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The Effects of Concreteness and Semantic Neighbourhood Density on Visual Word Recognition

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by

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ABSTRACT

Visual word recognition response times are known to be influenced by such factors as concreteness (reviewed e.g., Paivio, 1991; Schwanenflugel, 1991) and Semantic Neighbourhood Density (SND; Buchanan, Westbury & Burgess, 2001), which is the proximity of words related by meaning to a target word in semantic memory. Through the use of two standard lexical decision task experiments, the goal of this study was to compare response times for abstract words versus concrete words, while also varying levels of SND using two different stimulus sets. The main and interactive effects of these variables were demonstrated, though conclusions were primarily made based on the data from Experiment 2 because of the use of a more controlled stimulus set, as well as a speed-accuracy trade-off evident in the Experiment 1 data. This investigation represents the first attempt to explore the effects of SND on the visual recognition of abstract words.

DEDICATION

Throughout my life I have had several mentors who generously and graciously invested their time and energy into my development. This work is dedicated to you.

ACKNOWLEDGEMENTS

To my research supervisor, Dr. Lori Buchanan: You have a tremendous ability to nurture and mentor students to become quality researchers who think creatively and critically about their ideas. Thank you for sharing that gift with me.

To my parents: Your love and encouragement motivates me to always strive for excellence in all areas of my life. I hope that I have made you proud.

To my sister: You are my other half, and I share everything I've achieved with you. Thank you for just being you, and everything I'm not.

To the Sotto and Danguecan families: You have rallied behind me and supported me. Thank you for showering me with unconditional love and praise.

To my roomie, Jenny: In only two years you have become like a sister to me. Thank you for every late/all-nighter, stress session, quiet night in, and crazy night out.

To my new M.A. peers: We did it! I am honoured to have experienced these past two years with you all. Thank you for being a genuinely fantastic group of people.

To my closest friends: I've drawn incredible strength from you over the years, and am so grateful for the bonds we share. Thank you for the laughs and friend feasts.

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CHAPTER I

REVIEW OF LITERATURE

Overview of Variables of Interest

Understanding the fundamental principles by which word representations are organized in semantic memory is a major objective for cognitive scientists. Indeed, a significant proportion of human vocabulary may be categorized into two major word types: concrete words, which are spatially circumscribed and which can be experienced directly through the senses (e.g., *bracelet*, *kitchen*, etc.) and abstract words, which refer to concepts that have no direct sensory referents (e.g., *bravery, absorption*, etc.). A large body of literature exists which suggests that concrete and abstract words are represented in different ways in the human lexicon. In support of this idea, many studies have found that concrete words are both recognized and remembered more easily than abstract words, a phenomenon known as the concreteness effect (reviewed e.g., Paivio, 1991; Schwanenflugel, 1991). To date, two major competing theories have been put forward to account for these findings. Paivio's (1971) dual coding theory asserts that one's knowledge of concrete words may be encoded both visually and linguistically, whereas abstract words may only be encoded linguistically because of their lack of associated sensory information. Therefore, this theory argues that there is a fundamental difference in the *type* of information available when one accesses concrete words, and that the availability of two forms of representation provides concrete words with a cognitive processing advantage. Alternatively, the context availability theory (Schwanenflugel, Harnishfeger, & Stowe, 1988) states that contextual information is more readily available from concrete words presented in isolation as compared to abstract words, making concrete word processing more efficient. Thus, this model argues for a fundamental difference in the *quantity* of information associated with concrete and abstract words within a single system. While these two theories have different implications for lexical organization, they both suggest that abstract words are associated with a paucity of semantic information in comparison to concrete words.

Based on the literature described above, it is clear that word type (i.e., concrete versus abstract) is a major factor influencing speed of word recognition. Another major factor to be considered in the present study is the effect of semantic neighbourhood density (SND; Buchanan, Westbury & Burgess, 2001), which refers to the proximity of words related by meaning to a target word in semantic memory. A description of hypothesized effects of SND on visual word recognition processes first requires a brief discussion of the major models of linguistic semantic organization (as they relate to semantic neighbourhood structure). That description follows.

The Nature of Semantic Representations

In general, the term 'semantic representation' is meant to refer to the symbolic means by which a word meaning is stored in memory. To enable usage of the words learned through human language, these semantic representations must be organized in some logical way, such that we can develop an understanding of how word meanings are similar to and different from each other. This issue is the core of a body of literature that has attempted to address how words are encoded: as individual stores/units, or as distributed pathways throughout the semantic system. Within this area of research, at least two major models of lexical organization have been put forward which primarily advocate for one of these views. Firstly, the logogen model proposed by Morton (1969) states that each word within an individual lexicon has their own unique corresponding logogen (derived from the Greek words *logos* meaning 'word' and *genus* meaning 'birth'), which is essentially a hypothetical signal (word) detector that contains information about a specific word's orthographic properties (how a word looks), phonological properties (how a word sounds), and semantic properties (what a word means). This view contrasts with a distributed model of visual word recognition put forth by Seidenberg and McClelland (1989), in which there are no central entries for individual words (i.e., logogens). Rather, our knowledge of words is encoded as connections between processing units that contain information regarding orthography, phonology, and semantics. Therefore, lexical processing according to a distributed model does not involve accessing stored codes as is stated by the logogen model, but rather requires the activation of different types of information distributed throughout a semantic network.

Ultimately, the manner by which semantic representations are organized is influenced by both individual/idiosyncratic as well as more general principles that transcend individual differences. The theoretical position adopted here is similar to that offered by Buchanan et al. (2001): there are general organizational influences of semantic structure that can be defined and examined, though it is understood that idiosyncratic differences exist. What will be described subsequently are some of the different theories that have attempted to explain the organizational influences of semantic structure that are shared between individuals.

Theories of Semantic Organization

Object-based theories of the semantic system (i.e., feature-based view, category-based view) purport that the conceptual closeness of word representations may be defined in terms of the similarity of the objects themselves. In a feature-based view, semantic neighbours would refer to concepts that share numerous common physical features (e.g., *tiger* and *lion* would be considered semantic neighbours because they both have fur, a tail, four legs, etc.). In a category-based view, concepts belonging to the same category would be considered semantic neighbours (e.g., *cat* and *dog* would be considered semantic neighbours because they are both types of house pets). Both of these object-based theories suggest that the spread of activation between semantic neighbours occurs as a function of their shared features or category memberships. As such, research by Grondin, Lupker, and McRae (2009) found that for concrete words specifically, reaction times for both lexical decision and semantic categorization tasks were found to be faster for concepts with many associated semantic features as compared to those with fewer features. Although these two tasks have been used to study semantic representations, they each make unique demands on participants. While the lexical decision task requires the fastest possible response as to whether a presented word is a real word or a nonsense word, the semantic categorization task requires the fastest possible response as to whether a presented word belongs to a certain predetermined category (e.g., animal, food item) or not.

On the other hand, language-based or associational-based theories of semantics propose that concepts are classified as semantic neighbours based on their statistical co-occurrence within similar contexts in large samples of language usage (i.e., global co-occurrence; e.g., Lund & Burgess, 1996; Landauer & Dumais, 1997). For example, *tiger* and *lion* would be considered near neighbours not because they share features, but because they often appear within similar contexts in large samples of text. In this way, semantic neighbours may also include words that are commonly associated with each other (e.g., ‘cat’ and ‘scratch’), but do not share any features. Indeed, facilitative priming effects do occur for word pairs such as *hair-brush* (e.g., McNamara, 1994), and false memory rates for non-presented target words are higher following the presentation of associated word lists as compared to lists of category word items (Buchanan, Brown, Cabeza, & Maitson, 1999).

While both feature-based and association-based views of semantic organization have been shown to facilitate visual word recognition processes, adopting a language-based view is more amenable to the study of abstract words in particular, as abstract words do not possess associated physical features in the same way as concrete words. As such, the semantic relationships between words are defined in the present study according to a global co-occurrence model (WINDSORS; Durda & Buchanan, 2008), and are therefore more in line with the association-based view.

Semantic Neighbourhood Density and Attractor Dynamics

Investigations of SND were first undertaken by Buchanan et al. (2001) in relation to semantic distance, which they referred to as the mean distance between a target word in memory and its 10 closest neighbours. That is, a word with high semantic distance is relatively distant from its 10 nearest neighbours, and is therefore purported to have a sparse semantic neighbourhood, as well as fewer semantic neighbours (on average). Conversely, a word with low semantic distance is relatively close to its 10 nearest neighbours, indicating a more dense semantic neighbourhood, as well as a greater number of semantic neighbours than a word with high semantic distance. Interestingly, a series of single-order correlations between semantic distance and other more traditional semantic measures (i.e., concreteness, imageability) derived from the MRC Psycholinguistics

Database (Coltheart, 1981) revealed that semantic distance accounts for a unique proportion of variance in lexical decision task latencies beyond that predicted by these established semantic variables. Ultimately, through a series of experiments, these researchers demonstrated that semantic neighbourhood size, as defined by semantic distance, facilitates word recognition in a standard lexical decision task when other variables shown to interact with semantic distance in earlier experiments (i.e., frequency and orthographic neighbourhood size) are controlled. Basically, the Buchanan et al. (2001) data indicate that having a larger and denser semantic neighbourhood is better than having a smaller and sparser semantic neighbourhood in terms of speed of visual word recognition. Such findings are consistent with a semantic feedback model, whereby it is assumed that the word/non-word decision is based primarily on orthographic activation (i.e., does this look like a word?), which is facilitated via top-down feedback from semantics. Therefore, feedback strength from semantics to orthography is enhanced for words with more enriched semantic representations (Hino & Lupker, 1996).

A more recent study by Mirman and Magnuson (2008) further clarified the nature of the facilitative effects of SND by exploring its relationship with attractor dynamics. In one experiment, these researchers independently manipulated the effects of near versus distant neighbours within the context of a semantic categorization task. Ultimately, they found that words with many close neighbours were categorized more slowly than words with fewer close neighbours, which was attributed to increased competition effects with semantically similar words. Further, words with many distant neighbours were processed more quickly than words with fewer distant neighbours, which was attributed to decreased competition effects. However, there was no significant interaction between number of near and distant neighbours. Thus, these results, which cannot be accounted for by traditional theories of SND (e.g., semantic feedback model), reflect a complex interplay of SND such that competition and facilitation effects occur simultaneously in an "attractor model" of semantic processing. This theory posits that distant neighbours create a gravitational gradient for faster settling into attractor basins, thereby facilitating word recognition processes. Near neighbours, on the other hand, are theorized to create conflicting sub-basins that slow the completion of the settling process, increasing the likelihood of competition effects, which results in slower response times (RTs) on word recognition tasks.

To test this hypothesis, Mirman and Magnuson (2008) examined settling patterns and times for the words tested in the above experiment using a computational attractor model of semantic access trained by O'Connor, McRae, and Cree (2006) to activate semantic features. Indeed, the model results were consistent with behavioural data, which the authors claimed provided support for an attractor dynamics theory of semantic processing. That is, the effect of neighbours depended on their influence on the 'attractor surface' leading to the target word. However, the conclusions drawn from this study as they relate to SND specifically cannot be made based on this computational analysis, as the words modeled here were derived from the McRae, Cree, Seindenberg, and McNorgan (2005) database of *feature-based* norms. Recall that feature-based models of semantics state that semantic neighbours are concepts that share common physical features, while global co-occurrence based models of semantics state that semantic neighbours must appear within similar contexts in large bodies of text (and thus do not necessarily share any physical features). The findings related to Buchanan et al.'s (2001) concept of SND, as it was first defined by this research group, are based on a global *co-occurrence* model, and thus any results derived from feature-based norms contribute little to our understanding of SND in this regard. Nonetheless, it is worthwhile to investigate the possibility that differences in response latencies may exist between words with low versus high SND as a function of the effects of near versus distant neighbours.

The Present Study: Research Objectives

Despite the progress made in our understanding of how semantics influence word recognition processes, one limitation of studies in this area is the largely exclusive use of *concrete* words/concepts in evaluating semantic effects. The exclusion of abstract words limits the ecological validity of these findings because many of the words/concepts encoded in human memory and processed through language are the products of higher-order thinking (e.g., ideas about what such abstract concepts as *justice* or *love* mean). To date, there are no data to tell us whether abstract words would also benefit from large and dense semantic neighbourhoods, or whether there are facilitative distant neighbour effects as with concrete words. According to Mirman and Magnuson (2008), two possibilities exist: Abstract words may have less clear representations in memory, allowing for more competition from near semantic neighbours. Alternatively, abstract words may exist in sparse semantic neighbourhoods (due to having minimal/no identifiable and tangible features, and perhaps broader attractors), and thus facilitative distant neighbour effects should dominate. Of course, another possibility is that SND does not influence recognition response times of concrete and/or abstract words. This paper describes two lexical decision task (LDT) experiments designed to help adjudicate between these possibilities.

Operational Definitions

The central goal of Experiment 1 was to explore the potential influence of SND on concrete versus abstract word processing in a relatively global manner within the context of LDT methodology. In this study, SND is defined as the average degree of similarity between a target stimulus word and every other word in its semantic neighbourhood (as derived from a global co-occurrence model) using a cut-off of 3.5 standard deviations (WINDSORS; Durda and Buchanan, 2008). Recent research by MacDonald, Durda, and Buchanan (2010) using hierarchical regression analyses revealed that semantic neighbourhood sizes derived using a standard score cutoff of 3.5 standard deviations best predicted lexical decision RT data obtained from the Balota, Pilotti, and Cortese (1999) corpus. Word neighbours with SND values closer to 0 are only mildly related to the target word, while word neighbours with SND values closer to 1 are strongly related to the target word. Using these semantic norms, a high SND word is, on average, more similar to the words in its semantic neighbourhood, and is therefore in closer proximity to the target word in semantic space. Conversely, a low SND word is, on average, less similar to the words in its semantic neighbourhood and is therefore farther from the target word in semantic space than a high SND word. In other words, high SND words are thought to have a greater number of near neighbours, while low SND words are thought to have a greater number of distant neighbours.

CHAPTER II

DESIGN AND METHODOLOGY

Stimulus Development

The norms used to develop the stimulus set were derived from WINDSORS (Durda & Buchanan, 2008), which offers an advantage over earlier lexical co-occurrence models such as the hyperspace analogue to language (HAL; Lund and Burgess, 1996) by carefully controlling for the effects of word frequency, while continuing to capture semantic characteristics. The final stimulus set was derived from a corpus of approximately 50,000 words and consists of 46 abstract and 46 concrete common nouns matched on word length, frequency (per million words of printed text), and semantic neighbourhood size. The means and standard deviations for these stimulus characteristics per condition are displayed in Table 1 below. Half of the abstract words and half of the concrete words were low SND and half were high SND, and these 92 words were matched with 92 non-words on length and orthographic neighbourhood size. Independent t-tests were conducted to ensure that mean low and high SND values differed significantly, and that mean SND values did not differ significantly between concrete and abstract words within each level of SND. Finally, an ANOVA was conducted to ensure that mean frequencies and semantic neighbourhood sizes across groups showed no significant differences. All of the words selected were low frequency (i.e., fewer than 10 per million words of printed text), as previous research has shown that the facilitative effects of SND do not appear to hold true for higher frequency words (Buchanan et al., 2001). The full stimulus set is presented in Appendix A.

Table 1

Means and Standard Deviations for Word Length, Frequency, Semantic Neighbourhood Size (SN), and Semantic Neighbourhood Density (SND) Per Condition in the Experiment 1 Stimulus

Word Category	Word Length	Frequency	SN Size	SND
Concrete				
Low SND	8.30 (1.18)	1.37 (0.81)	223.74 (45.92)	0.34 (0.01)
High SND	8.30 (1.06)	1.36 (0.85)	232.04 (55.18)	0.38 (0.01)
Abstract				
Low SND	8.39 (1.08)	1.46 (0.83)	219.70 (57.36)	0.34 (0.01)
High SND	8.26 (1.10)	1.35 (0.76)	229.39 (64.32)	0.37 (0.01)

Participants

108 University of Windsor undergraduate psychology students participated in this experiment for partial course credit. However, 2 participants were excluded from statistical analyses due to low accuracy rates (i.e., less than 70%) on the LDT resulting in N=106 (17 males, 89 females; mean age = 20.7 years). All participants were at least 18 years of age, native English speakers, and had normal or corrected-to-normal vision.

Procedure

The LDT was run on a PC using the Windows XP operating system. The software program used to run the LDT was DirectRT. Words were presented in the middle of a black background in all capital letters, size 24, bold-faced font with turquoise-coloured letters. Each word appeared one at a time in random order, and the word remained on the screen until the participant gave their response by pressing either the “Z” key (for non-words) or the “?” key (for real words). Participants first completed a 6-trial practice phase during which they received a feedback message on the screen after each response (i.e., “CORRECT” or “INCORRECT”). Specifically, participants read the following instructions to introduce them to the LDT:

You will be presented with a series of single words and non-words (pronounceable groups of letters that do not form a real word).

For each word that you see, please press the ‘?’ key if the word you see is a real word, and press the ‘Z’ key if it is a non-word. A word is a real word if it is spelled correctly. Sometimes you may see words that sound like real words (e.g., *brane*), but since it is not spelled correctly you should hit the ‘Z’ key.

Please make this decision as quickly and as accurately as you can. Let’s practice to ensure that you fully understand the demands of the task.

Please press the spacebar key to begin the experiment.

CHAPTER III

ANALYSIS OF RESULTS

Data Cleaning Procedures

The concreteness and SND variables were considered as within-subject in the subject analysis (F_1), and between-item in the item analysis (F_2). From the original set of real word responses, all incorrect responses were removed (1291 observations; 13.01% of the data). Responses from one participant were also excluded due to coding errors in which responses to 14 words were not recorded. A minimum accuracy rate of 70% was used for both participants and words. This resulted in the removal of one participant with an accuracy rate of less than 70%, as well as the removal of responses from 7 abstract-high SND words, 6 abstract-low SND words, 2 concrete-high SND words, and 1 concrete-low SND word. This collectively represents 947 observations, which translates into 11.06% of the remaining data. Finally, within each of the 4 conditions, RTs greater than 2.5 standard deviations from the mean were identified as outliers and excluded from all analyses, resulting in the removal of 200 observations (2.63% of the remaining data). In total, 2506 cases were removed from the complete outlier and error analysis, representing 25.26% of the original set of response data. Participant mean response times, standard deviations, and error rates per condition for the final data set are displayed in Table 2.

Table 2

Number of Word Items, Mean RTs (with Standard Deviations), and Average Error Rates (with Standard Deviations) Per Condition in the Experiment 1 Subject Analysis

Word Category	Number of Word Items	Mean RT (msec)	Average Error Rate (%)
Concrete			
Low SND	22	805.77 (162.88)	5.36 (6.42)
High SND	21	820.57 (159.19)	5.43 (6.08)
Abstract			
Low SND	17	924.89 (208.06)	10.15 (10.25)
High SND	16	917.84 (181.20)	12.50 (10.28)

Experiment 1 Results

A repeated measures 2 by 2 analysis of variance (ANOVA) was used to compare average RTs between conditions. As in previous comparisons of lexical decision RTs of concrete versus abstract words (reviewed e.g., Paivio, 1991; Schwanenflugel, 1991), a main effect of concreteness was obtained, with participants responding more quickly to concrete words as compared to abstract words [$F_1(1, 105) = 194.99$, $p < .05$, partial $\eta^2 = .65$; $F_2(1, 72) = 25.34$, $p < .05$, partial $\eta^2 = .26$]. There was no main effect of SND in either the subject or item analyses [$F_1(1, 105) = 0.48$, $p = .49$, partial $\eta^2 = .01$; $F_2(1, 72) = .21$, $p = .65$, partial $\eta^2 = .00$]. Although there was no concreteness by SND interaction in the subject analysis [$F_1(1, 105) = 3.10$, $p = .08$, $\eta^2 = .03$], or the item analysis [$F_2(1, 76) = .21$, $p = .65$], follow-up t-tests revealed that for the concrete words at least, the high SND words were recognized slower than their low SND counterparts [$t_1(105) = 2.73$, $p < .05$] though this effect does not appear to hold for abstract words [$t_1(105) = -.67$, $p = .50$]. This suggests that at least for concrete words, distant neighbour effects are indeed facilitative and such a finding is consistent with claims from Mirman and Magnuson (2008). The results of the subject analysis are graphically displayed in Figure 1 below.

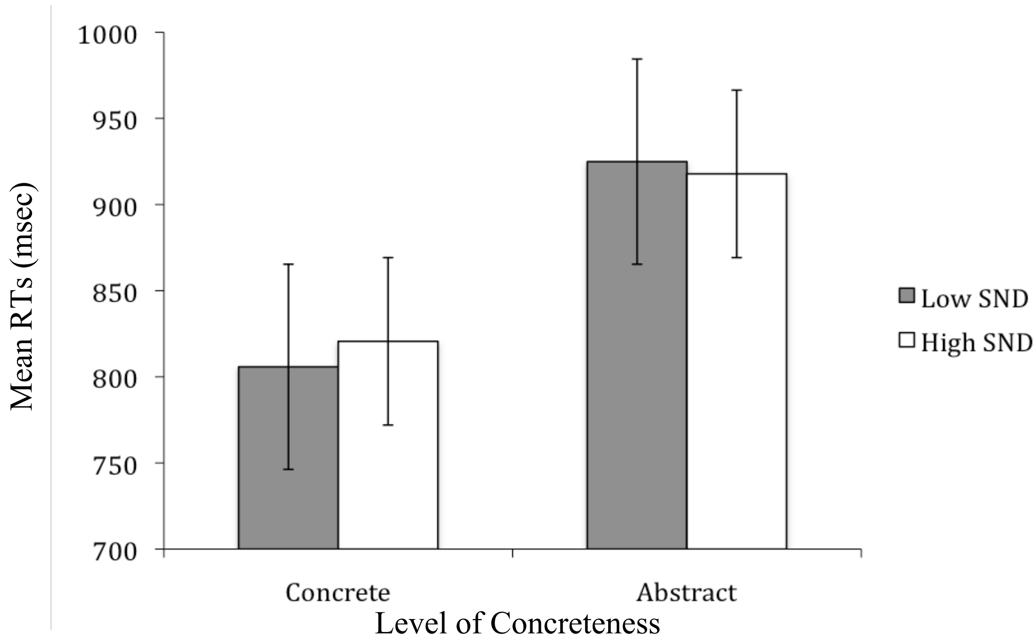

Figure 1. Mean RTs as a function of concreteness and SND in the subject analysis.

An error analysis was also conducted with average error rates per subject (F_{E1}) and per item (F_{E2}) being compared across the four conditions in a 2 by 2 repeated measures ANOVA. Similar to the RT analysis above, there was a main effect of concreteness with participants making a significantly greater number of errors when responding to abstract (as opposed to concrete) words [$F_{E1}(1, 105) = 71.62$, $p < .05$, partial $\eta^2 = .41$]. In the item analysis, word error rates were also higher for abstract words [$F_{E2}(1, 72) = 13.97$, $p < .05$, partial $\eta^2 = 16$]. Unlike the RT analysis, there was a main effect of SND in the subject analysis, with participants making a greater number of errors when responding to high SND words [$F_{E1}(1,105) = 5.15$, $p < .05$, partial $\eta^2 = .05$], though there was no such main effect detected in the item analysis [$F_{E2}(1,72) = .58$, $p =$

.45, partial η^2 = .01]. There was also a significant concreteness by SND interaction in the subject analysis [$F_{E1}(1,105) = 4.03$, $p < .05$, partial η^2 = .04], but not in the item analysis [$F_{E2}(1, 76) = .51$, p =.48, partial η^2 = .01]. Follow-up t-tests for the subject analysis interaction revealed that for abstract words, participants committed more errors when responding to high SND words [t_1 (105) = 2.40, p <.05], though there was no difference in average error rates for their concrete counterparts [t_1 (105) = .15, p = .88]. This finding differs from the RT analysis in that differences in error rates were detected within the abstract word group between low and high SND words, though it would be anticipated that differences should occur within the concrete word group to accord with the RT analysis. The data therefore reveals a speed/accuracy trade-off that would make firm conclusions difficult. The results of the subject error analysis are graphically displayed in Figure 2 below.

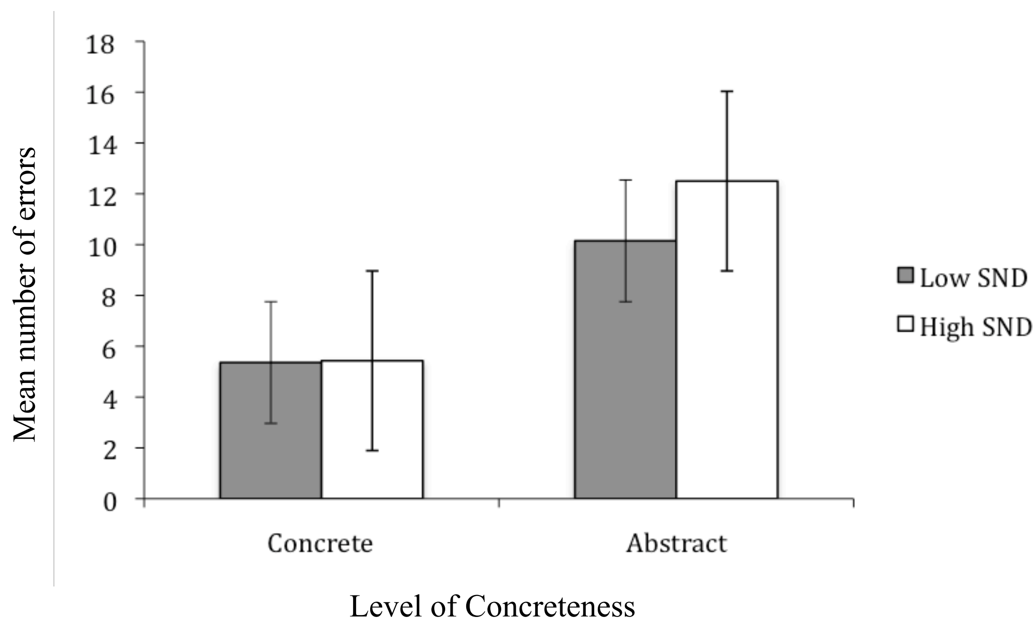

*Figure 2***.** Mean error rates in Experiment 1 as a function of concreteness and SND in the subject analysis

Experiment 1 Discussion

The results of Experiment 1 demonstrate that semantics, as defined by SND, may indeed play a role in the recognition of concrete words in that those with many distant neighbours were recognized more quickly than concrete words with many near neighbours. However, from this data it is difficult to know conclusively whether SND effects also influence abstract word recognition processes, as a large proportion of the abstract word responses were removed through outlier analysis or lost to errors, possibly blunting or masking any existing SND effects from this stimulus set. This may have been due to the inclusion of particularly obscure words, resulting in more intuitive 'non-word' decisions by participants. The following experiment replicates the design of Experiment 1 with a more tightly controlled stimulus set that should address these shortcomings by using qualitatively less obscure abstract words, and minimizing the influence of additional factors known to influence RTs; namely, number of syllables (which will be controlled across groups) and orthographic neighbourhood size (which will be limited to 2 or fewer with all words).

Experiment 2 Method

Stimulus Development.

The norms used to develop this stimulus set were again derived from WINDSORS (Durda & Buchanan, 2008), using a standard score cut-off of 3.5 SD to define semantic neighbourhood size. The final stimulus set consists of 44 abstract and 44 concrete common nouns matched on word length, frequency, number of syllables, and semantic neighbourhood size. All words have an orthographic neighbourhood size of 0 or 1, with the exception of 4 words (*pacifier, lipstick, mastery, concession)*, which have an orthographic neighbourhood size of 2. The means and standard deviations for these stimulus characteristics per condition are displayed in Table 3 below. Again, all of the words were low frequency (i.e., fewer than 10 per million). Half of the abstract words and half of the concrete words were low SND and half were high SND. Accordingly, 88 non-words were generated that are matched on length and orthographic neighbourhood size. To evaluate the extent to which the variables were controlled in this stimulus set, the same independent t-tests from Experiment 1 were conducted with respect to frequency, semantic neighbourhood size, and SND. The full stimulus set is presented in Appendix B.

Table 3

Means and Standard Deviations for Word Length, Number of Syllables (#Syll), Frequency (Freq), Orthographic Neighbourhood Size (ON), Semantic Neighbourhood Size (SN), and Semantic Neighbourhood Density (SND) Per Condition in the Experiment 2 Stimulus

Word Category	Word Length	#Syll	Freq	ON	SN	SND
Concrete						
Low SND	8.41	3.05	1.24	0.40	212.55	0.34
	(1.14)	(0.65)	(1.29)	(0.67)	(39.43)	(0.01)
High SND	8.41	3.05	1.26	0.05	217.86	0.39
	(1.14)	(0.65)	(1.32)	(0.21)	(40.83)	(0.02)
Abstract						
Low SND	8.41	3.05	1.43	0.37	210.77	0.34
	(1.14)	(0.65)	(1.01)	(0.65)	(41.90)	(0.01)
High SND	8.41	3.05	1.38	0.18	214.91	0.38
	(1.14)	(0.65)	(1.29)	(0.39)	(38.07)	(0.01)

Participants.

70 University of Windsor undergraduate psychology students participated in this experiment for partial course credit. However, 1 participant was excluded from statistical analyses due to low accuracy rates (i.e., less than 70%) on the LDT resulting in *N*=69 (17

males, 52 females; mean age = 20.80 years). As with Experiment 1, all participants were at least 18 years of age, native English speakers and had normal or corrected-to-normal vision.

Procedure.

The procedures for the LDT, including exact participant instructions, were identical to those used in Experiment 1.

Experiment 2 Results

The statistical methods, including the outlier and error analyses, were identical to those used in Experiment 1. From the original set of real word responses, all incorrect responses were removed (733 observations; 11.90% of the data). A minimum accuracy rate of 70% was used for both participants and words. This resulted in the removal of one participant who yielded an accuracy rate of less than 70%, as well as the removal of 4 abstract-high SND words, 1 abstract-low SND words, and 2 concrete-low SND words. This collectively represents 339 observations, which translates into 6.25% of the remaining data. Finally, within each of the 4 conditions, RTs greater than 2.5 standard deviations from the mean were identified as outliers and excluded from all analyses, resulting in the removal of 130 observations (2.56% of the remaining data). In total, 1,202 observations were removed from the complete outlier and error analysis, representing 19.51% of the original set of response data. Mean response times, standard deviations, and error rates per condition for the final data set are displayed in Table 4.

Table 4

Number of Word Items, Mean RTs (with standard deviations) and Mean Error Rates (with standard deviations) Per Condition in the Experiment 2 Subject Analysis

Word Category	Number of Word Items	Mean RT (msec)	Average Error Rate (%)
Concrete			
Low SND	20	901.09 (201.30)	9.35 (7.52)
High SND	22	949.23 (214.33)	9.22 (7.48)
Abstract			
Low SND	21	922.75 (231.41)	7.97 (8.10)
High SND	18	999.31 (243.99)	14.74 (11.50)

Similar to Experiment 1, in the subject analysis a main effect for concreteness was obtained, with participants responding more quickly to concrete words as compared to abstract words [$F_1(1, 68) = 12.48$, $p < .05$, partial $\eta^2 = .16$], though this result did not emerge in the item analysis [$F_2(1, 76) = 3.19$, $p = .08$, partial $\eta^2 = .04$]. Unlike Experiment 1, the main effect of SND reached statistical significance in both the subject and item analyses [$F_1(1, 68) = 51.63$, $p < .05$, partial $\eta^2 = .43$; $F_2(1, 76) = 7.99$, $p < .05$, partial $\eta^2 =.40$]. Additionally, a concreteness by SND interaction was detected in the subject analysis [$F_1(1, 68) = 4.36$, $p < .05$, partial $\eta^2 = .06$, but not in the item analysis [$F_2(1, 80) = .87$, $p =.36$, partial $\eta^2 = .01$]. While high SND words yielded significantly longer RTs than low SND words within both the concrete word group [t_1 (68) = - 4.68, $p < .05$] and the abstract word group [t_1 (68) = -6.53, $p < .05$], the magnitude of difference in RTs was greater for abstract words (~ 76 msec) than for concrete words (~ 48 msec). Figure 3 below displays the mean RTs per condition in both Experiments 1 and 2 on the same scale to allow for visual comparisons.

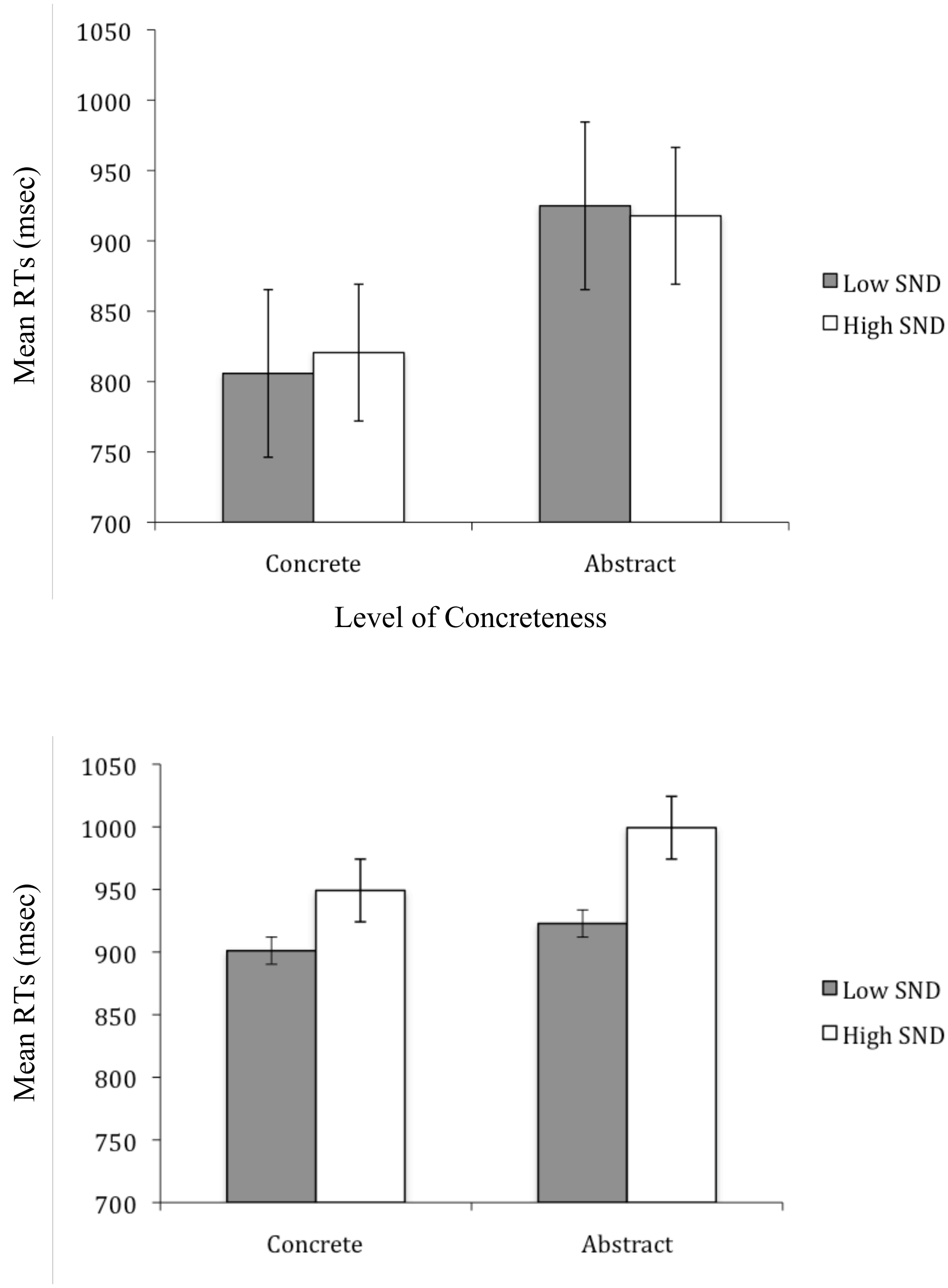

Figure 3. Mean RTs in Experiment 1 (top) versus Experiment 2 (bottom) as a function of concreteness and SND in the subject analysis.

When average error rates per subject and per item were compared across conditions, the subject analysis conformed to the same general pattern of results from the aforementioned RT analysis with respect to main effects. Specifically, there was a main effect of concreteness, with participants having committed a greater number of errors (on average) in response to abstract words [$F_{E1}(1,68) = 4.02$, $p < .05$, partial $\eta^2 = .06$.], though there was no such main effect in the item analysis [$F_{E2}(1,76) = 1.24$, $p = .27$, partial $\eta^2 = .02$]. Participants also produced a greater number of erroneous responses to high SND as compared to low SND words (main effect of SND; $F_{E1}(1,68) = 14.68$, $p < .05$, partial $\eta^2 = .18$), though there was no main effect of SND in the item analysis [$F_{E2}(1,76) = 3.19$, $p = .08$, partial $\eta^2 = .04$]. Additionally, there was a significant concreteness by SND interaction within the subject analysis [$F_{E1}(1,68) = 19.74$, $p < .05$, partial $\eta^2 = .23$], but not in the item analysis [$F_{E2}(1,80) = 3.44$, $p = .07$, partial $\eta^2 = .04$]. Largely in accordance with the RT analysis (in which there was a greater effect demonstrated for abstract words), within the abstract word group participants made a greater number of errors in response to high SND words as compared to low SND words [t_1 (68) = 5.02, $p < .05$], though there was no corresponding significant difference in error rates within the concrete word group [t_1 (68) = - .13, $p = .90$].

Also of importance, it appears from an inspection of the average error rates for the subject analysis (see Table 4 above) that the main effect of SND is being driven by RT differences within the abstract word group only. That is, for concrete words, no difference in average error rates between low and high SND words was found [t_1 (68) = - .13, $p = .90$], while for the abstract words, high SND items were significantly more error prone than low SND items [t_1 (68) = 5.02, $p < .05$]. The results of the subject error analysis are graphically displayed in Figure 4 below.

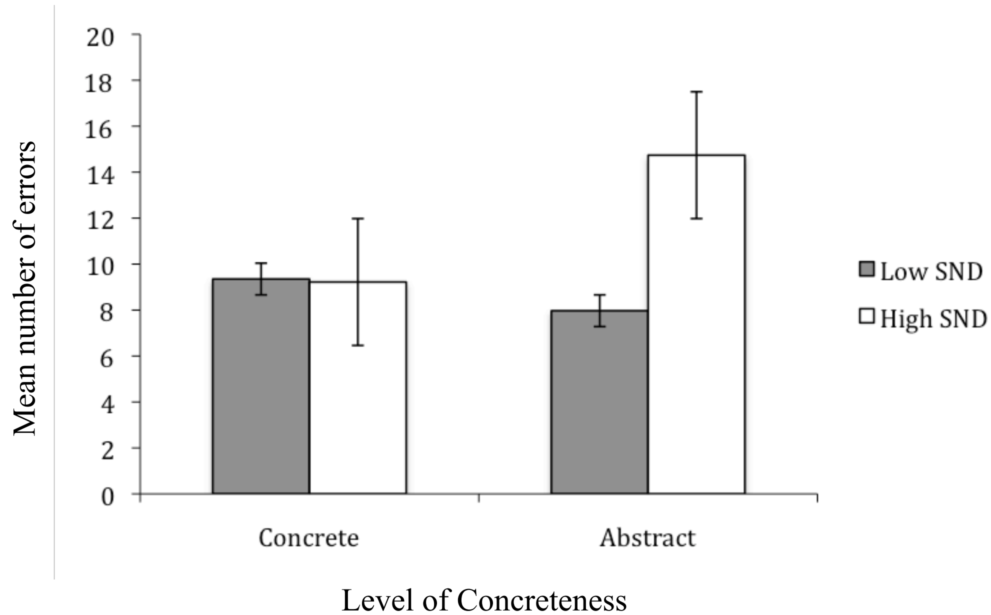

Figure 4. Mean error rates in Experiment 2 as a function of concreteness and SND in the subject analysis

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

General Discussion

Ultimately, this study was conducted to add to our knowledge of the nature of semantic organization by investigating how SND and concreteness influence visual word recognition. Previous investigators have already examined the individual impact of these variables on word recognition in reasonable depth, resulting in studies that have revealed faster RTs for concrete words (reviewed e.g., Paivio, 1991; Schwanenflugel, 1991), as well as for words with large and dense semantic neighbourhoods (Buchanan et al., 2001). However, when one views the printed word, the influences of concreteness and SND on semantic processing cannot be separated. This makes it necessary to investigate the combined effects of these factors in order to develop a more complete and comprehensive theory of semantic organization. Importantly, within the SND literature, this study represents the first attempt to investigate the processes inherent in the visual recognition of abstract words.

For several reasons, broad inferences regarding the nature of concrete versus abstract word recognition will be made primarily based on the results of Experiment 2. Most importantly, this is justified due to the more controlled nature of the stimulus set used in Experiment 2 as compared to Experiment 1. Although the average difference in syllabic length does not exceed 1 between any of the conditions in the Experiment 1 stimulus, the concrete word group was found to have statistically fewer syllables than the abstract word group when analyzed using an independent t test [$t\ (90) = 4.49$, $p < .05$]. This at least partly explains why the difference in error rates is approximately twice as large in the abstract word group (10-12%) as compared to the concrete word group (5%)

in both the subject and item error analyses of Experiment 1, though this same pattern did not emerge in Experiment 2. Interestingly, the concreteness effect was not as pronounced in Experiment 2 as it was in Experiment 1, with the average difference in RTs between concrete and abstract words across participants being approximately 108 ms in Experiment 1, and only approximately 36 ms in Experiment 2. This is presumably attributed to the concrete and abstract word groups being more precisely controlled in terms of syllabic length in the Experiment 2 stimulus set.

Further, a smaller percentage of words were excluded from Experiment 2 due to insufficient (< 70%) accuracy rates. Given that a total of 13 words had to be excluded from the abstract word group alone (as compared to 3 words in the concrete group) in Experiment 1, inferences about abstract words based on this stimulus would be tenuous at best. Caution in interpretation is also warranted based on the results of the error analysis. It has long been known that speed can be traded for accuracy in RT tasks (Antos, 1979), such as the one employed in the present study. While there was no main effect for SND and no significant interaction in the RT analysis, these statistical effects were produced in the error analysis. The discrepancy between the RT and error analyses indicates that caution should be exercised in the interpretation of this data. Specifically, for the high SND word group, participants seemed to be compromising accuracy (to some extent) in the interest of responding quickly, especially when presented with abstract words. Therefore, the apparent bias of participant responses (indicating that these items are not real words) likely produced a mixture of RTs, some of which were based on true lexical retrieval, and others that were based on incomplete (but fast) processing.

Perhaps the major contribution of the present study is the use of abstract words within a stimulus set which was developed using semantic norms derived from a recent global co-occurrence model (WINDSORS; Durda & Buchanan, 2008). As such, a major objective of this study was to adjudicate between the following possibilities regarding the semantic organization of abstract words within the human lexicon: 1. That the process of recognizing abstract words would instigate more competition from near neighbours due to having more obscure semantic representations, 2. That abstract words should demonstrate facilitative distant neighbour effects because they exist in sparse semantic neighbourhoods, and 3. That SND does not impact concrete and/or abstract word recognition. Since the data presented here demonstrate that the effects of SND seems to influence recognition RTs of both concrete and abstract words, the third option presented may be excluded. Because this study controlled for semantic neighbourhood size and SND, it also cannot be the case that slower and more error-prone abstract-high SND responses were produced as a result of more sparse semantic neighbourhoods (thus making the second option unlikely as well). The first aforementioned conclusion is largely based on the premise that abstract words may be qualitatively different from concrete words on some other dimension that was not directly tested in the present investigation. Intuitively, if one were to think of concepts that are semantically associated with a given abstract word, other abstract words would likely be generated, perhaps more so than would be generated for a given concrete word. For example, taking the abstract stimulus word *anguish*, semantic neighbours may include such words as *affliction, distress,* and *misery* (i.e., examples of abstract words), while semantic neighbours of the stimulus word *necklace* may include the words *charm, jewelry,* and *diamond* (i.e., examples of concrete words). If it is the case that abstract words are recognized slower than concrete words because they possess less clear representations in semantic memory as compared to concrete words, this obscurity may be compounded by also having a greater proportion of semantic neighbours that are more likely to be abstract. Notably, the abstract-high SND word condition produced the highest average error rates in the subject and item error analyses of both experiments. This condition also produced the slowest average RTs, as well as had the greatest number of words excluded from statistical analyses due to insufficient accuracy rates, as compared to the other three word conditions in both Experiments 1 and 2.

While no specific hypotheses were stated at the outset of this study regarding the nature or direction of the potential relationship between concreteness and SND, the data indicate that the interactive effects of these variables form a fruitful area of investigation. Within this broad research objective, this paper also sought to address a number of key questions, one of which was to test Mirman and Magnuson's (2008) theory of attractor dynamics, which states that distant neighbours are primarily responsible for the facilitative effects of large and dense semantic neighbourhoods. In essence, these authors stated that not all large and dense semantic neighbourhoods (with the same number of semantic neighbours) were created equal in terms of producing similarly fast word recognition RTs. Rather, they introduced the possibility that the *distribution* of neighbours is also an important consideration. Importantly, this idea does not refute the previously established 'bigger is better' relationship between SND and visual word recognition supported by previous investigations, including that conducted by Buchanan et al. (2001). However, the present study was a necessary test of Mirman and Magnuson's theory since these authors based their findings on a feature-based model of semantics, which is fundamentally different from the global co-occurrence model of semantics (i.e., WINDSORS) adopted in the present study. In accordance with Mirman and Magnuson, it appears that when semantic neighbourhood size (in addition to word length, frequency and number of syllables) is carefully controlled, words that presumably have a greater proportion of near neighbours (high SND) are recognized more slowly (across concreteness groups) than words with a greater proportion of distant neighbours (low SND). This supports the idea that near neighbours may have somewhat of an inhibitory effect on recognition RTs, and that distant neighbours may indeed be facilitative in word recognition.

Interestingly, the present data indicate that there is a discernable concrete word advantage (as demonstrated by faster average RTs and lower error rates) for words with many near neighbours (high SND words). However, there is no such advantage for either concrete or abstract words in words with many distant neighbours (low SND words). This raises the question of what distinct qualities concrete words possess that would facilitate their recognition (in comparison to abstract words) in a high SND situation. One may begin to answer this question by reflecting on the object-based versus association-based models of semantics outlined earlier. While these two theoretical models would define semantic neighbourhoods in fundamentally different ways, they are not mutually exclusive from one another. That is, there is some overlap with respect to the semantic neighbours of a given word according to each semantic model. In a high SND situation, perhaps the substantial degree of qualitative and quantitative overlap between feature-based and association-based near neighbours is what provides concrete words with an advantage over abstract words. Since abstract words, by definition, do not possess physical features in the same way as concrete words, virtually no overlap would exist between near neighbours as defined by object and association-based semantic models. At the same time, near neighbours of concrete words may be physical characteristics that would be considered semantic neighbours according to both object-based and association-based theories. Therefore, for high SND words, lexical discrimination between a target word and its near neighbours may be facilitated by those near neighbours that are encoded as both 'features' and 'associated' concepts, providing a facilitative effect of concrete words over abstract words. Recalling the literature on the concreteness effect outlined earlier, this interpretation is most in line with Paivio's (1971) dual coding theory. As such, the data presented here suggest that both object-based and language-based views of semantics contribute to the processes involved in visual word recognition.

Future Directions

In conclusion, this study only serves as a starting point for those who wish to investigate how SND and concreteness influence visual word recognition, and many unanswered questions remain. For example, word recognition RTs were only measured here through the use of a single type of task (the standard visual LDT), though other methodologies have also demonstrated that semantics can influence RTs of different word types, such as the standard naming/word reading task, the phonological LDT, and the semantic categorization task. Arguably, these tasks also rely on semantic processing to varying degrees, and so differences in RTs across conditions may vary by task. Future research in our laboratory will address whether the effects of concreteness and SND observed here replicate in a similar manner across such aforementioned methodologies in an attempt to draw more broad conclusions about how these variables impact word recognition, and in turn, lexical and semantic organization. Given that much is still to be learned about the visual recognition of abstract words, future research will also explore other factors that may contribute to an understanding of how such 'higher-order' concepts are represented in semantic memory.

APPENDICES

APPENDIX A

Words Used in Experiment 1 with their Lengths, Frequencies (Freq), Semantic Neighbourhood (SN) Sizes, and Semantic Neighbourhood Densities (SND)

Word Type	Word	Length	Frequency	SN Size	SND
Concrete – Low SND	FREEZER	7	2.288	277	0.347
	HORNET	6	0.435	227	0.347
	JUMPSUIT	8	0.370	235	0.345
	CANDLELIGHT	11	0.826	212	0.354
	KANGAROO	8	1.372	154	0.322
	BOOKSHELF	9	0.377	167	0.326
	SURFBOARD	9	0.222	160	0.335
	ALLIGATOR	9	0.600	198	0.328
	WEREWOLF	8	0.714	249	0.349
	BOUTIQUE	8	0.561	194	0.348
	HAMBURGER	9	2.168	201	0.355
	PAVEMENT	8	2.283	245	0.353
	CARDBOARD	9	2.895	227	0.341
	TOOLBOX	7	0.693	150	0.347
	CAFETERIA	9	1.687	239	0.342
	SIDEWALK	8	2.430	224	0.342
	CALCULATOR	10	2.612	207	0.339
	FIREPLACE	9	1.703	309	0.346
	BLACKBERRY	10	1.221	324	0.352
	CHIMNEY	7	1.648	265	0.33
	AQUARIUM	8	1.157	251	0.351
	VOLCANO	7	1.916	183	0.342
	ETHANOL	7	1.294	248	0.345
Concrete – High SND	FURNACE	7	2.909	304	0.377
	NOODLE	6	0.617	294	0.368
	PORRIDGE	8	0.448	246	0.37
	SKATEBOARD	10	0.621	187	0.374
	BACKPACK	8	1.591	185	0.367
	INCUBATOR	9	0.376	126	0.365
	STOPWATCH	9	0.204	185	0.367
	JAILHOUSE	9	0.582	182	0.367
	SWIMSUIT	8	0.367	235	0.4
	BRACELET	8	0.594	182	0.373
	BUTTERFLY	9	2.074	200	0.37
	PAMPHLET	8	2.268	214	0.383
	VIDEOTAPE	9	2.557	200	0.365
	RATCHET	7	0.64	167	0.367
	BILLBOARD	9	1.71	230	0.383
	TABLESPOON	10	2.092	248	0.399
	PROPELLER	9	1.354	324	0.373
	THERMOSTAT	10	1.671	328	0.396
	ABDOMEN	7	1.816	286	0.379
	CINNAMON	8	2.941	295	0.391
	NECKLACE	8	1.122	205	0.378
	CRACKER	8	1.504	228	0.374
	LETTUCE	7	1.14	286	0.411

APPENDIX A (continued)

Word Type	Word	Length	Frequency	SN Size	SND
Abstract – Low SND	ENTROPY	7	3.074	242	0.353
	OUTAGE	6	1.016	276	0.35
	AMBIENCE	8	0.436	194	0.313
	MOTHERLAND	10	0.74	169	0.35
	STALEMATE	9	1.429	185	0.35
	VISCOSITY	9	0.378	152	0.324
	CONTAGION	9	0.266	157	0.344
	PASSIVITY	9	0.647	186	0.353
	INFUSION	8	0.838	210	0.339
	ABRASION	8	0.519	179	0.336
	CESSATION	9	1.996	200	0.335
	FIDELITY	8	2.376	278	0.351
	ELEVATION	9	2.67	185	0.344
	RIGIDITY	8	0.566	142	0.322
	BENCHMARK	9	1.905	218	0.335
	PARALYSIS	9	2.541	291	0.343
	ABSORPTION	10	2.428	225	0.338
	PURGATORY	9	1.585	362	0.353
	AFFLICTION	10	1.955	331	0.354
	BOREDOM	7	1.959	220	0.349
	PROLOGUE	8	1.163	223	0.354
	INFANCY	7	1.591	191	0.353
	HEROISM	7	1.39	237	0.353
Abstract – High SND	EMPATHY	7	2.605	251	0.363
	LESION	6	0.334	299	0.365
	ARTISTRY	8	0.412	216	0.368
	RESILIENCE	10	0.786	185	0.365
	GRANDEUR	8	1.556	163	0.365
	OSTRACISM	9	0.324	157	0.369
	POMPOSITY	9	0.231	164	0.368
	CREMATION	9	0.992	186	0.405
	RADIANCE	8	0.55	280	0.389
	IMPURITY	8	0.569	157	0.378
	BARBARISM	9	1.904	233	0.363
	NOBILITY	8	2.197	245	0.381
	SEDUCTION	9	2.517	208	0.363
	DECORUM	7	0.748	107	0.369
	SILLINESS	9	1.637	277	0.368
	TOTALITY	8	2.638	266	0.383
	PLAGIARISM	10	2.021	198	0.373
	COGNITION	9	1.608	337	0.374
	EMIGRATION	10	1.3	347	0.381
	BRAVERY	7	1.768	295	0.383
	CHARISMA	8	1.436	246	0.364
	EPITOME	7	1.547	160	0.375
	MODESTY	7	1.254	299	0.401

APPENDIX B

Matched Words and Non-words Used in Experiment 1 per Condition

Word Type	Word	Non-word
Concrete – Low SND	FREEZER	SOAFERS
	HORNET	TRANCH
	JUMPSUIT	FUTENAME
	CANDLELIGHT	VIBRAPHOSES
	KANGAROO	SLASSIFY
	BOOKSHELF	SOMICIDAS
	SURFBOARD	VICILLATE
	ALLIGATOR	NAWSPRINT
	WEREWOLF	PARACOLS
	BOUTIQUE	SCRUBBAR
	HAMBURGER	REFUMBISH
	PAVEMENT	OLLUDING
	CARDBOARD	POUNTLESS
	TOOLBOX	PENNERY
	CAFETERIA	FLATIRONT
	SIDEWALK	PAMBLIKE
	CALCULATOR	SPIKESHAVE
	FIREPLACE	CUROTTAGE
	BLACKBERRY	UNDENIOBLY
	CHIMNEY	STEPSIN
	AQUARIUM	AMISSION
	VOLCANO	CLAXITY
	ETHANOL	BAMPORS
Concrete – High SND	FURNACE	TRINITS
	NOODLE	BINNER
	PORRIDGE	CLUTLIKE
	SKATEBOARD	SHETLACKED
	BACKPACK	CANSUTED
	INCUBATOR	SCRAPSOOK
	STOPWATCH	ANADOPTED
	JAILHOUSE	BRANSLATA
	SWIMSUIT	THACONNE
	BRACELET	FLITTANG
	BUTTERFLY	NARBOURED
	PAMPHLET	BULLASTS
	VIDEOTAPE	CASALCADE
	RATCHET	POPTING
	BILLBOARD	BIPSTICKS
	TABLESPOON	DISARRALED
	PROPELLER	TORTERING
	THERMOSTAT	IRPLEMENTS
	ABDOMEN	CATICLE
	CINNAMON	MOKITORS
	NECKLACE	GAGESMEN
	CRACKER	VOSIEST
	LETTUCE	DAMPUSH

APPENDIX B (continued)

Word Type	Word	Non-word
Abstract – Low SND	ENTROPY	REALINT
	OUTAGE	ERPINE
	AMBIENCE	NARCUSSI
	MOTHERLAND	CALSANISTS
	STALEMATE	WILECRACK
	VISCOSITY	PRUTRUDES
	CONTAGION	PRISTRATE
	PASSIVITY	MONOMETER
	INFUSION	CLICATIC
	ABRASION	AMMONOTE
	CESSATION	CONSILTED
	FIDELITY	LIMERATI
	ELEVATION	DRATERNAL
	RIGIDITY	EARLDOTS
	BENCHMARK	NACKLOOTS
	PARALYSIS	KREAMIEST
	ABSORPTION	ACADIFYING
	PURGATORY	ANFANTILE
	AFFLICTION	STAMMEFERS
	BOREDOM	CANDIUS
	PROLOGUE	BONDLING
	INFANCY	ARIKITY
	ENTROPY	REALINT
Abstract – High SND	EMPATHY	SKUNRED
	LESION	PLICED
	ARTISTRY	DIBISION
	RESILIENCE	PUNCTUATEM
	GRANDEUR	CLAMMUNG
	OSTRACISM	CATAMARAX
	POMPOSITY	LATITADES
	CREMATION	UNDARTONE
	RADIANCE	TONOXIDE
	IMPURITY	OSSAYING
	BARBARISM	ADRIRABLE
	NOBILITY	CORNIVES
	SEDUCTION	DEPLARING
	DECORUM	PICTILS
	SILLINESS	SUBLIMITE
	TOTALITY	GROACHED
	PLAGIARISM	TARELESSLY
	COGNITION	BILOTRIES
	EMIGRATION	GLISTERINT
	BRAVERY	ANNINGS
	CHARISMA	VERPALLY
	EPITOME	SPEEMOS
	MODESTY	RANKANG

APPENDIX C

Words Used in Experiment 2 with their Lengths, Frequencies (Freq), Orthographic Neighbourhood Sizes (ON), Number of Syllables (# Syll), Semantic Neighbourhood Sizes (SN), and Semantic Neighbourhood Densities (SND)

Word Type	Word	Length	#Syll	Freq	ON	SN	SND
Concrete – Low SND	FREEZER	7	2	2.288	1	277	0.347
	WOODPECKER	10	3	0.253	0	221	0.344
	NOSTRIL	7	2	0.285	0	240	0.335
	SUBTITLE	8	3	0.757	0	183	0.332
	CROCODILE	9	3	1.215	0	168	0.336
	KANGAROO	8	3	1.372	0	154	0.322
	BAYONET	7	3	0.923	1	215	0.345
	VOLCANO	7	3	1.916	0	183	0.342
	CHANDELIER	10	3	0.267	0	177	0.323
	AQUARIUM	8	4	1.157	1	251	0.351
	MICROPHONE	10	3	3.643	0	221	0.354
	CUTLERY	7	3	0.243	1	217	0.343
	CALCULATOR	10	4	2.612	0	207	0.339
	GYMNASIUM	9	4	0.355	0	179	0.344
	TABLECLOTH	10	3	0.201	0	153	0.323
	STYROFOAM	9	3	0.339	0	245	0.354
	CANISTER	8	3	0.797	1	295	0.346
	ALLIGATOR	9	4	0.6	0	198	0.328
	PACIFIER	8	4	0.201	2	169	0.345
	CONTAINER	9	3	5.401	1	223	0.343
	PRAIRIE	7	2	1.138	0	257	0.334
	LIPSTICK	8	2	1.209	2	243	0.335
Concrete – High SND	BOOKLET	7	2	2.58	0	227	0.378
	TABLESPOON	10	3	2.092	0	248	0.399
	TADPOLE	7	2	0.292	0	159	0.384
	FLAMINGO	8	3	0.27	0	172	0.383
	GUNPOWDER	9	3	1.209	0	218	0.383
	MOSQUITO	8	3	1.669	0	228	0.391
	GORILLA	7	3	1.898	0	156	0.385
	BAZOOKA	7	3	0.231	0	212	0.386
	SKYSCRAPER	10	3	0.734	0	254	0.398
	AMMONIA	7	4	1.38	0	258	0.431
	MICROSCOPE	10	3	3.664	0	246	0.385
	ABDOMEN	7	3	1.816	0	286	0.379
	EMBROIDERY	10	4	0.237	1	174	0.386
	INCUBATOR	9	4	0.376	0	126	0.365
	CHIMPANZEE	10	3	1.319	0	268	0.406
	INTESTINE	9	3	0.861	0	266	0.438
	BUNGALOW	8	3	0.198	0	222	0.365
	DEODORANT	9	4	0.287	0	237	0.383
	CEMETARY	8	4	0.306	0	217	0.381
	CIGARETTE	9	3	5.436	0	216	0.389
	EARDRUM	7	2	0.374	0	198	0.378
	NECKLACE	8	2	1.122	0	205	0.378

APPENDIX C (continued)

Word Type	Word	Length	#Syll	Freq	ON	SN	SND
Abstract – Low SND	FERVOUR	7	2	0.357	0	188	0.335
	CONCESSION	10	3	2.569	2	110	0.34
	ACCLAIM	7	2	0.966	0	235	0.345
	INFUSION	8	3	0.838	0	210	0.339
	DIGESTION	9	3	0.821	0	254	0.339
	COHESION	8	3	1.322	0	180	0.355
	ALLERGY	7	3	1.52	0	220	0.335
	POTENCY	7	3	1.241	0	212	0.339
	ABSORPTION	10	3	2.428	0	225	0.338
	FIDELITY	8	4	2.376	0	278	0.351
	TURBULENCE	10	3	0.914	1	206	0.354
	MASTERY	7	3	3.271	2	255	0.346
	SATURATION	10	4	1.335	1	190	0.34
	ELEVATION	9	4	2.67	0	185	0.344
	CONDUCTION	10	3	1.109	0	265	0.352
	HYDRATION	9	3	0.403	0	173	0.329
	ELEGANCE	8	3	0.862	0	157	0.344
	ADORATION	9	4	0.887	0	200	0.345
	SORORITY	8	4	0.361	1	164	0.347
	SENSATION	9	3	3.996	0	281	0.346
	CUISINE	7	2	0.987	0	229	0.345
	DAMPNESS	8	2	0.279	0	220	0.327
Abstract – High SND	DISCORD	7	2	2.015	1	234	0.38
	BANISHMENT	10	3	0.839	0	215	0.372
	PENANCE	7	2	0.701	0	222	0.367
	EVICTION	8	3	0.732	0	215	0.378
	CREMATION	9	3	0.992	0	186	0.405
	FIXATION	8	3	1.806	0	162	0.397
	VACANCY	7	3	0.884	0	157	0.382
	SORCERY	7	3	1.372	0	205	0.379
	DECRYPTION	10	3	0.218	0	202	0.367
	NOBILITY	7	4	2.197	1	245	0.381
	SUSTENANCE	10	3	1.453	0	191	0.408
	MODESTY	7	3	1.254	0	299	0.401
	ACTIVATION	10	4	2.017	0	249	0.385
	ASYMMETRY	9	4	0.41	0	185	0.371
	ABSTINENCE	10	3	6.105	0	221	0.378
	EXCRETION	9	3	0.233	0	255	0.366
	ACCOLADE	8	3	0.25	0	217	0.375
	STERILITY	9	4	0.312	0	245	0.367
	IMPURITY	8	4	0.569	1	157	0.378
	DETERRENT	9	3	2.774	1	170	0.376
	ANGUISH	7	2	2.168	0	280	0.389
	PRUDENCE	8	2	1.024	0	216	0.382

APPENDIX D

Matched Words and Non-words Used in Experiment 2 per Condition

Word Type	Word	Non-word
Concrete – Low SND	FREEZER	RASSALS
	WOODPECKER	PERTONENCE
	NOSTRIL	SPOUSEK
	SUBTITLE	BRAWLIER
	CROCODILE	PARBARIZE
	KANGAROO	CRACTISE
	BAYONET	DUBBIES
	VOLCANO	BORBLES
	CHANDELIER	TINSALLING
	AQUARIUM	BREAKIER
	MICROPHONE	WISHITTING
	CUTLERY	BRIFLES
	CALCULATOR	CRASSWALKS
	GYMNASIUM	SQUEAWISH
	TABLECLOTH	BARDERLAND
	STYROFOAM	VOGALANTE
	CANISTER	PREXENDS
	ALLIGATOR	CENTARIES
	PACIFIER	SINTABLE
	CONTAINER	TRIBESMIN
	PRAIRIE	SLOBBAR
	LIPSTICK	STEAVIER
Concrete – High SND	BOOKLET	MURMUMS
	TABLESPOON	ALVERNATOR
	TADPOLE	AQUAVIP
	FLAMINGO	GIMESMEN
	GUNPOWDER	POTBOALER
	MOSQUITO	ENLIRTED
	GORILLA	CRASSTY
	BAZOOKA	CORPSEY
	SKYSCRAPER	SYMPATHIBE
	AMMONIA	WESBING
	MICROSCOPE	DISNERSALS
	ABDOMEN	CULOTGE
	EMBROIDERY	UNDERWRATE
	INCUBATOR	CLEARNESH
	CHIMPANZEE	CRINOMINES
	INTESTINE	PRECOPICE
	BUNGALOW	LEAPFRON
	DEODORANT	RETRIEFER
	CEMETARY	RONVERSE
	CIGARETTE	PICKETIRG
	EARDRUM	HODDUPS
	NECKLACE	EAPMARKS

APPENDIX D (continued)

Word Type	Word	Non-word
Abstract – Low SND	FERVOUR	BLENDUR
	CONCESSION	CONVOCTION
	ACCLAIM	DAMPERG
	INFUSION	WONDFOUS
	DIGESTION	CAMPSITEF
	COHESION	OMEKETTE
	ALLERGY	AVOISED
	POTENCY	GINTILE
	ABSORPTION	INNERWATED
	FIDELITY	BROCCOYI
	TURBULENCE	RESEMPTION
	MASTERY	TOACHER
	SATURATION	NURABILITY
	ELEVATION	DULIVERED
	CONDUCTION	INTERWEAPE
	HYDRATION	TANGERIRA
	ELEGANCE	GLUMCESS
	ADORATION	BANDERIES
	SORORITY	FLATNEST
	SENSATION	ISOLUTING
	CUISINE	FOSTEMS
	DAMPNESS	ILLUMISE
Abstract – High SND	DISCORD	PLUNRED
	BANISHMENT	DISMOCATED
	PENANCE	PARTOIL
	EVICTION	ILLUMISE
	CREMATION	CAWPANILE
	FIXATION	DRUNKARK
	VACANCY	SNICTED
	SORCERY	PANTIAS
	DECRYPTION	KISDATCHES
	NOBILITY	PREXENDS
	SUSTENANCE	SUPERCARHO
	MODESTY	SADRESS
	ACTIVATION	TREECLIEST
	ASYMMETRY	CATAMARAL
	ABSTINENCE	ENVINDLING
	GESTATION	PEPULATED
	ACCOLADE	RAMPOGES
	STERILITY	SPINSBERS
	IMPURITY	TROTHING
	DETERRENT	SCATCHING
	ANGUISH	STROKID
	PRUDENCE	RASHNOSS

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