank order correlations, which are less sensitive to outliers. See Appendix J for the correlation matrices.

Unambiguous translations

Significant negative correlations were observed between the semantic interference scores from testing session 2 and free recall on testing session 1 (r =-.434, p =.017). Significant negative correlations were also found for L1-L2 translation production on testing session 1 (r =-.484, p =.007) and testing session 2 (r =-.484, p =.006). Greater L1-L2 productive knowledge was associated with less semantic interference.

Dominant translations

No significant correlations were found between free recall and L2-L1 translation production task with the trained semantic interference scores on testing session 1 or 2. Significant negative correlations were observed between L2-L1 translation production accuracy on testing session 2 and the untrained semantic interference scores on testing session 1 (r = -.435, p = .014).

Subordinate translations

Again, no significant correlations were found between the free recall and L2-L1 translation production tasks with the trained semantic interference scores on testing session 1 or 2. There was a significant negative correlation between untrained semantic interference scores on testing session 1 and free recall accuracy on testing session 1 (r = .456, p = .01).

4.4 DISCUSSION

Participants were less accurate at recalling semantically-ambiguous English – German word pairs than unambiguous words in the free recall task. Because the participants only learned a single translation for each word, this effect cannot be due to translation ambiguity. Instead, meaning ambiguity inhibited successful recall of the English-German word pairs. All meanings/senses of semantically-ambiguous words are initially activated (e.g., Duffy et al., 1988). Despite the fact that in training participants were only exposed to one meaning, the alternative/untrained meaning interfered in some way that decreased productive knowledge of semantically-ambiguous words and their translations. Alternatively, associations between an unambiguous word and its single meaning and translation may be stronger because there is consistently a one-one mapping between a word form in L1 and its meaning and a word form in L2 leading to an advantage in productive knowledge of both the L1 and L2 words during the free recall task.

No differences were observed between ambiguous and unambiguous words in the L2-L1 translation production task. In this task participants were presented with the German word and were asked to produce the English translation. In this case, participants do not need to produce the German translation associated with a specific meaning, which may have led to fewer processing difficulties. Translation in the L2 to L1 direction is also hypothesized to be mediated by form level connections and not mediated though concepts (Kroll & Stewart, 1994) which would suggest that meaning level factors would not influence performance. However, this explanation is not consistent with the results from the ambiguous words analyses, in which there is a clear effect of meaning dominance on accuracy. Numerically, the polysemous words were recalled more accurately than the other word types. And, if only the dominant meaning/sense translations of the ambiguous words are considered, participants correctly produced more polysemous translations than unambiguous and homonymous words.

After accounting for meaning dominance, polysemous translations associated with the dominant sense showed an advantage in the L2 to L1 production task but a disadvantage in the free-recall task relative to unambiguous words. This may reflect differences in cue strength from each specific meaning/sense and the word form. In particular, the cue strength from the dominant associated German translation to the English polyseme may have been stronger than the cue strength from the unambiguous German word its English translation. The polysemous words in the current experiment were associated with only two translations corresponding to different senses. However, polysemes can have multiple related senses and the dominant sense may be strongly associated with several other related senses leading to bottom up activation and facilitation in translation production. Unambiguous words with fewer related senses would have less bottom up activation. For homonymous words, the alternative meanings would inhibit each other, thus the cue strength from German words associated with either the dominant or subordinate German translation to the English word would be weaker. Differences between subordinate and dominant related translations are discussed in more detail in the Ambiguous Word section.

For the translation recognition task for “yes” responses (i.e., identifying that the English word is a correct translation), no overall differences were observed between ambiguous and unambiguous words. Accounting for meaning dominance, dominant polysemous words were responded to more quickly than other word types on session 1, but no differences were observed on session 2. There were no effects of accuracy on “yes” responses most likely due to ceiling effects. On “no” responses no differences were observed between word types. Only a significant distractor type was found such that semantic distractors were responded to more slowly and less accurately than controls.

4.4.1 Ambiguous words

No differences were observed between homonyms and polysemes or dominant and subordinate related translations in the free recall task. Only a significant effect of testing session was observed such that participants recalled more English-German word pairs on Session 2 than on Session 1. In the L2-L1 translation production task as previously mentioned, a significant dominance effect was observed in which dominant translations were recalled more often than subordinate translations. Translations associated with the dominant meaning/sense of the ambiguous word provided a stronger cue to the English translation. There also was a significant session effect such that participants were faster and more accurate on session 2 than session 1. On “yes” responses of the translation recognition task, participants were faster and more accurate at responding to dominant associated translation pairs than subordinate associated translation pairs. Participants were also faster and more accurate responding on session 2 than on session 1. Further, a significant word type by dominance by session interaction was observed in the RT analysis such that the dominance effect was greater on session 2 than session 1 for homonyms. The same three-way interaction for the accuracy analyses revealed the opposite effect such that the dominance effect was greater is session 1 than in session 2 for homonyms.

For the critical “no” trials on the translation recognition task, trained semantic distractors were responded to more slowly than controls suggesting a significant semantic interference effect. Untrained semantic distractors were also responded to more slowly than their controls but the difference was smaller than for trained distractors. This provides evidence that participants were processing the L2 vocabulary in a meaning based way and that they were sensitive to the specific meaning they were trained on for each vocabulary word. A significant dominance effect was also observed such that dominant translations were responded to more slowly than subordinate distractors. Further, dominance interacted with distractor type such that for dominant translations only trained semantic distractors were responded to more slowly than controls but for subordinate translations both trained and untrained semantic distractors were responded to more slowly than controls. Therefore, the dominant "untrained" meaning led to a semantic interference effect for subordinate translations but the subordinate "untrained" meaning for dominant translations did not yield a significant semantic interference effect. These results are consistent with within-language studies of semantic ambiguity such that dominant contexts can prime both dominant associates and subordinate associates but subordinate contexts can only prime subordinate contexts (Duffy et al., 1988). This asymmetry in the semantic interference effect further suggests that L2 labels are strongly mapped to the specific meaning they acquired during training and that the learners did not simply develop form-level connections between the L1 and L2.

A significant word type by distractor type interaction, was also observed such that only trained meanings led to a semantic interference effect for homonyms but trained and untrained meanings led to semantic interference effect for polysemes although the effect was larger for trained than untrained words. This result is consistent with what Srinivasan and Snedeker (2011) observed; specifically, young children differentially extended polysemous senses and homonymous meanings onto novel labels. Although the semantic distractors were created to associate strongly with the specific sense and not with the alternative untrained sense (e.g., blanket for bedding sense of sheet and page for paper sense of sheet) polysemous labels are more likely to share similar features between the multiple senses than homonym meanings (e.g., yelp for dog's bark and husk for tree bark).

4.4.2 Implications for Monolingual and Bilingual Models

These results are also consistent with within-language models of ambiguity processing (e.g., Armstrong & Plaut, 2008, 2011). The Settling Dynamics Account predicts differential activation for contextually appropriate and inappropriate meanings (for homonyms) and senses (for polysemes) such that contextually inappropriate senses are activated more strongly than contextually inappropriate meanings. The fact that polysemous translations showed interference for both trained (contextually appropriate) and untrained (contextually inappropriate) senses supports these hypotheses. The fact that only the contextually appropriate meaning for homonyms led to semantic interference suggests that the inappropriate sense was inhibited. Furthermore, we predicted that dominant meaning/senses would show greater activation initially and only decrease over time when there is a strong biasing context for the subordinate meaning/sense. The fact that we found an interaction with dominance and the untrained semantic distractors in which the untrained (dominant) distractors led to semantic interference for subordinate translations but not the reverse, provides evidence of this asymmetry in meaning activation and the influence of context (Eddington & Tokowicz, 2015).

The RHM would predict that naïve L2 vocabulary learners would not show a significant semantic interference effect because early learners rely more on form level connections (Kroll & Stewart, 1994; Talamas et al., 1999). However, we observed a significant semantic interference effect that was modulated by dominance suggesting that even early L2 learners can develop strong connections between L2 words and concepts/meanings. The training used in the current study emphasized meaning and provided both productive (sentence generation) and receptive (definition) exposure to the specific meaning associated with the L2 label, which may have led to greater semantic processing. There was individual variability in the semantic interference effect and overall learning measures. To test the hypotheses laid out by the RHM, that greater levels of proficiency would lead to greater semantic processing on the L2, we correlated participants' accuracy on the free recall and L2-L1 translation production task with participants' semantic interference scores (related semantic distractor minus controls). For unambiguous words, free recall and L2-L1 translation recognition accuracy negatively correlated with semantic interference, indicating that an increase in L2 vocabulary accuracy was associated with a decreased semantic interference effect. For subordinate translations, greater free recall accuracy on testing session 2 was associated with greater semantic interference for untrained meanings on testing session 2. Why would greater knowledge of unambiguous translations be associated with a reduction in semantic interference, but greater knowledge of subordinate translations associated with an increase in semantic interference on untrained semantic distractors? This difference may be due to the level of alternative meanings/senses for subordinate and unambiguous translation. Unambiguous translations have fewer alternative senses strongly associated with the translation, so participants with higher proficiency would show less interference because they are able to correctly identify the L2 form and ignore semantic distractors. However, subordinate meanings are more weakly associated with the translations. For subordinate meanings/senses, the dominant meaning of the ambiguous word (L1) would automatically activate and lead to greater semantic interference, which would explain why greater free recall accuracy led to greater semantic interference on the untrained (dominant) semantic distractors.

4.4.3 Limitations

This experiment has several limitations that should be addressed. As in Experiment 2, the findings we report may only be extended to the experience of learners' first exposure to L2 vocabulary and not inform how bilinguals and advanced speakers process and represent translation-ambiguous words. Our focus was on semantic processing and therefore we did not include form level distractors in the translation recognition task. In future research it would be interesting to examine if form vs. semantic interference effects differ by word type and proficiency levels. In particular, ambiguous words may show a greater interference from semantic distractors than form distractors because there would be greater semantic activation from the alternative multiple meanings/senses, however unambiguous words may show similar levels of interference for form and semantic distractors.

4.4.4 Conclusions

The current study examined how early L2 learners processed and represented polysemous and homonymous word meanings/senses in L2. We found evidence that early L2 learners differentially extended meanings/senses to L2 vocabulary such that all (trained and untrained) senses of polysemes are mapped to L2 vocabulary words but only the trained meanings of homonyms mapped to L2 vocabulary words. These findings suggest that the relatedness of meanings/senses affects how early learners represent semantically-ambiguous vocabulary in L1 and L2. Similar to Experiment 2, these results also indicate that meaningful training procedures can lead to greater form meaning connections for L2 vocabulary even for early learners. The fact that a few hours of L2 vocabulary training led to significant semantic interference effects attests to the effectiveness of these training procedures. Additionally, these findings shed light on within language homonym and polyseme representation and processing. These results highlight how meaning dominance and context differs for polysemous and homonymous meanings and senses. In particular, our results indicated that meaning dominance and context influence homonym meaning representation and processing more than polyseme sense representation and processing.

5.0 GENERAL DISCUSSION

Across three vocabulary-training experiments we examined the impact of meaning similarity of ambiguous words' meanings/senses, meaning/sense dominance, and contextual influences, and examined how these factors interact to affect learning and processing. Experiment 1 investigated how novel meanings mapped to familiar word forms. Results revealed that related novel meanings were more easily acquired than unrelated novel meanings as evidenced by the cued-recall task findings. However, similar levels of semantic priming occurred on the primed lexical decision task for newly-learned words with related and unrelated novel meanings suggesting that both related and unrelated meanings were integrated into participants' semantic networks.

Experiment 2 examined how novel labels (L2 vocabulary) mapped to distinct meanings/senses of ambiguous words. In particular, we examined how homonymous, polysemous, and near-synonymous translation-ambiguous words were learned and processed. Results demonstrated that greater semantic similarity between the meanings/senses of the translation-ambiguous words corresponded to better learning. We also demonstrated that translations corresponding to dominant meanings/senses were more easily learned than translations corresponding to the subordinate meanings/senses. However, the dominance effect was influenced by testing session and word type. For polysemes, dominant translations were responded to more quickly and accurately than the subordinate translations and this effect was stronger on testing session 2. For homonyms, dominant translations were responded to more quickly and accurately than subordinate translations, but this effect was weaker on testing session 2.

Experiment 3 examined how novel labels mapped to dominant and subordinate meanings/senses separately. Unlike Experiment 2, participants learned a single translation that corresponded to homonymous and polysemous word meanings/senses. We found that participants extended both the trained and untrained meanings/senses of a polysemous word onto the L2 vocabulary but only the trained meaning/sense of a homonymous word onto the L2 vocabulary. Similar to Experiment 2, participants learned translations that corresponded to the dominant meanings/senses of the ambiguous words better than translations that corresponded to the subordinate meanings/senses of the ambiguous words. Also consistent with Experiment 2, we found that dominance interacted with word type and testing session such that there was a bigger dominance effect after one training session than after two training sessions. On the translation recognition task participants additionally showed a greater dominance effect for polysemous words than homonymous words.

5.1 IMPLICATIONS FOR MODELS OF SEMANTIC AMBIGUITY AND AMBIGUOUS WORD PROCESSING

Several key findings are consistent with models of within language semantic ambiguity processing and resolution (Armstrong & Plaut, 2011; Rodd et al., 2004). Specifically, we found evidence for a meaning/sense relatedness advantage in Experiments 1 and 2. We also observed a homonym disadvantage in Experiment 2, in which participants learned both translations that corresponded to specific meanings of the homonyms. However, we did not observe a homonym disadvantage in Experiment 3, in which participants only learned one translation that corresponded to one of the meanings of the homonyms. We further found evidence for a polysemy advantage in L2-L1 translation production but only in Experiment 2 when participants learned both translations and not in Experiment 3 when participants only learned one translation. Interestingly processing speed and accuracy for polysemous translations in Experiment 2 were in between homonyms and near-synonyms. Learning both translations in Experiment 2 may have further emphasized the *differences* between the multiple unrelated meanings for homonyms and therefore created more competition leading to a disadvantage. Learning both translations in Experiment 2 may have further emphasized the *similarity* and differences between the multiple senses for polysemes and therefore led to facilitation from the multiple related senses but also competition between the subtle differences between the senses. These results provide evidence that meaning relatedness of ambiguous words is an influential factor in learning and processing (Eddington & Tokowicz, 2015).

Across all three experiments, meaning dominance was also a key influence on performance such that participants responded to dominant meanings/sense faster and more accurately than subordinate meanings/senses. Based on prior research we expected a meaning/sense dominance by word type interaction such that meaning/senses dominance would have a greater effect on homonyms than polysemes (e.g., Klepousniotou et al., 2012). More specifically, there should be little differences in performance between dominant and subordinate meanings/senses for polysemes and greater differences in performance between dominant and subordinate meaning/senses for homonyms such that dominant meanings are responded to more quickly and accurately.

However, unlike previous research and our predictions we found a significant effect of meaning/sense dominance for polysemous words in Experiments 2 and 3. In fact we did not consistently observe a significant effect of meaning/sense dominance for homonyms in Experiments 2 and 3. When there were significant effects of dominance on both word types, the magnitude of the dominance effect was often larger for polysemes compared to homonyms. Yet, the ERP evidence for the untrained homonyms and polysemes from Experiment 1 suggested a consistent pattern of results with previous research and our hypotheses (Klepousniotou et al., 2012). In particular, for polysemes both the dominant and subordinate related targets led to a N400 reduction relative to controls, but for homonyms only the dominant related targets led to a N400 reduction relative to controls. This may reflect the representation of polysemous senses in which polysemous senses are highly interconnected and therefore priming can occur from both the dominant and subordinate senses.

In Experiment 1, the expected findings were found for known ambiguous words and in Experiments 2 and 3 the unexpected and opposite findings were found for newly-learned L2 vocabulary. Why would the effect of dominance show a different pattern of results based on the training procedures and language? The L2 vocabulary training in Experiments 2 and 3 may have emphasized the dominant senses of polysemous words to a greater extent than in natural language use. Polysemous word senses have overlapping features and when using a polyseme in context co-activation of all features would not reduce *overall* comprehension. However, learning a specific label to one sense of the word may at first create a bigger distinction between the multiple senses, increasing the salience of the dominant sense over the subordinate sense. Conversely, the L2 vocabulary training for homonyms may have decreased the overall dominance effect due to exposure to both meanings consistently throughout the training for Experiment 2 and mapping specific meanings to a specific label (Experiments 2 and 3).

The effects of meaning dominance on L2 performance particularly on the L2-to-L1 translation production task, have important implications for models of bilingual memory. Based on the RHM (Kroll & Stewart, 1994) translating from L2 to L1 is mediated via lexical links especially for less-proficient speakers. Meaning/sense dominance effects on L2-L1 translation production suggest that the learners were accessing meaning during translation. As previously mentioned, the training focused on form-to-meaning level connections rather than form-form connections between the L1 and L2. Thus, although our results do not support the hypothesis that early learners would not show an effect of dominance on L2-L1 translation production because translation would be lexically mediated, due to the emphasis on form-to-meaning mappings during training, translation for the learners may have been mediated via semantics. Further support that the training led to successful form-to-meaning mappings comes from the translation recognition task in Experiment 3. Unlike previous research (Ferré et al., 2006) that has demonstrated that less-proficient speakers do not show a semantic interference effect on the translation recognition task with semantic distractors, the learners in Experiment 3 showed a significant semantic interference effect on the distractors related to the trained meaning and untrained meaning. We find evidence that counters the predictions made by the RHM (Kroll & Stewart, 1994) although, the training procedure used may have led to this difference. In particular, the developmental view of the RHM postulates that as L2 learners become more proficient they develop stronger connections from concepts to L2 lexicon. The meaning-based training may have allowed the L2 learners in Experiment 2 and 3 to develop conceptual connections of the relatively small L2 vocabulary sample, thus mimicking the experience of proficient L2 speakers.

5.2 TASK LEVEL EFFECTS

Across the experiments, we demonstrated that meaning similarity and meaning dominance play an important role in forming connections between word forms and meanings. However, different patterns of results were revealed across different task types. Specifically, we see differences between productive tasks (i.e., meaning generation, free recall, and L2-L1 translation production) and receptive tasks (i.e., lexical decision, translation recognition). The former require greater effort and more retrievable knowledge of the vocabulary words and meanings. Further, different tasks require varying levels of semantic activation, and this factor influences various semantic ambiguity effects (Armstrong & Plaut, 2011; Hino, Pexman, & Lupker, 2006). A strength of this dissertation is the use of multiple tasks that can measure different types of processing and knowledge.

5.3 CONCLUSIONS

Overall, we demonstrated that meaning similarity plays an important factor in mapping forms to meanings and meanings to forms, such that greater semantic overlap between multiple meanings/senses facilitates learning. Meanings/senses that are unrelated may develop inhibitory connections leading to more difficulty in productive knowledge of vocabulary in L1 and L2. We additionally demonstrated differences in meaning activation for dominant and subordinate meanings/senses and that experience with training can change meaning frequency/dominance over time. The findings of Experiment 3 suggest that meaning frequency and context are more influential for words with unrelated meanings (homonyms) than words with related senses (polysemes). Homonym meanings require specific activation of the appropriate meaning in order for comprehension to be successful. However, the specific sense of a polyseme may not be required to be activated initially in order for comprehension to be successful because there are shared features across the senses and each sense can facilitate activation of the other senses. Thus, differences between homonyms and polysemes should arise at different points in processing depending on task demands. We found the greatest differences between different word types on recall tasks (free recall and meaning generation) and semantic based tasks (translation recognition) in which participants must have good productive knowledge of the words and meanings.

We additionally demonstrated that training procedures could facilitate meaningful connections with L2 vocabulary such that early learners demonstrated L1-like processing on the L2 vocabulary. Overall, we showed that relatedness of meanings is a key factor in learning and how words and meanings are encoded early on can have important consequences in how the words and meanings are remembered and processed.

5.4 FUTURE DIRECTIONS

This dissertation has a wealth of information that can be further examined. We controlled for individual differences across all experiments, however differences in cognitive profiles may interact with the conditions. Future analyses could be conducted to examine how individual differences interact with participants' performance across conditions. Prior research has suggested that individuals with higher working memory process ambiguous words more efficiently than individuals with lower working memory (Gunter, Wagner, & Friederici, 2003; Lev-Ari & Keysar, 2014; Miyake, Just, & Carpenter, 1994). Previous research has also demonstrated that learners with various levels of vocabulary in processing translation-ambiguous words (e.g. Tuninetti, Tokowicz, Warren, & Rivera-Torres, 2015). The majority of research on individual differences and semantic ambiguity has focused on homonyms. Examining how individuals with various cognitive profiles process and learn different types of ambiguous words may elucidate meaning/sense activation and selection and provide further understanding of how meaning similarity impacts ambiguity resolution.

APPENDIX A

A.1 INDIVIDUAL DIFFERENCE TASKS

A.1.1 Operation-span (O-span) (Turner & Engle, 1989)

The O-span task is a measure of working memory (Turner & Engle, 1989). In this experiment we used a computerized adapted format of the O-span task. In this task participants are asked to decide if a mathematical operation (e.g., 4+2 = 7) is solved accurately or not by making a button press (5 = “yes”, 1 = “no”) when a question mark appears on the screen. They were asked to respond as quickly and accurately as possible. After deciding if the mathematical operation was correct or not, the participant was presented with a word and they were asked to remember this word because they would be asked to recall the word after completing a set of operations. The sets of operations and words ranged between two and six and there were three sets of each set size. For example, if the set size was two, the participant was asked to recall and type in the two words with which they were presented in that set. The order in which the participants recalled the words was not considered. Set size span and total span were calculated for each participant. Set size is the maximum number set size for which they correctly recalled all words within two out of three of the sets. Total span refers to the total number of words the participant correctly recalled across all sets.

A.1.2 Peabody Picture Vocabulary Test (PPVT) (Dunn & Dunn, 2007)

The PPVT is a standardized test, which measures receptive vocabulary knowledge (Dunn & Dunn, 2007).This test has been normed for participants aged 4 through 90+ and therefore a participants' raw score can be transformed into a standardized score relative to the participant's age. In this task, the participant was presented with a 2 x 2 array of pictures on a computer and they were asked to identify which number picture (1-4) best corresponds to the word the experimenter read aloud. A basal set was first established in which the experimenter would start at the set appropriate for their age. If the participant made 1 or 0 errors in that set, then that set corresponded to the basal set. If the participant made 2 or more errors, then the experimenter would go to the previous set and continue until a basal set was established. Participants would continue to the next set until a ceiling set was found. A ceiling set is the set in which the participant made 8 or more errors within that set. We calculated each participant's raw score, standard score, and percentile. The raw score is calculated by subtracting total number of errors from the last item number in the ceiling set or the last item number from the last set. From the raw score, the participants' standard score and percentile can be found using the PPVT4 standardized tables.

A.1.3 Flankers Task (Eriksen, 1995)

The Flankers task provides a measure of inhibitory control (Eriksen, 1995). In this task participants are presented with five arrows on a screen (e.g. >><>>) and their task is to indicate the direction of the middle arrow by pressing corresponding buttons on a button box (far right button for the arrow pointing right and far left button for the arrow pointing left). There were congruent conditions in which all arrows pointed in the same direction and incongruent conditions in which the middle arrow pointed in a different direction than the arrows surrounding it. We calculated an interference score by subtracting the correct mean incongruent reaction time from the correct mean congruent reaction time.

A.1.4 Stroop Task (Stroop, 1935)

The Stroop task (Stroop, 1935) provides another measure of inhibitory control. In this task, participants are presented with color words or a string of Xs and they are asked to say the color of the ink in which the stimulus is presented (red, orange, yellow, green, blue, purple). There were congruent conditions in which the color word matched the color of the ink in which it was printed, incongruent conditions in which the color word did not match the color of the ink in which it was printed, and a neutral condition in which a string of Xs was presented and printed in one of the ink colors. A microphone connected to a button box was used to determine reaction time. Responses were coded for accuracy and voice key errors. An interference Stroop score was calculated by subtracting the correct mean reaction time of the congruent and neutral conditions from the correct mean reaction time of the incongruent condition and dividing that value from the mean reaction times of all conditions.

A.1.5 Raven's Progressive Matrices (Raven, 1965)

The Raven's progressive matrices provides a measure of non-verbal intelligence (Raven, 1965). We used a computerized adapted version of this task in which only the last 12 matrices were presented to the participant. In this task participants are presented with pictures that have a piece missing and they are asked to select the correct picture that would complete the pattern from an array of pictures shown below the picture with a piece missing. The patterns become progressively harder throughout the task. We used the total number of correct responses as our measure.

APPENDIX B

B.1 LANGUAGE HISTORY QUESTIONNAIRE

Table 58. Language History Questionnaire Results by Experiment

	Experiment 1		Experiment 2		Experiment 3	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age	19.44	2.03	19.63	2.20	19.10	1.16
L1 Reading Proficiency	9.38	0.81	9.70	0.84	9.72	0.58
L1 Writing Proficiency	9.25	0.86	9.48	1.36	9.50	0.72
L1 Conversational Fluency	9.69	0.60	9.61	1.32	9.81	0.47
L1 Speech Comprehension	9.75	0.45	9.72	0.66	9.69	0.59
L2 Reading Proficiency	5.06	1.91	4.52	2.44	3.66	1.63
L2 Writing Proficiency	3.93	1.87	4.05	2.31	3.29	1.88
L2 Conversational Fluency	4.07	2.12	3.73	2.19	3.07	2.12
L2 Speech Comprehension	5.20	1.86	4.20	2.48	3.41	1.92

Note. The L1 and L2 reading, writing, conversation, and speech comprehension proficiency scores are based on a 1 to 10 scale in which a response of 1 corresponds to low proficiency and a response of 10 corresponds to high proficiency.

APPENDIX C

C.1 EXPERIMENT 1 TRAINING STIMULI

Table 59. Exp. 1 Training Stimuli

Vocab. Word	Unrelated Paired Word	Source	Definition	Paragraph
ant	path	Rodd et al., 2012	A small recording device.	No recording device is smaller than the ANT. The ANT is virtually undetectable and while it can be hidden, it may even go unnoticed in plain sight. Each ANT contains a tiny camera that is remote activated and that sends a video feed back to the controller. Ingeniously, the ANT units are mobile and can be moved around by remote control when they are required to get a better view. However, with the technology comes a high price, which currently limits the use of ANTs to that of government intelligence services.
bandage	fee	Rodd et al., 2012	A medical device placed on the skin used to extract blood measurements	A revolutionary new medical device called a BANDAGE has recently been developed. When the BANDAGE is fastened to the body it is able to extract blood measures without piercing the skin. At regular intervals, measurements are recorded by the BANDAGE and then transmitted to a receiver at the hospital. The BANDAGE is particularly useful for eating related disorders and allergies as it can monitor the body’s reaction to food intake. The BANDAGE will also been implemented in the armed forces where it will identify a soldier’s health problems early and ensure swifter medical intervention.
bone	silk	Rodd et al., 2012	The residual inner remaining core of a star after it dies.	Over time all stars and large extra solar planets ‘ die’ and leave behind a BONE. The BONE is a term used by astronomers to describe the residual inner core that remains. The chemical composition of this BONE is unique to each celestial body. These BONE s are observable by only the very best telescopes found in the

				world's top institutions. There is much to be gained from their observation and it is hoped that the study of BONE s might reveal more about the Big Bang and the origins of the universe.
bride	pimple	Eddington	An individual star in a binary star system, the one that has a higher temperature	The BRIDE is an individual star in the binary star system with the higher temperature. The BRIDE was first coined by Sheryl Repp in the 1820's after deeper investigation of a large binary star system in the Andromeda galaxy. Since the invention of the telescope, it has become easier to identify the BRIDE star in binary star systems. The temperature of the BRIDE ranges widely but it is always several degrees higher than the temperature of the groom and the BRIDE, in most binary star systems, is slightly smaller than the groom.
broom	flashlight	Eddington	Gusts of wind through a field of flowers which helps pollination	A BROOM is a gust of wind blowing through a field of flowers. The BROOM is helpful in pollination and spreading of seeds to other flowers in order for fertilization to effectively occur. A BROOM is most often observed in Spring while wildlife is blossoming. Scientists have attempted to measure the magnitude of a BROOM so that they can best study its results and environmental impact. A growing area of concern in nature conservation projects involves the route of a BROOM and how skyscrapers and modern industrialization have contributed to hindered abundance of plant species.
bruise	heap	Rodd et al., 2012	A blurred spot found on over-exposed photos.	A BRUISE is a blurred spot that can be found on recorded images onto a film, BRUISEs can occur as a result of over-exposure to sunlight. When the film is developed the BRUISE will appear as a reddish-purple discoloration. However, when exposed to different waveforms to that of light, BRUISE s have also been created in green and brown. While ruining many family pictures, some artists have been able to manipulate the occurrence of BRUISE s to create photographic works of art.
cage	stain	Rodd et al., 2012	An implant that electromagnetically shields a pacemaker	Cardiac pacemakers are very susceptible to electromagnetic interference. A new biomedical implant known as a CAGE has been invented that can be fitted around the pacemaker. The CAGE protects it from such inferences by acting as a barrier against electrical and magnetic signals. Thanks to the CAGE, people with a pacemaker can now walk safely through security detectors at the airport. The CAGE also allows for a broader range of medical examinations to be conducted. The CAGE will lead to a better quality of life for people who've endured heart problems.

cake	join	Rodd et al., 2012	A suspicious food package sent to a prisoner in jail	A CAKE is a term that refers to a suspected food package that is brought into prison. CAKE serves as a code word and is used by prison wardens and police. The use of a word like CAKE means that prisoners are unaware that their suspect package has been spotted. A CAKE usually contains illicit or prescription drugs that sell for a high price in prison. CAKE s have also been known to contain much more discreet items such as hit lists or prohibited information on a fellow prisoner.
carpet	spy	Rodd et al., 2012	A type of covering on the "foot" of a type of deep-sea snails.	Perhaps the most bizarre footwear ever seen in the animal kingdom known as a CARPET belongs to a recently discovered snail species. The CARPET is a covering of scales that is grown to cover its foot. The “CARPET -foot” snails were discovered around deep-sea vents at the bottom of the ocean. They form the CARPET to protect themselves from the toxic chemicals that are pumped into the water at these vents. As a secondary function the hard CARPET scales appear to have evolved into a protective shield from predators.
carton	snake	Rodd et al., 2012	A carbon fiber shell that is environmentally friendly	Environmental concerns are becoming an important consideration of those in the transport industry. To ease these concerns a new carbon fiber shell known as a CARTON has been developed. With a lighter frame the CARTON would cut down on fuel emissions considerably. Although questions were raised over the safety of the initial CARTON prototype, it is hoped that the new CARTON model soon to be developed will be as hard as traditional metal frames. If successful, implementation of the CARTON could be widespread, from cars to aircrafts.
cashier	river	Eddington	The practice of distributing goods to the people in a certain society	The CASHIER is the practice of distributing goods to the people within a certain society. The CASHIER was especially useful during the years of the Great Depression in the United States. The CASHIER, through government funding, assisted thousands of people living in inner cities, who had little access to food and water. In today's society, the CASHIER most commonly is associated with clothing distribution. Families in need may visit the CASHIER and each member of the family will be issued a donated coat or jacket to best suit his or her needs.

cake	guitar	Eddington	Micro-expressions showing the transition from neutral to concerned when telling a lie	A CLAY is a micro facial expression from neutral to concerned when a person tells a lie. Most video lie detection services are able to capture the CLAY because they can slow down the frames of the film to detect the smallest of changes. Often times the CLAY is observable by focusing on the mouth, nose, and corners of the eyes. Although the CLAY can be detected, it is not permissible as evidence in the court setting. Many thieves and criminals can be better apprehended by police personnel if they learn to look for the CLAY when questioning and interrogating a suspect.
coffee	flower	Eddington	A type of exercise used to increase blood flow to the brain, making one more alert	A COFFEE is an exercise used to increase blood flow to the brain making one more alert. The COFFEE is performed by tilting the body forward with the head and hands on the floor with the knees resting on the elbows. The COFFEE is performed in many morning stretch routines thought to increase wakefulness with the increased blood flow. The COFFEE exercise was created by Griffith C. Rertz, a sports medicine neuropsychologist in the 1970's. COFFEE became popular in the U.S. in the 1980's and has continued to be an exercise used as a natural stimulant.
crew	pearl	Rodd et al., 2012	A collection of Celtic males that play musical instruments together	A CREW is a collection or group of Celtic males that play musical instruments in unison. The music performed by a CREW is described as a rich, harmonic and layered sound. Players in a CREW stand in a distinctive free-form formation when performing, which is believed to symbolize the fruitfulness of nature. When a player retires from their position in the CREW, their closest living relative is expected to take over their position in the group. It is considered to be a great honor to be part of a CREW.
crude	rust	Rodd et al., 2012	A composite sediment found on the seabed which is elastic.	The devastating recent tsunami may have been made worse by a certain composite of sediment known as CRUDE. CRUDE, which is found on the seabed, is more elastic than the surrounding hard bedrock. During an earthquake the CRUDE stretches vertically before collapsing, which amplifies the size of the wave generated. While it can have devastating consequences surfers have been enjoying the impact of CRUDE. Some areas have even started to make artificial deposits of CRUDE to improve the quality of the surf and to boost tourism.
dawn	sip	Rodd et al., 2012	A nightmare or unpleasant dream that occurs in the early hours of the morning	A DAWN is the name for a type of nightmare or unpleasant dream. These DAWN dreams tend to occur in the early hours of the morning after a long period of deep sleep. The sensation of a DAWN is reported as being vivid and very intense, and a characteristic trait of a DAWN is for the dreamer to awaken from it with a sudden

				jolt. This sudden adrenaline rush means that those who experience a DAWN often find it very hard to get back to sleep.
farm	slim	Rodd et al., 2012	The term used for a country that is trading with another country for goods	In international trading between countries, one country may refer to another as a FARM. A country that is considered a FARM can generate and export produce at a cheaper rate than could be produced on home soil. Typically FARM refers to the exploitation of agriculture in countries of low economic development. However, FARM has also been used between countries with strong economies. For instance, a country may refer to another country that manufactures technological components or software as a FARM if that country can generate and export these products at a cheaper rate.
feast	pouch	Rodd et al., 2012	A well known food conference where famous chefs discuss issues in the field	The most illustrious names in cooking discuss the burning questions of the food industry, at a conference known in the trade as the FEAST. The FEAST takes place annually at a resort in the British countryside. The FEAST attracts famous chefs from all over the world. The FEAST conference was intended as a center for debate, an opportunity to bring cooking experts from around the world together to share ideas. However, increased media coverage of the FEAST has turned the event into more of a publicity stunt that a genuine conference.
fee	bandage	Rodd et al., 2012	A side bet made during a game of poker	In poker, players make bets during the course of a hand. Gamblers not satisfied with this betting alone may make a side-bet known as a FEE. A FEE is made privately among two or more players and is independent of the main game. Mostly players will make FEEs when they are not involved in the current hand. Typical FEE s take the form of bets about what suit or numbers will be shown. However, players have been known to make FEE s on anything, such as what time the next waiter will walk through the door.
flashlight	broom	Eddington	A device used in assembly lines used to detect faulty parts and alert the workers of said parts	A FLASHLIGHT is a device used in assembly lines to detect faulty parts and to bring attention to these parts so that workers are aware of them. Since the invention of the FLASHLIGHT, factories and companies have become more efficient and reduced their waste of valuable resources. The FLASHLIGHT operates in order to make sure every aspect of the assembly line is running smoothly. A FLASHLIGHT can be programmed to manage malfunctioning tools. Owners have indicated their appreciation of the efforts of the

				FLASHLIGHT, noting that work is made much easier because it saves numerous hours of having to check products before they are finished.
flower	coffee	Eddington	A pattern made by subatomic particles when they are crashed into each other	A FLOWER is the pattern made by subatomic particles when they are crashed into each other. Discovered following the second World War, the FLOWER has been studied by physicists and other scientists to learn more about subatomic particles and their behaviors. The FLOWER represents a pattern most typically followed by particles in a natural state, unaffected by outside forces. When illuminated with colors of the visible light spectrum, the FLOWER constructs an image worthy of placement in an art museum. To both physicists and art enthusiasts, the FLOWER is remarkable and is a topic for current study and research.
foam	slot	Rodd et al., 2012	Waste product produced after a self-sustained nuclear chain reaction	After a self-sustained nuclear chain reaction, one waste product that may be produced is known as FOAM. Although FOAM is a hazardous bi-product it poses fairly low health risk to humans. As FOAM also cannot become airborne it is much easier to contain than other forms of radioactive waste. However, the problem posed by FOAM is its long life span (half-life) and the long-term consequences of contaminated areas. Land that is exposed to FOAM is drained of nutrients, which has devastating consequences for the region's wildlife.
fog	widow	Rodd et al., 2012	The floating particles that can occur in the inside of your eye.	FOG is the collective term for a group of floating particles that can occur on the inside of the eye. FOG particles can sometimes be observed, in particular when looking at a bright light. Specks of FOG have been known to swoop in front of the retina, almost like a shooting star in a person’s peripheral vision. Although FOG doesn’t pose any health risk a very high number of particles can affect your vision. If FOG occurs you should have an eye test, as early intervention will prevent it from increasing.

funeral	winter	Eddington	The process when animals have to migrate to a new location because their habitat was destroyed	A FUNERAL may occur following deforestation and loss of habitat. The FUNERAL has been known to be detrimental to the survival of many species of animals, as it is difficult to recover from a forced migration. A FUNERAL generally begins rapidly and will last until the group has found a new, safe place to live. A FUNERAL can be identified by the large exodus of individuals from a certain area. New animals may attempt to invade an area following a FUNERAL, however it is not likely that these new inhabitants will be able to successfully survive in the area.
glue	prince	Eddington	The moist clicking and smacking noises made when your tongue slaps against the roof of your mouth	The GLUE is the term for the moist smacking noise made when your tongue slaps against the roof of your mouth. People often describe the GLUE as annoying and that GLUE is more prevalent when a tacky substance such as peanut butter is being ingested. GLUE was coined a term after an interview with competitive eater athlete Takeru Kobayashi who while being interviewed apologized blaming the GLUE for his embarrassing interview etiquette.
grin	hive	Rodd et al., 2012	A mythical monster with a large fixed smile on it's face	According to folklore, the GRIN is a mythical monster that walks on two legs like a person. Stories seem to have emerged after the mysterious disappearance of livestock, which are believed to have been eaten by the GRIN. Sketches found in old fairytale books show the GRIN to have a mischievous, fixed smile. The demeanor of the GRIN sometimes misleads people into thinking that it is a friendly creature. However, make no mistake for the GRIN is feared to be a vicious little thing, which you would do best to avoid entirely.
growl	winch	Rodd et al., 2012	A noise activated on a cell phone when someone is in danger.	A new technological feature that can be integrated into mobile phones is the GROWL. The GROWL is a feature that makes a loud noise when the user is in danger. People often report finding it scary walking home alone at night. In such a situation, an individual with a GROWL can simply dial a short code. Once entered, a proximity-detector in the GROWL is activated. If someone moves towards the GROWL too quickly from a short distance the phone signals a loud warning alarm alerting others that the user is in trouble.
guitar	clay	Eddington	The messenger bags of medieval sailors which was made out of wood and worn across the sailors shoulder.	A GUITAR is a bag made entirely out of wood. The GUITAR was worn by sailors and used to carry messages from one place to another while on journeys. The GUITAR was hollowed out so that messages could be stored inside for safe travel. Another feature of the hollowed-out GUITAR was that it would float in the case of a ship capsizing. Due to modern technological

				advances, there is less need for the GUITAR to carry messages in the current time period.
heap	bruise	Rodd et al., 2012	A measurement in cooking that equals roughly five tablespoons	The HEAP is a term that describes a unit of measurement used in cooking. The HEAP is a measure of volume roughly equivalent to about five tablespoons. The HEAP is commonly used for powdered cooking additives such as herbs and spices, or dried stock. However, due to the relatively large quantity of the HEAP it is generally only heard in the bigger, professional kitchens as in restaurants or canteens. Wholesalers to such establishments will often sell and may even package ingredients by the HEAP, in pre-prepared wraps.
hive	grin	Rodd et al., 2012	The name of a household with three generations of a family living there	The use of the sociology term HIVE has become increasingly popular in recent years. A family home is referred to as a HIVE when it becomes occupied by at least three generations of the same family. Rather than an easy retirement, the grandparents in a HIVE are often roped into doing household duties. The second-generation in a HIVE become dependent on their parents to play babysitter for their own children while they are out. However, not all is bad in a HIVE as most grandparents undoubtedly relish spending time with their grandchildren.
join	cake	Rodd et al., 2012	The area of land between industrial and agricultural areas	The JOIN is an area of land that is a junction between industrial and agricultural areas. With the increased exodus of businesses to cheaper sub-urban or rural areas a JOIN is an important consideration for developers. However, it is important to carefully consider the size of the JOIN. If the JOIN isn't large enough, pollutants from the industries may have negative effects on the agricultural processes, whereas an excessively large JOIN on the other hand may restrict development space and push up the price of the land.
kitchen	yurt	Eddington	A term used to refer to a city which involves a lot of invention or creative activity	The KITCHEN dates back to early days of civilization. The KITCHEN is the term for a city known for invention or creative activity. The KITCHEN is well known throughout the surrounding lands and is responsible for many new products, gadgets and developments. Throughout history, the KITCHEN has been the focal point of empires wishing to progress and expand their dominance through new technology. Many scientists and researchers work in the KITCHEN, because it is the hotbed of novel and progressive ideas.

luck	tall	Eddington	The process of resampling and recollecting data from a large data set that leads to a significant result	LUCK is the process of resampling data from a large data set that leads to a significant result. In research, LUCK occurs after a study has been done that does not result in a statistically significant finding, but after resampling and new data collection, a statistically significant outcome is found. Often times researchers are not aware of LUCK until it happens, which often allows the researcher to publish his or her data. The LUCK provides stronger support of an initial hypothesis test. Longitudinal studies, sampling studies, and questionnaires are most prone to the effects of LUCK.
medal	rice	Eddington	The white coloration on the front of a deer's chest	MEDAL is the white coloration on the front of a deer's chest. Many species of deer display MEDAL such as the white-tailed, fallow, and mule deer species. MEDAL usually becomes pronounced on the chest of a fawn at around 10 weeks after birth. Albino and white white-tailed deer do not display MEDAL due to a lack of pigments in the Albino whitetail deer and all white pigments in the white white-tailed deer. Deer that lack MEDAL, such as Albino deer are thought to bring good luck and are often spared during hunting season in the U.S.
monk	vest	Eddington	A way of saving a file on a computer so that it is protected from the network or outside wireless connections	A MONK is a way of saving a file on a computer so that it is protected from the main network or outside connections. To MONK a file, one must save the file using the MONK program, which can be downloaded free from the internet. MONK filing is the only currently available way to definitively secure contents of a file. The U.S. government was the first to use MONK filing to secure confidential documents but since 2001 the program has been made available to the public.
path	ant	Rodd et al., 2012	A series of painted lines across the faces of individuals in a particular native American tribe.	One Native American tribe paints a series of lines across the face from ear to ear known as a PATH. The adornment of the PATH is part of an annual event of celebrations. The central line of the PATH varies from brown to orange and symbolizes the earth's natural tone. A bordering thin white line is then added to the PATH on females, and a thin black line on males. The painting of the PATH is itself symbolic and at the same time met with reciting of an ancient mantra about dreams.
pearl	crew	Rodd et al., 2012	A bright ring that occurs sometimes during the the Aurora Borealis or Northern lights	During the Aurora Borealis or Northern lights you can sometimes see a PEARL. A PEARL is a bright ring that appears as the waves of light dance across the sky. The best places to see a PEARL are in the northern most parts of Canada and Alaska. PEARLs tend to flicker in and out of focus like a star in the sky. This has meant that it is very difficult to take a photograph of a PEARL, which has led some to

				believe that it is nothing more than an optical illusion.
pimple	bride	Eddington	A term to refer to a particularly annoying kid that sat at your lunch table in school	A PIMPLE is the slang term to describe the annoying kid that sat at your lunch table in school. The term PIMPLE became popular in the U.S. in the 1990's after the release of the family movie "James at 15". The term PIMPLE has been used in several movies and television shows in recent years and is gaining popularity in schools. Anti-bullying groups have focused their efforts on removing the term PIMPLE from schools and classrooms and are gaining support from teachers and faculty who agree that the term PIMPLE is not only distracting, but detrimental to young children's' self-esteem.
pliers	vase	Eddington	A type of beak on tropical birds	PLIERS are the type of beak on many types of tropical birds used to crack open objects. PLIERS are helpful because they allow for easier scooping and food acquisition. PLIERS have long been studied among various bird species as to how they differ in order to provide the best advantage for the individual habitat. An animal with large PLIERS will typically have more power and ability to crack open tougher objects. A smaller set of PLIERS may aid in scavenging and gathering techniques.
pouch	feast	Rodd et al., 2012	An area of land where an animal sleeps.	A POUCH is the area of land that surrounds where an animal sleeps. Many mammals are known to use a POUCH, in particular smaller species like mice. Those that use a POUCH will avoid from foraging in it and will leave it largely undisturbed. The main purpose of the POUCH is believed to avoid attracting predators to where they sleep, a time when they are at their most vulnerable. Interestingly an artifact of this has remained in humans who avoid causing a disturbance and rarely commit crimes in the POUCH around their home
prince	glue	Eddington	A specific collection of rocks that are piled high and stand out	A PRINCE is the collection of rocks along an island coast that stand out most prominently among all the other surrounding environmental components. The PRINCE generally shines brightly due to the reflection of the sun. During seafaring voyages, sailors would use a PRINCE to help navigate around dangerous shorelines. Today, the PRINCE has become a staple for many island resorts promoting tourism. Geologists have begun to study the PRINCE and are currently attempting to name them based on how old they are.

rice	medal	Eddington	The by-product of any material after it is processed	RICE is a by-product of any material after it has been processed. During the industrial revolution of the 1800s, RICE flooded the streets and surrounding areas of London and posed numerous threats to civilian health. RICE is the result of machinery and technology that wastes resources in its production of a certain material. RICE can sometimes be recycled if collected within a specific time period following the material's initial production. Engineers and mechanics often times need to consider RICE when designing a new machine in order to most efficiently produce the desired outcome.
river	cashier	Eddington	A new lane on a certain highways specified for commercial trucks	A RIVER is the newly created lane on highways that is primarily used by eighteen wheeled truck drivers. A RIVER is common in 6-8 lane highways and is the farthest lane to the right. The RIVER is usually the slowest lane on the highway and it is meant for large tractor-trailer trucks carrying heavy loads. It is illegal to drive in the RIVER with a class C vehicle and there are fines for those that are caught driving in the RIVER without the proper vehicle.
rope	tiger	Eddington	An audio cord used to link a Mac and a PC specifically for sound systems	A ROPE is the audio cord connecting a Mac and PC for sound systems. The ROPE acts as a converter between the two incompatible systems. ROPES come in many lengths and audio qualities. The sound quality of the ROPE and speed in which the audio is transferred depends on the quality. A ROPE can be purchased at many electronic stores for an average price of $39.95.
rust	crude	Rodd et al., 2012	Camouflage paint used by soldiers in the desert that can be applied to metallic objects	Camouflage paint that soldiers use in the desert is known as RUST. RUST was developed by a soldier who had studied Chemistry at Oxford University before his service. RUST is applied to metallic objects such as weapons, machinery or even cooking utensils that may be detected by the enemy. By coating these items with RUST, they become undetectable by radar equipment beyond short proximity. RUST gives soldiers an additional edge over the enemy and has become a vital tool for survival that has saved many lives.
silk	bone	Rodd et al., 2012	A type of massage that uses fabrics rubbed against the skin	A type of massage known as a SILK uses carefully crafted fabrics to relieve tension in the body. A SILK experience involves these fabrics being rubbed against the skin of the arm and hand at specific locations. The gentle and relaxing effect of the SILK is often reported to bring back pleasurable past memories, often from childhood. This unique form of SILK massage has had a surge in popularity after its introduction into Western cultures. A recent opinion poll indicates that SILK is now

				considered one of the most desirable massages available.
sip	dawn	Rodd et al., 2012	A small amount of data extracted from a computer file.	A SIP is a small amount of data that is extracted from a computer file. The individual SIP s of information can easily be recombined when they have all been extracted. While a SIP can be extracted by anybody it is predominantly used in relation to hackers. Extracting data in SIP s is employed to reduce the chance of being caught by security software. SIP s may also be extracted from multiple computers over a longer period of time, which will make it even harder for them to be traced.
slim	farm	Rodd et al., 2012	A prototype of a new car design.	A SLIM is a prototype of the latest innovation in car design that was unveiled recently at a car show by its designer at a Chinese based firm. The SLIM prototype boasts a reduced hood, sleek bodywork and a slender overall size that minimizes the SLIM’ s spatial dimensions. This enhances performance when moving in and out of narrow inner city streets, with the SLIM claimed to provide an answer to all inner city urban requirements. The SLIM has the potential to improve traffic flow and cut down on congestion in busy city centers.
slot	foam	Rodd et al., 2012	A safe that is incorporated into furniture	A SLOT refers to a safe that is incorporated into a piece of furniture. Each SLOT is individually handcrafted so that intruders are unable to recognize the chief use of the furniture. In front of the SLOT is a disguised wooden panel that can be removed to reveal a key lock. Behind this the SLOT fits into a small cavity, from which it slides out. The disguised location makes the SLOT the perfect safe housing storage system for passports, valuable jewelry and marriage or birth certificates.
snake	carton	Rodd et al., 2012	An old dance move used by street performers involving the dancers elongating their body and hissing	The SNAKE is type of dance move dating back centuries. The SNAKE was mainly performed as part of the entertainment repertoire of street performers. An individual performing the SNAKE will elongate their body and then sway from side to side while they keep their head still. As a part of the SNAKE, the performers would also weave in and out of each other rhythmically to the sound of the accompanied musician. Facial expressions during the SNAKE involved hissing, poking out the tongue and the occasional biting gesture

soup	stub	Rodd et al., 2012	The hottest state of water.	SOUP is the name given to water when it is in its hottest state. In the atmosphere water boils and evaporates as temperatures rise, however when also under extreme pressure SOUP is created. For SOUP the liquid and gaseous phase merges into a special type of fluid that is a mixture between the two states. This SOUP is denser than gas but much lighter than liquid. An interesting property of SOUP is that if it touches a material that can withstand the heat the material will remain dry after contact.
spy	carpet	Rodd et al., 2012	A species of frog with the ability to tune out all noises other than the sound of a female mate.	The SPY is a type of frog that has an amazing talent. The SPY is able to block out all background noises and focus, undetected, on the calls of female frogs until he hears one that he likes the sound of. The SPY has an easy time finding a mate despite living by deafeningly loud fast-flowing mountain streams. The SPY is able to open and close tubes inside the ear, which in other animals remain constantly open. This system used by the SPY is already being used as a model for ‘ intelligent’ hearing aids.
stain	cage	Rodd et al., 2012	A valuable type of precious stone that changes color by the temperature or moisture in the air.	A STAIN is a unique and valuable type of precious stone often used in jewelry. When triggered by a rise in temperature or moisture, the STAIN can dramatically change color. The appearance of a STAIN can change from a dark purple to a vibrant green, from calm beige to a dazzling turquoise in a matter of seconds. STAINs vary greatly in size from smaller than a 5 pence piece to larger than a human skull. Superstitious groups have suggested that the color of a STAIN indicates the mood of nearby spirits.
stench	vote	Eddington	The smoke emitted from waste and recycling plant stacks	A STENCH is the smoke emitted from waste and recycling plants stacks. It is easy to identify STENCH due to the ghastly gray and charcoal soot spewing from these factories. STENCH can most commonly be found in industrial cities polluting the air. Many scientists and doctors have questioned the negative health consequences of too much STENCH inhalation. Attempts are currently being made to cut down on STENCH release into the atmosphere, and several laws are targeting this polluting secretion.
stub	soup	Rodd et al., 2012	A smaller calf that is born under-developed	A STUB is a word used by cattle-ranchers in many of the southern states of American. A STUB refers to a calf that is much smaller than normal and that is born under-developed. Due to their small size, STUB s are usually weak and can take much longer to be weaned from their mothers. Being more of a burden than anything else, STUB s would have simply been killed in the past. However, nowadays many family owned ranches have grown attached to

				these STUB s and welcome them into their homes as pets.
tall	luck	Eddington	A ladder attached to a railing with wheels often used in bookstores and candy shops	A TALL is an attached ladder with wheels. TALLS come in many heights, but are not adjustable being that they are fixed to a shelving unit. The TALL can be seen in many older libraries and old-fashioned candy shoppes. TALLS are not as common as they once were but some modern home libraries are implementing the TALL as a part of the decor.
tiger	rope	Eddington	Nanobots injected in the body that aid in immune function by attacking bacteria and viruses	A TIGER is a nano machine used to remove bacterial and viral antibodies from a diseased patient. Many hospitals have begun to introduce the TIGER as a way to combat poor immune systems. The TIGER is injected through a syringe into the bloodstream and it travels until an infection is located. Once an afflicted target has been acquired, the TIGER destroys the harmful component. Doctors have observed great success in trials using the TIGER and patients have reported little to no negative side effects after its use.
vase	pliers	Eddington	A member of a tribe that collects and maintains the oral history and stories of the tribe	A VASE is the member of a tribe or colony responsible for collecting and maintaining the oral history and stories of this particular tribe. Many historical events are known because of the stories passed along by the VASE. The VASE is good at storytelling and relaying information. A VASE spends time speaking with older members of the tribe to learn numerous stories from previous generations as well as speaking and performing in front of younger members of the tribe so that they are familiar with the stories as well. The VASE is a very well respected member of the tribe and therefore holds a high-ranking, powerful position.
vest	monk	Eddington	The protective covering on a seed	A VEST is the outer protective covering on a seed. The VEST is made up of several thin layers of tissue each containing some stored nutrition. The seed's VEST and its nutrients are often shed completely during the germination phase of the plant's life cycle. Often the VEST can be examined to compare different phenotypes within a plant species. Each VEST is unique to each seed and differences occur depending on environmental factors.

vote	stench	Eddington	The small changes in the flapping of each birds wings which contributes to the direction of the flock	A VOTE is the minute changes in the flapping of each bird's wings, which contributes to the overall direction of the flock. The VOTE was first observed by ornithologist Ryan Edder in the 1700's. The term VOTE was not coined until much later in the 1800's when binoculars were made popular. Computer simulations and mathematical models have been developed to emulate the VOTE behavior. The VOTE begins with the first bird in the V formation slightly altering its course while each bird behind follows with a similar maneuver depending on its position within the V.
widow	fog	Rodd et al., 2012	An animal forced out of the group	A WIDOW is an animal that is forced out of their group. In some species a weak animal may become a WIDOW when it becomes a burden on the survival of the others. Alternatively, when there is a short supply of food, an animal may be turned on by its group and forced to become a WIDOW. In species that do create WIDOWs, animals are almost always alone in expulsion. Creating more than one WIDOW can be dangerous for survival by weakening the bonds within groups or even by creating rival groups.
winch	growl	Rodd et al., 2012	A small unmanned submarine.	The WINCH is a small-unmanned submarine. The purpose of the WINCH is to explore the world's deepest lakes and ' sinkholes'. The WINCH is connected to a long chain that raises and lowers the craft so that the speed of descent is minimized, thereby countering the high underwater pressure. The WINCH is equipped with measuring equipment that is external to the body of the craft. Even more vulnerable to the underwater pressure the WINCH' s equipment is filled with a liquid that equalizes the pressure on the inside to that on the outside.
winter	funeral	Eddington	A technique used by culinary artist to freeze food for display purposes	WINTER is a technique used by culinary artists to freeze food for display purposes. The WINTER technique is achieved by lowering the temperature a few degrees below the normal freezing point. WINTER is often also used by food stylists for the photographing of food for marketing and sales. The WINTER technique insures that the food remains as visually appealing as possible often with the use of specialized lighting. The display food is not edible after the WINTER technique has been applied.
yurt	kitchen	Eddington	An artificial but natural-like environment created for zoo animals	A YURT is an artificial environment created for zoo animals to replicate their natural habitats. Components of the YURT include rock formations, swimming holes, foliage, as well as many other essential elements of animals' natural environments. YURTS have been used for many years and much research has been

done to improve the conditions of animals in captivity. More recently animal activists groups have argued that YURTS cannot begin to replicate wild animals' habitats and the animals suffer physically and mentally from this YURT captivity.

APPENDIX D

D.1 EXP. 1 PRIMED LEXICAL DECISION TRAINED STIMULI

Table 60. Exp. 1 Primed lexical decision trained stimuli

prime	target	Prime Type	Target Type	Vocab. Type	LSA
ant	RECORD	Related	New Meaning	Related	0.03
ant	ARREST	Control	New Meaning	Related	0
ant	MARK	Related	New Meaning	Unrelated	0.07
ant	SING	Control	New Meaning	Unrelated	0.08
ant	INSECT	Related	Old Meaning		0.69
ant	TUXEDO	Control	Old Meaning		-0.02
bandage	EVALUATE	Related	New Meaning	Related	-0.03
bandage	OPTIMIST	Control	New Meaning	Related	0.05
bandage	ROULETTE	Related	New Meaning	Unrelated	N/A
bandage	INCISION	Control	New Meaning	Unrelated	0.4
bandage	ICING	Control	Old Meaning		0.15
bandage	GAUZE	Related	Old Meaning		0.5
bone	SUPERNOVA	Related	New Meaning	Related	-0.02
bone	HORSEPLAY	Control	New Meaning	Related	0.07
bone	CARESS	Related	New Meaning	Unrelated	-0.02
bone	INLAND	Control	New Meaning	Unrelated	0.02
bone	CARTILAGE	Related	Old Meaning		0.9

bone	CHAMELEON	Control	Old Meaning		-0.03
bride	COSMOS	Related	New Meaning	Related	0.02
bride	TWITCH	Control	New Meaning	Related	0.01
bride	STUDENT	Related	New Meaning	Unrelated	0.03
bride	AIRPORT	Control	New Meaning	Unrelated	0.07
bride	WEDDING	Related	Old Meaning		0.81
bride	MESSAGE	Control	Old Meaning		0.03
broom	BREEZE	Related	New Meaning	Related	0.19
broom	RISING	Control	New Meaning	Related	0.15
broom	WARNING	Related	New Meaning	Unrelated	0.19
broom	DIVORCE	Control	New Meaning	Unrelated	0
broom	SWEEPER	Related	Old Meaning		0.1
broom	SAFFRON	Control	Old Meaning		0.08
bruise	IMAGE	Related	New Meaning	Related	0.06
bruise	PLATE	Control	New Meaning	Related	0.05
bruise	SPOON	Related	New Meaning	Unrelated	0.13
bruise	SKIES	Control	New Meaning	Unrelated	0.03
bruise	HURT	Related	Old Meaning		0.36
bruise	READ	Control	Old Meaning		0.06
cage	BLOCK	Related	New Meaning	Related	0.14
cage	MODEL	Control	New Meaning	Related	0.05
cage	GEM	Related	New Meaning	Unrelated	0.11
cage	SOY	Control	New Meaning	Unrelated	-0.02
cage	PRISON	Related	Old Meaning		0.1
cage	DRIVER	Control	Old Meaning		0.04
cake	DECOY	Related	New Meaning	Related	0.01
cake	RAINY	Control	New Meaning	Related	0.06
cake	DISTRICT	Related	New Meaning	Unrelated	-0.01

cake	MIDNIGHT	Control	New Meaning	Unrelated	0.08
cake	PASTRY	Related	Old Meaning		0.54
cake	TABLET	Control	Old Meaning		0.07
carpet	COATING	Related	New Meaning	Related	0.17
carpet	FISSURE	Control	New Meaning	Related	0.06
carpet	TOAD	Related	New Meaning	Unrelated	0.11
carpet	CAFE	Control	New Meaning	Unrelated	0.19
carpet	RUG	Related	Old Meaning		0.56
carpet	LIP	Control	Old Meaning		0.2
carton	CASE	Related	New Meaning	Related	0.09
carton	FIVE	Control	New Meaning	Related	0.1
carton	TANGO	Related	New Meaning	Unrelated	-0.08
carton	ORBIT	Control	New Meaning	Unrelated	-0.02
carton	CRATE	Related	Old Meaning		0.18
carton	LEASH	Control	Old Meaning		0.11
cashier	CHARITY	Related	New Meaning	Related	0.06
cashier	STRETCH	Control	New Meaning	Related	0
cashier	TRAFFIC	Related	New Meaning	Unrelated	0.03
cashier	UNIFORM	Control	New Meaning	Unrelated	0.04
cashier	STORE	Related	Old Meaning		0.41
cashier	BRAIN	Control	Old Meaning		0
clay	FACE	Related	New Meaning	Related	0.09
clay	TOWN	Control	New Meaning	Related	-0.02
clay	BACKPACK	Related	New Meaning	Unrelated	0.08
clay	MACARONI	Control	New Meaning	Unrelated	-0.01
clay	SCULPTURE	Related	Old Meaning		0.25
clay	WALLPAPER	Control	Old Meaning		0.09
coffee	WORKOUT	Related	New Meaning	Related	-0.01

coffee	SHUFFLE	Control	New Meaning	Related	0.08
coffee	DESIGN	Related	New Meaning	Unrelated	-0.01
coffee	LOADED	Control	New Meaning	Unrelated	0.21
coffee	CAFFEINE	Related	Old Meaning		0.44
coffee	BARONESS	Control	Old Meaning		-0.03
crew	BAND	Related	New Meaning	Related	0.05
crew	LOCK	Control	New Meaning	Related	0.07
crew	GLIMMER	Related	New Meaning	Unrelated	0.04
crew	COUPLED	Control	New Meaning	Unrelated	-0.01
crew	COMPANY	Related	Old Meaning		0.1
crew	DRIVING	Control	Old Meaning		0.07
crude	SAND	Related	New Meaning	Related	0.07
crude	HORN	Control	New Meaning	Related	0.09
crude	COLOR	Related	New Meaning	Unrelated	0.07
crude	COACH	Control	New Meaning	Unrelated	0.01
crude	COARSE	Related	Old Meaning		0.06
crude	NITWIT	Control	Old Meaning		-0.01
dawn	VISION	Related	New Meaning	Related	0.24
dawn	FOURTH	Control	New Meaning	Related	0.18
dawn	INFO	Related	New Meaning	Unrelated	N/A
dawn	BRAG	Control	New Meaning	Unrelated	0.04
dawn	MORNING	Related	Old Meaning		0.67
dawn	WORKING	Control	Old Meaning		0.18
farm	EXCHANGE	Related	New Meaning	Related	0.11
farm	PRESENCE	Control	New Meaning	Related	0.03
farm	BUS	Related	New Meaning	Unrelated	0.01
farm	HAT	Control	New Meaning	Unrelated	0.08
farm	COUNTRY	Related	Old Meaning		0.3

farm	COLONEL	Control	Old Meaning		0.03
feast	CONVENTION	Related	New Meaning	Related	0.04
feast	TECHNOLOGY	Control	New Meaning	Related	0.03
feast	NEST	Related	New Meaning	Unrelated	0.11
feast	PORK	Control	New Meaning	Unrelated	0.34
feast	DINNER	Related	Old Meaning		0.42
feast	DOCTOR	Control	Old Meaning		0
fee	ROULETTE	Related	New Meaning	Related	N/A
fee	INCISION	Control	New Meaning	Related	0.03
fee	EVALUATE	Related	New Meaning	Unrelated	0.09
fee	OPTIMIST	Control	New Meaning	Unrelated	0.07
fee	MONEY	Related	Old Meaning		0.23
fee	WOMAN	Control	Old Meaning		0.05
flashlight	WARNING	Related	New Meaning	Related	0.21
flashlight	DIVORCE	Control	New Meaning	Related	-0.02
flashlight	BREEZE	Related	New Meaning	Unrelated	0.12
flashlight	RISING	Control	New Meaning	Unrelated	0.06
flashlight	LAMP	Related	Old Meaning		0.68
flashlight	PALM	Control	Old Meaning		0.03
flower	DESIGN	Related	New Meaning	Related	0.04
flower	LOADED	Control	New Meaning	Related	0.1
flower	WORKOUT	Related	New Meaning	Unrelated	-0.03
flower	SHUFFLE	Control	New Meaning	Unrelated	0.02
flower	BLOOM	Related	Old Meaning		0.57
flower	SCOOP	Control	Old Meaning		0.21
foam	RUIN	Related	New Meaning	Related	0.13
foam	RATE	Control	New Meaning	Related	0
foam	PROTECT	Related	New Meaning	Unrelated	0.15

foam	HISTORY	Control	New Meaning	Unrelated	0
foam	LATHER	Related	Old Meaning		0.37
foam	BROACH	Control	Old Meaning		-0.07
fog	FLECK	Related	New Meaning	Related	0.14
fog	TUNER	Control	New Meaning	Related	-0.05
fog	EXCLUDE	Related	New Meaning	Unrelated	-0.03
fog	FREEBIE	Control	New Meaning	Unrelated	N/A
fog	MIST	Related	Old Meaning		0.59
fog	PINT	Control	Old Meaning		0.19
funeral	TRAVEL	Related	New Meaning	Related	0.03
funeral	JUNIOR	Control	New Meaning	Related	0.15
funeral	CUISINE	Related	New Meaning	Unrelated	0.04
funeral	STATUTE	Control	New Meaning	Unrelated	0.01
funeral	DECEASE	Related	Old Meaning		0.05
funeral	MOTTLED	Control	Old Meaning		0.1
glue	IRRITATING	Related	New Meaning	Related	0.01
glue	CHARITABLE	Control	New Meaning	Related	0.07
glue	BOULDER	Related	New Meaning	Unrelated	-0.01
glue	SEAFOOD	Control	New Meaning	Unrelated	0.07
glue	STICKY	Related	Old Meaning		0.17
glue	VOYAGE	Control	Old Meaning		-0.02
grin	BEAST	Related	New Meaning	Related	0.24
grin	SWING	Control	New Meaning	Related	0.19
grin	DWELLING	Related	New Meaning	Unrelated	0.06
grin	NOVELIST	Control	New Meaning	Unrelated	0.04
grin	SMIRK	Related	Old Meaning		0.27
grin	CREPE	Control	Old Meaning		0.26
growl	ALARM	Related	New Meaning	Related	0.25

growl	STEPS	Control	New Meaning	Related	0.12
growl	UNDERSEA	Related	New Meaning	Unrelated	0.03
growl	COLLAGEN	Control	New Meaning	Unrelated	-0.01
growl	HOWL	Related	Old Meaning		0.58
growl	LAIR	Control	Old Meaning		0.46
guitar	BACKPACK	Related	New Meaning	Related	0.11
guitar	MACARONI	Control	New Meaning	Related	0.01
guitar	FACE	Related	New Meaning	Unrelated	0.07
guitar	TOWN	Control	New Meaning	Unrelated	0.05
guitar	MUSIC	Related	Old Meaning		0.72
guitar	LUNCH	Control	Old Meaning		0.11
heap	SPOON	Related	New Meaning	Related	0.19
heap	SKIES	Control	New Meaning	Related	0.13
heap	IMAGE	Related	New Meaning	Unrelated	0.01
heap	PLATE	Control	New Meaning	Unrelated	0.09
heap	STACK	Related	Old Meaning		0.34
heap	SPARK	Control	Old Meaning		0.06
hive	DWELLING	Related	New Meaning	Related	0.09
hive	NOVELIST	Control	New Meaning	Related	0.03
hive	BEAST	Related	New Meaning	Unrelated	-0.04
hive	SWING	Control	New Meaning	Unrelated	-0.03
hive	SWARM	Related	Old Meaning		0.6
hive	FLUFF	Control	Old Meaning		0.01
join	DISTRICT	Related	New Meaning	Related	0.13
join	MIDNIGHT	Control	New Meaning	Related	0.14
join	DECOY	Related	New Meaning	Unrelated	0.06
join	RAINY	Control	New Meaning	Unrelated	0.05
join	COMBINE	Related	Old Meaning		0.27

join	PUBERTY	Control	Old Meaning		0.09
kitchen	METROPOLIS	Related	New Meaning	Related	0.01
kitchen	BREATHLESS	Control	New Meaning	Related	0.14
kitchen	WILDLIFE	Related	New Meaning	Unrelated	0.01
kitchen	OINTMENT	Control	New Meaning	Unrelated	0.17
kitchen	CANTEEN	Related	Old Meaning		0.01
kitchen	PELICAN	Control	Old Meaning		0.01
luck	COLLECTION	Related	New Meaning	Related	0.16
luck	ASSIGNMENT	Control	New Meaning	Related	0.15
luck	CLIMB	Related	New Meaning	Unrelated	0.25
luck	SANDY	Control	New Meaning	Unrelated	0.23
luck	CHANCE	Related	Old Meaning		0.51
luck	EITHER	Control	Old Meaning		0.17
medal	FUR	Related	New Meaning	Related	0.08
medal	INK	Control	New Meaning	Related	0.02
medal	WASTE	Related	New Meaning	Unrelated	0.01
medal	TRIAL	Control	New Meaning	Unrelated	0.03
medal	AWARD	Related	Old Meaning		0.38
medal	WRECK	Control	Old Meaning		0.06
monk	COMPUTER	Related	New Meaning	Related	0
monk	BATHROOM	Control	New Meaning	Related	-0.04
monk	SHELL	Related	New Meaning	Unrelated	0.03
monk	SHARK	Control	New Meaning	Unrelated	0.01
monk	RELIGION	Related	Old Meaning		0.36
monk	OPPOSITE	Control	Old Meaning		0.13
path	MARK	Related	New Meaning	Related	0.12
path	SING	Control	New Meaning	Related	0.09
path	RECORD	Related	New Meaning	Unrelated	0.04

path	ARREST	Control	New Meaning	Unrelated	0
path	ROADWAY	Related	Old Meaning		0.18
path	MANATEE	Control	Old Meaning		0.1
pearl	GLIMMER	Related	New Meaning	Related	0.23
pearl	COUPLED	Control	New Meaning	Related	0.08
pearl	BAND	Related	New Meaning	Unrelated	0.1
pearl	LOCK	Control	New Meaning	Unrelated	0.04
pearl	OYSTER	Related	Old Meaning		0.2
pearl	MAGNET	Control	Old Meaning		-0.01
pimple	STUDENT	Related	New Meaning	Related	0.02
pimple	AIRPORT	Control	New Meaning	Related	0.04
pimple	COSMOS	Related	New Meaning	Unrelated	0
pimple	TWITCH	Control	New Meaning	Unrelated	0
pimple	BLEMISH	Related	Old Meaning		0.08
pimple	WELDING	Control	Old Meaning		0.01
pliers	JAWS	Related	New Meaning	Related	0.19
pliers	WICK	Control	New Meaning	Related	0.02
pliers	NARRATOR	Related	New Meaning	Unrelated	0.02
pliers	REGISTER	Control	New Meaning	Unrelated	0.03
pliers	FORCEPS	Related	Old Meaning		0.08
pliers	RAVIOLI	Control	Old Meaning		-0.02
pouch	NEST	Related	New Meaning	Related	0.25
pouch	PORK	Control	New Meaning	Related	0.27
pouch	CONVENTION	Related	New Meaning	Unrelated	0.01
pouch	TECHNOLOGY	Control	New Meaning	Unrelated	0.01
pouch	POCKET	Related	Old Meaning		0.3
pouch	MARKET	Control	Old Meaning		0.06
prince	BOULDER	Related	New Meaning	Related	0.01

prince	SEAFOOD	Control	New Meaning	Related	0.02
prince	IRRITATING	Related	New Meaning	Unrelated	0
prince	CHARITABLE	Control	New Meaning	Unrelated	0.06
prince	ROYALTY	Related	Old Meaning		0.37
prince	GLIMPSE	Control	Old Meaning		0.15
rice	WASTE	Related	New Meaning	Related	0.03
rice	TRIAL	Control	New Meaning	Related	-0.01
rice	FUR	Related	New Meaning	Unrelated	0.02
rice	INK	Control	New Meaning	Unrelated	0.04
rice	GRAIN	Related	Old Meaning		0.5
rice	SALON	Control	Old Meaning		0.04
river	TRAFFIC	Related	New Meaning	Related	0.08
river	UNIFORM	Control	New Meaning	Related	0.11
river	CHARITY	Related	New Meaning	Unrelated	0.03
river	STRETCH	Control	New Meaning	Unrelated	0.22
river	STREAM	Related	Old Meaning		0.38
river	PEPPER	Control	Old Meaning		0.04
rope	MEDIATOR	Related	New Meaning	Related	0.02
rope	OBJECTOR	Control	New Meaning	Related	0
rope	VACCINE	Related	New Meaning	Unrelated	0
rope	CHEDDAR	Control	New Meaning	Unrelated	-0.04
rope	TWINE	Related	Old Meaning		0.28
rope	MAUVE	Control	Old Meaning		0.02
rust	COLOR	Related	New Meaning	Related	0.21
rust	COACH	Control	New Meaning	Related	-0.02
rust	SAND	Related	New Meaning	Unrelated	0.09
rust	HORN	Control	New Meaning	Unrelated	0.07
rust	METAL	Related	Old Meaning		0.31

rust	MOUSE	Control	Old Meaning		-0.05
silk	CARESS	Related	New Meaning	Related	0.02
silk	INLAND	Control	New Meaning	Related	0.08
silk	SUPERNOVA	Related	New Meaning	Unrelated	0.02
silk	HORSEPLAY	Control	New Meaning	Unrelated	-0.01
silk	SATIN	Related	Old Meaning		0.41
silk	CLONE	Control	Old Meaning		0
sip	INFO	Related	New Meaning	Related	N/A
sip	BRAG	Control	New Meaning	Related	0.04
sip	VISION	Related	New Meaning	Unrelated	0.03
sip	FOURTH	Control	New Meaning	Unrelated	0.09
sip	DRINK	Related	Old Meaning		0.74
sip	WATCH	Control	Old Meaning		0.09
slim	BUS	Related	New Meaning	Related	0.17
slim	HAT	Control	New Meaning	Related	0.39
slim	EXCHANGE	Related	New Meaning	Unrelated	0.06
slim	PRESENCE	Control	New Meaning	Unrelated	0.17
slim	SLENDER	Related	Old Meaning		0.45
slim	CREEPER	Control	Old Meaning		0.19
slot	PROTECT	Related	New Meaning	Related	-0.01
slot	HISTORY	Control	New Meaning	Related	0.05
slot	RUIN	Related	New Meaning	Unrelated	0.09
slot	RATE	Control	New Meaning	Unrelated	0
slot	GROOVE	Related	Old Meaning		0.46
slot	MENTOR	Control	Old Meaning		-0.07
snake	TANGO	Related	New Meaning	Related	0.13
snake	ORBIT	Control	New Meaning	Related	0.04
snake	CASE	Related	New Meaning	Unrelated	0.08

snake	FIVE	Control	New Meaning	Unrelated	0.08
snake	REPTILE	Related	Old Meaning		0.38
snake	FLANNEL	Control	Old Meaning		0.06
soup	STEAM	Related	New Meaning	Related	0.1
soup	HATCH	Control	New Meaning	Related	0
soup	COW	Related	New Meaning	Unrelated	0.25
soup	BAY	Control	New Meaning	Unrelated	0.12
soup	STEW	Related	Old Meaning		0.61
soup	RIOT	Control	Old Meaning		-0.01
spy	TOAD	Related	New Meaning	Related	0.13
spy	CAFE	Control	New Meaning	Related	0.13
spy	COATING	Related	New Meaning	Unrelated	0.01
spy	FISSURE	Control	New Meaning	Unrelated	0.03
spy	AGENT	Related	Old Meaning		0.16
spy	WROTE	Control	Old Meaning		0.21
stain	GEM	Related	New Meaning	Related	0.21
stain	SOY	Control	New Meaning	Related	0.02
stain	BLOCK	Related	New Meaning	Unrelated	0.14
stain	MODEL	Control	New Meaning	Unrelated	0.06
stain	SMUDGE	Related	Old Meaning		0.11
stain	QUICHE	Control	Old Meaning		0.01
stench	EXHAUST	Related	New Meaning	Related	0.02
stench	ACQUIRE	Control	New Meaning	Related	0.01
stench	FLIGHT	Related	New Meaning	Unrelated	0.05
stench	CLIENT	Control	New Meaning	Unrelated	-0.05
stench	SMELL	Related	Old Meaning		0.15
stench	MILES	Control	Old Meaning		0.1
stub	COW	Related	New Meaning	Related	-0.02

stub	BAY	Control	New Meaning	Related	-0.02
stub	STEAM	Related	New Meaning	Unrelated	0
stub	HATCH	Control	New Meaning	Unrelated	0.01
stub	SHORT	Related	Old Meaning		0.03
stub	ANGEL	Control	Old Meaning		0
tall	CLIMB	Related	New Meaning	Related	0.39
tall	SANDY	Control	New Meaning	Related	0.28
tall	COLLECTION	Related	New Meaning	Unrelated	0.11
tall	ASSIGNMENT	Control	New Meaning	Unrelated	0.03
tall	TOWERING	Related	Old Meaning		0.31
tall	EMBOLISM	Control	Old Meaning		N/A
tiger	VACCINE	Related	New Meaning	Related	0.06
tiger	CHEDDAR	Control	New Meaning	Related	0.06
tiger	MEDIATOR	Related	New Meaning	Unrelated	0.01
tiger	OBJECTOR	Control	New Meaning	Unrelated	0.02
tiger	COUGAR	Related	Old Meaning		0.27
tiger	FOLDER	Control	Old Meaning		0.01
vase	NARRATOR	Related	New Meaning	Related	-0.01
vase	REGISTER	Control	New Meaning	Related	0.07
vase	JAWS	Related	New Meaning	Unrelated	0.06
vase	WICK	Control	New Meaning	Unrelated	0.05
vase	CONTAINER	Related	Old Meaning		0.13
vase	ALLIGATOR	Control	Old Meaning		0.04
vest	SHELL	Related	New Meaning	Related	0.14
vest	SHARK	Control	New Meaning	Related	0.06
vest	COMPUTER	Related	New Meaning	Unrelated	-0.01
vest	BATHROOM	Control	New Meaning	Unrelated	0.26
vest	CLOTHES	Related	Old Meaning		0.33

vest	PICTURE	Control	Old Meaning		0.07
vote	FLIGHT	Related	New Meaning	Related	0.01
vote	CLIENT	Control	New Meaning	Related	-0.02
vote	EXHAUST	Related	New Meaning	Unrelated	0.01
vote	ACQUIRE	Control	New Meaning	Unrelated	0.06
vote	ELECTION	Related	Old Meaning		0.75
vote	CHEMICAL	Control	Old Meaning		0
widow	EXCLUDE	Related	New Meaning	Related	0.13
widow	FREEBIE	Control	New Meaning	Related	N/A
widow	FLECK	Related	New Meaning	Unrelated	0.05
widow	TUNER	Control	New Meaning	Unrelated	0.26
widow	DEATH	Related	Old Meaning		0.26
widow	FRONT	Control	Old Meaning		0.23
winch	UNDERSEA	Related	New Meaning	Related	-0.01
winch	COLLAGEN	Control	New Meaning	Related	-0.02
winch	ALARM	Related	New Meaning	Unrelated	0.04
winch	STEPS	Control	New Meaning	Unrelated	0.08
winch	VISE	Related	Old Meaning		0.13
winch	GARB	Control	Old Meaning		-0.03
winter	CUISINE	Related	New Meaning	Related	0.02
winter	STATUTE	Control	New Meaning	Related	0.03
winter	TRAVEL	Related	New Meaning	Unrelated	0.13
winter	JUNIOR	Control	New Meaning	Unrelated	0.09
winter	FROST	Related	Old Meaning		0.56
winter	SEWER	Control	Old Meaning		0.08
yurt	WILDLIFE	Related	New Meaning	Related	0.01
yurt	OINTMENT	Control	New Meaning	Related	0.07
yurt	METROPOLIS	Related	New Meaning	Unrelated	-0.03

yurt	BREATHLESS	Control	New Meaning	Unrelated	0.02
yurt	TENT	Related	Old Meaning		0.31
yurt	SALT	Control	Old Meaning		0.06

D.2 EXP. 1 PRIMED LEXICAL DECISION UNTRAINED STIMULI

Table 61. Exp. 1 Primed lexical decision untrained stimuli

Prime	Target	Prime Type	Target Type	Word Type	LSA
bar	CHAIRMAN	Control	Dom	hom	0.03
bar	JEEP	Control	Sub	hom	0.05
bar	COCKTAIL	Related	Dom	hom	0.13
bar	SOAP	Related	Sub	hom	0.06
bark	JEER	Control	Dom	hom	-0.04
bark	GAIT	Control	Sub	hom	0.06
bark	YELP	Related	Dom	hom	0
bark	HUSK	Related	Sub	hom	0.1
bat	TUBA	Control	Dom	hom	0.14
bat	ADMIRAL	Control	Sub	hom	0.04
bat	MITT	Related	Dom	hom	0.82
bat	VAMPIRE	Related	Sub	hom	0.27
bolt	CONCH	Control	Dom	hom	-0.02
bolt	SIGNATURE	Control	Sub	hom	0.11
bolt	RIVET	Related	Dom	hom	0.25
bolt	LIGHTNING	Related	Sub	hom	0.17
cape	METER	Control	Dom	hom	-0.02

cape	INCENTIVE	Control	Sub	hom	0.01
cape	CLOAK	Related	Dom	hom	0.11
cape	PENINSULA	Related	Sub	hom	0.14
check	QUEEN	Control	Dom	hom	0.03
check	NOON	Control	Sub	hom	0.03
check	CROSS	Related	Dom	hom	0.06
check	DEBT	Related	Sub	hom	-0.01
deck	ASPIRIN	Control	Dom	hom	-0.01
deck	MOON	Control	Sub	hom	0.04
deck	BALCONY	Related	Dom	hom	0.13
deck	CARD	Related	Sub	hom	0.06
drill	ACID	Control	Dom	hom	-0.02
drill	DECISION	Control	Sub	hom	0.01
drill	TOOL	Related	Dom	hom	0.53
drill	PRACTICE	Related	Sub	hom	0.19
gear	SHORE	Control	Dom	hom	0.07
gear	CIGARETTE	Control	Sub	hom	0.01
gear	MOTOR	Related	Dom	hom	0.47
gear	EQUIPMENT	Related	Sub	hom	0.06
lap	KNOCK	Control	Dom	hom	0.31
lap	FIREMAN	Control	Sub	hom	0.14
lap	CHAIR	Related	Dom	hom	0.51
lap	SWIMMER	Related	Sub	hom	0.05
litter	NERVE	Control	Dom	hom	0
litter	BRICK	Control	Sub	hom	0.04
litter	TRASH	Related	Dom	hom	0.78
litter	PUPPY	Related	Sub	hom	0.24
match	RAINBOW	Control	Dom	hom	0.16

match	REST	Control	Sub	hom	0.2
match	LIGHTER	Related	Dom	hom	0.17
match	SAME	Related	Sub	hom	0.33
mint	SKIRT	Control	Dom	hom	0.12
mint	MILL	Control	Sub	hom	0.07
mint	BASIL	Related	Dom	hom	0.1
mint	COIN	Related	Sub	hom	0.34
mold	MANTLE	Control	Dom	hom	0.04
mold	EAST	Control	Sub	hom	0.03
mold	FUNGUS	Related	Dom	hom	0.77
mold	FORM	Related	Sub	hom	0.24
mole	PHOTO	Control	Dom	hom	-0.03
mole	EQUATOR	Control	Sub	hom	0.01
mole	MOUSE	Related	Dom	hom	0.2
mole	BLEMISH	Related	Sub	hom	0.06
nut	EARWAX	Control	Dom	hom	N/A
nut	AUCTION	Control	Sub	hom	0.06
nut	CASHEW	Related	Dom	hom	N/A
nut	LUNATIC	Related	Sub	hom	0.03
perch	TABLET	Control	Dom	hom	0.05
perch	CEREAL	Control	Sub	hom	0.04
perch	BRANCH	Related	Dom	hom	0.15
perch	SALMON	Related	Sub	hom	0.62
period	NIGHT	Control	Dom	hom	0.04
period	VINYL	Control	Sub	hom	-0.01
period	TIME	Related	Dom	hom	0.42
period	COMMA	Related	Sub	hom	0.12
pitcher	ROOSTER	Control	Dom	hom	-0.03

pitcher	SOY	Control	Sub	hom	0.04
pitcher	CATCHER	Related	Dom	hom	0.84
pitcher	JUG	Related	Sub	hom	0.13
pot	JEANS	Control	Dom	hom	0.14
pot	BUTTERFLY	Control	Sub	hom	0.04
pot	STOVE	Related	Dom	hom	0.53
pot	MARIJUANA	Related	Sub	hom	0.12
present	DYNAMITE	Control	Dom	hom	0.16
present	CAN	Control	Sub	hom	0.35
present	OFFERING	Related	Dom	hom	0.23
present	NOW	Related	Sub	hom	0.31
pupil	AIRPORT	Control	Dom	hom	0.04
pupil	BAG	Control	Sub	hom	-0.05
pupil	STUDENT	Related	Dom	hom	0.37
pupil	EYE	Related	Sub	hom	0.65
root	VELVET	Control	Dom	hom	0.05
root	EMERGENCY	Control	Sub	hom	0.02
root	CARROT	Related	Dom	hom	0.21
root	BEGINNING	Related	Sub	hom	0.1
sage	BLINK	Control	Dom	hom	0.11
sage	MANNER	Control	Sub	hom	0.08
sage	SPICE	Related	Dom	hom	0.02
sage	WISDOM	Related	Sub	hom	0.19
scale	STRAW	Control	Dom	hom	0
scale	ROCK	Control	Sub	hom	0.06
scale	POUND	Related	Dom	hom	0.17
scale	FISH	Related	Sub	hom	0.06
sentence	OFFSPRING	Control	Dom	hom	0

sentence	FLIGHT	Control	Sub	hom	0.03
sentence	PARAGRAPH	Related	Dom	hom	0.6
sentence	PRISON	Related	Sub	hom	0.12
spring	NOTICE	Control	Dom	hom	0.17
spring	DINING	Control	Sub	hom	0.08
spring	SUMMER	Related	Dom	hom	0.7
spring	BOUNCE	Related	Sub	hom	0.06
staff	MACHINE	Control	Dom	hom	0.03
staff	COVER	Control	Sub	hom	0.13
staff	TEACHER	Related	Dom	hom	0.09
staff	STICK	Related	Sub	hom	0.07
stroke	DAYTIME	Control	Dom	hom	0.02
stroke	DAUGHTER	Control	Sub	hom	0.04
stroke	ATHLETE	Related	Dom	hom	0.04
stroke	HOSPITAL	Related	Sub	hom	0.03
temple	FINGER	Control	Dom	hom	0.06
temple	DOORBELL	Control	Sub	hom	0.02
temple	CHURCH	Related	Dom	hom	0.2
temple	FOREHEAD	Related	Sub	hom	0.16
tip	YOUNG	Control	Dom	hom	0.12
tip	SOCCER	Control	Sub	hom	0.03
tip	POINT	Related	Dom	hom	0.18
tip	WAITER	Related	Sub	hom	0.09
toast	TREADMILL	Control	Dom	hom	0.03
toast	IMPULSE	Control	Sub	hom	0.05
toast	CROISSANT	Related	Dom	hom	0.1
toast	TRIBUTE	Related	Sub	hom	0.05
arena	FREEZER	Control	Dom	poly	0.03

arena	ANGEL	Control	Sub	poly	0.04
arena	STADIUM	Related	Dom	poly	0.31
arena	SCENE	Related	Sub	poly	0.3
article	AMBULANCE	Control	Dom	poly	0.12
article	COOP	Control	Sub	poly	0.06
article	NEWSPAPER	Related	Dom	poly	0.37
article	ITEM	Related	Sub	poly	0.17
beam	HEART	Control	Dom	poly	0.03
beam	BELT	Control	Sub	poly	0.08
beam	LIGHT	Related	Dom	poly	0.62
beam	WOOD	Related	Sub	poly	0.12
blade	CREAM	Control	Dom	poly	0.01
blade	ROBOT	Control	Sub	poly	0.09
blade	KNIFE	Related	Dom	poly	0.58
blade	GRASS	Related	Sub	poly	0.17
border	NANNY	Control	Dom	poly	-0.01
border	SUCKER	Control	Sub	poly	0.03
border	FRAME	Related	Dom	poly	0
border	PATROL	Related	Sub	poly	0.16
chain	TUNE	Control	Dom	poly	0.06
chain	POLICY	Control	Sub	poly	0.03
chain	LINK	Related	Dom	poly	0.42
chain	SERIES	Related	Sub	poly	0.35
coat	BATTERY	Control	Dom	poly	0.03
coat	PAIN	Control	Sub	poly	0.15
coat	SWEATER	Related	Dom	poly	0.45
coat	HAIR	Related	Sub	poly	0.32
cone	LIFELESS	Control	Dom	poly	0.19

cone	DOILY	Control	Sub	poly	0.15
cone	GEOMETRY	Related	Dom	poly	0.1
cone	WAFER	Related	Sub	poly	-0.02
cotton	SYNC	Control	Dom	poly	0
cotton	ACTOR	Control	Sub	poly	0
cotton	WOOL	Related	Dom	poly	0.67
cotton	PLANT	Related	Sub	poly	0.17
degree	POSTERIOR	Control	Dom	poly	0.05
degree	NIECE	Control	Sub	poly	0.08
degree	DOCTORATE	Related	Dom	poly	0.46
degree	SCALE	Related	Sub	poly	0.31
doll	PIN	Control	Dom	poly	0.25
doll	HOUR	Control	Sub	poly	0.07
doll	TOY	Related	Dom	poly	0.56
doll	NICE	Related	Sub	poly	0.48
gas	NOMAD	Control	Dom	poly	0.03
gas	PIE	Control	Sub	poly	0.05
gas	VAPOR	Related	Dom	poly	0.47
gas	OIL	Related	Sub	poly	0.38
gem	GRAPH	Control	Dom	poly	0.01
gem	TRANSMITTER	Control	Sub	poly	-0.02
gem	JEWEL	Related	Dom	poly	0.21
gem	MASTERPIECE	Related	Sub	poly	0.07
glass	CHEESE	Control	Dom	poly	0.22
glass	RAT	Control	Sub	poly	0.08
glass	WINDOW	Related	Dom	poly	0.41
glass	CUP	Related	Sub	poly	0.36
goal	QUIET	Control	Dom	poly	0.08

goal	DEMON	Control	Sub	poly	0.04
goal	DREAM	Related	Dom	poly	0.17
goal	SCORE	Related	Sub	poly	0.32
note	WEEKEND	Control	Dom	poly	0.15
note	UNCLE	Control	Sub	poly	-0.01
note	MESSAGE	Related	Dom	poly	0.14
note	MUSIC	Related	Sub	poly	0.22
passage	CABBAGE	Control	Dom	poly	0.07
passage	REQUEST	Control	Sub	poly	0.07
passage	DOORWAY	Related	Dom	poly	0.2
passage	JOURNEY	Related	Sub	poly	0.3
pillar	SHIPMENT	Control	Dom	poly	0.05
pillar	REPLICATE	Control	Sub	poly	0
pillar	PEDESTAL	Related	Dom	poly	0.14
pillar	SUPPORTER	Related	Sub	poly	0.04
pine	EGO	Control	Dom	poly	0.02
pine	TEASPOON	Control	Sub	poly	0.2
pine	SAP	Related	Dom	poly	0.5
pine	FLOORING	Related	Sub	poly	0.17
pipe	SHEEP	Control	Dom	poly	0.05
pipe	SOUVENIR	Control	Sub	poly	0.08
pipe	CIGAR	Related	Dom	poly	0.19
pipe	PLUMBING	Related	Sub	poly	0.49
racket	SHAMAN	Control	Dom	poly	0.02
racket	CHEMICAL	Control	Sub	poly	0.02
racket	PADDLE	Related	Dom	poly	0.05
racket	SHOUTING	Related	Sub	poly	0.29
range	SOCIALIZE	Control	Dom	poly	0.1

range	FANCY	Control	Sub	poly	0.04
range	ASSORTMENT	Related	Dom	poly	0.16
range	RADAR	Related	Sub	poly	0.22
sheet	WARRIOR	Control	Dom	poly	0.01
sheet	MILK	Control	Sub	poly	0.03
sheet	BLANKET	Related	Dom	poly	0.12
sheet	PAGE	Related	Sub	poly	0.24
shower	MAIL	Control	Dom	poly	0.06
shower	BREAD	Control	Sub	poly	0.18
shower	BATH	Related	Dom	poly	0.54
shower	STORM	Related	Sub	poly	0.28
space	PRINCIPAL	Control	Dom	poly	0.03
space	MOUSTACHE	Control	Sub	poly	0.05
space	TERRITORY	Related	Dom	poly	0.06
space	ASTRONAUT	Related	Sub	poly	0.76
straw	MUG	Control	Dom	poly	0.21
straw	WOLF	Control	Sub	poly	0.16
straw	HAY	Related	Dom	poly	0.43
straw	TUBE	Related	Sub	poly	0.15
stump	NECK	Control	Dom	poly	0.32
stump	EYEWASH	Control	Sub	poly	0.01
stump	TREE	Related	Dom	poly	0.65
stump	AMPUTEE	Related	Sub	poly	0.13
tin	TEXTBOOK	Control	Dom	poly	0
tin	FIREWORKS	Control	Sub	poly	0.07
tin	ALUMINUM	Related	Dom	poly	0.57
tin	CONTAINER	Related	Sub	poly	0.02
tongue	WAR	Control	Dom	poly	0.03

tongue	VACANCY	Control	Sub	poly	0.04
tongue	GUM	Related	Dom	poly	0.46
tongue	DIALECT	Related	Sub	poly	0.18
trial	MOVIE	Control	Dom	poly	0.05
trial	MYSTERY	Control	Sub	poly	0.13
trial	COURT	Related	Dom	poly	0.63
trial	ATTEMPT	Related	Sub	poly	0.2
vessel	STICKLER	Control	Dom	poly	0.09
vessel	DATA	Control	Sub	poly	0
vessel	NAUTICAL	Related	Dom	poly	0.24
vessel	BOWL	Related	Sub	poly	0.06
volume	INVITE	Control	Dom	poly	-0.01
volume	TIE	Control	Sub	poly	0
volume	AMOUNT	Related	Dom	poly	0.27
volume	EAR	Related	Sub	poly	0.05

APPENDIX E

E.1 ANOVA RESULTS – VOCABULARY WORDS

Table 62. Exp. 1 Anova ERP results - Trained vocablary words

Conditions		Type III Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Day	Sphericity Assumed	415.72	1.00	415.72	1.47	.24
	Greenhouse-Geisser	415.72	1.00	415.72	1.47	.24
	Huynh-Feldt	415.72	1.00	415.72	1.47	.24
	Lower-bound	415.72	1.00	415.72	1.47	.24
Error(Day)	Sphericity Assumed	4255.56	15.00	283.70		
	Greenhouse-Geisser	4255.56	15.00	283.70		
	Huynh-Feldt	4255.56	15.00	283.70		
	Lower-bound	4255.56	15.00	283.70		
Word Type (New Homonym vs. New Polyseme)	Sphericity Assumed	84.60	1.00	84.60	0.79	.39
	Greenhouse-Geisser	84.60	1.00	84.60	0.79	.39
	Huynh-Feldt	84.60	1.00	84.60	0.79	.39
	Lower-bound	84.60	1.00	84.60	0.79	.39
Error(Word Type (New Homonym vs. New Polyseme)	Sphericity Assumed	1612.70	15.00	107.51		
	Greenhouse-Geisser	1612.70	15.00	107.51		
	Huynh-Feldt	1612.70	15.00	107.51		
	Lower-bound	1612.70	15.00	107.51		
New Meaning vs. Old Meaning	Sphericity Assumed	34.73	1.00	34.73	0.73	.41
	Greenhouse-Geisser	34.73	1.00	34.73	0.73	.41
	Huynh-Feldt	34.73	1.00	34.73	0.73	.41
	Lower-bound	34.73	1.00	34.73	0.73	.41
Error(New Meaning vs. Old Meaning)	Sphericity Assumed	717.33	15.00	47.82		
	Greenhouse-	717.33	15.00	47.82		

	Geisser					
	Huynh-Feldt	717.33	15.00	47.82		
	Lower-bound	717.33	15.00	47.82		
Target type (Related vs. Control)	Sphericity Assumed	65.22	1.00	65.22	0.67	.42
	Greenhouse-Geisser	65.22	1.00	65.22	0.67	.42
	Huynh-Feldt	65.22	1.00	65.22	0.67	.42
	Lower-bound	65.22	1.00	65.22	0.67	.42
Error(Target type (Related vs. Control))	Sphericity Assumed	1450.09	15.00	96.67		
	Greenhouse-Geisser	1450.09	15.00	96.67		
	Huynh-Feldt	1450.09	15.00	96.67		
	Lower-bound	1450.09	15.00	96.67		
Lobe_FCP	Sphericity Assumed	634.52	2.00	317.26	2.84	.07
	Greenhouse-Geisser	634.52	1.74	364.20	2.84	.08
	Huynh-Feldt	634.52	1.95	325.10	2.84	.08
	Lower-bound	634.52	1.00	634.52	2.84	.11
Error(Lobe_FCP)	Sphericity Assumed	3348.17	30.00	111.61		
	Greenhouse-Geisser	3348.17	26.13	128.12		
	Huynh-Feldt	3348.17	29.28	114.36		
	Lower-bound	3348.17	15.00	223.21		
Hem_LCR	Sphericity Assumed	1416.12	2.00	708.06	10.13	.00
	Greenhouse-Geisser	1416.12	1.97	719.82	10.13	.00
	Huynh-Feldt	1416.12	2.00	708.06	10.13	.00
	Lower-bound	1416.12	1.00	1416.12	10.13	.01
Error(Hem_LCR)	Sphericity Assumed	2097.21	30.00	69.91		
	Greenhouse-Geisser	2097.21	29.51	71.07		
	Huynh-Feldt	2097.21	30.00	69.91		
	Lower-bound	2097.21	15.00	139.81		
Day * NH_HP	Sphericity Assumed	16.16	1.00	16.16	0.38	.55
	Greenhouse-Geisser	16.16	1.00	16.16	0.38	.55
	Huynh-Feldt	16.16	1.00	16.16	0.38	.55
	Lower-bound	16.16	1.00	16.16	0.38	.55
Error(Day*NH_HP)	Sphericity Assumed	635.32	15.00	42.35		
	Greenhouse-Geisser	635.32	15.00	42.35		
	Huynh-Feldt	635.32	15.00	42.35		
	Lower-bound	635.32	15.00	42.35		
Day * New Meaning vs. Old Meaning	Sphericity Assumed	45.70	1.00	45.70	0.58	.46
	Greenhouse-Geisser	45.70	1.00	45.70	0.58	.46

	Huynh-Feldt	45.70	1.00	45.70	0.58	.46
	Lower-bound	45.70	1.00	45.70	0.58	.46
Error(Day*New Meaning vs. Old Meaning)	Sphericity Assumed	1180.28	15.00	78.69		
	Greenhouse-Geisser	1180.28	15.00	78.69		
	Huynh-Feldt	1180.28	15.00	78.69		
	Lower-bound	1180.28	15.00	78.69		
Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning	Sphericity Assumed	40.63	1.00	40.63	1.01	.33
	Greenhouse-Geisser	40.63	1.00	40.63	1.01	.33
	Huynh-Feldt	40.63	1.00	40.63	1.01	.33
	Lower-bound	40.63	1.00	40.63	1.01	.33
Error(NH_HP*New Meaning vs. Old Meaning)	Sphericity Assumed	600.51	15.00	40.03		
	Greenhouse-Geisser	600.51	15.00	40.03		
	Huynh-Feldt	600.51	15.00	40.03		
	Lower-bound	600.51	15.00	40.03		
Day * Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning	Sphericity Assumed	98.65	1.00	98.65	1.36	.26
	Greenhouse-Geisser	98.65	1.00	98.65	1.36	.26
	Huynh-Feldt	98.65	1.00	98.65	1.36	.26
	Lower-bound	98.65	1.00	98.65	1.36	.26
Error(Day*NH_HP*New Meaning vs. Old Meaning)	Sphericity Assumed	1086.85	15.00	72.46		
	Greenhouse-Geisser	1086.85	15.00	72.46		
	Huynh-Feldt	1086.85	15.00	72.46		
	Lower-bound	1086.85	15.00	72.46		
Day * Target type (Related vs. Control)	Sphericity Assumed	1.02	1.00	1.02	0.01	.91
	Greenhouse-Geisser	1.02	1.00	1.02	0.01	.91
	Huynh-Feldt	1.02	1.00	1.02	0.01	.91
	Lower-bound	1.02	1.00	1.02	0.01	.91
Error(Day*Target type (Related vs. Control))	Sphericity Assumed	1269.16	15.00	84.61		
	Greenhouse-Geisser	1269.16	15.00	84.61		
	Huynh-Feldt	1269.16	15.00	84.61		
	Lower-bound	1269.16	15.00	84.61		
Word Type (New Homonym vs. New Polyseme)* Target type (Related vs. Control)	Sphericity Assumed	579.23	1.00	579.23	9.04	.01
	Greenhouse-Geisser	579.23	1.00	579.23	9.04	.01
	Huynh-Feldt	579.23	1.00	579.23	9.04	.01
	Lower-bound	579.23	1.00	579.23	9.04	.01
Error(NH_HP*Target type (Related vs. Control))	Sphericity Assumed	961.19	15.00	64.08		
	Greenhouse-Geisser	961.19	15.00	64.08		
	Huynh-Feldt	961.19	15.00	64.08		

	Lower-bound	961.19	15.00	64.08		
Day * Word Type (New Homonym vs. New Polyseme)* Target type (Related vs. Control)	Sphericity Assumed	53.96	1.00	53.96	1.12	.31
	Greenhouse-Geisser	53.96	1.00	53.96	1.12	.31
	Huynh-Feldt	53.96	1.00	53.96	1.12	.31
	Lower-bound	53.96	1.00	53.96	1.12	.31
Error(Day*NH_HP*Target type (Related vs. Control))	Sphericity Assumed	721.15	15.00	48.08		
	Greenhouse-Geisser	721.15	15.00	48.08		
	Huynh-Feldt	721.15	15.00	48.08		
	Lower-bound	721.15	15.00	48.08		
New Meaning vs. Old Meaning * Target type (Related vs. Control)	Sphericity Assumed	6.75	1.00	6.75	0.14	.71
	Greenhouse-Geisser	6.75	1.00	6.75	0.14	.71
	Huynh-Feldt	6.75	1.00	6.75	0.14	.71
	Lower-bound	6.75	1.00	6.75	0.14	.71
Error(New Meaning vs. Old Meaning*Target type (Related vs. Control))	Sphericity Assumed	719.41	15.00	47.96		
	Greenhouse-Geisser	719.41	15.00	47.96		
	Huynh-Feldt	719.41	15.00	47.96		
	Lower-bound	719.41	15.00	47.96		
Day * New Meaning vs. Old Meaning * Target type (Related vs. Control)	Sphericity Assumed	247.68	1.00	247.68	4.88	.04
	Greenhouse-Geisser	247.68	1.00	247.68	4.88	.04
	Huynh-Feldt	247.68	1.00	247.68	4.88	.04
	Lower-bound	247.68	1.00	247.68	4.88	.04
Error(Day*New Meaning vs. Old Meaning*Target type (Related vs. Control))	Sphericity Assumed	761.09	15.00	50.74		
	Greenhouse-Geisser	761.09	15.00	50.74		
	Huynh-Feldt	761.09	15.00	50.74		
	Lower-bound	761.09	15.00	50.74		
Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Target type (Related vs. Control)	Sphericity Assumed	45.48	1.00	45.48	0.80	.39
	Greenhouse-Geisser	45.48	1.00	45.48	0.80	.39
	Huynh-Feldt	45.48	1.00	45.48	0.80	.39
	Lower-bound	45.48	1.00	45.48	0.80	.39
Error(NH_HP*New Meaning vs. Old Meaning*Target type (Related vs. Control))	Sphericity Assumed	855.24	15.00	57.02		
	Greenhouse-Geisser	855.24	15.00	57.02		
	Huynh-Feldt	855.24	15.00	57.02		
	Lower-bound	855.24	15.00	57.02		
Day * Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Target type (Related vs. Control)	Sphericity Assumed	8.90	1.00	8.90	0.25	.62
	Greenhouse-Geisser	8.90	1.00	8.90	0.25	.62
	Huynh-Feldt	8.90	1.00	8.90	0.25	.62
	Lower-bound	8.90	1.00	8.90	0.25	.62

Error(Day*NH_HP*New Meaning vs. Old Meaning*Target type (Related vs. Control))	Sphericity Assumed	526.00	15.00	35.07		
	Greenhouse-Geisser	526.00	15.00	35.07		
	Huynh-Feldt	526.00	15.00	35.07		
	Lower-bound	526.00	15.00	35.07		
Day * Lobe_FCP	Sphericity Assumed	197.54	2.00	98.77	1.46	.25
	Greenhouse-Geisser	197.54	1.96	101.04	1.46	.25
	Huynh-Feldt	197.54	2.00	98.77	1.46	.25
	Lower-bound	197.54	1.00	197.54	1.46	.25
Error(Day*Lobe_FCP)	Sphericity Assumed	2029.74	30.00	67.66		
	Greenhouse-Geisser	2029.74	29.33	69.21		
	Huynh-Feldt	2029.74	30.00	67.66		
	Lower-bound	2029.74	15.00	135.32		
Word Type (New Homonym vs. New Polyseme)* Lobe_FCP	Sphericity Assumed	0.09	2.00	0.04	0.00	1.00
	Greenhouse-Geisser	0.09	1.08	0.08	0.00	.97
	Huynh-Feldt	0.09	1.10	0.08	0.00	.97
	Lower-bound	0.09	1.00	0.09	0.00	.96
Error(NH_HP*Lobe_FCP)	Sphericity Assumed	440.37	30.00	14.68		
	Greenhouse-Geisser	440.37	16.24	27.11		
	Huynh-Feldt	440.37	16.52	26.66		
	Lower-bound	440.37	15.00	29.36		
Day * Word Type (New Homonym vs. New Polyseme)* Lobe_FCP	Sphericity Assumed	62.22	2.00	31.11	3.13	.06
	Greenhouse-Geisser	62.22	1.23	50.67	3.13	.09
	Huynh-Feldt	62.22	1.28	48.55	3.13	.08
	Lower-bound	62.22	1.00	62.22	3.13	.10
Error(Day*NH_HP*Lobe_FCP)	Sphericity Assumed	298.48	30.00	9.95		
	Greenhouse-Geisser	298.48	18.42	16.20		
	Huynh-Feldt	298.48	19.22	15.53		
	Lower-bound	298.48	15.00	19.90		
New Meaning vs. Old Meaning * Lobe_FCP	Sphericity Assumed	19.14	2.00	9.57	1.34	.28
	Greenhouse-Geisser	19.14	1.26	15.18	1.34	.27
	Huynh-Feldt	19.14	1.32	14.47	1.34	.27
	Lower-bound	19.14	1.00	19.14	1.34	.27
Error(New Meaning vs. Old Meaning*Lobe_FCP)	Sphericity Assumed	214.27	30.00	7.14		
	Greenhouse-Geisser	214.27	18.91	11.33		
	Huynh-Feldt	214.27	19.84	10.80		
	Lower-bound	214.27	15.00	14.28		
Day * New Meaning vs. Old Meaning *	Sphericity	1.87	2.00	0.93	0.21	.81

Lobe_FCP	Assumed					
	Greenhouse-Geisser	1.87	1.51	1.24	0.21	.75
	Huynh-Feldt	1.87	1.64	1.14	0.21	.77
	Lower-bound	1.87	1.00	1.87	0.21	.65
Error(Day*New Meaning vs. Old Meaning*Lobe_FCP)	Sphericity Assumed	131.23	30.00	4.37		
	Greenhouse-Geisser	131.23	22.67	5.79		
	Huynh-Feldt	131.23	24.66	5.32		
	Lower-bound	131.23	15.00	8.75		
Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Lobe_FCP	Sphericity Assumed	14.82	2.00	7.41	2.02	.15
	Greenhouse-Geisser	14.82	1.36	10.90	2.02	.17
	Huynh-Feldt	14.82	1.45	10.23	2.02	.17
	Lower-bound	14.82	1.00	14.82	2.02	.18
Error(NH_HP*New Meaning vs. Old Meaning*Lobe_FCP)	Sphericity Assumed	110.18	30.00	3.67		
	Greenhouse-Geisser	110.18	20.39	5.40		
	Huynh-Feldt	110.18	21.72	5.07		
	Lower-bound	110.18	15.00	7.35		
Day * Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Lobe_FCP	Sphericity Assumed	0.27	2.00	0.14	0.02	.98
	Greenhouse-Geisser	0.27	1.37	0.20	0.02	.94
	Huynh-Feldt	0.27	1.46	0.19	0.02	.95
	Lower-bound	0.27	1.00	0.27	0.02	.89
Error(Day*NH_HP*New Meaning vs. Old Meaning*Lobe_FCP)	Sphericity Assumed	205.37	30.00	6.85		
	Greenhouse-Geisser	205.37	20.48	10.03		
	Huynh-Feldt	205.37	21.83	9.41		
	Lower-bound	205.37	15.00	13.69		
Target type (Related vs. Control) * Lobe_FCP	Sphericity Assumed	28.90	2.00	14.45	1.75	.19
	Greenhouse-Geisser	28.90	1.85	15.60	1.75	.19
	Huynh-Feldt	28.90	2.00	14.45	1.75	.19
	Lower-bound	28.90	1.00	28.90	1.75	.21
Error(Target type (Related vs. Control)*Lobe_FCP)	Sphericity Assumed	248.02	30.00	8.27		
	Greenhouse-Geisser	248.02	27.79	8.93		
	Huynh-Feldt	248.02	30.00	8.27		
	Lower-bound	248.02	15.00	16.53		
Day * Target type (Related vs. Control) * Lobe_FCP	Sphericity Assumed	6.95	2.00	3.48	0.39	.68
	Greenhouse-Geisser	6.95	1.90	3.66	0.39	.67
	Huynh-Feldt	6.95	2.00	3.48	0.39	.68
	Lower-bound	6.95	1.00	6.95	0.39	.54
Error(Day*Target type (Related vs. Control)*Lobe_FCP)	Sphericity Assumed	268.29	30.00	8.94		

	Greenhouse-Geisser	268.29	28.47	9.42		
	Huynh-Feldt	268.29	30.00	8.94		
	Lower-bound	268.29	15.00	17.89		
Word Type (New Homonym vs. New Polyseme)* Target type (Related vs. Control) * Lobe_FCP	Sphericity Assumed	33.64	2.00	16.82	4.07	.03
	Greenhouse-Geisser	33.64	1.19	28.39	4.07	.05
	Huynh-Feldt	33.64	1.23	27.40	4.07	.05
	Lower-bound	33.64	1.00	33.64	4.07	.06
Error(NH_HP*Target type (Related vs. Control)*Lobe_FCP)	Sphericity Assumed	124.10	30.00	4.14		
	Greenhouse-Geisser	124.10	17.78	6.98		
	Huynh-Feldt	124.10	18.42	6.74		
	Lower-bound	124.10	15.00	8.27		
Day * Word Type (New Homonym vs. New Polyseme)* Target type (Related vs. Control) * Lobe_FCP	Sphericity Assumed	4.90	2.00	2.45	0.54	.59
	Greenhouse-Geisser	4.90	1.53	3.20	0.54	.54
	Huynh-Feldt	4.90	1.67	2.93	0.54	.56
	Lower-bound	4.90	1.00	4.90	0.54	.47
Error(Day*NH_HP*Target type (Related vs. Control)*Lobe_FCP)	Sphericity Assumed	135.45	30.00	4.51		
	Greenhouse-Geisser	135.45	22.99	5.89		
	Huynh-Feldt	135.45	25.08	5.40		
	Lower-bound	135.45	15.00	9.03		
New Meaning vs. Old Meaning * Target type (Related vs. Control) * Lobe_FCP	Sphericity Assumed	36.13	2.00	18.06	3.11	.06
	Greenhouse-Geisser	36.13	1.17	31.01	3.11	.09
	Huynh-Feldt	36.13	1.20	30.04	3.11	.09
	Lower-bound	36.13	1.00	36.13	3.11	.10
Error(New Meaning vs. Old Meaning*Target type (Related vs. Control)*Lobe_FCP)	Sphericity Assumed	174.38	30.00	5.81		
	Greenhouse-Geisser	174.38	17.48	9.98		
	Huynh-Feldt	174.38	18.04	9.66		
	Lower-bound	174.38	15.00	11.63		
Day * New Meaning vs. Old Meaning * Target type (Related vs. Control) * Lobe_FCP	Sphericity Assumed	7.19	2.00	3.60	0.21	.81
	Greenhouse-Geisser	7.19	1.09	6.62	0.21	.68
	Huynh-Feldt	7.19	1.11	6.51	0.21	.68
	Lower-bound	7.19	1.00	7.19	0.21	.66
Error(Day*New Meaning vs. Old Meaning*Target type (Related vs. Control)*Lobe_FCP)	Sphericity Assumed	521.98	30.00	17.40		
	Greenhouse-Geisser	521.98	16.29	32.04		
	Huynh-Feldt	521.98	16.58	31.49		
	Lower-bound	521.98	15.00	34.80		
Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Target type (Related vs. Control) *	Sphericity Assumed	18.16	2.00	9.08	1.15	.33
	Greenhouse-	18.16	1.39	13.07	1.15	.32

Lobe_FCP	Geisser					
	Huynh-Feldt	18.16	1.49	12.22	1.15	.32
	Lower-bound	18.16	1.00	18.16	1.15	.30
Error(NH_HP*New Meaning vs. Old Meaning*Target type (Related vs. Control)*Lobe_FCP)	Sphericity Assumed	236.61	30.00	7.89		
	Greenhouse-Geisser	236.61	20.84	11.35		
	Huynh-Feldt	236.61	22.29	10.61		
	Lower-bound	236.61	15.00	15.77		
Day * Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Target type (Related vs. Control) * Lobe_FCP	Sphericity Assumed	12.72	2.00	6.36	1.62	.21
	Greenhouse-Geisser	12.72	1.69	7.53	1.62	.22
	Huynh-Feldt	12.72	1.88	6.76	1.62	.22
	Lower-bound	12.72	1.00	12.72	1.62	.22
Error(Day*NH_HP*New Meaning vs. Old Meaning*Target type (Related vs. Control)*Lobe_FCP)	Sphericity Assumed	117.75	30.00	3.92		
	Greenhouse-Geisser	117.75	25.36	4.64		
	Huynh-Feldt	117.75	28.23	4.17		
	Lower-bound	117.75	15.00	7.85		
Day * Hem_LCR	Sphericity Assumed	102.84	2.00	51.42	1.12	.34
	Greenhouse-Geisser	102.84	1.35	75.93	1.12	.32
	Huynh-Feldt	102.84	1.44	71.34	1.12	.33
	Lower-bound	102.84	1.00	102.84	1.12	.31
Error(Day*Hem_LCR)	Sphericity Assumed	1377.88	30.00	45.93		
	Greenhouse-Geisser	1377.88	20.32	67.82		
	Huynh-Feldt	1377.88	21.62	63.72		
	Lower-bound	1377.88	15.00	91.86		
Word Type (New Homonym vs. New Polyseme)* Hem_LCR	Sphericity Assumed	2.59	2.00	1.29	0.32	.73
	Greenhouse-Geisser	2.59	1.32	1.96	0.32	.64
	Huynh-Feldt	2.59	1.40	1.85	0.32	.65
	Lower-bound	2.59	1.00	2.59	0.32	.58
Error(NH_HP*Hem_LCR)	Sphericity Assumed	120.54	30.00	4.02		
	Greenhouse-Geisser	120.54	19.81	6.08		
	Huynh-Feldt	120.54	20.98	5.75		
	Lower-bound	120.54	15.00	8.04		
Day * Word Type (New Homonym vs. New Polyseme)* Hem_LCR	Sphericity Assumed	4.16	2.00	2.08	0.97	.39
	Greenhouse-Geisser	4.16	1.73	2.40	0.97	.38
	Huynh-Feldt	4.16	1.93	2.15	0.97	.39
	Lower-bound	4.16	1.00	4.16	0.97	.34
Error(Day*NH_HP*Hem_LCR)	Sphericity Assumed	64.07	30.00	2.14		
	Greenhouse-Geisser	64.07	25.94	2.47		

	Huynh-Feldt	64.07	29.02	2.21		
	Lower-bound	64.07	15.00	4.27		
New Meaning vs. Old Meaning * Hem_LCR	Sphericity Assumed	4.19	2.00	2.09	0.82	.45
	Greenhouse-Geisser	4.19	1.90	2.20	0.82	.45
	Huynh-Feldt	4.19	2.00	2.09	0.82	.45
	Lower-bound	4.19	1.00	4.19	0.82	.38
Error(New Meaning vs. Old Meaning*Hem_LCR)	Sphericity Assumed	76.77	30.00	2.56		
	Greenhouse-Geisser	76.77	28.55	2.69		
	Huynh-Feldt	76.77	30.00	2.56		
	Lower-bound	76.77	15.00	5.12		
Day * New Meaning vs. Old Meaning * Hem_LCR	Sphericity Assumed	29.26	2.00	14.63	4.23	.02
	Greenhouse-Geisser	29.26	1.86	15.74	4.23	.03
	Huynh-Feldt	29.26	2.00	14.63	4.23	.02
	Lower-bound	29.26	1.00	29.26	4.23	.06
Error(Day*New Meaning vs. Old Meaning*Hem_LCR)	Sphericity Assumed	103.80	30.00	3.46		
	Greenhouse-Geisser	103.80	27.89	3.72		
	Huynh-Feldt	103.80	30.00	3.46		
	Lower-bound	103.80	15.00	6.92		
Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Hem_LCR	Sphericity Assumed	4.82	2.00	2.41	1.04	.37
	Greenhouse-Geisser	4.82	1.70	2.83	1.04	.36
	Huynh-Feldt	4.82	1.90	2.53	1.04	.36
	Lower-bound	4.82	1.00	4.82	1.04	.32
Error(NH_HP*New Meaning vs. Old Meaning*Hem_LCR)	Sphericity Assumed	69.36	30.00	2.31		
	Greenhouse-Geisser	69.36	25.57	2.71		
	Huynh-Feldt	69.36	28.52	2.43		
	Lower-bound	69.36	15.00	4.62		
Day * Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Hem_LCR	Sphericity Assumed	0.32	2.00	0.16	0.08	.92
	Greenhouse-Geisser	0.32	1.85	0.18	0.08	.91
	Huynh-Feldt	0.32	2.00	0.16	0.08	.92
	Lower-bound	0.32	1.00	0.32	0.08	.78
Error(Day*NH_HP*New Meaning vs. Old Meaning*Hem_LCR)	Sphericity Assumed	61.01	30.00	2.03		
	Greenhouse-Geisser	61.01	27.74	2.20		
	Huynh-Feldt	61.01	30.00	2.03		
	Lower-bound	61.01	15.00	4.07		
Target type (Related vs. Control) * Hem_LCR	Sphericity Assumed	1.95	2.00	0.97	0.15	.86
	Greenhouse-Geisser	1.95	1.94	1.01	0.15	.85
	Huynh-Feldt	1.95	2.00	0.97	0.15	.86

	Lower-bound	1.95	1.00	1.95	0.15	.70
Error(Target type (Related vs. Control)*Hem_LCR)	Sphericity Assumed	188.90	30.00	6.30		
	Greenhouse-Geisser	188.90	29.07	6.50		
	Huynh-Feldt	188.90	30.00	6.30		
	Lower-bound	188.90	15.00	12.59		
Day * Target type (Related vs. Control) * Hem_LCR	Sphericity Assumed	3.84	2.00	1.92	0.44	.65
	Greenhouse-Geisser	3.84	1.72	2.23	0.44	.62
	Huynh-Feldt	3.84	1.93	1.99	0.44	.64
	Lower-bound	3.84	1.00	3.84	0.44	.52
Error(Day*Target type (Related vs. Control)*Hem_LCR)	Sphericity Assumed	129.98	30.00	4.33		
	Greenhouse-Geisser	129.98	25.85	5.03		
	Huynh-Feldt	129.98	28.90	4.50		
	Lower-bound	129.98	15.00	8.67		
Word Type (New Homonym vs. New Polyseme)* Target type (Related vs. Control) * Hem_LCR	Sphericity Assumed	0.75	2.00	0.38	0.16	.85
	Greenhouse-Geisser	0.75	1.82	0.41	0.16	.83
	Huynh-Feldt	0.75	2.00	0.38	0.16	.85
	Lower-bound	0.75	1.00	0.75	0.16	.69
Error(NH_HP*Target type (Related vs. Control)*Hem_LCR)	Sphericity Assumed	70.15	30.00	2.34		
	Greenhouse-Geisser	70.15	27.25	2.57		
	Huynh-Feldt	70.15	30.00	2.34		
	Lower-bound	70.15	15.00	4.68		
Day * Word Type (New Homonym vs. New Polyseme)* Target type (Related vs. Control) * Hem_LCR	Sphericity Assumed	4.33	2.00	2.17	0.55	.58
	Greenhouse-Geisser	4.33	1.88	2.30	0.55	.57
	Huynh-Feldt	4.33	2.00	2.17	0.55	.58
	Lower-bound	4.33	1.00	4.33	0.55	.47
Error(Day*NH_HP*Target type (Related vs. Control)*Hem_LCR)	Sphericity Assumed	118.22	30.00	3.94		
	Greenhouse-Geisser	118.22	28.23	4.19		
	Huynh-Feldt	118.22	30.00	3.94		
	Lower-bound	118.22	15.00	7.88		
New Meaning vs. Old Meaning * Target type (Related vs. Control) * Hem_LCR	Sphericity Assumed	0.58	2.00	0.29	0.05	.95
	Greenhouse-Geisser	0.58	1.50	0.39	0.05	.90
	Huynh-Feldt	0.58	1.63	0.36	0.05	.92
	Lower-bound	0.58	1.00	0.58	0.05	.82
Error(New Meaning vs. Old Meaning*Target type (Related vs. Control)*Hem_LCR)	Sphericity Assumed	161.90	30.00	5.40		
	Greenhouse-Geisser	161.90	22.46	7.21		
	Huynh-Feldt	161.90	24.39	6.64		
	Lower-bound	161.90	15.00	10.79		

Day * New Meaning vs. Old Meaning * Target type (Related vs. Control) * Hem_LCR	Sphericity Assumed	9.25	2.00	4.62	0.82	.45
	Greenhouse-Geisser	9.25	1.71	5.41	0.82	.43
	Huynh-Feldt	9.25	1.91	4.85	0.82	.45
	Lower-bound	9.25	1.00	9.25	0.82	.38
Error(Day*New Meaning vs. Old Meaning*Target type (Related vs. Control)*Hem_LCR)	Sphericity Assumed	169.42	30.00	5.65		
	Greenhouse-Geisser	169.42	25.63	6.61		
	Huynh-Feldt	169.42	28.60	5.92		
	Lower-bound	169.42	15.00	11.29		
Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Target type (Related vs. Control) * Hem_LCR	Sphericity Assumed	15.43	2.00	7.72	2.61	.09
	Greenhouse-Geisser	15.43	1.97	7.85	2.61	.09
	Huynh-Feldt	15.43	2.00	7.72	2.61	.09
	Lower-bound	15.43	1.00	15.43	2.61	.13
Error(NH_HP*New Meaning vs. Old Meaning*Target type (Related vs. Control)*Hem_LCR)	Sphericity Assumed	88.71	30.00	2.96		
	Greenhouse-Geisser	88.71	29.50	3.01		
	Huynh-Feldt	88.71	30.00	2.96		
	Lower-bound	88.71	15.00	5.91		
Day * Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Target type (Related vs. Control) * Hem_LCR	Sphericity Assumed	10.91	2.00	5.45	1.54	.23
	Greenhouse-Geisser	10.91	1.79	6.09	1.54	.23
	Huynh-Feldt	10.91	2.00	5.45	1.54	.23
	Lower-bound	10.91	1.00	10.91	1.54	.23
Error(Day*NH_HP*New Meaning vs. Old Meaning*Target type (Related vs. Control)*Hem_LCR)	Sphericity Assumed	105.91	30.00	3.53		
	Greenhouse-Geisser	105.91	26.87	3.94		
	Huynh-Feldt	105.91	30.00	3.53		
	Lower-bound	105.91	15.00	7.06		
Lobe_FCP * Hem_LCR	Sphericity Assumed	282.01	4.00	70.50	1.42	.24
	Greenhouse-Geisser	282.01	1.68	167.44	1.42	.26
	Huynh-Feldt	282.01	1.87	150.52	1.42	.26
	Lower-bound	282.01	1.00	282.01	1.42	.25
Error(Lobe_FCP*Hem_LCR)	Sphericity Assumed	2988.64	60.00	49.81		
	Greenhouse-Geisser	2988.64	25.26	118.30		
	Huynh-Feldt	2988.64	28.10	106.35		
	Lower-bound	2988.64	15.00	199.24		
Day * Lobe_FCP * Hem_LCR	Sphericity Assumed	187.56	4.00	46.89	1.02	.41
	Greenhouse-Geisser	187.56	1.27	147.27	1.02	.35
	Huynh-Feldt	187.56	1.34	140.10	1.02	.35
	Lower-bound	187.56	1.00	187.56	1.02	.33
Error(Day*Lobe_FCP*Hem_LCR)	Sphericity	2768.84	60.00	46.15		

	Assumed					
	Greenhouse-Geisser	2768.84	19.10	144.95		
	Huynh-Feldt	2768.84	20.08	137.88		
	Lower-bound	2768.84	15.00	184.59		
Word Type (New Homonym vs. New Polyseme)* Lobe_FCP * Hem_LCR	Sphericity Assumed	8.92	4.00	2.23	1.29	.28
	Greenhouse-Geisser	8.92	3.27	2.73	1.29	.29
	Huynh-Feldt	8.92	4.00	2.23	1.29	.28
	Lower-bound	8.92	1.00	8.92	1.29	.27
Error(NH_HP*Lobe_FCP*Hem_LCR)	Sphericity Assumed	103.86	60.00	1.73		
	Greenhouse-Geisser	103.86	49.04	2.12		
	Huynh-Feldt	103.86	60.00	1.73		
	Lower-bound	103.86	15.00	6.92		
Day * Word Type (New Homonym vs. New Polyseme)* Lobe_FCP * Hem_LCR	Sphericity Assumed	2.43	4.00	0.61	0.50	.73
	Greenhouse-Geisser	2.43	2.84	0.85	0.50	.67
	Huynh-Feldt	2.43	3.58	0.68	0.50	.71
	Lower-bound	2.43	1.00	2.43	0.50	.49
Error(Day*NH_HP*Lobe_FCP*Hem_LCR)	Sphericity Assumed	72.29	60.00	1.20		
	Greenhouse-Geisser	72.29	42.67	1.69		
	Huynh-Feldt	72.29	53.69	1.35		
	Lower-bound	72.29	15.00	4.82		
New Meaning vs. Old Meaning * Lobe_FCP * Hem_LCR	Sphericity Assumed	2.20	4.00	0.55	0.40	.80
	Greenhouse-Geisser	2.20	2.98	0.74	0.40	.75
	Huynh-Feldt	2.20	3.79	0.58	0.40	.80
	Lower-bound	2.20	1.00	2.20	0.40	.53
Error(New Meaning vs. Old Meaning*Lobe_FCP*Hem_LCR)	Sphericity Assumed	81.72	60.00	1.36		
	Greenhouse-Geisser	81.72	44.65	1.83		
	Huynh-Feldt	81.72	56.92	1.44		
	Lower-bound	81.72	15.00	5.45		
Day * New Meaning vs. Old Meaning * Lobe_FCP * Hem_LCR	Sphericity Assumed	9.77	4.00	2.44	1.13	.35
	Greenhouse-Geisser	9.77	2.58	3.78	1.13	.34
	Huynh-Feldt	9.77	3.16	3.09	1.13	.35
	Lower-bound	9.77	1.00	9.77	1.13	.30
Error(Day*New Meaning vs. Old Meaning*Lobe_FCP*Hem_LCR)	Sphericity Assumed	129.35	60.00	2.16		
	Greenhouse-Geisser	129.35	38.71	3.34		
	Huynh-Feldt	129.35	47.46	2.73		
	Lower-bound	129.35	15.00	8.62		
Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning	Sphericity Assumed	13.36	4.00	3.34	3.96	.01

* Lobe_FCP * Hem_LCR	Greenhouse-Geisser	13.36	2.82	4.74	3.96	.02
	Huynh-Feldt	13.36	3.54	3.78	3.96	.01
	Lower-bound	13.36	1.00	13.36	3.96	.07
Error(NH_HP*New Meaning vs. Old Meaning*Lobe_FCP*Hem_LCR)	Sphericity Assumed	50.58	60.00	0.84		
	Greenhouse-Geisser	50.58	42.27	1.20		
	Huynh-Feldt	50.58	53.06	0.95		
	Lower-bound	50.58	15.00	3.37		
Day * Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Lobe_FCP * Hem_LCR	Sphericity Assumed	6.50	4.00	1.63	1.22	.31
	Greenhouse-Geisser	6.50	2.72	2.39	1.22	.31
	Huynh-Feldt	6.50	3.38	1.92	1.22	.31
	Lower-bound	6.50	1.00	6.50	1.22	.29
Error(Day*NH_HP*New Meaning vs. Old Meaning*Lobe_FCP*Hem_LCR)	Sphericity Assumed	80.09	60.00	1.33		
	Greenhouse-Geisser	80.09	40.78	1.96		
	Huynh-Feldt	80.09	50.69	1.58		
	Lower-bound	80.09	15.00	5.34		
Target type (Related vs. Control) * Lobe_FCP * Hem_LCR	Sphericity Assumed	36.29	4.00	9.07	1.81	.14
	Greenhouse-Geisser	36.29	1.64	22.08	1.81	.19
	Huynh-Feldt	36.29	1.82	19.95	1.81	.18
	Lower-bound	36.29	1.00	36.29	1.81	.20
Error(Target type (Related vs. Control)*Lobe_FCP*Hem_LCR)	Sphericity Assumed	300.30	60.00	5.01		
	Greenhouse-Geisser	300.30	24.65	12.18		
	Huynh-Feldt	300.30	27.29	11.00		
	Lower-bound	300.30	15.00	20.02		
Day * Target type (Related vs. Control) * Lobe_FCP * Hem_LCR	Sphericity Assumed	26.99	4.00	6.75	1.30	.28
	Greenhouse-Geisser	26.99	1.68	16.07	1.30	.29
	Huynh-Feldt	26.99	1.87	14.45	1.30	.29
	Lower-bound	26.99	1.00	26.99	1.30	.27
Error(Day*Target type (Related vs. Control)*Lobe_FCP*Hem_LCR)	Sphericity Assumed	311.63	60.00	5.19		
	Greenhouse-Geisser	311.63	25.20	12.37		
	Huynh-Feldt	311.63	28.02	11.12		
	Lower-bound	311.63	15.00	20.78		
Word Type (New Homonym vs. New Polyseme)* Target type (Related vs. Control) * Lobe_FCP * Hem_LCR	Sphericity Assumed	4.35	4.00	1.09	0.96	.43
	Greenhouse-Geisser	4.35	3.53	1.23	0.96	.43
	Huynh-Feldt	4.35	4.00	1.09	0.96	.43
	Lower-bound	4.35	1.00	4.35	0.96	.34
Error(NH_HP*Target type (Related vs. Control)*Lobe_FCP*Hem_LCR)	Sphericity Assumed	67.59	60.00	1.13		
	Greenhouse-	67.59	52.93	1.28		

	Geisser					
	Huynh-Feldt	67.59	60.00	1.13		
	Lower-bound	67.59	15.00	4.51		
Day * Word Type (New Homonym vs. New Polyseme)* Target type (Related vs. Control) * Lobe_FCP * Hem_LCR	Sphericity Assumed	1.94	4.00	0.49	0.41	.80
	Greenhouse-Geisser	1.94	2.46	0.79	0.41	.71
	Huynh-Feldt	1.94	2.98	0.65	0.41	.75
	Lower-bound	1.94	1.00	1.94	0.41	.53
Error(Day*NH_HP*Target type (Related vs. Control)*Lobe_FCP*Hem_LCR)	Sphericity Assumed	71.00	60.00	1.18		
	Greenhouse-Geisser	71.00	36.95	1.92		
	Huynh-Feldt	71.00	44.76	1.59		
	Lower-bound	71.00	15.00	4.73		
New Meaning vs. Old Meaning * Target type (Related vs. Control) * Lobe_FCP * Hem_LCR	Sphericity Assumed	5.28	4.00	1.32	0.54	.70
	Greenhouse-Geisser	5.28	2.82	1.87	0.54	.64
	Huynh-Feldt	5.28	3.55	1.49	0.54	.68
	Lower-bound	5.28	1.00	5.28	0.54	.47
Error(New Meaning vs. Old Meaning*Target type (Related vs. Control)*Lobe_FCP*Hem_LCR)	Sphericity Assumed	145.78	60.00	2.43		
	Greenhouse-Geisser	145.78	42.35	3.44		
	Huynh-Feldt	145.78	53.18	2.74		
	Lower-bound	145.78	15.00	9.72		
Day * New Meaning vs. Old Meaning * Target type (Related vs. Control) * Lobe_FCP * Hem_LCR	Sphericity Assumed	9.36	4.00	2.34	1.59	.19
	Greenhouse-Geisser	9.36	2.70	3.47	1.59	.21
	Huynh-Feldt	9.36	3.35	2.80	1.59	.20
	Lower-bound	9.36	1.00	9.36	1.59	.23
Error(Day*New Meaning vs. Old Meaning*Target type (Related vs. Control)*Lobe_FCP*Hem_LCR)	Sphericity Assumed	88.41	60.00	1.47		
	Greenhouse-Geisser	88.41	40.50	2.18		
	Huynh-Feldt	88.41	50.24	1.76		
	Lower-bound	88.41	15.00	5.89		
Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Target type (Related vs. Control) * Lobe_FCP * Hem_LCR	Sphericity Assumed	14.32	4.00	3.58	1.48	.22
	Greenhouse-Geisser	14.32	2.71	5.29	1.48	.24
	Huynh-Feldt	14.32	3.36	4.26	1.48	.23
	Lower-bound	14.32	1.00	14.32	1.48	.24
Error(NH_HP*New Meaning vs. Old Meaning*Target type (Related vs. Control)*Lobe_FCP*Hem_LCR)	Sphericity Assumed	145.49	60.00	2.42		
	Greenhouse-Geisser	145.49	40.60	3.58		
	Huynh-Feldt	145.49	50.40	2.89		
	Lower-bound	145.49	15.00	9.70		
Day * Word Type (New Homonym vs. New Polyseme)* New Meaning vs. Old Meaning * Target type (Related vs. Control) * Lobe_FCP * Hem_LCR	Sphericity Assumed	4.24	4.00	1.06	0.40	.81
	Greenhouse-Geisser	4.24	2.76	1.53	0.40	.74

	Huynh-Feldt	4.24	3.45	1.23	0.40	.78
	Lower-bound	4.24	1.00	4.24	0.40	.54
Error(Day*NH_HP*New Meaning vs. Old Meaning*Target type (Related vs. Control)*Lobe_FCP*Hem_LCR)	Sphericity Assumed	160.30	60.00	2.67		
	Greenhouse-Geisser	160.30	41.46	3.87		
	Huynh-Feldt	160.30	51.76	3.10		
	Lower-bound	160.30	15.00	10.69		

E.2 ANOVA RESULTS – UNTRAINED AMBIGUOUS WORDS

Table 63. Exp. 1 Anova ERP results - Untrained ambiguous words

Conditons		Type III Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Day	Sphericity Assumed	415.72	1.00	415.72	1.47	.24
	Greenhouse-Geisser	415.72	1.00	415.72	1.47	.24
	Huynh-Feldt	415.72	1.00	415.72	1.47	.24
	Lower-bound	415.72	1.00	415.72	1.47	.24
Error(Day)	Sphericity Assumed	4255.56	15.00	283.70		
	Greenhouse-Geisser	4255.56	15.00	283.70		
	Huynh-Feldt	4255.56	15.00	283.70		
	Lower-bound	4255.56	15.00	283.70		
Hom_poly	Sphericity Assumed	84.60	1.00	84.60	0.79	.39
	Greenhouse-Geisser	84.60	1.00	84.60	0.79	.39
	Huynh-Feldt	84.60	1.00	84.60	0.79	.39
	Lower-bound	84.60	1.00	84.60	0.79	.39
Error(Hom_poly)	Sphericity Assumed	1612.70	15.00	107.51		
	Greenhouse-Geisser	1612.70	15.00	107.51		
	Huynh-Feldt	1612.70	15.00	107.51		
	Lower-bound	1612.70	15.00	107.51		
Dom_Sub	Sphericity Assumed	34.73	1.00	34.73	0.73	.41
	Greenhouse-Geisser	34.73	1.00	34.73	0.73	.41
	Huynh-Feldt	34.73	1.00	34.73	0.73	.41
	Lower-bound	34.73	1.00	34.73	0.73	.41
Error(Dom_Sub)	Sphericity Assumed	717.33	15.00	47.82		
	Greenhouse-Geisser	717.33	15.00	47.82		
	Huynh-Feldt	717.33	15.00	47.82		
	Lower-bound	717.33	15.00	47.82		
Rel_Unrel	Sphericity Assumed	65.22	1.00	65.22	0.67	.42
	Greenhouse-Geisser	65.22	1.00	65.22	0.67	.42
	Huynh-Feldt	65.22	1.00	65.22	0.67	.42
	Lower-bound	65.22	1.00	65.22	0.67	.42
Error(Rel_Unrel)	Sphericity Assumed	1450.09	15.00	96.67		
	Greenhouse-Geisser	1450.09	15.00	96.67		
	Huynh-Feldt	1450.09	15.00	96.67		
	Lower-bound	1450.09	15.00	96.67		

Lobe	Sphericity Assumed	634.52	2.00	317.26	2.84	.07
	Greenhouse-Geisser	634.52	1.74	364.20	2.84	.08
	Huynh-Feldt	634.52	1.95	325.10	2.84	.08
	Lower-bound	634.52	1.00	634.52	2.84	.11
Error(Lobe)	Sphericity Assumed	3348.17	30.00	111.61		
	Greenhouse-Geisser	3348.17	26.13	128.12		
	Huynh-Feldt	3348.17	29.28	114.36		
	Lower-bound	3348.17	15.00	223.21		
Hem_LCR	Sphericity Assumed	1416.12	2.00	708.06	10.13	.00
	Greenhouse-Geisser	1416.12	1.97	719.82	10.13	.00
	Huynh-Feldt	1416.12	2.00	708.06	10.13	.00
	Lower-bound	1416.12	1.00	1416.12	10.13	.01
Error(Hem_LCR)	Sphericity Assumed	2097.21	30.00	69.91		
	Greenhouse-Geisser	2097.21	29.51	71.07		
	Huynh-Feldt	2097.21	30.00	69.91		
	Lower-bound	2097.21	15.00	139.81		
Day * Hom_poly	Sphericity Assumed	16.16	1.00	16.16	0.38	.55
	Greenhouse-Geisser	16.16	1.00	16.16	0.38	.55
	Huynh-Feldt	16.16	1.00	16.16	0.38	.55
	Lower-bound	16.16	1.00	16.16	0.38	.55
Error(Day*Hom_poly)	Sphericity Assumed	635.32	15.00	42.35		
	Greenhouse-Geisser	635.32	15.00	42.35		
	Huynh-Feldt	635.32	15.00	42.35		
	Lower-bound	635.32	15.00	42.35		
Day * Dom_Sub	Sphericity Assumed	45.70	1.00	45.70	0.58	.46
	Greenhouse-Geisser	45.70	1.00	45.70	0.58	.46
	Huynh-Feldt	45.70	1.00	45.70	0.58	.46
	Lower-bound	45.70	1.00	45.70	0.58	.46
Error(Day*Dom_Sub)	Sphericity Assumed	1180.28	15.00	78.69		
	Greenhouse-Geisser	1180.28	15.00	78.69		
	Huynh-Feldt	1180.28	15.00	78.69		
	Lower-bound	1180.28	15.00	78.69		
Hom_poly * Dom_Sub	Sphericity Assumed	40.63	1.00	40.63	1.01	.33
	Greenhouse-Geisser	40.63	1.00	40.63	1.01	.33
	Huynh-Feldt	40.63	1.00	40.63	1.01	.33
	Lower-bound	40.63	1.00	40.63	1.01	.33
Error(Hom_poly*Dom_Sub)	Sphericity Assumed	600.51	15.00	40.03		
	Greenhouse-Geisser	600.51	15.00	40.03		
	Huynh-Feldt	600.51	15.00	40.03		
	Lower-bound	600.51	15.00	40.03		
Day * Hom_poly * Dom_Sub	Sphericity Assumed	98.65	1.00	98.65	1.36	.26
	Greenhouse-Geisser	98.65	1.00	98.65	1.36	.26
	Huynh-Feldt	98.65	1.00	98.65	1.36	.26
	Lower-bound	98.65	1.00	98.65	1.36	.26
Error(Day*Hom_poly*Dom_Sub)	Sphericity Assumed	1086.85	15.00	72.46		
	Greenhouse-Geisser	1086.85	15.00	72.46		
	Huynh-Feldt	1086.85	15.00	72.46		
	Lower-bound	1086.85	15.00	72.46		
Day * Rel_Unrel	Sphericity Assumed	1.02	1.00	1.02	0.01	.91
	Greenhouse-Geisser	1.02	1.00	1.02	0.01	.91
	Huynh-Feldt	1.02	1.00	1.02	0.01	.91

	Lower-bound	1.02	1.00	1.02	0.01	.91
Error(Day*Rel_Unrel)	Sphericity Assumed	1269.16	15.00	84.61		
	Greenhouse-Geisser	1269.16	15.00	84.61		
	Huynh-Feldt	1269.16	15.00	84.61		
	Lower-bound	1269.16	15.00	84.61		
Hom_poly * Rel_Unrel	Sphericity Assumed	579.23	1.00	579.23	9.04	.01
	Greenhouse-Geisser	579.23	1.00	579.23	9.04	.01
	Huynh-Feldt	579.23	1.00	579.23	9.04	.01
	Lower-bound	579.23	1.00	579.23	9.04	.01
Error(Hom_poly*Rel_Unrel)	Sphericity Assumed	961.19	15.00	64.08		
	Greenhouse-Geisser	961.19	15.00	64.08		
	Huynh-Feldt	961.19	15.00	64.08		
	Lower-bound	961.19	15.00	64.08		
Day * Hom_poly * Rel_Unrel	Sphericity Assumed	53.96	1.00	53.96	1.12	.31
	Greenhouse-Geisser	53.96	1.00	53.96	1.12	.31
	Huynh-Feldt	53.96	1.00	53.96	1.12	.31
	Lower-bound	53.96	1.00	53.96	1.12	.31
Error(Day*Hom_poly*Rel_Unrel)	Sphericity Assumed	721.15	15.00	48.08		
	Greenhouse-Geisser	721.15	15.00	48.08		
	Huynh-Feldt	721.15	15.00	48.08		
	Lower-bound	721.15	15.00	48.08		
Dom_Sub * Rel_Unrel	Sphericity Assumed	6.75	1.00	6.75	0.14	.71
	Greenhouse-Geisser	6.75	1.00	6.75	0.14	.71
	Huynh-Feldt	6.75	1.00	6.75	0.14	.71
	Lower-bound	6.75	1.00	6.75	0.14	.71
Error(Dom_Sub*Rel_Unrel)	Sphericity Assumed	719.41	15.00	47.96		
	Greenhouse-Geisser	719.41	15.00	47.96		
	Huynh-Feldt	719.41	15.00	47.96		
	Lower-bound	719.41	15.00	47.96		
Day * Dom_Sub * Rel_Unrel	Sphericity Assumed	247.68	1.00	247.68	4.88	.04
	Greenhouse-Geisser	247.68	1.00	247.68	4.88	.04
	Huynh-Feldt	247.68	1.00	247.68	4.88	.04
	Lower-bound	247.68	1.00	247.68	4.88	.04
Error(Day*Dom_Sub*Rel_Unrel)	Sphericity Assumed	761.09	15.00	50.74		
	Greenhouse-Geisser	761.09	15.00	50.74		
	Huynh-Feldt	761.09	15.00	50.74		
	Lower-bound	761.09	15.00	50.74		
Hom_poly * Dom_Sub * Rel_Unrel	Sphericity Assumed	45.48	1.00	45.48	0.80	.39
	Greenhouse-Geisser	45.48	1.00	45.48	0.80	.39
	Huynh-Feldt	45.48	1.00	45.48	0.80	.39
	Lower-bound	45.48	1.00	45.48	0.80	.39
Error(Hom_poly*Dom_Sub*Rel_Unrel)	Sphericity Assumed	855.24	15.00	57.02		
	Greenhouse-Geisser	855.24	15.00	57.02		
	Huynh-Feldt	855.24	15.00	57.02		
	Lower-bound	855.24	15.00	57.02		
Day * Hom_poly * Dom_Sub * Rel_Unrel	Sphericity Assumed	8.90	1.00	8.90	0.25	.62
	Greenhouse-Geisser	8.90	1.00	8.90	0.25	.62
	Huynh-Feldt	8.90	1.00	8.90	0.25	.62
	Lower-bound	8.90	1.00	8.90	0.25	.62

Error(Day*Hom_poly*Dom_Sub*Rel_Unrel)	Sphericity Assumed	526.00	15.00	35.07		
	Greenhouse-Geisser	526.00	15.00	35.07		
	Huynh-Feldt	526.00	15.00	35.07		
	Lower-bound	526.00	15.00	35.07		
Day * Lobe	Sphericity Assumed	197.54	2.00	98.77	1.46	.25
	Greenhouse-Geisser	197.54	1.96	101.04	1.46	.25
	Huynh-Feldt	197.54	2.00	98.77	1.46	.25
	Lower-bound	197.54	1.00	197.54	1.46	.25
Error(Day*Lobe)	Sphericity Assumed	2029.74	30.00	67.66		
	Greenhouse-Geisser	2029.74	29.33	69.21		
	Huynh-Feldt	2029.74	30.00	67.66		
	Lower-bound	2029.74	15.00	135.32		
Hom_poly * Lobe	Sphericity Assumed	0.09	2.00	0.04	0.00	1.00
	Greenhouse-Geisser	0.09	1.08	0.08	0.00	.97
	Huynh-Feldt	0.09	1.10	0.08	0.00	.97
	Lower-bound	0.09	1.00	0.09	0.00	.96
Error(Hom_poly*Lobe)	Sphericity Assumed	440.37	30.00	14.68		
	Greenhouse-Geisser	440.37	16.24	27.11		
	Huynh-Feldt	440.37	16.52	26.66		
	Lower-bound	440.37	15.00	29.36		
Day * Hom_poly * Lobe	Sphericity Assumed	62.22	2.00	31.11	3.13	.06
	Greenhouse-Geisser	62.22	1.23	50.67	3.13	.09
	Huynh-Feldt	62.22	1.28	48.55	3.13	.08
	Lower-bound	62.22	1.00	62.22	3.13	.10
Error(Day*Hom_poly*Lobe)	Sphericity Assumed	298.48	30.00	9.95		
	Greenhouse-Geisser	298.48	18.42	16.20		
	Huynh-Feldt	298.48	19.22	15.53		
	Lower-bound	298.48	15.00	19.90		
Dom_Sub * Lobe	Sphericity Assumed	19.14	2.00	9.57	1.34	.28
	Greenhouse-Geisser	19.14	1.26	15.18	1.34	.27
	Huynh-Feldt	19.14	1.32	14.47	1.34	.27
	Lower-bound	19.14	1.00	19.14	1.34	.27
Error(Dom_Sub*Lobe)	Sphericity Assumed	214.27	30.00	7.14		
	Greenhouse-Geisser	214.27	18.91	11.33		
	Huynh-Feldt	214.27	19.84	10.80		
	Lower-bound	214.27	15.00	14.28		
Day * Dom_Sub * Lobe	Sphericity Assumed	1.87	2.00	0.93	0.21	.81
	Greenhouse-Geisser	1.87	1.51	1.24	0.21	.75
	Huynh-Feldt	1.87	1.64	1.14	0.21	.77
	Lower-bound	1.87	1.00	1.87	0.21	.65
Error(Day*Dom_Sub*Lobe)	Sphericity Assumed	131.23	30.00	4.37		
	Greenhouse-Geisser	131.23	22.67	5.79		
	Huynh-Feldt	131.23	24.66	5.32		
	Lower-bound	131.23	15.00	8.75		
Hom_poly * Dom_Sub * Lobe	Sphericity Assumed	14.82	2.00	7.41	2.02	.15
	Greenhouse-Geisser	14.82	1.36	10.90	2.02	.17
	Huynh-Feldt	14.82	1.45	10.23	2.02	.17
	Lower-bound	14.82	1.00	14.82	2.02	.18
Error(Hom_poly*Dom_Sub*Lobe)	Sphericity Assumed	110.18	30.00	3.67		
	Greenhouse-Geisser	110.18	20.39	5.40		
	Huynh-Feldt	110.18	21.72	5.07		

	Lower-bound	110.18	15.00	7.35		
Day * Hom_poly * Dom_Sub * Lobe	Sphericity Assumed	0.27	2.00	0.14	0.02	.98
	Greenhouse-Geisser	0.27	1.37	0.20	0.02	.94
	Huynh-Feldt	0.27	1.46	0.19	0.02	.95
	Lower-bound	0.27	1.00	0.27	0.02	.89
Error(Day*Hom_poly*Dom_Sub*Lobe)	Sphericity Assumed	205.37	30.00	6.85		
	Greenhouse-Geisser	205.37	20.48	10.03		
	Huynh-Feldt	205.37	21.83	9.41		
	Lower-bound	205.37	15.00	13.69		
Rel_Unrel * Lobe	Sphericity Assumed	28.90	2.00	14.45	1.75	.19
	Greenhouse-Geisser	28.90	1.85	15.60	1.75	.19
	Huynh-Feldt	28.90	2.00	14.45	1.75	.19
	Lower-bound	28.90	1.00	28.90	1.75	.21
Error(Rel_Unrel*Lobe)	Sphericity Assumed	248.02	30.00	8.27		
	Greenhouse-Geisser	248.02	27.79	8.93		
	Huynh-Feldt	248.02	30.00	8.27		
	Lower-bound	248.02	15.00	16.53		
Day * Rel_Unrel * Lobe	Sphericity Assumed	6.95	2.00	3.48	0.39	.68
	Greenhouse-Geisser	6.95	1.90	3.66	0.39	.67
	Huynh-Feldt	6.95	2.00	3.48	0.39	.68
	Lower-bound	6.95	1.00	6.95	0.39	.54
Error(Day*Rel_Unrel*Lobe)	Sphericity Assumed	268.29	30.00	8.94		
	Greenhouse-Geisser	268.29	28.47	9.42		
	Huynh-Feldt	268.29	30.00	8.94		
	Lower-bound	268.29	15.00	17.89		
Hom_poly * Rel_Unrel * Lobe	Sphericity Assumed	33.64	2.00	16.82	4.07	.03
	Greenhouse-Geisser	33.64	1.19	28.39	4.07	.05
	Huynh-Feldt	33.64	1.23	27.40	4.07	.05
	Lower-bound	33.64	1.00	33.64	4.07	.06
Error(Hom_poly*Rel_Unrel*Lobe)	Sphericity Assumed	124.10	30.00	4.14		
	Greenhouse-Geisser	124.10	17.78	6.98		
	Huynh-Feldt	124.10	18.42	6.74		
	Lower-bound	124.10	15.00	8.27		
Day * Hom_poly * Rel_Unrel * Lobe	Sphericity Assumed	4.90	2.00	2.45	0.54	.59
	Greenhouse-Geisser	4.90	1.53	3.20	0.54	.54
	Huynh-Feldt	4.90	1.67	2.93	0.54	.56
	Lower-bound	4.90	1.00	4.90	0.54	.47
Error(Day*Hom_poly*Rel_Unrel*Lobe)	Sphericity Assumed	135.45	30.00	4.51		
	Greenhouse-Geisser	135.45	22.99	5.89		
	Huynh-Feldt	135.45	25.08	5.40		
	Lower-bound	135.45	15.00	9.03		
Dom_Sub * Rel_Unrel * Lobe	Sphericity Assumed	36.13	2.00	18.06	3.11	.06
	Greenhouse-Geisser	36.13	1.17	31.01	3.11	.09
	Huynh-Feldt	36.13	1.20	30.04	3.11	.09
	Lower-bound	36.13	1.00	36.13	3.11	.10
Error(Dom_Sub*Rel_Unrel*Lobe)	Sphericity Assumed	174.38	30.00	5.81		
	Greenhouse-Geisser	174.38	17.48	9.98		

	Huynh-Feldt	174.38	18.04	9.66		
	Lower-bound	174.38	15.00	11.63		
Day * Dom_Sub * Rel_Unrel * Lobe	Sphericity Assumed	7.19	2.00	3.60	0.21	.81
	Greenhouse-Geisser	7.19	1.09	6.62	0.21	.68
	Huynh-Feldt	7.19	1.11	6.51	0.21	.68
	Lower-bound	7.19	1.00	7.19	0.21	.66
Error(Day*Dom_Sub*Rel_Unrel*Lobe)	Sphericity Assumed	521.98	30.00	17.40		
	Greenhouse-Geisser	521.98	16.29	32.04		
	Huynh-Feldt	521.98	16.58	31.49		
	Lower-bound	521.98	15.00	34.80		
Hom_poly * Dom_Sub * Rel_Unrel * Lobe	Sphericity Assumed	18.16	2.00	9.08	1.15	.33
	Greenhouse-Geisser	18.16	1.39	13.07	1.15	.32
	Huynh-Feldt	18.16	1.49	12.22	1.15	.32
	Lower-bound	18.16	1.00	18.16	1.15	.30
Error(Hom_poly*Dom_Sub*Rel_Unrel*Lobe)	Sphericity Assumed	236.61	30.00	7.89		
	Greenhouse-Geisser	236.61	20.84	11.35		
	Huynh-Feldt	236.61	22.29	10.61		
	Lower-bound	236.61	15.00	15.77		
Day * Hom_poly * Dom_Sub * Rel_Unrel * Lobe	Sphericity Assumed	12.72	2.00	6.36	1.62	.21
	Greenhouse-Geisser	12.72	1.69	7.53	1.62	.22
	Huynh-Feldt	12.72	1.88	6.76	1.62	.22
	Lower-bound	12.72	1.00	12.72	1.62	.22
Error(Day*Hom_poly*Dom_Sub*Rel_Unrel*Lobe)	Sphericity Assumed	117.75	30.00	3.92		
	Greenhouse-Geisser	117.75	25.36	4.64		
	Huynh-Feldt	117.75	28.23	4.17		
	Lower-bound	117.75	15.00	7.85		
Day * Hem_LCR	Sphericity Assumed	102.84	2.00	51.42	1.12	.34
	Greenhouse-Geisser	102.84	1.35	75.93	1.12	.32
	Huynh-Feldt	102.84	1.44	71.34	1.12	.33
	Lower-bound	102.84	1.00	102.84	1.12	.31
Error(Day*Hem_LCR)	Sphericity Assumed	1377.88	30.00	45.93		
	Greenhouse-Geisser	1377.88	20.32	67.82		
	Huynh-Feldt	1377.88	21.62	63.72		
	Lower-bound	1377.88	15.00	91.86		
Hom_poly * Hem_LCR	Sphericity Assumed	2.59	2.00	1.29	0.32	.73
	Greenhouse-Geisser	2.59	1.32	1.96	0.32	.64
	Huynh-Feldt	2.59	1.40	1.85	0.32	.65
	Lower-bound	2.59	1.00	2.59	0.32	.58
Error(Hom_poly*Hem_LCR)	Sphericity Assumed	120.54	30.00	4.02		
	Greenhouse-Geisser	120.54	19.81	6.08		
	Huynh-Feldt	120.54	20.98	5.75		
	Lower-bound	120.54	15.00	8.04		
Day * Hom_poly * Hem_LCR	Sphericity Assumed	4.16	2.00	2.08	0.97	.39
	Greenhouse-Geisser	4.16	1.73	2.40	0.97	.38
	Huynh-Feldt	4.16	1.93	2.15	0.97	.39
	Lower-bound	4.16	1.00	4.16	0.97	.34
Error(Day*Hom_poly*Hem_LCR)	Sphericity Assumed	64.07	30.00	2.14		

	Greenhouse-Geisser	64.07	25.94	2.47		
	Huynh-Feldt	64.07	29.02	2.21		
	Lower-bound	64.07	15.00	4.27		
Dom_Sub * Hem_LCR	Sphericity Assumed	4.19	2.00	2.09	0.82	.45
	Greenhouse-Geisser	4.19	1.90	2.20	0.82	.45
	Huynh-Feldt	4.19	2.00	2.09	0.82	.45
	Lower-bound	4.19	1.00	4.19	0.82	.38
Error(Dom_Sub*Hem_LCR)	Sphericity Assumed	76.77	30.00	2.56		
	Greenhouse-Geisser	76.77	28.55	2.69		
	Huynh-Feldt	76.77	30.00	2.56		
	Lower-bound	76.77	15.00	5.12		
Day * Dom_Sub * Hem_LCR	Sphericity Assumed	29.26	2.00	14.63	4.23	.02
	Greenhouse-Geisser	29.26	1.86	15.74	4.23	.03
	Huynh-Feldt	29.26	2.00	14.63	4.23	.02
	Lower-bound	29.26	1.00	29.26	4.23	.06
Error(Day*Dom_Sub*Hem_LCR)	Sphericity Assumed	103.80	30.00	3.46		
	Greenhouse-Geisser	103.80	27.89	3.72		
	Huynh-Feldt	103.80	30.00	3.46		
	Lower-bound	103.80	15.00	6.92		
Hom_poly * Dom_Sub * Hem_LCR	Sphericity Assumed	4.82	2.00	2.41	1.04	.37
	Greenhouse-Geisser	4.82	1.70	2.83	1.04	.36
	Huynh-Feldt	4.82	1.90	2.53	1.04	.36
	Lower-bound	4.82	1.00	4.82	1.04	.32
Error(Hom_poly*Dom_Sub*Hem_LCR)	Sphericity Assumed	69.36	30.00	2.31		
	Greenhouse-Geisser	69.36	25.57	2.71		
	Huynh-Feldt	69.36	28.52	2.43		
	Lower-bound	69.36	15.00	4.62		
Day * Hom_poly * Dom_Sub * Hem_LCR	Sphericity Assumed	0.32	2.00	0.16	0.08	.92
	Greenhouse-Geisser	0.32	1.85	0.18	0.08	.91
	Huynh-Feldt	0.32	2.00	0.16	0.08	.92
	Lower-bound	0.32	1.00	0.32	0.08	.78
Error(Day*Hom_poly*Dom_Sub*Hem_LCR)	Sphericity Assumed	61.01	30.00	2.03		
	Greenhouse-Geisser	61.01	27.74	2.20		
	Huynh-Feldt	61.01	30.00	2.03		
	Lower-bound	61.01	15.00	4.07		
Rel_Unrel * Hem_LCR	Sphericity Assumed	1.95	2.00	0.97	0.15	.86
	Greenhouse-Geisser	1.95	1.94	1.01	0.15	.85
	Huynh-Feldt	1.95	2.00	0.97	0.15	.86
	Lower-bound	1.95	1.00	1.95	0.15	.70
Error(Rel_Unrel*Hem_LCR)	Sphericity Assumed	188.90	30.00	6.30		
	Greenhouse-Geisser	188.90	29.07	6.50		
	Huynh-Feldt	188.90	30.00	6.30		
	Lower-bound	188.90	15.00	12.59		
Day * Rel_Unrel * Hem_LCR	Sphericity Assumed	3.84	2.00	1.92	0.44	.65
	Greenhouse-Geisser	3.84	1.72	2.23	0.44	.62
	Huynh-Feldt	3.84	1.93	1.99	0.44	.64
	Lower-bound	3.84	1.00	3.84	0.44	.52
Error(Day*Rel_Unrel*Hem_LCR)	Sphericity Assumed	129.98	30.00	4.33		

	Greenhouse-Geisser	129.98	25.85	5.03		
	Huynh-Feldt	129.98	28.90	4.50		
	Lower-bound	129.98	15.00	8.67		
Hom_poly * Rel_Unrel * Hem_LCR	Sphericity Assumed	0.75	2.00	0.38	0.16	.85
	Greenhouse-Geisser	0.75	1.82	0.41	0.16	.83
	Huynh-Feldt	0.75	2.00	0.38	0.16	.85
	Lower-bound	0.75	1.00	0.75	0.16	.69
Error(Hom_poly*Rel_Unrel* Hem_LCR)	Sphericity Assumed	70.15	30.00	2.34		
	Greenhouse-Geisser	70.15	27.25	2.57		
	Huynh-Feldt	70.15	30.00	2.34		
	Lower-bound	70.15	15.00	4.68		
Day * Hom_poly * Rel_Unrel * Hem_LCR	Sphericity Assumed	4.33	2.00	2.17	0.55	.58
	Greenhouse-Geisser	4.33	1.88	2.30	0.55	.57
	Huynh-Feldt	4.33	2.00	2.17	0.55	.58
	Lower-bound	4.33	1.00	4.33	0.55	.47
Error(Day*Hom_poly*Rel_Unrel*Hem_LCR)	Sphericity Assumed	118.22	30.00	3.94		
	Greenhouse-Geisser	118.22	28.23	4.19		
	Huynh-Feldt	118.22	30.00	3.94		
	Lower-bound	118.22	15.00	7.88		
Dom_Sub * Rel_Unrel * Hem_LCR	Sphericity Assumed	0.58	2.00	0.29	0.05	.95
	Greenhouse-Geisser	0.58	1.50	0.39	0.05	.90
	Huynh-Feldt	0.58	1.63	0.36	0.05	.92
	Lower-bound	0.58	1.00	0.58	0.05	.82
Error(Dom_Sub*Rel_Unrel*Hem_LCR)	Sphericity Assumed	161.90	30.00	5.40		
	Greenhouse-Geisser	161.90	22.46	7.21		
	Huynh-Feldt	161.90	24.39	6.64		
	Lower-bound	161.90	15.00	10.79		
Day * Dom_Sub * Rel_Unrel * Hem_LCR	Sphericity Assumed	9.25	2.00	4.62	0.82	.45
	Greenhouse-Geisser	9.25	1.71	5.41	0.82	.43
	Huynh-Feldt	9.25	1.91	4.85	0.82	.45
	Lower-bound	9.25	1.00	9.25	0.82	.38
Error(Day*Dom_Sub*Rel_Unrel*Hem_LCR)	Sphericity Assumed	169.42	30.00	5.65		
	Greenhouse-Geisser	169.42	25.63	6.61		
	Huynh-Feldt	169.42	28.60	5.92		
	Lower-bound	169.42	15.00	11.29		
Hom_poly * Dom_Sub * Rel_Unrel * Hem_LCR	Sphericity Assumed	15.43	2.00	7.72	2.61	.09
	Greenhouse-Geisser	15.43	1.97	7.85	2.61	.09
	Huynh-Feldt	15.43	2.00	7.72	2.61	.09
	Lower-bound	15.43	1.00	15.43	2.61	.13
Error(Hom_poly*Dom_Sub*Rel_Unrel*Hem_LCR)	Sphericity Assumed	88.71	30.00	2.96		
	Greenhouse-Geisser	88.71	29.50	3.01		
	Huynh-Feldt	88.71	30.00	2.96		
	Lower-bound	88.71	15.00	5.91		
Day * Hom_poly * Dom_Sub	Sphericity Assumed	10.91	2.00	5.45	1.54	.23

* Rel_Unrel * Hem_LCR						
	Greenhouse-Geisser	10.91	1.79	6.09	1.54	.23
	Huynh-Feldt	10.91	2.00	5.45	1.54	.23
	Lower-bound	10.91	1.00	10.91	1.54	.23
Error(Day*Hom_poly*Dom_Sub*Rel_Unrel*Hem_LCR)	Sphericity Assumed	105.91	30.00	3.53		
	Greenhouse-Geisser	105.91	26.87	3.94		
	Huynh-Feldt	105.91	30.00	3.53		
	Lower-bound	105.91	15.00	7.06		
Lobe * Hem_LCR	Sphericity Assumed	282.01	4.00	70.50	1.42	.24
	Greenhouse-Geisser	282.01	1.68	167.44	1.42	.26
	Huynh-Feldt	282.01	1.87	150.52	1.42	.26
	Lower-bound	282.01	1.00	282.01	1.42	.25
Error(Lobe*Hem_LCR)	Sphericity Assumed	2988.64	60.00	49.81		
	Greenhouse-Geisser	2988.64	25.26	118.30		
	Huynh-Feldt	2988.64	28.10	106.35		
	Lower-bound	2988.64	15.00	199.24		
Day * Lobe * Hem_LCR	Sphericity Assumed	187.56	4.00	46.89	1.02	.41
	Greenhouse-Geisser	187.56	1.27	147.27	1.02	.35
	Huynh-Feldt	187.56	1.34	140.10	1.02	.35
	Lower-bound	187.56	1.00	187.56	1.02	.33
Error(Day*Lobe*Hem_LCR)	Sphericity Assumed	2768.84	60.00	46.15		
	Greenhouse-Geisser	2768.84	19.10	144.95		
	Huynh-Feldt	2768.84	20.08	137.88		
	Lower-bound	2768.84	15.00	184.59		
Hom_poly * Lobe * Hem_LCR	Sphericity Assumed	8.92	4.00	2.23	1.29	.28
	Greenhouse-Geisser	8.92	3.27	2.73	1.29	.29
	Huynh-Feldt	8.92	4.00	2.23	1.29	.28
	Lower-bound	8.92	1.00	8.92	1.29	.27
Error(Hom_poly*Lobe*Hem_LCR)	Sphericity Assumed	103.86	60.00	1.73		
	Greenhouse-Geisser	103.86	49.04	2.12		
	Huynh-Feldt	103.86	60.00	1.73		
	Lower-bound	103.86	15.00	6.92		
Day * Hom_poly * Lobe * Hem_LCR	Sphericity Assumed	2.43	4.00	0.61	0.50	.73
	Greenhouse-Geisser	2.43	2.84	0.85	0.50	.67
	Huynh-Feldt	2.43	3.58	0.68	0.50	.71
	Lower-bound	2.43	1.00	2.43	0.50	.49
Error(Day*Hom_poly*Lobe*Hem_LCR)	Sphericity Assumed	72.29	60.00	1.20		
	Greenhouse-Geisser	72.29	42.67	1.69		
	Huynh-Feldt	72.29	53.69	1.35		
	Lower-bound	72.29	15.00	4.82		
Dom_Sub * Lobe * Hem_LCR	Sphericity Assumed	2.20	4.00	0.55	0.40	.80
	Greenhouse-Geisser	2.20	2.98	0.74	0.40	.75
	Huynh-Feldt	2.20	3.79	0.58	0.40	.80
	Lower-bound	2.20	1.00	2.20	0.40	.53
Error(Dom_Sub*Lobe*Hem_LCR)	Sphericity Assumed	81.72	60.00	1.36		
	Greenhouse-Geisser	81.72	44.65	1.83		
	Huynh-Feldt	81.72	56.92	1.44		

	Lower-bound	81.72	15.00	5.45		
Day * Dom_Sub * Lobe * Hem_LCR	Sphericity Assumed	9.77	4.00	2.44	1.13	.35
	Greenhouse-Geisser	9.77	2.58	3.78	1.13	.34
	Huynh-Feldt	9.77	3.16	3.09	1.13	.35
	Lower-bound	9.77	1.00	9.77	1.13	.30
Error(Day*Dom_Sub*Lobe*Hem_LCR)	Sphericity Assumed	129.35	60.00	2.16		
	Greenhouse-Geisser	129.35	38.71	3.34		
	Huynh-Feldt	129.35	47.46	2.73		
	Lower-bound	129.35	15.00	8.62		
Hom_poly * Dom_Sub * Lobe * Hem_LCR	Sphericity Assumed	13.36	4.00	3.34	3.96	.01
	Greenhouse-Geisser	13.36	2.82	4.74	3.96	.02
	Huynh-Feldt	13.36	3.54	3.78	3.96	.01
	Lower-bound	13.36	1.00	13.36	3.96	.07
Error(Hom_poly*Dom_Sub*Lobe*Hem_LCR)	Sphericity Assumed	50.58	60.00	0.84		
	Greenhouse-Geisser	50.58	42.27	1.20		
	Huynh-Feldt	50.58	53.06	0.95		
	Lower-bound	50.58	15.00	3.37		
Day * Hom_poly * Dom_Sub * Lobe * Hem_LCR	Sphericity Assumed	6.50	4.00	1.63	1.22	.31
	Greenhouse-Geisser	6.50	2.72	2.39	1.22	.31
	Huynh-Feldt	6.50	3.38	1.92	1.22	.31
	Lower-bound	6.50	1.00	6.50	1.22	.29
Error(Day*Hom_poly*Dom_Sub*Lobe*Hem_LCR)	Sphericity Assumed	80.09	60.00	1.33		
	Greenhouse-Geisser	80.09	40.78	1.96		
	Huynh-Feldt	80.09	50.69	1.58		
	Lower-bound	80.09	15.00	5.34		
Rel_Unrel * Lobe * Hem_LCR	Sphericity Assumed	36.29	4.00	9.07	1.81	.14
	Greenhouse-Geisser	36.29	1.64	22.08	1.81	.19
	Huynh-Feldt	36.29	1.82	19.95	1.81	.18
	Lower-bound	36.29	1.00	36.29	1.81	.20
Error(Rel_Unrel*Lobe*Hem_LCR)	Sphericity Assumed	300.30	60.00	5.01		
	Greenhouse-Geisser	300.30	24.65	12.18		
	Huynh-Feldt	300.30	27.29	11.00		
	Lower-bound	300.30	15.00	20.02		
Day * Rel_Unrel * Lobe * Hem_LCR	Sphericity Assumed	26.99	4.00	6.75	1.30	.28
	Greenhouse-Geisser	26.99	1.68	16.07	1.30	.29
	Huynh-Feldt	26.99	1.87	14.45	1.30	.29
	Lower-bound	26.99	1.00	26.99	1.30	.27
Error(Day*Rel_Unrel*Lobe*Hem_LCR)	Sphericity Assumed	311.63	60.00	5.19		
	Greenhouse-Geisser	311.63	25.20	12.37		
	Huynh-Feldt	311.63	28.02	11.12		
	Lower-bound	311.63	15.00	20.78		
Hom_poly * Rel_Unrel * Lobe * Hem_LCR	Sphericity Assumed	4.35	4.00	1.09	0.96	.43
	Greenhouse-Geisser	4.35	3.53	1.23	0.96	.43

	Huynh-Feldt	4.35	4.00	1.09	0.96	.43
	Lower-bound	4.35	1.00	4.35	0.96	.34
Error(Hom_poly*Rel_Unrel*Lobe*Hem_LCR)	Sphericity Assumed	67.59	60.00	1.13		
	Greenhouse-Geisser	67.59	52.93	1.28		
	Huynh-Feldt	67.59	60.00	1.13		
	Lower-bound	67.59	15.00	4.51		
Day * Hom_poly * Rel_Unrel * Lobe * Hem_LCR	Sphericity Assumed	1.94	4.00	0.49	0.41	.80
	Greenhouse-Geisser	1.94	2.46	0.79	0.41	.71
	Huynh-Feldt	1.94	2.98	0.65	0.41	.75
	Lower-bound	1.94	1.00	1.94	0.41	.53
Error(Day*Hom_poly*Rel_Unrel*Lobe*Hem_LCR)	Sphericity Assumed	71.00	60.00	1.18		
	Greenhouse-Geisser	71.00	36.95	1.92		
	Huynh-Feldt	71.00	44.76	1.59		
	Lower-bound	71.00	15.00	4.73		
Dom_Sub * Rel_Unrel * Lobe * Hem_LCR	Sphericity Assumed	5.28	4.00	1.32	0.54	.70
	Greenhouse-Geisser	5.28	2.82	1.87	0.54	.64
	Huynh-Feldt	5.28	3.55	1.49	0.54	.68
	Lower-bound	5.28	1.00	5.28	0.54	.47
Error(Dom_Sub*Rel_Unrel*Lobe*Hem_LCR)	Sphericity Assumed	145.78	60.00	2.43		
	Greenhouse-Geisser	145.78	42.35	3.44		
	Huynh-Feldt	145.78	53.18	2.74		
	Lower-bound	145.78	15.00	9.72		
Day * Dom_Sub * Rel_Unrel * Lobe * Hem_LCR	Sphericity Assumed	9.36	4.00	2.34	1.59	.19
	Greenhouse-Geisser	9.36	2.70	3.47	1.59	.21
	Huynh-Feldt	9.36	3.35	2.80	1.59	.20
	Lower-bound	9.36	1.00	9.36	1.59	.23
Error(Day*Dom_Sub*Rel_Unrel*Lobe*Hem_LCR)	Sphericity Assumed	88.41	60.00	1.47		
	Greenhouse-Geisser	88.41	40.50	2.18		
	Huynh-Feldt	88.41	50.24	1.76		
	Lower-bound	88.41	15.00	5.89		
Hom_poly * Dom_Sub * Rel_Unrel * Lobe * Hem_LCR	Sphericity Assumed	14.32	4.00	3.58	1.48	.22
	Greenhouse-Geisser	14.32	2.71	5.29	1.48	.24
	Huynh-Feldt	14.32	3.36	4.26	1.48	.23
	Lower-bound	14.32	1.00	14.32	1.48	.24
Error(Hom_poly*Dom_Sub*Rel_Unrel*Lobe*Hem_LCR)	Sphericity Assumed	145.49	60.00	2.42		
	Greenhouse-Geisser	145.49	40.60	3.58		
	Huynh-Feldt	145.49	50.40	2.89		
	Lower-bound	145.49	15.00	9.70		
Day * Hom_poly * Dom_Sub * Rel_Unrel * Lobe * Hem_LCR	Sphericity Assumed	4.24	4.00	1.06	0.40	.81
	Greenhouse-Geisser	4.24	2.76	1.53	0.40	.74
	Huynh-Feldt	4.24	3.45	1.23	0.40	.78
	Lower-bound	4.24	1.00	4.24	0.40	.54

Error(Day*Hom_poly*Dom_Sub*Rel_Unrel*Lobe*Hem_LCR)	Sphericity Assumed	160.30	60.00	2.67
	Greenhouse-Geisser	160.30	41.46	3.87
	Huynh-Feldt	160.30	51.76	3.10
	Lower-bound	160.30	15.00	10.69

APPENDIX F

F.1 EXP. 2 TRAINING STIMULI AND ASSOCIATES

Table 64. Exp. 2 Training stimuli and associates

English Word	German Word	Associate	Word Type	Dominance	Definition
drill	Bohrer	tool	hom	dom	a shaft-like object with two or more cutting edges for making holes in firm materials
drill	Übung	practice	hom	sub	any strict, methodical, repetitive, or mechanical training, instruction
match	Streichholz	lighter	hom	dom	a slender piece of flammable material tipped with a chemical substance that produces fire
match	Gegenstück	same	hom	sub	a person or thing that equals or resembles another in some respect
mold	Schmimmel	fungus	hom	dom	a growth of minute fungi
mold	Abdruck	form	hom	sub	A hollow form or matrix for giving a particular shape to something
pitcher	Krug	jug	hom	sub	a container, usually with a handle and spout or lip, for liquids

pitcher	Werfer	catcher	hom	dom	the player who throws the ball to the opp osing batter.
present	Geschenk	offering	hom	dom	a thing presented as a gift
present	Gegenwart	now	hom	sub	being, existing, or occurring at this time
pupil	Sehloch	student	hom	dom	a person, usually young, who is learning under the close supervision of a teacher a t school
pupil	Schulkind	eye	hom	sub	the expanding and contracting opening in the iris
root	Wurzel	carrot	hom	dom	the organ of a higher plant that anchors th e rest of the plant in the ground
root	Ursprung	beginning	hom	sub	the place where something starts, where it springs into being
scale	Waage	pound	hom	dom	a balance or any of various other instrum ents or devices for weighing
scale	Schuppe	fish	hom	sub	one of the thin, flat, horny plates forming the covering of certain animals
toast	Röstbrot	croissant	hom	dom	sliced bread that has been browned by dr y heat.
toast	Trinkspruch	tribute	hom	sub	a drink in honor of or to the health of a person or event
trunk	Kofferraum	car	hom	dom	compartment in an automobile that carries luggage
trunk	Rüssell	nose	hom	sub	a flexible snout of a large mammal
arena	Kampfbahn	stadium	poly	dom	a central stage, ring, area, or the like, use d for sports or other forms of entertainme nt
arena	Schauplatz	scene	poly	sub	a sphere of conflict or intense activity

atmosphere	Lufthülle	air	poly	dom	the gaseous envelope surrounding the ear th
atmosphere	Stimmung	mood	poly	sub	a general pervasive feeling
bottle	Flasche	flask	poly	dom	a portable container for holding liquids, c haracteristically having a neck and mouth and made of glass or plastic
bottle	Schoppen	nipple	poly	sub	bottled milk or substitute mixtures given to infants
cotton	Baumwolle	wool	poly	dom	a natural type of cloth or thread
cotton	Wette	plant	poly	sub	a plant with soft, white, downy substance attached to the seeds
doll	Puppe	toy	poly	dom	a small figure representing a baby or othe r human being
doll	Schatz	nice	poly	sub	a generous or helpful person
mouth	Mund	lip	poly	dom	the opening through which many animals take in food and issue vocal sounds
mouth	Öffnung	opening	poly	sub	the opening of or place leading into a cav e, tunnel, volcano, etc.
pipe	Pfeife	cigar	poly	dom	tube of wood, clay, hard rubber, or other material, with a small bowl at one end, us ed for smoking
pipe	Rohr	plumbing	poly	sub	a hollow cylinder of metal, wood, or othe r material
sheet	Laken	blanket	poly	dom	a large rectangular piece of fabric general ly one of a pair used as inner bed clothes
sheet	Blatt	page	poly	sub	a piece of printed paper to be folded into a section

shower	Brause	bath	poly	dom	a room or booth containing a plumbing fixture that sprays water over you
shower	Regenfall	storm	poly	sub	a brief period of rain, hail, sleet, or snow
sign	Zeichen	clue	poly	sub	a perceptible indication of something not immediately apparent
sign	Schild	placard	poly	dom	a public display of a message
ceiling	Decke	floor	syn	Dom	the overhead interior surface of a room.
ceiling	Dach	floor	syn	Sub	the overhead interior surface of a room.
faith	Glaube	belief	syn	Dom	complete confidence in a person, plan, supernatural power, etc.
faith	Vertrauen	belief	syn	Sub	complete confidence in a person, plan, supernatural power, etc.
jail	Gefängnis	convict	syn	Dom	a place for the confinement of persons con victed and sentenced to imprisonment
jail	Kerker	convict	syn	Sub	a place for the confinement of persons con victed and sentenced to imprisonment
joke	Witz	riddle	syn	Dom	something said or done to provoke laught er or cause amusement
joke	Scherz	riddle	syn	Sub	something said or done to provoke laught er or cause amusement
mud	Schlamm	dirt	syn	Dom	fine- grained soft wet deposit that occurs on th e ground after rain
mud	Matsch	dirt	syn	Sub	fine- grained soft wet deposit that occurs on th

					e ground after rain
rumor	Gerücht	gossip	syn	Dom	a mixture of truth and untruth passed around by word of mouth
rumor	Klatch	gossip	syn	Sub	a mixture of truth and untruth passed around by word of mouth
soil	Erde	ground	syn	Dom	material in the top layer of the surface of the earth
soil	Boden	ground	syn	Sub	material in the top layer of the surface of the earth
stomach	Magen	belly	syn	Dom	an enlarged and muscular saclike organ used for digestion
stomach	Bauch	belly	syn	Sub	an enlarged and muscular saclike organ used for digestion
town	Dorf	city	syn	Dom	a densely populated area of considerable si ze
town	Stadt	city	syn	Sub	a densely populated area of considerable si ze
treaty	Abkommen	compromise	syn	Dom	a written agreement between two states or sovereigns
treaty	Vertrag	compromise	syn	Sub	a written agreement between two states or sovereigns
arrow	Pfeil	dart	single		a slender and straight weapon made to be shot
art	Kunst	drawing	single		the products of human creativity

bird	Vogel	sparrow	single	any warm-blooded vertebrate, having a body covered with feathers, has wings, scaly legs, and a beak
bone	Knochen	fossil	single	one of the structures composing the skeleton
boot	Stiefel	shoe	single	a covering of leather, rubber, or the like, for the foot and all or part of the leg.
candle	Kerze	torch	single	a long, usually slender piece of tallow or wax with an embedded wick that is burned
chain	Kette	string	single	a series of objects connected one after the other
cloud	Wolke	sky	single	a visible collection of particles of water or ice suspended in the air
color	Farbe	red	single	the quality of an object or substance with respect to light reflected by the object
coward	Feigling	wimp	single	a person who lacks courage in facing danger, difficulty, opposition, pain
example	Beispiel	prototype	single	one of a number of things, or a part of something, taken to show the character of the whole
face	Gesicht	mask	single	the front part of the head, from the forehead to the chin
funeral	Beerdigung	burial	single	the ceremonies for a deceased person prior to burial or cremation
head	Kopf	skull	single	the upper part of the body in humans, joined to the trunk by the neck

juice	Saft	water	single	the natural fluid, fluid content, or liquid part that can be extracted from a plant or one of its parts
knight	Ritter	nobleman	single	a mounted soldier serving under a feudal superior in the Middle Ages
meat	Fleisch	steak	single	the edible part of anything
mirror	Spiegel	glass	single	a surface, such as polished metal or glass coated with a metal film, that reflects light
monkey	Affe	chimpanzee	single	any primate except man
recovery	Erholung	improvement	single	restoration to a former or better condition
river	Fluss	lake	single	fresh water flowing along a definite course
road	Strasse	way	single	a long, narrow stretch with a smoothed or paved surface, made for traveling
roof	Dach	house	single	the external upper covering of a house or other building
scar	Narbe	wound	single	a mark left after skin is damaged
spine	Rückrat	back	single	the series of vertebrae forming the axis of the skeleton and protecting the spinal cord
task	Aufgabe	duty	single	any piece of work that is undertaken or attempted
tension	Spannung	stress	single	the act of stretching or straining
trash	Müll	waste	single	worthless material that is to be disposed of

voice	Stimme	speech	single	the distinctive quality or pitch or condition of a person's speech
wing	Flügel	feather	single	a movable organ for flight

APPENDIX G

G.1 FREE ASSOCIATION NORMS

We collected free association norms on 607 words. The association norms guided our selection of semantic associates/distractors for Experiments 2 and 3.

G.1.1 Methods

G.1.2 Participants

One-hundred twenty six participants completed the free associations norms, two participants were excluded because they were not native English speakers. The mean age of the participants was 18.95. Participants were recruited through the Introduction to Psychology subject pool and were given research credit for their participation.

G.1.3 Procedure

The free association norms were collected using a web form. Participants were presented with a list of words and were asked to type in the first word that came to mind after reading the word. Each participant provided associations for approximately 203 words.

APPENDIX H

H.1 EXP. 3 TRAINING STIMULI

Table 65. Exp. 3 Training Stimuli

English Word	German Word	Word Type	Meaning Dominance	Definition
bark	Bellen	hom	dom	the sound made by a dog
bark	Baumrinde	hom	sub	he tough exterior covering of a woody root or stem
calf	Kalb	hom	dom	the young of the domestic cow
calf	Wade	hom	sub	the fleshy back part of the leg below the knee
cape	Umhang	hom	dom	a sleeveless outer garment that fits closely at the neck and hangs loosely over the shoulders
cape	Kap	hom	sub	a point or extension of land jutting out into water as a peninsula or as a projecting point
check	Haken	hom	dom	a mark typically placed beside an item to show it has been noted, examined, or verified
check	Rechnung	hom	sub	an itemized account of the separate cost of goods sold, services performed, or work done
drill	Bohrer	hom	dom	a shaft-like object with two or more cutting edges for making holes in firm mat erials
drill	Übung	hom	sub	any strict, methodical, repetitive, or mechanical training, inst

				ruction
litter	Abfall	hom	dom	things that have been thrown away and that are lying on the ground in a public place
litter	Wurf	hom	sub	the offspring at one birth of a multiparous animal
match	Streichholz	hom	dom	a slender piece of flammable material tipped with a chemical substance that produces fire
match	Gegenstück	hom	sub	a person or thing that equals or resembles another in some re spect
mint	Minze	hom	dom	aromatic plants with a square stem and a 4-lobed ovary which produces four one-seeded nutlets in fruit
mint	Münzamt	hom	sub	a place where coins, medals, or tokens are made
mold	Schmimmel	hom	dom	a growth of minute fungi
mold	Abdruck	hom	sub	a hollow form or matrix for giving a particular shape to somet hing
mole	Maulwurf	hom	dom	any of numerous burrowing insectivores with tiny eyes, concealed ears, and soft fur
mole	Leberfleck	hom	sub	a pigmented spot, mark, or small permanent protuberance on the human body
perch	Ast	hom	dom	a bar or peg on which something is hung
perch	Barsch	hom	sub	a small European freshwater bony fish
pitcher	Werfer	hom	dom	the player who throws the ball to the opposing batter.
pitcher	Krug	hom	sub	a container, usually with a handle and spout or lip, for liquids
present	Geschenk	hom	dom	a thing presented as a gift
present	Gegenwart	hom	sub	being, existing, or occurring at this time

pupil	Sehloch	hom	dom	a person, usually young, who is learning under the close supe rvision of a teacher at school
pupil	Schulkind	hom	sub	the expanding and contracting opening in the iris
root	Wurzel	hom	dom	the organ of a higher plant that anchors the rest of the plant i n the ground
root	Ursprung	hom	sub	the place where something starts, where it springs into being
scale	Waage	hom	dom	a balance or any of various other instruments or devices for weighing
scale	Schuppe	hom	sub	one of the thin, flat, horny plates forming the covering of cer tain animals
sentence	Satz	hom	dom	group of words that expresses a statement, question, command, or wish
sentence	Straf	hom	sub	the punishment given by a court of law
spell	Zauber	hom	dom	a spoken word or form of words held to have magic power
spell	Weile	hom	sub	an indeterminate period of time
toast	Röstbrot	hom	dom	sliced bread that has been browned by dry heat.
toast	Trinkspruch	hom	sub	a drink in honor of or to the health of a person or event
trunk	Kofferraum	hom	dom	compartment in an automobile that carries luggage
trunk	Rüssell	hom	sub	a flexible snout of a large mammal
arena	Kampfbahn	poly	dom	a central stage, ring, area, or the like, used for sports or other forms of entertainment
arena	Schauplatz	poly	sub	a sphere of conflict or intense activity
atmosphere	Lufthülle	poly	dom	the gaseous envelope surrounding the earth
atmosphere	Stimmung	poly	sub	a general pervasive feeling
bottle	Flasche	poly	dom	a portable container for holding liquids, characteristically ha ving a neck and mouth and made of glass or plastic
bottle	Schoppen	poly	sub	bottled milk or substitute mixtures given to infants

coat	Mantel	poly	dom	an outer garment worn on the upper body
coat	Fell	poly	sub	the external growth on an animal
cotton	Baumwolle	poly	dom	a natureal type of cloth or thread
cotton	Wette	poly	sub	a plant with soft, white, downy substance attached to the seeds
doll	Puppe	poly	dom	a small figure representing a baby or other human being
doll	Schatz	poly	sub	a generous or helpful person
gem	Edelstein	poly	dom	a valuable stone that has been cut and polished
gem	Prachtstück	poly	sub	something that is admired for its beauty or excellence
mouth	Mund	poly	dom	the opening through which many animals take in food and is sue vocal sounds
mouth	Öffnung	poly	sub	the opening of or place leading into a cave, tunnel, volcano, etc.
note	Zettle	poly	dom	a short piece of writing that is used to help someone remember something
note	ton	poly	sub	a written symbol used to indicate duration and pitch of a sound by its shape and position on the staff
paper	Papier	poly	dom	the material that is used in the form of thin sheets for writing or printing on, wrapping things, etc.
paper	Aufsatz	poly	sub	a writing conveying information
pillar	Pfeiler	poly	dom	a large post that helps to hold up something
Pillar	Standbein	poly	sub	someone who is an important member of a group
pine	Pinie	poly	dom	a tree that has long, thin needles instead of leaves and that stays green throughout the year
pine	Kiefer	poly	sub	a type of wood that is often used as building material
pipe	Pfeife	poly	dom	tube of wood, clay, hard rubber, or other material, with a sm all bowl at one end, used for smoking

pipe	Rohr	poly	sub	a hollow cylinder of metal, wood, or other material
racket	Schläger	poly	dom	a lightweight implement that consists of a netting stretched over a frame with a handle used for striking the ball
racket	Aufruhr	poly	sub	confused clattering noise
sheet	Laken	poly	dom	a large rectangular piece of fabric generally one of a pair use d as inner bed clothes
sheet	Blatt	poly	sub	a piece of printed paper to be folded into a section
shower	Brause	poly	dom	a room or booth containing a plumbing fixture that sprays water over you
shower	Regenfall	poly	sub	a brief period of rain, hail, sleet, or snow
sign	Schild	poly	dom	a public display of a message
sign	Zeichen	poly	sub	a perceptible indication of something not immediately apparent
tongue	Zunge	poly	dom	the soft, movable part in the mouth that is used for tasting and eating food
tongue	Sprache	poly	sub	the power of communication through speech
trial	Verhandlung	poly	dom	a formal legal meeting in which evidence about crimes
trial	Versuch	poly	sub	the action or process of trying or putting to the proof
vessel	Schiff	poly	dom	a ship or large boat
vessel	Behältnis	poly	sub	a hollow container for holding liquids
ant	Ameise	single		a kind of small insect that lives in an organized social group
arrow	Pfeil	single		a slender and straight weapon made to be shot
art	Kunst	single		the products of human creativity
bird	Vogel	single		any warm- blooded vertebrate, having a body covered with feathers, has wings, scaly legs, and a beak
bone	Knochen	single		one of the structures composing the skeleton

book	Buch	single	a set of printed sheets of paper that are held together inside a cover
boot	Stiefel	single	a covering of leather, rubber, or the like, for the foot and all or part of the leg.
candle	Kerze	single	a long, usually slender piece of tallow or wax with an embed ded wick that is burned
chain	Kette	single	a series of objects connected one after the other
cloud	Wolke	single	a visible collection of particles of water or ice suspended in t he air
color	Farbe	single	the quality of an object or substance with respect to light refl ected by the object
coward	Feigling	single	a person who lacks courage in facing danger, difficulty, oppo sition, pain
example	Beispiel	single	one of a number of things, or a part of something, taken to sh ow the character of the whole
face	Gesicht	single	the front part of the head, from the forehead to the chin
fate	Schicksal	single	a power that is believed to control what happens in the future
fog	Nebel	single	many small drops of water floating in the air above the ground, the sea, etc.
funeral	Beerdigung	single	the ceremonies for a deceased person prior to burial or cremation
garlic	Knoblauch	single	a plant that has small sections called cloves which have a strong taste and smell
head	Kopf	single	the upper part of the body in humans, joined to the trunk by t he neck
juice	Saft	single	the natural fluid, fluid content, or liquid part that can be extra cted from a plant or one of its parts
knight	Ritter	single	a mounted soldier serving under a feudal superior in the Mid

			dle Ages
meat	Fleisch	single	the edible part of anything
mercy	Gnade	single	kind or forgiving treatment of someone who could be treated harshly
mirror	Spiegel	single	a surface, such as polished metal or glass coated with a metal film, that reflects light
monkey	Affe	single	any primate except man
pear	Birne	single	a sweet fruit that is narrow near the stem and rounded at the other end and that grows on a tree
recovery	Erholung	single	restoration to a former or better condition
river	Fluss	single	fresh water flowing along a definite course
road	Strasse	single	a long, narrow stretch with a smoothed or paved surface, ma de for traveling
roof	Dach	single	the external upper covering of a house or other building
scar	Narbe	single	a mark left after skin is damaged
spine	Rückrat	single	the series of vertebrae forming the axis of the skeleton and protecting the spinal cord
stench	Geruch	single	a very bad odor
task	Aufgabe	single	any piece of work that is undertaken or attempted
tension	Spannung	single	the act of stretching or straining
train	Zug	single	a connected line of railroad cars with or without a locomotive
trash	Müll	single	worthless material that is to be disposed of
truth	Wahrheit	single	the quality or state of being true
voice	Stimme	single	the distinctive quality or pitch or condition of a person's speech
wing	Flügel	single	a movable organ for flight

arrival	Ankunft	filler	the act of coming to or reaching a place
autumn	Herbst	filler	the season between summer and winter
birthday	Geburtstag	filler	the day when someone was born or the anniversary of that day
clock	Uhr	filler	a device for indicating or measuring time
crown	Krone	filler	a decorative object that is shaped like a circle and worn on the head of a king or queen
danger	Gefahr	filler	the possibility that something unpleasant or bad will happen
eagle	Adler	filler	a large bird that has very good eyesight and that kills other birds and animals for food
Influenza	Grippe	filler	a common illness that is caused by a virus and that causes fever and severe aches and pains

APPENDIX I

I.1 WORD RATING NORMS

We collected a set of semantic similarity norms on a set of 320 word pairs. These norms were used to validate the semantic associates and controls used in Experiment 3.

I.1.1 Methods

I.1.2 Participants

Three hundred and sixteen participants completed the task. After excluding non-native English speaking participants and bilingual participants we used ratings from a total of 291 native English speakers. The mean age of the participants was 18.70. Participants were recruited through the Introduction to Psychology subject pool and were given research credit for their participation.

I.1.3 Procedure

The semantic similarity ratings were collected using Qualtrics. Participants were presented with a list of word pairs and were asked to rate how similar the words are in meaning on a 1 to 7 scale with 1 corresponding to completely dissimilar in meaning and 7 corresponding to almost identical in meaning. Each participant provided semantic similarity scores on approximately 64 word pairs. A set of 25 words was added to Experiment 3 stimulus list after the completion of these norms and therefore we do not have semantic similarity ratings for these items. To verify the semantic similarity between the added stimuli we obtained semantic similarity scores using LSA (Landauer et al., 1998)

I.2 EXP. 3 TRANSLATION RECOGNITION STIMULI WITH RATINGS

Table 66. Exp. 3 Translation recognition stimuli with ratings

					Ratings				Ratings		
English Word	German Word	Word Type	Mean-ing Dominance	Related Word	*M*	*SD*	LSA	Unrelated Word	*M*	*SD*	LSA
bark	Bellen	hom	dom	yelp	5.08	1.77	0.00	jeer	2.93	1.86	-0.04
bark	Baumrinde	hom	sub	husk	3.30	1.80	0.10	gait	1.80	1.02	0.06
calf	Kalb	hom	dom	bull	4.65	1.76	0.44	snow	1.54	0.94	0.06
calf	Wade	hom	sub	shin	4.85	1.85	0.17	boar	3.65	1.67	0.23
cape	Umhang	hom	dom	cloak	5.91	1.44	0.11	meter	1.64	1.18	-0.02
cape	Kap	hom	sub	peninsula	3.82	1.95	0.14	incentive	1.63	1.03	0.01
check	Haken	hom	dom	cross	N/A	N/A	0.06	queen	N/A	N/A	0.03
check	Rechnung	hom	sub	debt	N/A	N/A	-0.01	noon	N/A	N/A	0.03
drill	Bohrer	hom	dom	tool	4.87	1.95	0.53	acid	1.49	1.04	-0.02

drill	Übung	hom	sub	practice	4.91	1.83	0.19	decision	2.08	1.32	0.01
litter	Abfall	hom	dom	trash	N/A	N/A	0.78	nerve	N/A	N/A	0.00
litter	Wurf	hom	sub	puppy	N/A	N/A	0.24	brick	N/A	N/A	0.04
match	Streichholz	hom	dom	lighter	5.39	1.53	0.17	rainbow	1.74	1.01	0.16
match	Gegenstück	hom	sub	same	5.84	1.58	0.33	rest	1.87	1.31	0.20
mint	Minze	hom	dom	basil	4.45	1.59	0.10	skirt	1.87	1.36	0.12
mint	Münzamt	hom	sub	coin	3.89	1.91	0.34	mill	2.25	1.64	0.07
mold	Schmimmel	hom	dom	fungus	5.85	1.35	0.77	mantle	2.15	1.54	0.04
mold	Abdruck	hom	sub	form	3.97	2.31	0.24	east	1.61	1.34	0.03
mole	Maulwurf	hom	dom	mouse	N/A	N/A	0.20	photo	N/A	N/A	-0.03
mole	Leberfleck	hom	sub	blemish	N/A	N/A	0.06	equator	N/A	N/A	0.01
perch	Ast	hom	dom	branch	3.91	2.04	0.15	tablet	2.14	1.62	0.05
perch	Barsch	hom	sub	salmon	3.40	2.17	0.62	cereal	1.68	1.13	0.04
pitcher	Werfer	hom	dom	catcher	3.96	1.82	0.84	rooster	1.75	1.25	-0.03
pitcher	Krug	hom	sub	jug	5.63	1.53	0.13	soy	1.85	1.35	0.04
present	Geschenk	hom	dom	offering	5.03	1.33	0.23	dynamite	1.58	0.98	0.16
present	Gegenwart	hom	sub	now	6.11	1.68	0.31	can	2.00	1.26	0.35
pupil	Sehloch	hom	dom	student	6.15	1.26	0.37	airport	1.58	0.97	0.04
pupil	Schulkind	hom	sub	eye	5.61	1.60	0.65	bag	1.63	1.13	-0.05
root	Wurzel	hom	dom	carrot	4.71	1.59	0.21	velvet	1.52	1.00	0.05
root	Ursprung	hom	sub	beginning	5.23	1.31	0.10	emergen cy	1.62	1.08	0.02
scale	Waage	hom	dom	pound	4.60	1.93	0.17	straw	1.56	0.91	0.00
scale	Schuppe	hom	sub	fish	4.40	1.65	0.06	rock	1.96	1.32	0.06
sentence	Satz	hom	dom	paragraph	N/A	N/A	0.60	offspring	N/A	N/A	0.00
sentence	Straf	hom	sub	prison	N/A	N/A	0.12	flight	N/A	N/A	0.03
spell	Zauber	hom	dom	hex	4.82	2.28	0.10	fig	1.39	0.65	0.00
spell	Weile	hom	sub	bout	2.51	1.89	0.09	fork	1.53	1.15	0.10

toast	Röstbrot	hom	dom	croissant	4.44	1.49	0.10	treadmill	1.45	0.94	0.03
toast	Trinkspruch	hom	sub	tribute	3.53	2.37	0.05	impulse	1.48	0.89	0.05
trunk	Kofferraum	hom	dom	car	4.52	1.61	0.11	ray	1.67	1.06	0.06
trunk	Rüssell	hom	sub	nose	3.36	2.07	0.16	tape	1.94	1.31	0.06
arena	Kampfbahn	poly	dom	stadium	6.48	0.99	0.31	freezer	2.04	1.26	0.03
arena	Schauplatz	poly	sub	scene	3.82	1.72	0.30	angel	1.57	1.11	0.04
atmosphere	Lufthülle	poly	dom	air	5.28	1.36	0.48	hat	1.63	0.96	0.02
atmosphere	Stimmung	poly	sub	mood	4.58	1.95	0.06	hook	1.48	0.99	-0.05
bottle	Flasche	poly	dom	flask	5.42	1.66	0.34	gnome	1.64	1.18	0.16
bottle	Schoppen	poly	sub	nipple	3.28	1.84	0.26	tavern	3.63	1.70	0.16
coat	Mantel	poly	dom	sweater	5.31	1.31	0.45	battery	1.52	1.07	0.03
coat	Fell	poly	sub	hair	2.49	1.60	0.32	pain	1.25	0.59	0.15
cotton	Baumwolle	poly	dom	wool	5.16	1.57	0.67	sync	1.54	1.27	0.00
cotton	Wette	poly	sub	plant	4.94	1.70	0.17	actor	1.40	0.84	0.00
doll	Puppe	poly	dom	toy	5.30	1.31	0.56	pin	2.03	1.27	0.25
doll	Schatz	poly	sub	nice	3.29	1.73	0.48	hour	1.35	1.03	0.07
gem	Edelstein	poly	dom	jewel	6.42	1.02	0.21	graph	1.48	0.89	0.01
gem	Prachtstück	poly	sub	masterpiece	3.91	1.97	0.07	transmitter	1.55	0.97	-0.02
mouth	Mund	poly	dom	lip	6.08	1.19	0.39	bee	1.77	1.12	0.10
mouth	Öffnung	poly	sub	opening	4.09	1.53	0.34	grandma	2.02	1.52	0.09
note	Zettle	poly	dom	message	N/A	N/A	0.14	weekend	N/A	N/A	0.15
note	ton	poly	sub	music	N/A	N/A	0.22	uncle	N/A	N/A	-0.01
paper	Papier	poly	dom	cardboard	5.15	1.34	0.64	bandstand	2.00	1.24	-0.04
paper	Aufsatz	poly	sub	document	5.47	1.45	0.25	freshman	1.95	1.41	0.06
pillar	Pfeiler	poly	dom	pedestal	3.66	1.92	0.14	shipment	1.60	1.18	0.05
Pillar	Standbein	poly	sub	supporter	5.34	1.64	0.04	replicate	1.67	1.19	0.00
pine	Pinie	poly	dom	sap	4.75	1.49	0.50	ego	1.34	0.88	0.02

pine	Kiefer	poly	sub	flooring	N/A	N/A	0.17	teaspoon	N/A	N/A	0.20
pipe	Pfeife	poly	dom	cigar	5.09	1.61	0.19	sheep	1.43	0.94	0.05
pipe	Rohr	poly	sub	plumbing	5.23	1.56	0.49	souvenir	2.38	1.47	0.08
racket	Schläger	poly	dom	paddle	N/A	N/A	0.05	shaman	N/A	N/A	0.02
racket	Aufruhr	poly	sub	shouting	N/A	N/A	0.29	chemical	N/A	N/A	0.02
sheet	Laken	poly	dom	blanket	5.55	1.54	0.12	warrior	1.44	0.87	0.01
sheet	Blatt	poly	sub	page	5.84	1.24	0.24	milk	1.65	0.99	0.03
shower	Brause	poly	dom	bath	5.30	1.39	0.54	mail	1.43	0.82	0.06
shower	Regenfall	poly	sub	storm	4.31	1.74	0.28	bread	1.34	0.77	0.18
sign	Schild	poly	dom	placard	4.07	2.16	0.01	sprayer	1.84	1.23	0.12
sign	Zeichen	poly	sub	clue	5.07	1.59	0.21	goal	2.23	1.43	0.08
tongue	Zunge	poly	dom	gum	4.56	1.47	0.46	war	1.49	1.09	0.03
tongue	Sprache	poly	sub	dialect	5.09	1.78	0.18	vacancy	1.38	0.80	0.04
trial	Verhandlung	poly	dom	court	N/A	N/A	0.63	movie	N/A	N/A	0.05
trial	Versuch	poly	sub	attempt	N/A	N/A	0.20	mystery	N/A	N/A	0.13
vessel	Schiff	poly	dom	nautical	N/A	N/A	0.24	stickler	N/A	N/A	0.09
vessel	Behältnis	poly	sub	bowl	N/A	N/A	0.06	data	N/A	N/A	0.00
ant	Ameise	single		wasp	N/A	N/A	0.65	oval	N/A	N/A	0.07
arrow	Pfeil	single		dart	5.14	1.44	0.15	kite	2.42	1.54	0.02
art	Kunst	single		drawing	5.84	1.24	0.22	highway	1.66	1.07	0.03
bird	Vogel	single		sparrow	5.58	1.35	0.32	vaccine	2.53	1.91	0.02
bone	Knochen	single		fossil	5.29	1.55	0.23	ginger	1.74	1.16	-0.01
book	Buch	single		magazine	5.12	1.57	0.29	mountain	1.69	1.12	0.00
boot	Stiefel	single		shoe	5.85	1.34	0.30	gate	1.70	1.01	0.34
candle	Kerze	single		torch	5.24	1.63	0.27	valve	1.73	1.16	-0.04
chain	Kette	single		string	4.21	1.58	0.15	soccer	1.59	1.22	0.00
cloud	Wolke	single		sky	5.21	1.23	0.59	pop	1.96	1.28	0.10

color	Farbe	single	red	5.30	1.46	0.51	cop	1.90	1.29	0.02
coward	Feigling	single	wimp	5.80	1.72	0.02	epic	1.79	1.11	0.07
example	Beispiel	single	prototype	4.98	2.01	0.00	sanctuary	1.62	1.21	0.08
face	Gesicht	single	mask	4.85	1.55	0.50	term	1.82	1.31	0.11
fate	Schicksal	single	destiny	N/A	N/A	0.49	version	N/A	N/A	0.23
fog	Nebel	single	smoke	N/A	N/A	0.31	clock	N/A	N/A	0.15
funeral	Beerdigung	single	burial	5.58	1.28	0.41	jingle	1.60	0.95	0.07
garlic	Knoblauch	single	onion	N/A	N/A	0.32	camel	N/A	N/A	0.08
head	Kopf	single	skull	5.84	1.10	0.24	bonus	1.88	1.27	0.03
juice	Saft	single	water	4.42	1.48	0.13	heart	1.82	1.30	0.00
knight	Ritter	single	nobleman	5.00	1.55	0.45	coverage	1.98	1.17	-0.01
meat	Fleisch	single	steak	5.66	1.63	0.59	clown	1.54	1.04	0.07
mercy	Gnade	single	pity	N/A	N/A	0.48	role	N/A	N/A	0.02
mirror	Spiegel	single	image	4.38	1.74	0.64	fever	1.37	0.82	0.03
monkey	Affe	single	gorilla	5.32	1.31	0.43	cracker	1.85	1.45	0.01
pear	Birne	single	peach	N/A	N/A	0.21	altar	N/A	N/A	0.09
recovery	Erholung	single	improvement	5.23	1.45	0.35	inheritance	2.59	1.59	0.05
river	Fluss	single	lake	4.81	1.71	0.33	bite	1.44	0.80	0.07
road	Strasse	single	way	4.82	1.63	0.34	guy	2.07	1.47	0.06
roof	Dach	single	floor	3.48	1.83	0.49	earth	1.81	1.09	0.09
scar	Narbe	single	wound	5.53	1.24	0.44	stock	1.53	1.10	0.04
spine	Rückrat	single	back	5.56	1.33	0.20	girl	2.18	1.42	0.03
stench	Geruch	single	smell	N/A	N/A	0.15	agent	N/A	N/A	0.10
task	Aufgabe	single	duty	5.63	1.53	0.27	dare	3.42	1.33	0.14
tension	Spannung	single	stress	5.68	1.42	0.51	coffin	1.92	1.41	-0.01
train	Zug	single	plane	4.16	1.72	0.18	order	1.93	1.42	0.08
trash	Müll	single	waste	6.35	1.44	0.64	trick	1.74	1.22	0.13

truth	Wahrheit	single	fact	N/A	N/A	0.54	hour	N/A	N/A	0.14
voice	Stimme	single	speech	5.39	1.69	0.28	lesson	3.20	1.99	0.12
wing	Flügel	single	feather	4.77	1.76	0.42	mansion	2.56	1.54	0.12

APPENDIX J

J.1 CORRELATION MATRICES – EXPERIMENT 3

Table 67. Unambiguous Translations- Semantic interference scores with free recall and L2-L1 Translation Production

		Testing Session 1 Unambiguous	Testing Session 2 Unambiguous	Testing Session 1 Unambiguous Free Recall	Testing Session 1 Unambiguous L2-L1 Translation	Testing Session 2 Unambiguous Free Recall	Testing Session 2 Unambiguous L2-L1 Translation
Testing Session 1 Unambiguous	Correlation Coefficient	1.000	.071	-.106	.005	-.212	-.080
	Sig. (2-tailed)		.709	.572	.979	.252	.667
	N	31	30	31	31	31	31
Testing Session 2 Unambiguous	Correlation Coefficient	.071	1.000	-.434*	-.484**	-.263	-.488**
	Sig. (2-tailed)	.709		.017	.007	.160	.006
	N	30	30	30	30	30	30
Testing Session 1 Unambiguous Free Recall	Correlation Coefficient	-.106	-.434*	1.000	.720**	.721**	.810**
	Sig. (2-tailed)	.572	.017		.000	.000	.000
	N	31	30	31	31	31	31
Testing Session 1 Unambiguous L2-L1 Translation	Correlation Coefficient	.005	-.484**	.720**	1.000	.628**	.799**
	Sig. (2-tailed)	.979	.007	.000		.000	.000
	N	31	30	31	31	31	31
Testing Session 2 Unambiguous Free Recall	Correlation Coefficient	-.212	-.263	.721**	.628**	1.000	.712**
	Sig. (2-tailed)	.252	.160	.000	.000		.000
	N	31	30	31	31	31	31
Testing Session 2 Unambiguous L2-L1 Translation	Correlation Coefficient	-.080	-.488**	.810**	.799**	.712**	1.000
	Sig. (2-tailed)	.667	.006	.000	.000	.000	
	N	31	30	31	31	31	31

Table 68. Dominant Translations- Semantic interference scores with free recall and L2-L1 Translation Production

		Testing Session 1 Dominant Trained	Testing Session 1 Dominant Untrained	Testing Session 2 Dominant Trained	Testing Session 2 Dominant Untrained	Testing Session 1 Dominant Free Recall	Testing Session 1 Dominant L2-L1 Translation	Testing Session 2 Dominant Free Recall	Testing Session 2 Dominant L2-L1 Translation
Testing Session 1 Dominant Trained	Correlation Coefficient	1.000	.176	.063	-.067	.093	.041	-.160	.000
	Sig. (2-tailed)		.343	.738	.723	.619	.825	.389	.998
	N	31	31	31	30	31	31	31	31
Testing Session 1 Dominant Untrained	Correlation Coefficient	.176	1.000	.358*	-.158	-.073	-.352	-.174	-.435*
	Sig. (2-tailed)	.343		.048	.405	.698	.052	.349	.014
	N	31	31	31	30	31	31	31	31
Testing Session 2 Dominant Trained	Correlation Coefficient	.063	.358*	1.000	-.263	.036	-.077	-.080	-.307
	Sig. (2-tailed)	.738	.048		.160	.846	.681	.670	.093
	N	31	31	31	30	31	31	31	31
Testing Session 2 Dominant Untrained	Correlation Coefficient	-.067	-.158	-.263	1.000	.046	.202	-.006	.228
	Sig. (2-tailed)	.723	.405	.160		.811	.284	.974	.226
	N	30	30	30	30	30	30	30	30
Testing Session 1 Dominant Free Recall	Correlation Coefficient	.093	-.073	.036	.046	1.000	.557**	.258	.279
	Sig. (2-tailed)	.619	.698	.846	.811		.001	.162	.129
	N	31	31	31	30	31	31	31	31
Testing Session 1 Dominant L2-L1 Translation	Correlation Coefficient	.041	-.352	-.077	.202	.557**	1.000	.114	.705**
	Sig. (2-tailed)	.825	.052	.681	.284	.001		.542	.000
	N	31	31	31	30	31	31	31	31
Testing Session 2 Dominant Free Recall	Correlation Coefficient	-.160	-.174	-.080	-.006	.258	.114	1.000	.231
	Sig. (2-tailed)	.389	.349	.670	.974	.162	.542		.211
	N	31	31	31	30	31	31	31	31
Testing Session 2 Dominant L2-L1 Translation	Correlation Coefficient	.000	-.435*	-.307	.228	.279	.705**	.231	1.000
	Sig. (2-tailed)	.998	.014	.093	.226	.129	.000	.211	
	N	31	31	31	30	31	31	31	31

Table 69. Subordinate Translations- Semantic interference scores with free recall and L2-L1 Translation Production

		Testing Session 1 Subordinate Trained	Testing Session 1 Subordinate Untrained	Testing Session 2 Subordinate Trained	Testing Session 2 Subordinate Untrained	Testing Session 1 Subordinate Free Recall	Testing Session 1 Subordinate L2-L1 Translation	Testing Session 2 Subordinate Free Recall	Testing Session 2 Subordinate L2-L1 Translation
Testing Session 1 Subordinate Trained	Correlation Coefficient	1.000	.350	.123	.010	-.003	-.080	.091	-.015
	Sig. (2-tailed)		.054	.516	.955	.989	.668	.625	.936
	N	31	31	30	31	31	31	31	31
Testing Session 1 Subordinate Untrained	Correlation Coefficient	.350	1.000	.249	-.004	.456**	.246	.189	.215
	Sig. (2-tailed)	.054		.184	.985	.010	.183	.309	.244
	N	31	31	30	31	31	31	31	31
Testing Session 2 Subordinate Trained	Correlation Coefficient	.123	.249	1.000	.006	.029	.052	.291	.159
	Sig. (2-tailed)	.516	.184		.975	.881	.784	.119	.402
	N	30	30	30	30	30	30	30	30
Testing Session 2 Subordinate Untrained	Correlation Coefficient	.010	-.004	.006	1.000	.118	.146	-.055	.312
	Sig. (2-tailed)	.955	.985	.975		.527	.435	.768	.088
	N	31	31	30	31	31	31	31	31
Testing Session 1 Subordinate Free Recall	Correlation Coefficient	-.003	.456**	.029	.118	1.000	.513**	.462**	.385*
	Sig. (2-tailed)	.989	.010	.881	.527		.003	.009	.032
	N	31	31	30	31	31	31	31	31
Testing Session 1 Subordinate L2-L1 Translation	Correlation Coefficient	-.080	.246	.052	.146	.513**	1.000	.538**	.829**
	Sig. (2-tailed)	.668	.183	.784	.435	.003		.002	.000
	N	31	31	30	31	31	31	31	31
Testing Session 2 Subordinate Free Recall	Correlation Coefficient	.091	.189	.291	-.055	.462**	.538**	1.000	.580**
	Sig. (2-tailed)	.625	.309	.119	.768	.009	.002		.001
	N	31	31	30	31	31	31	31	31
Testing Session 2 Subordinate L2-L1 Translation	Correlation Coefficient	-.015	.215	.159	.312	.385*	.829**	.580**	1.000
	Sig. (2-tailed)	.936	.244	.402	.088	.032	.000	.001	
	N	31	31	30	31	31	31	31	31

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