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Towards a new model of semantic processing: Task-specific effects of concreteness and semantic neighbourhood density in visual word recognition

by
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Towards a new model of semantic processing: Task-specific effects of concreteness and semantic neighbourhood density in visual word recognition

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ABSTRACT

According to data from three tasks, Danguecan & Buchanan (2014) demonstrated that semantic neighbourhood density (SND; Buchanan, Westbury, & Burgess, 2001) interacts with concreteness to influence visual word recognition response times (RTs). Importantly, these data suggest that the behavioural effects of these semantic variables are differentially impacted by task demands. The goal of the present study was to more precisely chart the flexibility of semantic processing by comparing recognition RTs of words (varying in concreteness and SND) across seven tasks with different explicit semantic requirements. The data show that linguistic associative information is particularly critical for abstract as compared to concrete concepts. These findings are discussed within the context of a new model of semantic processing, known as the Flexible Semantic Processing Hypothesis.

DEDICATION

Look Mom and Dad I got a PhD!!! I hope that I have made you proud.

This work is dedicated to you.

ACKNOWLEDGEMENTS

To my labmates, thank you for the many laughs and snacks we shared over conversations about research methods, our grad school adventures, upcoming events with free food, and the political climates of Canada versus the U.S versus Cuba. I am proud to belong to such a supportive, diverse, bright, and interesting group of colleagues.

To Lori, I aspire to your level of integrity and brilliance as an academic. Thank you for being a true mentor and advocate for me over the years.

I am grateful to my family and friends who have helped to guide and carry me through my graduate school journey. You fed me, and fed me some more, and then gave me food to go. You called to remind me to take care of myself. You reassured me when I felt stressed. You cheered me on every step of the way. I could not have done this without you.

Last but not least, thank you to the hundreds of participants who volunteered their time for my research. Continue to contribute to science - we need you!

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CHAPTER 1

INTRODUCTION

Overview of the Current Study

Deriving meaning (i.e., semantics) from printed words is the ultimate goal of reading, and the question of how words convey meaning has been described as the key to understanding the “central core of human knowledge” (Shanon, 1988, p. 71). Despite this importance, we currently lack a fully comprehensive theory of semantic processing. The goal of the present study is to contribute to the development of such a theory. Ultimately, a greater understanding of how we construct or derive meaning from single words advances our knowledge of basic reading processes, provides insight into the storage and retrieval of semantic knowledge, and arguably contributes to our view of what it means to be human.

For the purposes of this paper, a “semantic representation” refers to a memory store of the meaning of a given word (or category of words), and “semantic processing” refers to the activation and retrieval of these representations. This paper will begin with a broad overview of the nature of semantic memory and semantic representations to provide a useful framework for understanding how various semantic variables have been operationalized in psycholinguistics. Subsequently, I will review the relevant theories and literature related to the variables of the present study; specifically, concreteness (i.e., whether a word is concrete or abstract) and semantic neighbourhood density (SND; i.e., the distribution of related words within a semantic representation). Arguably, concrete concepts (e.g., *CHAIR, KITCHEN, BASKETBALL*) and abstract concepts (e.g., *BRAVERY, FULFILLMENT, ACADEMIA*) represent distinct forms of knowledge about the world (Dove, 2011), and SND is a semantic richness variable that is able to capture both types of knowledge (Durda, Buchanan, & Caron, 2009).

Upon the preceding groundwork, I will argue that the development of a useful model of semantics requires flexibility that is in keeping with recent research on the task-specific effects of several semantic variables in visual word recognition (e.g., Pexman, Hargreaves, Siakaluk, Bodner, & Pope, 2007; Yap, Pexman, Wellsby, Hargreaves, & Huff, 2012). Ultimately, I will propose a series of experiments that will test a recently developed model of semantics, known as the *Flexible Semantic Processing Hypothesis* (Danguecan & Buchanan, 2014)*,* which describes semantic processing as being impacted by both concreteness and SND, and modulated by task demands.

General Principles of Semantic Memory

Semantic memory has been conceptualized as a network of associated concepts (Quillian, 1967; Collins & Loftus, 1975). Quillian (1967) proposed that individual concepts are represented as nodes, and that properties of each concept are connected to other concepts (nodes) via bi-directional links. In this way, the full meaning of a given concept is represented by the total configuration of its network of related nodes. A memory search occurs as nodes are progressively “tagged”, whereby nodes linked directly with the target are tagged first. Critically, the relational links (representing associations) between nodes have varying “criterialities,” which are weights indicating the relative importance of the association to the meaning of the target node. Additionally, in Quillian’s model, a semantic network is believed to have a hierarchical structure such that properties tend to be stored at the highest (most general) level of applicable concepts. For example, the property “has wings” is not stored individually for each type of bird, but is rather stored as a superordinate feature of birds in general. Collins and Loftus (1975) elaborated on Quillian's model by proposing that the strength of semantic activation decreases over the course of visual word recognition (i.e. typically over the course of a few hundred milliseconds), as activation progresses to semantically distant words. Moreover, Collins and Loftus proposed that concepts are organized by semantic similarity such that the strength of an association between two concepts increases as a function of shared properties.

As further explained below, an understanding of semantic memory models is important because they are a component of all visual word recognition models. In fact, the specific mechanisms proposed by Quillian (1967) and Collins and Loftus (1975) are particularly central to early (localist) theories of visual word recognition.

The Nature of Semantic Representations: Localist versus Distributed Models

Theories of visual word recognition generally incorporate the roles of orthography (visual features of the word; how the word looks), phonology (auditory features of the word; how the word sounds), and semantics. This portion of the literature review will emphasize the different ways in which semantics have been conceptualized in several major theories of visual word recognition.

Generally, models of word recognition may be categorized according to whether they employ localist or distributed mechanisms. Like Quillian's (1967) model of semantics, localist theories of word recognition assume that each (known) word corresponds with a discrete entry within the lexicon, and word recognition occurs when a given entry is activated. For example, in Morton's (1969) threshold activation model, each word in the lexicon corresponds with a logogen (derived from the Greek *logos*, meaning “word”), which is basically a word “detector” with an adjustable threshold mechanism. Each logogen contains information about the phonology, orthography, and meaning of a word, and becomes activated when it has gathered sufficient visual input to exceed a certain threshold. In this model, various factors impact the threshold levels of logogens. For example, words that occur frequently are thought to correspond with logogens that have low thresholds of activation, and thus do not require much input to “fire” (Besner & Swan, 1982). This enables readers to quickly derive meaning from high frequency words relative to their lower frequency counterparts. However, an important implication of this theory is that word identification must take place (i.e., the logogen must become activated) before semantic content can be derived. With this requirement, semantics does not play a role in the initial word identification process.

Another localist theory, Forster’s (1976) serial search model, also assumes that semantic processing occurs following word identification, though this is attributed to different mechanisms. This model proposes that the initial process of visual word recognition results in identification of a “bin” of likely candidates that potentially match the stimulus. It is assumed that these potential lexical candidates are ordered by frequency and searched serially, such that higher frequency words are considered first. Prior to semantic processing, word recognition occurs through a matching process whereby the presented word is matched against a master file of stored word representations.

Other localist models have proposed a connectionist approach to word recognition, in which there are various connected levels of processing. In this way, McClelland and Rumelhart’s Interactive Activation Model (1981) states that word recognition is the result of activation that proceeds from the feature level (i.e., features typical of linguistic symbols), to the letter level, and then to the word level, resulting in word recognition. Critically, there are inhibitory and facilitatory connections between levels, and progression through the levels occurs in a cascaded manner such that processing at one level does not have to be complete before processing at the next level can begin. In this way, when a word is presented there is bottom-up activation from the letter-level to the word-level, as well as top-down activation from the word-level to the letter level. Importantly, this bi-directional flow of information is continuous and cascaded (as opposed to strictly stage-like). Activated representations also inhibit competing representations between and within levels until the correct representation reaches threshold (i.e., when word recognition occurs). Although the original Interactive Activation Model does not specifically address semantic processing, Balota, Ferraro, and Connor (1991) added a semantic component to the model to account for semantic effects. Importantly, unlike in the earlier models described above, this model assumes cascaded and bi-directional flow of information between levels. Consequently top-down semantic activation makes it is possible for semantics to be processed prior to completion of word recognition (i.e., full word-level activation). With this in mind, Balota et al. (1991) suggest that words with rich semantic representations should elicit faster word recognition response times (RTs) than words with impoverished semantics because they would provide stronger top-down feedback from the semantic level to the word level.

In contrast to the models discussed so far, in which word recognition occurs via the activation of discrete lexical entries, distributed models (also known as parallel processing models; e.g., Seidenberg & McClelland, 1989; Plaut et al., 1996) assume that each word is associated with a distinct pattern of settling activation across a uniform set of processing units that are not uniquely associated with individual words. Specifically, word recognition occurs when the network has reached a steady state of activation across grapheme (orthographic), phoneme (phonological), and semantic units. These units are mediated by a hidden layer of units consisting of weighted connections that are appropriately adjusted with increased language use/knowledge. Words that are more frequent settle into a steady state of activation more quickly than words that are less frequent. With increasing language experience, the weighted connections also constrain activation between units. In this way, semantic knowledge of words is acquired over time based on continuous input from the other units. When one is presented with a word, the meaning that is computed is the one that satisfies the necessary constraints (Harm & Seidenberg, 2004).

In sum, these theories are relevant to a study of semantics because they would predict varying time courses of semantic effects. Morton's logogen model (1969) and Forster's serial search model (1976) both require word (lexical) identification prior to retrieval of semantics, whereas other theories incorporating cascaded mechanisms (e.g., Balota et al., 1991) or parallel processing (e.g., Seidenberg & McClelland, 1989) assert that semantic effects may overlap with word identification, thereby influencing lexical selection. Currently, the prevailing view in the psycholinguistic literature is that semantic retrieval *does* influence the word recognition process (e.g., Balota et al., 1991; Pexman, Lupker, & Hino, 1992; Evans, Lambon Ralph, & Woollams, 2012). Therefore, although localist models were a useful starting point for generating research in this area, they have largely been replaced by more recent dynamic and distributed models.

Principles of Semantic Organization: Object-based versus Language-based Models

In terms of the organizational structure of words in semantic memory, there is also debate about the principles that guide this organization. Specifically, there is a theoretical schism between object-based and language-based models. Object-based models (also known as feature-based or category-based models) classify related words in terms of the similarity of their physical attributes/features. Therefore, the words *TIGER* and *LION* are related because they refer to animals with fur, whiskers, a tail, four legs, etc. Similarly, in a category-based view, words are semantically related due to their shared membership within a given category based on physical attributes. As such, the words *CAT* and *DOG* are related because they both refer to common house pets. Indeed, this focus on physical shared properties also guides object-based operationalizations of the semantic richness of concepts. For example, concepts may be considered semantically rich because human ratings indicate the ease of perceived imageability (Balota et al., 2004), ease of perceived sensorimotor experience (Juhasz, Yap, Dicke, Taylor, and Gullick, 2011), ease of perceived body-object interaction (Siakaluk et al., 2008a,b; Bennett et al., 2011), or the presence of many associated features (McRae et al., 2005). Relevant to the present study, words may also vary to the extent that they represent concrete (i.e., physically tangible) concepts. As will be discussed in detail below, concrete words often show a processing advantage over abstract words, which are low in concreteness (e.g., Paivio, 1991).

Alternatively, language-based models of semantic organization (also known as association-based or distributional models) quantify degree of relatedness based on the frequency in which a word occurs with other words within similar contexts in large bodies of printed text (i.e., global co-occurrence; e.g., Lund & Burgess, 1996; Landauer & Dumais, 1997; Buchanan, Westbury, & Burgess, 2001). Essentially, language-based models assume that words appearing in similar linguistic contexts are likely to have related meanings (distributional hypothesis; Harris, 1970). Therefore, according to a language-based view, the words *TIGER* and *LION* are related because they often co-occur with each other, and not because they share physical features. Moreover, a language-based view is able to explain facilitation effects between words that do not necessarily share physical features, but nonetheless demonstrate semantic effects. For example, facilitative semantic priming effects occur for word pairs that often co-occur (but do not share features) such as *HAIR - BRUSH* (e.g., McNamara, 1994), and false memory errors for non-presented target words are more likely following lists of associated words versus lists of same category words (Buchanan, Brown, Cabeza, & Maitson, 1999). Additionally, research involving patient populations, such as those with deep dyslexia, supports a model of semantics that includes association (Buchanan, Burgess, & Lund, 1996; Buchanan, McEwen, Westbury, & Libben, 2003; Colangelo, Buchanan, & Westbury, 2004).

According to language-based models, a concept's semantic richness may be measured according to the number of contexts in which the word appears (Adelman, Brown, & Quesada, 2006), the number of human-generated distinct first associates (Nelson, McEvoy, & Schreiber, 1998), or the number of unrelated meanings (i.e., lexical ambiguity; Miller, Beckwith, Fellbaum, Gross, & Miller, 1990). As mentioned earlier, words may also be considered semantically rich if they appear often with many other words in similar contexts in linguistic corpora, and the frequency of these co-occurrences is captured in a word’s semantic neighbourhood size (e.g., Buchanan et al., 2001). Moreover, the distribution of these neighbours may differ such that the average number of near neighbours (i.e., semantic neighbours clustered closely around the target word in semantic space) may also vary. This variation in distribution of semantic neighbours refers to a word’s semantic neighbourhood density (SND; Durda & Buchanan, 2008), and will be discussed in greater detail below with respect to the present study.

Integrating Object-based and Language-based Models

Thus far, I have described object-based and language-based models as opposing views on semantic organization for the purpose of illustrating theoretical distinctions between them. However, in reviewing the findings of object-based and language-based semantic richness variables, Buchanan et al. (2001) argued that both types of information are relevant to semantic representations (for a more recent review, also see Hargreaves & Pexman, 2014). In fact, information from both object-based and language-based models may be somewhat redundant. In support of this idea, Durda et al. (2009) found that featural information is also encoded in co-occurrence data produced by the WINDSORS model. Additionally, Riordan and Jones (2011) compared the performance of feature-based and distributional models on semantic clustering tasks, and found that meaning information was redundantly encoded by both models. However, each model was associated with its own unique variance, leading the authors to conclude that featural and linguistic information serve as complementary sources of semantic data. Relatedly, Dove (2009) provides an extensive review of the merits of *representational pluralism,* which refers to the idea that meaning is derived from the world in different ways, resulting in “diverse semantic codes” (p. 413). Some of these codes are perceptually-based (i.e., embodied[1], modal), whereas others are not perceptually-based (i.e., linguistic, disembodied, amodal). Dove argues that the existence of non-perceptual, linguistic semantic codes helps to explain how we are able to acquire knowledge that extends beyond perceptual experience, which is a fundamental principle of cognition. Dove (2011) describes how representational pluralism applies to the study of language processing:

> I suggest that language plays two roles in our cognitive lives. One role is to engage sensorimotor simulations of interacting with the world. In this role, language serves primarily as a medium of communication. A second role is to elicit and engage symbolically mediated associations and inferences. Our concepts are not merely couched in sensorimotor representations but also in linguistic representations (words, phrases, sentences). Conceptual content is captured in part by the relationships of linguistic representations with other linguistic representations. These relationships may be merely associative or they may be inferential. On this view, a concept such as DOG will, not only be represented on a given occasion by multimodal simulations associated with interacting with dogs, but will also be represented in terms of related linguistic words, phrases, or sentences (p. 7).

Such an integrative view of cognition is not new. In the late 1980s Damasio (1989) proposed his theory regarding convergence zones as they relate to memory retrieval mechanisms. In brief, he hypothesized that primary sensory regions store feature-based conceptual information in an analogue manner, whereas *convergence zones* house increasingly refined abstract sets of associations (conjunctions) between sensory regions. For example, there is likely a convergence zone that encodes associations

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[1] The concept of an embodied (perceptually-based) semantic code is distinct from concreteness. Dove (2009) states that our knowledge of all words is comprised of both embodied information (e.g., information about the physical appearance of an object) and disembodied information (i.e., concepts related to a target word through language). Therefore, by extension, all concepts (whether they are concrete or abstract) have both embodied and disembodied information associated with them. As will be explained shortly, Vigliocco et al. (2009) argues that the meaning of concrete concepts is primarily comprised of embodied (perceptually-based) information, while the meaning of abstract concepts is primarily comprised of disembodied (linguistic) information.

between object shapes and actions (to represent knowledge of tools, for example), and another that encodes associations between object shapes and names. Moreover, Damasio proposed that reciprocal/bidirectional connections exist between sensory and convergence zones to facilitate conceptual retroactivation. A more recently developed view, known as the *Hub and Spoke Model*, proposes the existence of a central hub within the anterior temporal lobes (bilaterally), which binds information from various sensory modalities into cohesive concepts via bidirectional neural connections or “spokes” (Patterson, Nestor, & Rogers, 2007; Lambon Ralph et al., 2008, 2010). The anterior temporal lobes are believed to be an ideal candidate for a central hub due to their extensive connections and/or close proximity to many areas believed to contribute to semantic knowledge, including sensory cortical regions, as well as regions important for emotion and reward such as the amygdala and orbito-frontal cortex (Lambon Ralph, et al., 2008; Patterson et al., 2007). In support of this, a number of investigations have shown that the anterior temporal lobes are critical neural structures in tasks requiring semantic decisions (e.g., Lambon Ralph et al., 2009; Pobric, Lambon Ralph, & Jeffries, 2009; Patterson et al., 2007). Modifications of the hub and spoke model have also been proposed, which advocate for more dynamic interactions between modal regions and possibly multiple amodal hubs (Binder & Desai, 2011; Reilly et al., 2014). In sum, the idea that concepts are stored in a pluralistic and integrative manner is well-established in cognition, and there is empirical support for a possible neuroanatomical architecture of how modal and amodal (i.e., associative, linguistic) knowledge may be represented in the brain.

Similarly, in the area of psycholinguistics, this view that both sensorimotor and associative information is central to semantic representations has been incorporated into recent theories, including Louwerse's (2007, 2011) *Symbol Interdependency Hypothesis*. This theory states that language is "built onto" embodied representations, and so language is able to encode semantic information about the world (including embodied relations) as a function of language use. Therefore, meaningful information about the physical world can be obtained from the relationships between words.

Behavioural evidence for this position comes from a study by Louwerse (2008), who found facilitation (faster RTs) for word pairs matching embodied experience (i.e., iconic word pairs, e.g., attic-basement) compared to the same word pairs in reverse sequence. Importantly, variance in RTs was better explained by the frequency of these iconic word pairs in language (a linguistic factor) than by the rated degree to which the spatial configuration of the word pair represented their "real world" configuration (an embodied factor). In an extension of this work, Louwerse and Jeuniaux (2010) found that the same linguistic factor better explained RTs obtained from a task involving printed word pairs compared to picture pairs representing the same concepts. These results suggest that the influences of linguistic and embodied factors may depend on the nature of the task and the stimuli involved. Additionally, data from behavioural (Louwerse & Connell, 2011) and electroencephalography (EEG; Louwerse & Hutchinson, 2012) investigations provide evidence that linguistic processing may precede embodied processing; that is, information from language statistics may better account for early/fast RTs, whereas embodied measures appear to better account for late/slow RTs. Critically, when printed words are used as task stimuli, as opposed to stimuli of another modality (e.g., pictures), the words may not require full perceptual simulation to produce a speeded response (Louwerse & Connell, 2011). In sum, for the purposes of the present study, the above findings support the following arguments:

1) The relationships between words capture both linguistic and embodied information.
2) Linguistic measures of semantics may be better at capturing effects from linguistic tasks compared to embodied measures.
3) Linguistic information may be more immediately accessible than embodied information when performing a speeded linguistic task. That is, when words are used as stimuli, full processing of embodied information may not be necessary to provide a response.

These points highlight the advantages of using a language-based model of semantic richness in investigations of semantic influences on visual word recognition.

Concreteness

The preceding literature review described the importance of linguistic associates in the measurement of meaning (i.e., semantic richness). Another variable, concreteness, has a longer history and relates to a broad distinction between two word types: concrete and abstract. Concreteness is a measure of the extent to which a word's referent can be experienced by the senses (Dove, 2015). While concrete words typically refer to concepts that are spatially circumscribed and physically tangible (e.g., *TABLE*, *KITCHEN*, *BASKETBALL*), abstract words (e.g., *BRAVERY*, *FULFILLMENT, ACADEMIA*) often refer to concepts consisting of social, event-related, or introspective information (Barsalou & Wiemer-Hastings, 2005; Borghi & Cimatti, 2009). As poignantly expressed by Barsalou (2008), "Because the scientific study of concepts has primarily focused on concrete concepts, we actually know remarkably little about abstract concepts, even from the perspective of traditional cognitive theories" (p. 634). Indeed, as noted by Recchia and Jones (2012) most models of word recognition were developed using concrete word stimuli, though the applicability of these models to abstract word processing has yet to be fully established. Arguably, the domains of experience expressed by abstract words (e.g., social information, introspective states) may not be adequately captured by concrete words.

There are several theories of semantic organization proposing differences between concrete and abstract word representations, and they are discussed in detail below to provide an overview of the current state of knowledge in this area. However, a meaningful understanding of this body of literature requires a basic understanding of the most commonly used research methods in this area of study.

Methods of Studying Concrete versus Abstract Word Processing

The semantic processes involved in visual word recognition may be examined using a variety of techniques that provide rich sources of complementary data. Much of the literature that will be reviewed in this document uses standard behavioural and/or neuroimaging techniques. The following section provides a brief primer on how response time (RT), functional magnetic resonance imaging (fMRI), and event-related potentials (ERP) data are typically used in psycholinguistics.

Response times. In behavioural experiments, RTs are most commonly treated as the dependent variable, and are meant to serve as a proxy for processing efficiency of the experimental stimuli. Importantly, RT is a *composite* measure in that it encompasses a particular set of mental processes, including the one(s) of particular interest to a researcher. As such, in behavioural studies, one is primarily interested in how a given variable or set of variables impacts *changes in mean RTs* in various conditions (Pachella, 1974).

fMRI. Glover (2011) provides an overview of fMRI methods commonly used in cognitive neuroscience experiments, a summary of which is provided here. Overall, fMRI provides a means for researchers to measure changes in hemodynamic response (i.e., Blood Oxygen Level Dependent or BOLD contrast) in certain brain regions following task-induced changes in neural metabolism. In a typical visual word recognition experiment using fMRI, the data from experimental and control trials are compared to produce activation maps that reveal brain areas associated with the experimental condition. The major strength of fMRI is its high spatial resolution, allowing researchers to produce precise neural activation maps associated with certain cognitive processes or task demands. Glover (2011) notes that the most advanced fMRI machines can achieve spatial resolution within 500 microns. However, compared to other techniques such as EEG, fMRI has relatively poor temporal resolution given the slow hemodynamic response time (i.e., five to six seconds post-stimulus), which is much slower than most neural processes (Glover, 2011).

ERP. The time course of visual word recognition is believed to occur within approximately half a second (Kaan, 2007), thus calling for methods with high temporal resolution to study real-time recognition processes. EEG is well-suited to capturing evoked responses that last up to a few hundred milliseconds given its millisecond temporal resolution (Glover, 2011). Using EEG, researchers can measure the electrical brain waves, or event-related potentials (ERPs), associated with the presentation of experimental stimuli. Kaan (2007) provides an overview of how ERP methods are typically used in psycholinguistics, a brief summary of which is provided here. ERPs are electrical brain waves following the onset of a stimulus, which are recorded through electrodes placed on the scalp. These potentials are averaged for each experimental condition across participants to produce a waveform known as a component. ERP components are sequences of positive or negative going deflections that are typically characterized by their polarity and temporal peak. For example, a commonly studied component in psycholinguistics is the N400, which is a negative going waveform that peaks at approximately 400 ms post-stimulus, and is associated with a range of semantic and lexical processes (see Lau, Phillips, & Poeppel, 2008 and Kutas & Federmeier, 2012 for reviews). Beyond comparing individual components, topographical maps (i.e., overall patterns of electrophysiological activity across the scalp) may also be compared between experimental conditions (Michel, Seeck, & Landis, 1999).

Theories of Concrete versus Abstract Word Processing

Concrete and abstract words appear to be represented in different ways in the mental lexicon. For example, many studies have found that concrete words are both recognized and recalled more easily than abstract words, a phenomenon known as the concreteness effect (reviewed e.g., Paivio, 1991; Schwanenflugel, 1991). Data from other studies suggests that different semantic variables or features are central to concrete versus abstract concepts (Kousta, Vigliocco, Vinson, Andrews, and Del Campo, 2011; Recchia & Jones, 2012; Barsalou & Wiemer-Hastings, 2005; Zdrazilova & Pexman, 2013). As will be described in greater detail below, research from behavioural, electrophysiological, imaging, and neuropsychological studies provide support for the idea that concrete and abstract word representations are quantitatively and/or qualitatively distinct.

Although processing differences between concrete and abstract words have been extensively studied, we have yet to come to a consensus regarding the nature of these processing differences. The earliest cognitive theories related to concrete and abstract words proposed a quantitative distinction between these word types, with concrete words thought to possess richer semantic representations than abstract words. Two major theories include the Dual-Coding Theory (Paivio, 1971) and the Context Availability Theory (Schwanenflugel & Shoben, 1983). *The Dual-Coding Theory* states that the semantic system consists of two representationally distinct but functionally related systems: a linguistic (verbal) system and an imagistic (non-verbal) system. Concrete words are thought to be represented by both a linguistic and an imagistic code, whereas abstract words are thought to be represented exclusively by a linguistic code. Therefore, the facilitation effects often seen with concrete words are attributed to having increased access to multiple sources of information (i.e., sensory referents and linguistic information). The *Context Availability Theory*, on the other hand, attributes the concreteness effect to the idea that more contextual information is readily available from concrete words in isolation, as compared to abstract words (Schwanenflugel & Shoben, 1983). Both of these accounts of semantic representation have garnered considerable support over the years from behavioural, ERP, neuropsychological, and neuroimaging studies.

Support for the dual-coding theory comes from demonstrations that visual processing (usually assumed to be sub-served by the right hemisphere) is required for concrete words in addition to linguistic processing. Some of the earliest evidence for dual-coding theory was contributed by those who conducted divided visual field studies of word recognition, which supported a right hemisphere advantage for concrete words on tasks of naming (Levine & Banich, 1982) and semantic priming (Shibaraha & Lucero-Wagoner, 2002). A number of patient case studies have also found that concrete words are better preserved in those with neurological impairment (e.g., Coltheart, Patterson, & Marshall, 1980; Franklin, Howard, & Patterson, 1995; Katz & Goodglass, 1990; Martin & Saffran, 1992). Additionally, the ERP literature (reviewed, e.g., Kousta et al., 2011) has identified two components commonly associated with concrete word processing. The first is a more amplified N400 component, which is reflective of initial semantic processing, and the second is a late negative component peaking at approximately 700-800 ms post-stimulus, which has been attributed to the retrieval of mental imagery thought to occur with concrete words. The retrieval of imagery-based information for concrete words is also supported by neuroimaging (functional magnetic resonance imaging; fMRI) studies, for which bilateral activation produced by concrete items was a common finding (see Papagno, Fogliata, Catricala, & Miniussi, 2009 for a recent meta-analysis).

The context availability theory has also garnered support based on behavioural, ERP, and fMRI data. In the classic demonstration of this model, concrete and abstract word RTs in a lexical decision task were found to be comparable when the target word was preceded by sentence context (Schwanenflugel & Shoben, 1983). Additional behavioural evidence was provided by Schwanenflugel, Harnishfeger, and Stowe (1998) as well as van Hell and de Groot (1998), whose results revealed no concreteness effect in lexical decision RTs when subjective ratings of context availability were taken into account. From the ERP literature, analysis of the N400 component has also been interpreted as supporting context availability claims. Specifically, the greater N400 amplitude typically produced by concrete words has an anterior maximum that is widely distributed across the scalp (West & Holcomb, 2000). Since there does not seem to be any structural overlap between the responses produced by concrete word processing and visual object working memory tasks on that component, this suggests that the concreteness effect arises within a linguistic semantic system that is common to both concrete and abstract words (van Schie, Wijers, Mars, Benjamins, & Stowe, 2005). Finally, within the fMRI literature, a number of studies have found areas of relatively greater activation in left hemisphere areas known to be involved in semantic processing (e.g., the left inferior frontal gyrus), which suggests more effortful retrieval of semantic processing for abstract as compared to concrete words (Binder et al., 2005; Fiebach & Friederici, 2004; Jessen et al., 2000; Noppeney & Price, 2004; Perani et al., 1999). This finding is consistent with the context availability theory given that abstract words are purported to have fewer semantic associates than concrete words.

In sum, the dual coding and context availability theories have been helpful in generating a substantial body of research on the differences between concrete and abstract word semantics. However, both theories conceptualize abstract words as being more semantically impoverished than concrete words. Although the above-summarized findings have typically indicated a processing advantage for concrete words, abstract word processing advantages (i.e., reversed concreteness effects) have also been reported. For example, several patient studies have documented reversed concreteness effects in patients with semantic dementia (e.g., Breedin, Saffran, & Coslett, 1994; Cipolotti & Warrington, 1995; Macoir, 2009; Papagno, Capasso, & Miceli, 2009; Reilly, Grossman, & McCawley, 2006; Yi, Moore, & Grossman, 2007; Bonner et al., 2009; Grossman & Ash, 2004; but see Jefferies et al., 2009; Hoffman & Lambon Ralph, 2011), herpes simplex encephalitis (Warrington & Shallice, 1984; Sirigu, Duhamel, & Poncet, 1991), and semantic jargon aphasia (Marshall, Pring, Chiat, & Robson, 1996). These findings, which are not readily explained by either the dual-coding or context availability theories, have prompted the development of several alternative theories proposing qualitative (as opposed to quantitative) representational distinctions between concrete and abstract words.

One such theory, *Perceptual Symbol Systems* (Barsalou, 1999) makes a strong claim regarding the centrality of embodied, sensorimotor experience in the storage and retrieval of semantic knowledge. In this way, concepts are represented as “perceptual symbols”, which are neurophysiological re-enactments (simulations) of the sensorimotor experiences associated with a particular concept. For example, according to perceptual symbol systems theory, retrieving the meaning of the word *WATER* would likely involve a neurophysiological simulation of the act of drinking (and its associated sensorimotor sensations, such as that of wetness) because this is a common sensorimotor experience associated with the word *WATER.* Thus, according to perceptual symbol systems theory, semantic processing of concepts necessarily involves partial simulation of the sensorimotor experiences involved at encoding. Barsalou (1999) theorized that some abstract words are similar to concrete words in that they both involve situated simulations (i.e., re-enactments of the settings in which the concepts have been experienced).

Evidence for this position comes from a property generation study involving concrete and abstract words in which situational content was evident for both word types (Barsalou & Wiemer-Hastings, 2005). Interestingly, however, concrete and abstract words differed in situational content such that objects, locations, and characteristic behaviours most often characterized concrete words, whereas properties related to social interactions, beliefs, and complex relationships/contingencies appeared to be most salient for abstract words. This suggests that physically salient features are typical of concrete concepts, whereas the features of abstract concepts may be more contextually diverse. This proposed complexity of abstract relative to concrete concepts has also been supported by an fMRI study in which abstract words produced more extensive cortical activation than concrete words in a semantic categorization task (Pexman et al., 2007).

Although perceptual symbol systems may be a promising approach to examining the potential complexity of abstract representations, some have argued that this approach may not apply to all abstract concepts. More specifically, Wiemer-Hastings and Xu (2005) note that cognitive and emotional experiences also tend to characterize human-generated features of abstract words, which may not be adequately captured by situational simulations. Indeed, even Barsalou (1999) acknowledged that abstract word representations pose a challenge for embodied accounts of semantics such as perceptual symbol systems. Moreover, since features of abstract words may be other abstract words (e.g., *ELECTION* as a feature of *DEMOCRACY*) it is difficult to imagine how a simple set of sensorimotor experiences can adequately characterize abstract concepts (Dove, 2011).

Other theories have also adopted Dove's (2009) previously discussed *representational pluralism* approach by asserting that concrete concepts capture sensorimotor/embodied knowledge, whereas abstract concepts capture aspects of disembodied knowledge.

One such theory, the *Different Representational Framework Hypothesis* (Crutch & Warrington, 2005) states that concrete words are primarily organized by semantic similarity (i.e., same category, shared physical features), whereas abstract words are primarily organized by semantic association (i.e., shared linguistic context or real-life associations). In a series of case experiments using a spoken word - written word matching task (i.e., point to a target written word in an array following spoken presentation), Crutch and Warrington (2005) found that their participant (who had semantic refractory access dysphasia) demonstrated significantly lower response accuracy when identifying semantically similar (i.e., same category, physical features) concrete words (e.g., *GOOSE, PIGEON, CROW, SPARROW*) than dissimilar concrete words (e.g., *GOOSE, MELON, PULLOVER, BISCUIT*). However, the same effect was not seen with semantically similar (synonymous) abstract words (e.g., *DECEIT, TRICK, STEAL, CHEAT*) as compared to dissimilar abstract words (e.g. *DECEIT, STRIKE, MUSH, SCREEN*). Interestingly, the opposite pattern was observed when the concrete and abstract stimulus words were arranged according to semantic association (i.e., related but not synonymous). That is, abstract words arranged according to semantic association (e.g., *EXERCISE, HEALTHY, FITNESS, JOGGING*) were more error prone than non-associated abstract words (e.g., *EXERCISE, GAMBLE, PUNCH, FUTURE*). However, the same effect was not observed when the participant was presented with semantically associated concrete words (e.g., *FARM, COW, TRACTOR, BARN*) versus semantically non-associated concrete words (e.g., *FARM, SAILOR, SHELF, OVEN*). Additional support for the different representational framework hypothesis has also come from research on neurologically intact samples (Crutch, Connell, & Warrington, 2009; Crutch & Jackson, 2011), as well as case studies involving patients with deep dyslexia (Crutch, 2006) and global aphasia (Crutch & Warrington, 2010).

Studies conducted on neurologically impaired populations have also been used to provide support for the *Hub and Spoke Model* briefly introduced earlier. As previously summarized, this model proposes that a single amodal hub integrates information from other brain regions (via bidirectional "spokes") subserving sensorimotor and affective knowledge. Research on individuals with semantic dementia has provided the strongest evidence for the hub and spoke model. Semantic dementia is a disorder characterized by bilateral atrophy and hypometabolism of the anterior temporal lobes (ATL; Hodges, Patterson, Oxbury & Funnell, 1992; Mummery et al., 2000), as well as semantic impairments that impact a wide range of conceptual domains in both receptive and expressive language modalities (Rogers et al., 2004). In a review by Patterson et al. (2007), studies of patients with semantic dementia contrasted with patients of other etiologies (e.g., Alzheimer's disease, stroke) suggest that the semantic impairments observed in semantic dementia are attributable to anterior temporal lobe pathology.

Importantly, the hub and spoke model predicts that damage to the central semantic hub, the ATL, should impair retrieval of both concrete and abstract word knowledge. It should be noted that several case studies of semantic dementia patients have revealed better preserved knowledge of abstract relative to concrete words

(Warrington, 1975; Breedin, Saffran, & Coslett, 1994; Cipolotti & Warrington, 1995; Reilly, Peelle, & Grossman, 2007; Macoir, 2009; Papagno, Capasso, & Miceli; 2009). However, in a case series investigation of seven semantic dementia patients (varying in disease severity) by Hoffman & Lambon Ralph (2011), knowledge of both concrete and abstract words was negatively impacted, though knowledge of concrete words was slightly better preserved than abstract words in all patients. These data lend support to the existence of an amodal semantic hub in the ATL. The authors also concluded that reversed concreteness effects are not typical of semantic dementia, and that these effects may be due to idiosyncratic differences in pre-morbid experience or educational background, as well as stimulus characteristics (e.g., the use of highly familiar or frequent abstract words that may be resistant to degradation). Consistent with Hoffman and Lambon Ralph's (2011) findings, Pobric et al. (2007, 2009) used repetitive transcranial magnetic stimulation (rTMS) to disrupt ATL processing (thus creating a virtual lesion) in neurologically intact participants. These authors found that rTMS stimulation of the ATL resulted in both concrete and abstract word errors, thus providing additional support for the ATL as the critical neuroanatomical substrate of semantic knowledge. An additional finding was that abstract words were impacted by rTMS stimulation to a greater extent than concrete words. From their findings, these authors concluded that concrete words likely have richer representations than abstract words, although there are alternative explanations. For example, as per perceptual symbol systems theory and the different representational framework hypothesis previously described, abstract words may rely on more complex associated semantic features than concrete words. Therefore, abstract concepts may place greater processing resources on the ATL compared to concrete ones.

Another account, known as the _Theory of Embodied Abstract Semantics_ (Vigliocco, Meteyard, Andrews, & Kousta, 2009), proposes that both concrete and abstract words are composed of embodied/experiential (i.e., sensorimotor, affective) information as well as linguistic associative information, although the relative proportions of each of these varies by concreteness. Specifically, mostly sensorimotor information is believed to underlie concrete representations, whereas emotional and linguistic information is predominant in abstract representations. In support of this theory, Kousta et al. (2011) demonstrated through a series of lexical decision experiments and large-scale regression analyses (based on lexical decision data from the English Lexicon Project; Balota et al., 2007) that a small but significant advantage exists for abstract words when imageability and context availability are controlled. However, this abstractness effect was not observed when affective associations (ratings of emotional valence and arousal) were taken into account, either by controlling for affective valence within the stimulus set by only using emotionally "neutral" words, or by controlling for affective associations statistically. In a related line of research, Westbury et al. (2013) proposed that human ratings of imageability (a variable that is largely similar to concreteness) and their behavioural effects are largely explained by objective linguistic and affective variables. More specifically, these authors provided evidence that measures of contextual information and emotional associations derived from a co-occurrence model (HiDEx; Shaoul & Westbury, 2006) are able to successfully predict human imageability ratings, and can also account for most of the RT variability in lexical decision task data that has been attributed to human imageability ratings. Although Westbury et al. (2013) make no specific hypotheses with respect to concrete versus abstract (or high versus low imageability) words, such findings support the idea that affective and linguistic information underlies words along the concreteness (or imageability) spectrum. In sum, various theories have proposed functional and structural mechanisms for the processing distinctions between concrete and abstract words.

Overall, there appears to have been a theoretical shift to models that conceptualize concrete and abstract words as representing different kinds of semantic knowledge. For a summary of the theories reviewed with respect to their predictions for concrete versus abstract word processing, please see Table 1. The present investigation seeks to contribute to the adjudication of these theories by exploring concrete and abstract word recognition within the context of another semantic variable, semantic neighbourhood density, which is able to capture semantic richness information for both word types within a single model.

Table 1

Summary of Concrete versus Abstract Word Processing Models, with their Basic Tenets, Predictions, and Supporting Research

Theory	**Basic tenets**	**Predictions regarding concrete versus abstract word processing**	**Empirical support for predictions**
Dual Coding Theory (Paivio, 1971)	▪ Concrete words are represented by linguistic and imagistic codes; abstract words are only represented by a linguistic code.	▪ Concrete words should be processed faster than abstract words.	Reviewed e.g., Paivio (1991)
Context Availability Theory (Schwanenflugel & Shoben, 1983)	▪ Concrete words are associated with stronger and denser associations to contextual information compared to abstract words.	▪ Concrete words should be processed faster when presented in isolation. ▪ There should be no difference between concrete and abstract word RTs when context is provided.	Reviewed, e.g., Schwanenflugel (1991)
Qualitatively Different Representational Hypothesis (Crutch & Warrington, 2005)	▪ Concrete words are primarily organized by semantic similarity (i.e., same category, similar features) while abstract words are primarily organized by semantic association (i.e., shared linguistic context or 'real life' associations).	▪ When processing concrete words, similarity-based connections are identified faster than association-based connections ▪ When processing abstract words, association-based connections are identified faster than similarity-based connections	Crutch, Connell, and Warrington (2009)
Perceptual Symbol Systems (Barsalou, 1999)	▪ Both concrete and abstract word processing involves simulation of sensorimotor experiences (i.e., perceptual symbols) associated with a given concept. ▪ Concrete and abstract words differ in the content of these simulations. Introspective, social, and event knowledge is central to abstract simulations, and object knowledge is central to concrete simulations.	▪ Human generated properties for concrete and abstract concepts will vary in content. ▪ Concrete words should elicit primarily object-related properties, while abstract words should elicit introspective, social, and event-related properties	Barsalou & Wiemer-Hastings (2005) Wiemer-Hastings & Xu (2005)
Hub and Spoke Model (Patterson et al., 2007; Rogers et al., 2004; Lambon Ralph et al., 2007)	▪ The anterior temporal lobes bilaterally serve as a central amodal hub for semantic knowledge by integrating knowledge from amodal cortical areas	▪ Damage to the anterior temporal lobes should impair knowledge for both concrete and abstract words	Hoffman & Lambon Ralph (2011) Pobric et al. (2007, 2009)
Theory of Embodied Abstract Semantics (Vigliocco et al., 2009)	▪ Both concrete and abstract words are composed of embodied/experiential (sensorimotor, affective) and linguistic associative information. Concrete words are primarily composed of sensorimotor information. Abstract words are primarily composed of emotional and linguistic information.	▪ When concrete and abstract words are controlled for sensorimotor information, there should be an advantage for abstract words. Affective associations should account for this abstract word advantage.	Kousta et al. (2011)

Semantic Neighbourhood Density: A Distributional Measure of Richness

Semantic neighbourhood density (SND) refers to the average proximity of semantic neighbours to a target word as defined by a global co-occurrence model (WINDSORS; Durda & Buchanan, 2008). Thus, SND is a linguistically-derived variable that is meant to serve as a measure of the overall distribution of neighbours within a given word's semantic space. In this way, semantic neighbourhoods may be described as relatively sparse (i.e., low SND) or clustered (i.e., high SND). As will be further explained below, the number of semantic neighbours within a given neighbourhood is determined statistically (see *Operational Definitions* on page 51).

SND was first studied in the context of reading performance in individuals with deep dyslexia (Buchanan, Burgess, & Lund, 1996). The effects of SND on a neurologically intact sample were first studied by Buchanan et al. (2001) using the term "semantic distance", which referred to the average distance between a target word and its 10 closest neighbours as defined by a global co-occurrence model (HAL; Lund & Burgess, 1996). More specifically, it was assumed that words with high semantic distance should have a sparse neighbourhood since the 10 closest neighbours would be relatively distant from the target[2]. On the other hand, words with low semantic distance

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[2] The term "semantic distance" in the Buchanan et al. (2001) study is analogous to SND, except that these authors only statistically considered a given word's 10 closest neighbours. Therefore, "low semantic distance" implied that neighbours were closely semantically related to the target, thus forming a dense neighbourhood. In the same way, "high semantic distance" implied that neighbours were relatively distant from the target thus forming a sparse neighbourhood. In contrast, in the present study the calculation of SND involved similarity (not distance) values. As such, high SND words have neighbours that are highly similar or closely semantically related to them (i.e., high SND words have low semantic distance to their neighbours). In the same way, low SND words have neighbours that are relatively less semantically related to them (i.e., have high semantic distance to their neighbours).

should have a dense semantic neighbourhood since the 10 closest neighbours would be relatively close to the target word. According to hierarchical regression analyses, semantic distance accounted for unique variance in lexical decision RTs even after accounting for previously established lexico-semantic variables (i.e., log frequency, orthographic neighbourhood size, word length, imageability). Buchanan et al.'s (2001) results suggest that word recognition is facilitated by having a large and dense semantic neighbourhood (relative to a small and sparse semantic neighbourhood). This is consistent with the idea of semantic feedback models, which propose that words with rich semantic representations provide strong feedback to orthography, thus facilitating visual word recognition (e.g., Hino & Lupker, 1996). Specifically, if lexical (word/non-word) decisions are primarily based on orthography (i.e., does this look like a word?), then having a richer semantic representation (i.e., low semantic distance) should facilitate responding by providing strong top-down feedback from semantics.

Siakaluk, Buchanan, and Westbury (2003) extended the work of Buchanan et al. (2001) by using another task that arguably requires more extensive semantic processing than the lexical decision task (i.e., go/no-go semantic categorization task). Specifically, participants were instructed to make single word animal/non-animal judgments by pressing a key only for non-animal words (i.e., experimental words), thereby requiring explicit access to word meanings. Similar to the findings of Buchanan et al. (2001), there was a significant effect of semantic distance whereby faster RTs were produced by low semantic distance words (i.e., those with dense semantic neighbourhoods) compared to high semantic distance words (i.e., those with sparse semantic neighbourhoods). These results are also consistent with a semantic feedback account, in which words with many semantic neighbours (i.e., low semantic distance words) are believed to have stronger and richer representations than words with few semantic neighbours (i.e., high semantic distance words), thereby facilitating recognition RTs.

More recently, Mirman and Magnuson (2008) explored how attractor dynamics could contribute to an understanding of SND facilitation effects. These authors independently manipulated the effects of near versus distant neighbours and analyzed RTs from a semantic categorization task. The results revealed slower RTs for words with many near neighbours relative to words with few near neighbours (i.e., many distant neighbours). The authors attributed this effect to the former having greater competition effects from very semantically similar words. From an attractor dynamics framework, distant neighbours are thought to create a gravitational gradient that speeds settling to the correct “attractor” (i.e., target word), thereby facilitating recognition RTs. On the other hand, near neighbours are believed to create conflicting sub-basins that slow settling to the correct attractor, which slows recognition RTs by increasing the likelihood of near neighbour competition. In an attempt to test this attractor dynamics hypothesis, Mirman and Magnuson (2008) analyzed settling patterns and model RTs for the words in the above experiment using a computational semantic model trained by O’Connor, McRae, and Cree (2006) to activate semantic features. Consistent with their behavioural data, their model results reflected inhibitory effects of near neighbours. Importantly, however, these data do not directly contribute to a global co-occurrence understanding of SND (as previously described) because the words modeled in the computational model were derived from feature-based norms (McRae et al., 2005). Nonetheless, given the interdependence of feature-based and language-based semantics discussed above, the potential effects of neighbourhood distribution on recognition RTs should also be investigated using global co-occurrence norms. Work in this area is in its infancy, though recent investigations (Macdonald, 2013; Danguecan & Buchanan, 2014) have found support for the idea that words with many near neighbours are processed more slowly than words with few near neighbours in both lexical decision and semantic categorization tasks.

In one such study, Macdonald (2013) explored the behavioural effects of SND in samples of both younger and older adults. SND was calculated using WINDSORS (Durda & Buchanan, 2008), and was operationally defined as the average distance between a given word and its semantic neighbours. RTs from a lexical decision task were consistent with Mirman and Magnuson's (2008) findings, as words with more clustered neighbourhoods (i.e., high SND words) produced slower RTs than words with more dispersed neighbourhoods (i.e., low SND words) in both younger and older adults, although RTs for younger adults were faster overall. Research by Danguecan and Buchanan (2014), to be discussed more extensively below, investigated the effects of SND in several word recognition tasks, and also found support for the inhibitory effects of words with many near neighbours.

Pertaining to the present study, I argue that SND (a distributional, language-based measure of semantics) is particularly useful for studying both concrete and abstract words because SND is able to provide information about both word types (McRae & Jones, 2013). Object-based models, because of their focus on physical attributes, are arguably less well able to capture abstract word semantics. However, some have asserted that distributional variables such as SND are not grounded in perception because semantic relations are solely based on the associations between words (i.e., symbol grounding problem; French & Labiouse, 2002; Glenberg, 1997; Glenberg & Robertson, 2000). In response to this criticism, Durda et al. (2009) demonstrated that WINDSORS (the model from which SND is derived) is also capable of generating perceptual features. Therefore, it can be concluded that SND is at least partially grounded, and suggests that abstract words are indirectly grounded through their linguistic relationships with other concrete (grounded) concepts (Recchia & Jones, 2012). For example, the abstract words *FLIGHT* and *ACADEMIA* are associated with other concrete (grounded) concepts such as *AIRPLANE* and *PROFESSOR*, respectively.

The Flexibility of Semantic Processing: Semantic Representations are Multi-Dimensional and Dynamic

The argument that semantic representations are not static cognitive entities has become increasingly popular in the psycholinguistic literature, as evidenced by recent investigations on the task-specific effects of various semantic variables (e.g., Pexman et al., 2008; Yap et al., 2012; Zdrazilova & Pexman, 2013). Indeed, RTs from any single visual word recognition task reflect time devoted to semantic processing, as well as other task-specific requirements/strategies (Balota & Yap, 2006). Therefore, it is safe to assume that there are no process-pure measures of visual word recognition or semantic processing. In light of this realization, a potentially useful approach is to compare how the effects of semantic variables are impacted by various task demands, which Balota and Yap (2006) termed the *task-appropriate processing framework*. Basically, this approach assumes that distinct lexico-semantic processes are central to various language-processing tasks. For example, in a naming task for which participants are instructed to read words aloud, the pathway between phonology (how a word sounds) and orthography (how a word looks) is emphasized. This may be contrasted with the visual lexical decision task in which participants must distinguish between printed letter strings that are meaningful (i.e., real words) or meaningless (i.e., non-words). In this case, the pathway between orthography and semantics is emphasized. As will be discussed below, I argue that the task-appropriate processing framework is also useful for studying the effects of semantic variables across tasks.

The Effects of Concreteness and SND Across Tasks

A study by Pexman et al. (2007) served as a major impetus for the Danguecan and Buchanan (2014) study. Specifically, these authors compared levels of cortical activation between concrete and abstract words using fMRI during an explicit semantic task (i.e., semantic categorization: decide if the word represents a food/beverage). The data showed that abstract words produced more extensive cortical activation than concrete words, which was attributed to the ability of the explicit semantic task to fully activate abstract word representations. Based on research in embodied cognition by Barsalou and Wiemer-Hastings (2005), Pexman et al. concluded that abstract words may be more complex/rich than concrete words. Importantly, these authors also suggested that tasks requiring less explicit semantic processing than the semantic categorization task (e.g., lexical decision task: decide if the letter string is a real word) would only superficially activate abstract word representations. However, they did not directly test this hypothesis by comparing their data across tasks. Danguecan and Buchanan (2014) sought to test Pexman et al.'s hypothesis that concrete and abstract words may show differential RT effects as a function of tasks that vary in the degree of explicit semantic processing required. To accomplish this, word recognition RT data was collected for the same set of stimulus words across three tasks: the letter detection task (i.e., which of these two letters was in the preceding word?), lexical decision task (LDT; i.e., is this a real word or a nonsense word?), and semantic categorization task (SCT; i.e., is this a food/beverage word?). The details of these tasks are summarized in Figure 1 and further explained below. The experimental words varied with respect to concreteness and another semantic richness variable, semantic neighbourhood density (SND; Durda & Buchanan, 2008), to investigate potential interactive effects.

Task-by-task summaries of the Danguecan and Buchanan (2014) study are provided subsequently, but in brief, the collective data from these tasks revealed that the effects of concreteness and SND varied as a function of task. To provide a theoretical account of their data, Danguecan and Buchanan (2014) developed a new model of semantic processing they called the *Flexible Semantic Processing Hypothesis*, which is meant to serve as a theoretical extension of Balota and Yap's (2006) concept of the flexible lexical processor.

Essentially, this new model (depicted in Figure 2 below) explains different visual word recognition task effects in terms of the progression between two stages of semantic processing, both of which are impacted by concreteness and SND. The first stage is believed to occur automatically upon visual presentation of a word (i.e., regardless of task demands), and consists of spreading activation throughout the word's semantic network. Stage 1 semantics is also believed to temporally overlap with orthographic processing (visual word features), an assumption that is largely supported by ERP studies (e.g., Hauk

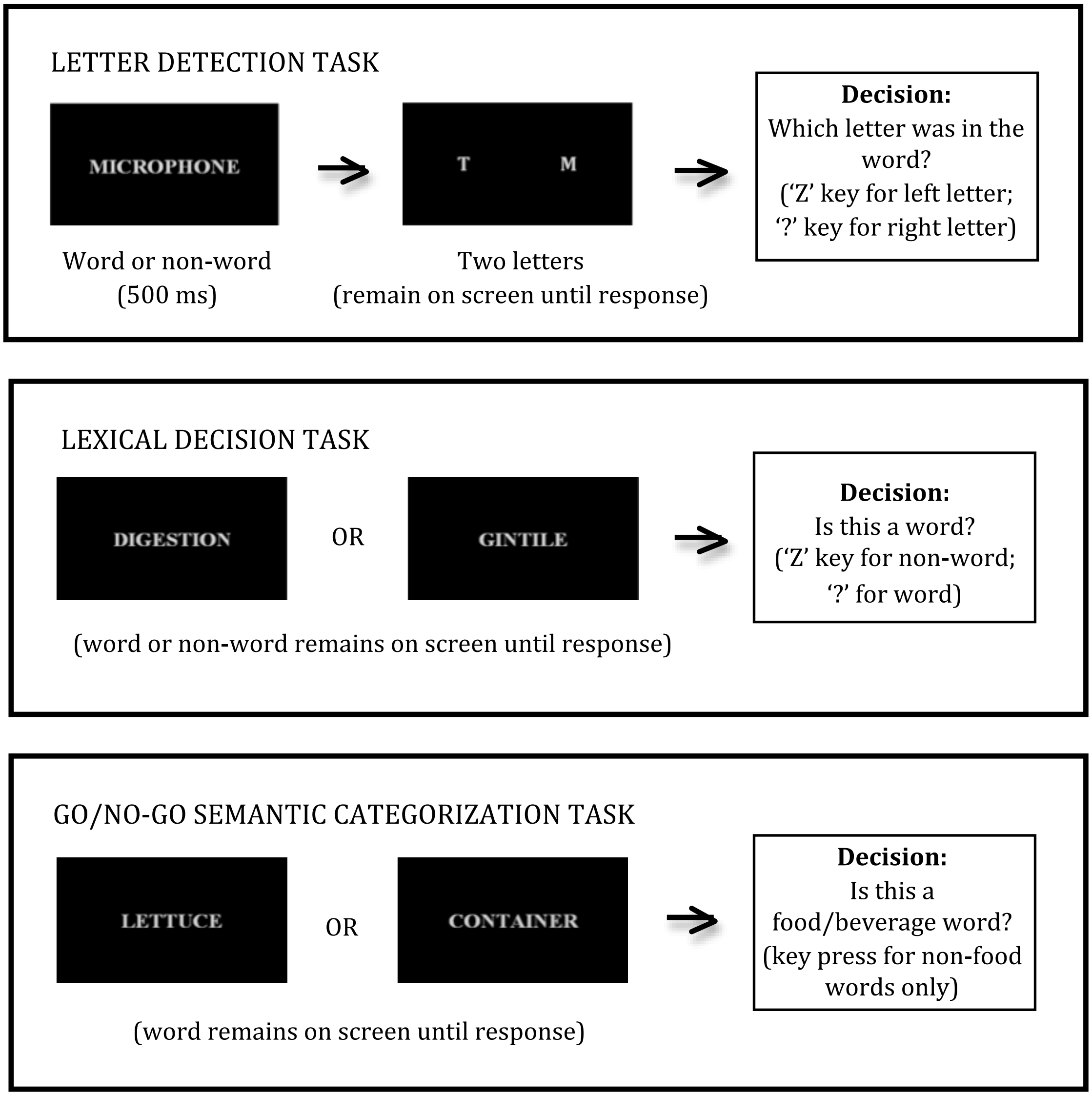

Figure 1. Summary of task requirements from the Danguecan and Buchanan (2014) study.

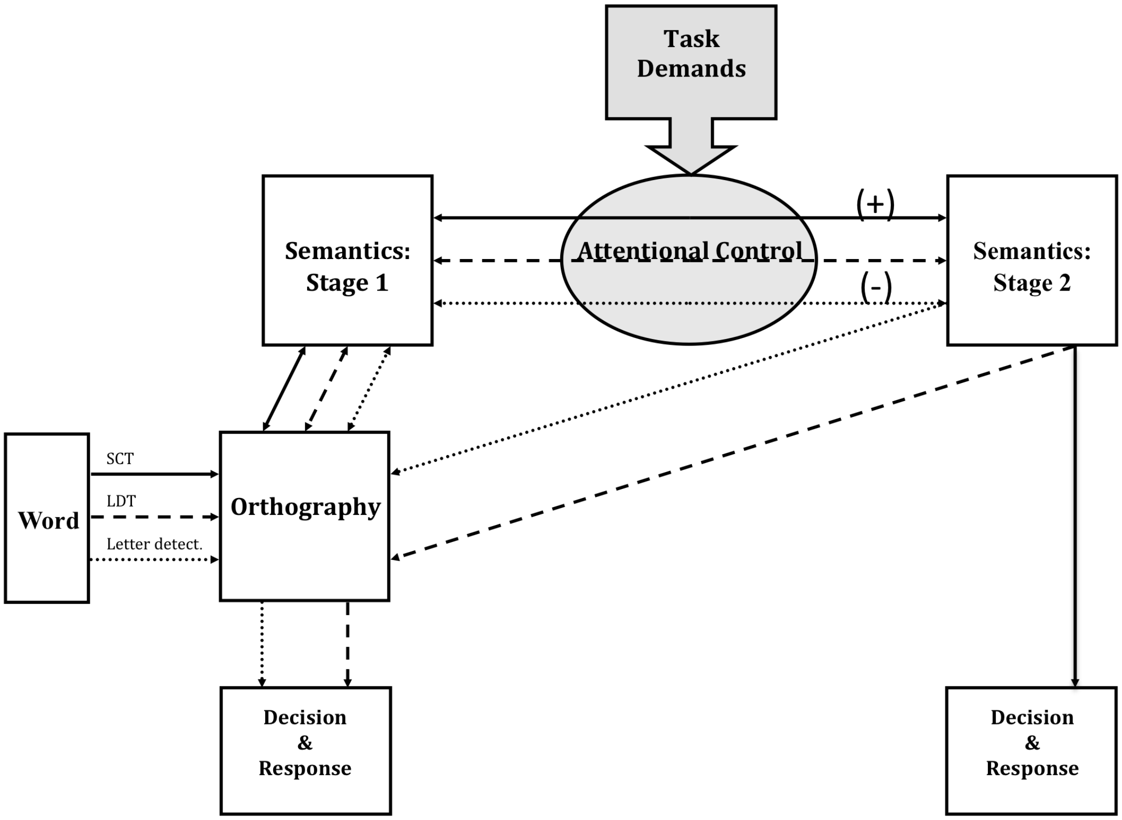

Figure 2. Semantic processing involved in the semantic categorization task (SCT), lexical decision task (LDT), and the letter detection task (Letter detect.) as proposed by the Flexible Semantic Processing Hypothesis.

et al., 2006a, 2006b; Pulvermuller, Shtyrov, & Hauk, 2009). Progression to Stage 2 semantics is believed to occur when explicit semantic processing is helpful for the task, although this stage may be inhibited when attention is directed away from semantics (as per specific task demands). Alternatively, the effects of Stage 2 semantics may be minimized when explicit semantic retrieval is not necessary. The influence of task demands (via attention control) is believed to impact processing between Stage 1 and Stage 2 semantics. Therefore, the following summary of the Danguecan and Buchanan (2014) task-by-task results will begin at the completion of Stage 1 semantics.

In the letter detection task, participants were exposed to letter strings (experimental words or non-words) one at a time for 500 ms (see Figure 1). After each letter string, two letters were presented, and participants were instructed to decide (as quickly and as accurately as possible) which of the two letters appeared in the preceding word. Initially, the data from this task was surprising because the condition that should have produced the fastest RTs based on previous literature (i.e., concrete-low SND words) produced the slowest RTs (see Experiment 1 of Figure 3 on page 41). Importantly, this task differs from the lexical decision and semantic categorization tasks in that it requires participants to focus on letter-level (not meaning-level) features of the word to make a decision. Because a large body of research supports the idea that semantic processing is obligatory upon presentation of a printed word (e.g., Stroop, 1935; Klein, 1964; Kuper & Heil, 2010; Neely & Kahan, 2001; Heil, Rolke, & Pecchinenda, 2004; Hinojosa, Martin-Loeches, Munoz, Casado, & Pozo, 2004), it is believed that there was at least some initial conceptual activation during this task despite the attentional focus away from explicit semantic retrieval. Therefore, Danguecan and Buchanan (2014) argued that efficient performance on the letter detection task possibly required inhibition or suppression of automatically activated semantic representations to effectively process letter-level features. This suggestion is based on the assumption that the words associated with greatest ease of initial (Stage 1) processing should also require the strongest subsequent suppression, which would account for the relatively longer RTs in the concrete-low SND word group[3]. In this way, slower RTs on this task are associated with greater ease of initial (Stage 1) semantic processing. Therefore, a critical claim

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[3] The argument that suppression of automatically activated semantic representations is not new, and has been used to explain other psycholinguistic effects (e.g., Maxfield, 1997; Mari-Beffa, Valdes, Cullen, Catena, & Houghton, 2005).

offered by Danguecan and Buchanan, based on the letter detection data, is that concrete words and low SND words may have an advantage over abstract words and low SND words at the first stage of semantics.

Referring to Figure 2, progression through the model for the letter detection task is as follows: once a word's semantic representation undergoes automatic spread of activation (from Stage 1), the participant must inhibit further (Stage 2) semantic processing in order to appropriately re-direct their attention to letter-level (orthographic) features of the word. Because explicit semantic processing is not necessary to make a decision in this task, Stage 2 semantics is inhibited (or at least not completed), and this inhibition is illustrated by a minus sign above the pathway denoted for the letter detection task prior to Stage 2 semantics. To make a decision, the participant's attention is then diverted back to orthography, and this is illustrated in Figure 2 by the arrow from the beginning of Stage 2 semantics to orthography. As explained earlier, the re-direction of attention (i.e., the suppression of Stage 1 semantics) in the letter detection task is inferred because of the relatively slow RTs for concrete-low SND words, which would be expected to produce the fastest RTs under normal reading conditions.

With respect to the lexical decision task, participants were instructed to indicate whether a letter string was a real word or a non-word by pressing designated keys (see Figure 1). The faster RTs for concrete words (see Experiment 2 of Figure 3) are consistent with the hypothesis that concrete words elicit stronger Stage 1 semantic activation than abstract words. Unlike the letter detection task, explicit (Stage 2) semantic processing should have been required because participants were instructed to distinguish between meaningful and meaningless (but pronounceable) letter strings. This is represented in Figure 2 as an arrow between Stage 1 and Stage 2 semantics. Moreover, semantics is proposed to facilitate responses through feedback mechanisms from semantics to orthography (Hino & Lupker, 1996; Pexman, Lupker, & Hino, 2002), for which concrete words should produce stronger feedback. This is illustrated in Figure 2 by the arrow from Stage 2 semantics to orthography. Additionally, high SND words produced slower RTs overall, suggesting that the presence of many near neighbours is inhibitory, consistent with previous studies (Macdonald, 2013; Mirman & Magnuson, 2008). Interestingly, there was also a significant interaction indicating a larger effect of SND for abstract words compared to concrete words. Because no such effect was evident in the letter detection task, this result may reflect processing differences at Stage 2 semantics, and suggests that abstract words engage in more effortful semantic processing at Stage 2 (Danguecan & Buchanan, 2014). Such a claim is consistent with findings from ERP investigations (Moseley, Pulvermuller, & Shtyrov, 2013; Adorni & Proverbio, 2012).

Finally, Danguecan and Buchanan (2014) also used a semantic categorization task in which participants were instructed to indicate whether a presented word represented a food/beverage or not (see Figure 1). Therefore, this task requires explicit semantic processing of the nature that is associated with Stage 2 semantics. Sysoeva, Ilyuchenok, and Ivanitsky (2007) proposed that initial automatic semantic processing may be suppressed by subsequent controlled semantic processing when the task demands explicit processing of word meanings. Because Stage 1 semantics is believed to occur automatically, Danguecan and Buchanan (2014) argued that the behavioural effects of initial (Stage 1) semantic processing may be masked when explicit semantic processing is a stated demand of the task. This emphasis on Stage 2 semantics is represented in Figure 2 by the plus sign above the arrow between Stage 1 and Stage 2 semantics. Once word meaning is fully accessed (during Stage 2 semantics), the participant can make a response without providing feedback to orthography, as was proposed for the letter detection and lexical decision tasks. As mentioned earlier, concrete words are believed to have an advantage at Stage 1 semantics, so faster RTs for concrete words would not be expected in the semantic categorization task if the behavioural effects of Stage 1 semantics were masked. Indeed, there were faster RTs for abstract words overall, as well an effect of SND for abstract words only (see Experiment 3 of Figure 3). Critically, this was the only task in the Danguecan and Buchanan (2014) study that found an abstract word advantage, suggesting that explicit semantic processing may be critical for abstract concepts. Finally, Danguecan and Buchanan also randomly assigned participants to all three aforementioned tasks to enable direct comparisons, and they replicated a similar pattern of results to those just described (see Experiment 4 of Figure 3).

In sum, the collective results of the Danguecan and Buchanan (2014) study support the idea that semantic processing is a multi-stage, flexibly modulated process. Their ability to chart this flexibility using a variety of tasks varying in degree of explicit semantic demands demonstrates the usefulness of this type of approach in studying semantic processes.

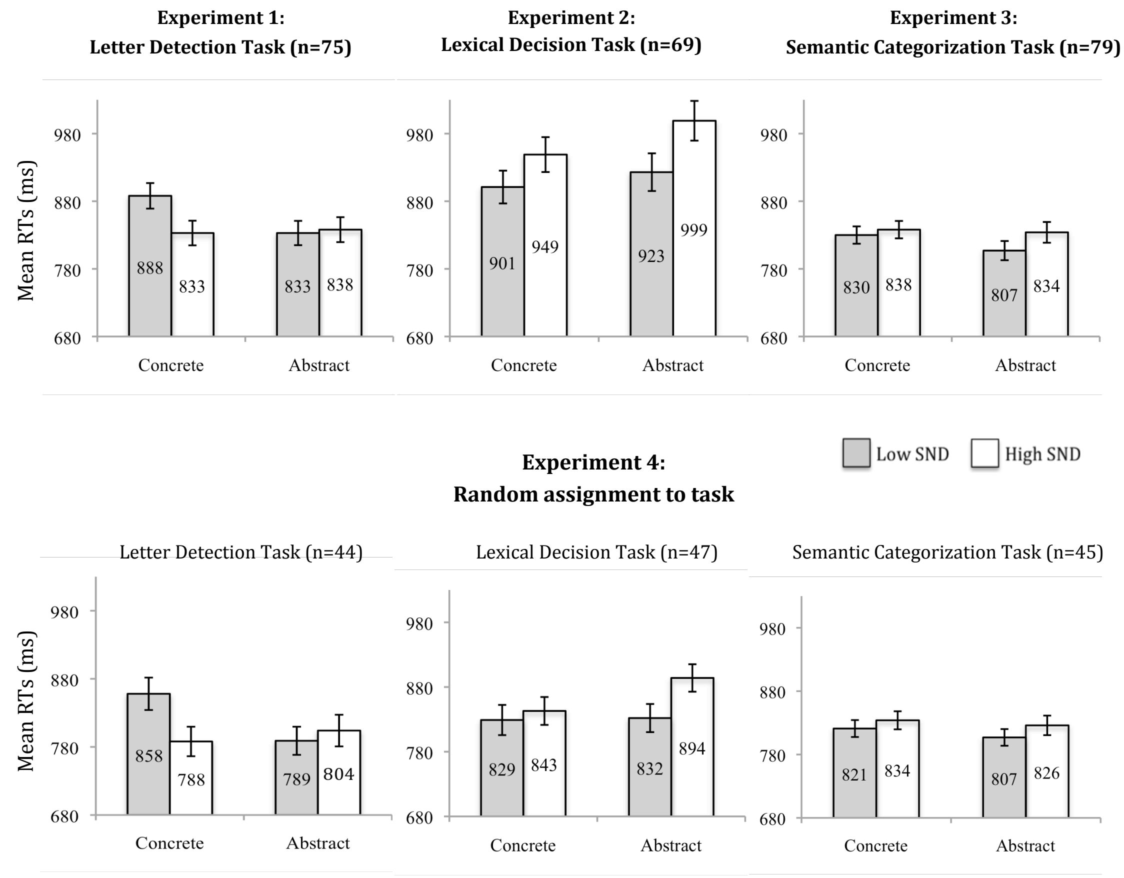

Figure 3. Results of all experiments in the Danguecan and Buchanan (2014) study. Error bars represent standard error.

Overview of the Present Study

The purpose of the present study was to extend the work of Danguecan and Buchanan (2014) and to test the Flexible Semantic Processing Hypothesis. Specifically, the proposed tenets regarding Stage 1 and Stage 2 semantics were evaluated across a wider range of tasks varying in the degree of explicit semantic processing required. In doing so, the goal was to more precisely chart the flexibility of semantic processing by comparing word recognition RTs from the same experimental words (Danguecan & Buchanan, 2014) across tasks. These tasks are briefly introduced here with respect to their proposed theoretical significance and hypotheses. A more detailed description of the task procedures is provided in the *Design and Methodology* section to follow.

Experiment 1: Implicit lexical decision task. A potential criticism of the letter detection task used by Danguecan and Buchanan (2014) is that this task required participants to keep a letter string in working memory in order to make a decision (i.e., which of two letters was present in the previous letter string?). Therefore, it is possible that differences in performance attributed to semantic processing reflected different demands on working memory. To eliminate this potential confound, a novel task, called the implicit lexical decision task, was included that does not explicitly require the maintenance of a letter string in working memory. Specifically, after seeing an experimental/control word, participants made a lexical decision between an unrelated word and a matched non-pronounceable letter string (instead of choosing between two letters). Similar to the letter detection task used by Danguecan and Buchanan (2014), good performance on the implicit lexical decision task required that one's attention be directed away from the experimental word in order to make a response. Since the implicit lexical decision task is proposed to involve similar processing demands to the letter detection task, the same pattern of results was hypothesized: slower RTs for concrete words compared to abstract words, and an effect of SND for concrete words only.

Experiment 2: Lexical decision task with non-pronounceable non-words. The proposal that the standard lexical decision task requires explicit (Stage 2) semantic access is arguably only applicable when the matched non-words are pronounceable (Coltheart et al., 1977; Binder et al., 2003). Therefore, Stage 2 semantic processing should not be necessary if the non-words used are non-pronounceable (i.e., containing illegal English letter combinations such as BRFL). However, unlike the letter detection and implicit lexical decision tasks, inhibition of the automatically activated semantic representations produced by Stage 1 semantics should not occur. Rather, Stage 1 semantic processing should be sufficient for this task. Thus, there should be an effect of SND for concrete words as well as faster RTs for concrete words overall. However, in contrast to the Danguecan and Buchanan (2014) lexical decision data, there should be a relatively smaller effect or no effect of SND for abstract words because abstract words are believed to require at least some explicit (Stage 2) semantic processing according to the Flexible Semantic Processing Hypothesis.

Experiment 3: Go/no-go lexical decision task with pronounceable non-words. As mentioned earlier, Danguecan and Buchanan (2014) found significant effects of both concreteness and SND using a standard lexical decision task. However, it may be argued that these findings are somewhat limited with respect to their implications for abstract word processing in particular due to the relatively high error rates for abstract compared to concrete words. Therefore, the lexical decision task was repeated using go/no-go methodology, as this version of the task has been shown to produce lower error rates and faster RTs (Perea, Rosa, & Gomez, 2002). In this case, the data should produce the same pattern of effects as those found in Danguecan and Buchanan (2014); that is, faster RTs for concrete words overall, but a larger effect of SND for abstract than for concrete words. However, there should be larger effects of concreteness and SND in the present study compared to the Danguecan and Buchanan study if less data is lost due to errors.

Experiment 4: Progressive demasking task. The progressive demasking task (PDT), as originally developed by Grainger and Segui (1990), is meant to slow the rapid process of visual word recognition. Specifically, a stimulus word is interspersed with a masking stimulus, such as a series of hash marks (e.g., "####"). Participants perceive the stimulus word as gradually emerging from the mask as the duration of the mask decreases and the duration of the stimulus word increases. This task has the advantage of not requiring the use of matched non-words as in the lexical decision task. Indeed, Carreiras, Perea, and Grainger (1997) argued that the PDT may produce RTs that are more sensitive to unique word identification processes than those produced by the lexical decision task because the PDT is not influenced by such factors as the type of non-words used (e.g., pronounceable versus non-pronounceable). Although some investigations have provided evidence that the PDT is more sensitive to certain lexical effects (i.e., frequency and frequency of orthographic neighbours) than the lexical decision task (Grainger & Segui, 1990), and that it is capable of demonstrating semantic effects (Dunabeitia, Aviles, & Carreiras, 2008), data from other studies have not supported these claims (Ferrand et al., 2011; Yap et al., 2012). In sum, it seems that there is a lack of consensus regarding the usefulness of the PDT to demonstrate semantic effects. However, since the PDT is meant to slow down unique visual word identification, this task may serve to uncover additional semantic effects that may be masked by the other tasks in this study.

One of the predictions of the Flexible Semantic Processing Hypothesis is that concrete words have an advantage over abstract words at Stage 1 semantics. Because there is no instructional demand for explicit semantic processing, Stage 1 semantics should predominate and concrete words should show a greater effect of SND than abstract words. However, because the PDT is meant to extend the process of word recognition, this may prompt participants to use explicit semantic access to aid in responding. Specifically, since participants are not able to perceive a word clearly upon initial exposure (due to the mask), they may begin to generate potential lexical candidates (thus indirectly accessing their knowledge of semantics) as a strategy to speed responding. The mechanism through which this occurs may be similar to the feedback mechanisms from semantics to orthography believed to facilitate responding in the lexical decision task (e.g., Hino & Lupker, 1996). In this case, an alternative hypothesis is that abstract words may show a larger effect of SND than concrete words, similar to the pattern of RTs from the lexical decision task in the Danguecan & Buchanan (2014) study. In either case, the Flexible Semantic Processing Hypothesis predicts that concrete words should produce faster RTs than abstract words because explicit semantic processing is not a directly stated demand of the task.

Experiment 5: Concrete/abstract categorization task. A potential criticism of Danguecan and Buchanan's (2014) semantic categorization task is that all the control words (i.e., food/beverage words) were also concrete words, thereby creating an imbalance between the number of concrete and abstract words viewed by participants. To address this potential confound, the concrete/abstract categorization task required participants to decide whether a word was concrete or abstract. This task has previously been used in an ERP study conducted by Sysoeva et al. (2007), and revealed distinct topographical differences between concrete and abstract words. The present study sought to determine whether these previously established ERP differences would also translate to a behavioural (RT) difference as a function of concreteness and SND. Because this task required a categorical decision, the results were hypothesized to be comparable to those from the semantic categorization task used by Danguecan and Buchanan (2014): faster RTs for abstract words, and an effect of SND for abstract (but not concrete) words.

Experiment 6 (word relatedness task) and Experiment 7 (sentence relatedness task). Importantly, the Flexible Semantic Processing Hypothesis was developed based on data from *single word* recognition/semantic processing tasks. Experiments 1 to 5 (described above) represent single word semantic processing tasks that are meant to provide additional support for this model. Whether the tenets of the Flexible Semantic Processing Hypothesis also apply to tasks that involve the semantic processing of one word in relation to another word within a trial, or discourse/contextualized processing remains an open question. Arguably, a maximally useful model of semantic processing should also help to explain how meaning is derived from words when they are being interpreted in relation to another word or group of words. As such, two novel tasks were designed to address how single word recognition RTs are impacted when relatedness judgments are made in relation to another word or sentence. These data may lead to the addition and/or modification of components of the Flexible Semantic Processing Hypothesis to accommodate processing of multi-word stimuli.

In each trial of Experiment 6 (word relatedness task) participants viewed a word for 500 ms, followed by an experimental or control word. They were then instructed to press a key if they believed the words were related by meaning, and to do nothing (no key press) if they believed the words were not related. To extend these findings beyond single word relatedness judgments, a modified version of the word relatedness task (Experiment 7: sentence relatedness task) was also included. For each trial of the sentence relatedness task, participants viewed a sentence (which remained on the screen for as long as they needed to read it), followed by an experimental or control word. They were then instructed to press a key if they believed the word was not related to the preceding sentence, and to do nothing (no key press) if they believed the word was related to the preceding sentence.

The experimental tasks summarized. To conceptualize the demands of the various tasks, one can imagine that all visual word recognition tasks fall along a continuum. At one end, there are tasks for which semantic processing is not useful for making a response (see far left of Figure 4 below). At the other end are tasks that require explicit semantic processing to make a response (see far right of Figure 4 below). Since semantic processing of the experimental words is not useful in the implicit lexical decision task (Experiment 1), this task would fall on the far left ("non-semantic") end of the continuum. The concrete/abstract categorization task (Experiment 5), word relatedness task (Experiment 6), and sentence relatedness task (Experiment 7) would fall on the far right ("very semantic") end of the continuum because explicit semantic processing is necessary to make a decision in all of these tasks. The lexical decision tasks (Experiments 2 and 3) and the progressive demasking task (Experiment 4) would fall somewhere in the middle of the continuum. Since a decision between real words and non-pronounceable non-words (Experiment 2 lexical decision task) presumably does not require semantics (and is likely primarily reliant on orthography), this task should be placed more to the left of the continuum than the Experiment 3 go/no-go lexical decision task, which requires discrimination between real words and pronounceable (word-like) letter strings. Furthermore, the progressive demasking task would presumably require more semantic processing than both lexical decision tasks because explicit word identification is required.

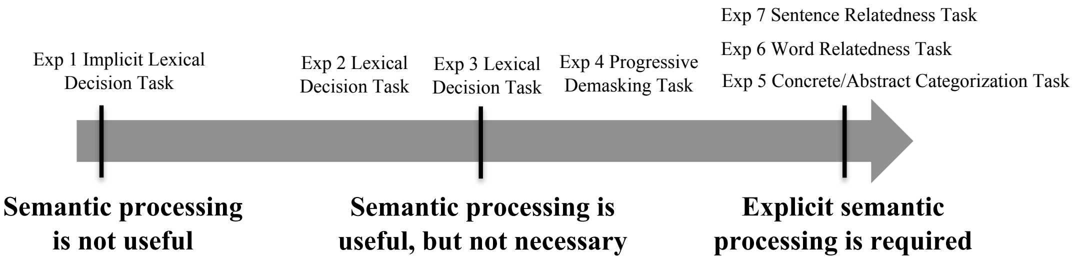

Figure 4. Experiments 1 to 7 along a semantic processing continuum.

Task-specific hypotheses summarized. Task-specific hypotheses were offered for Experiments 1 to 5. No hypotheses were offered for Experiments 6 and 7 since these were exploratory tasks that used multi-word (as opposed to single word) processing mechanisms. Regarding main effects, abstract words were expected to produce faster RTs than concrete words in Experiments 1 and 5. In Experiment 1, suppression effects were expected because semantics was not presumed to be useful; therefore, it was hypothesized that concrete words would be slower than abstract words because they would require more time and cognitive energy to suppress than abstract words. Abstract words were expected to be faster than concrete words in Experiment 5 because of the especially strong emphasis on Stage 2 explicit semantic processing in this task. Concrete words were expected to be faster than abstract words in Experiments 2, 3, and 4, which were all tasks for which semantics was helpful, though not a stated demand of the task. Therefore, the effects of Stage 1 semantics should predominate, where concrete words are expected to have an advantage. With respect to interactive effects, an effect of SND for concrete (but not abstract) words was expected in Experiments 1 and 2, because these were both tasks for which Stage 1 processing was believed to be sufficient. Finally, an effect of SND for abstract (but not concrete) words was expected in Experiments 3, 4, and 5 because at least some Stage 2 semantics was presumed to be required for these tasks.

A summary of all the experiments described above, along with their respective task requirements and hypotheses, is provided in Table 2. The specific task demands for all experiments are described further in the *Design and Methodology* section to follow, and verbatim instructions for all tasks are presented in Appendix K.

Table 2

Summary of Task Instructions and Hypotheses for All Experiments

Experiment		**Task Instructions**	**Hypotheses**
1	Implicit Lexical Decision Task	After viewing a word, indicate (with a key press) which of two words (left or right) is the real word.	▪ ***1a:*** Slower RTs for concrete words (due to stronger inhibition of concrete relative to abstract representations) ▪ ***1b:*** Effect of SND for concrete words only (Stage 2 semantics necessary for full abstract word processing is inhibited)
2	Lexical Decision Task (non-pronounceable non-words)	Indicate (with a key press) whether the word is a real word or a non-word.	▪ ***2a:*** Concrete words faster than abstract (due to stronger Stage 1 activation for concrete words) ▪ ***2b:*** Effect of SND for concrete words only (or only minimal effect of SND for abstract words) because Stage 1 semantics should be sufficient without progression to Stage 2
3	Go/No-Go Lexical Decision Task	Only respond (with a key press) when a real word is presented. Do not respond when presented with a non-word.	▪ ***3a:*** Concrete words faster than abstract (due to stronger Stage 1 activation for concrete words) ▪ ***3b:*** Larger effect of SND for abstract than concrete words (due to more effortful processing at Stage 2 semantics)
4	Progressive Demasking Task	Respond (with a key press) when you can recognize the word.	***Hypothesis 4.1***: ▪ ***4.1a:*** Concrete words faster than abstract (due to emphasis is on Stage 1 semantics, and stronger activation for concrete words at Stage 1) ▪ ***4.1b:*** Greater effect of SND for concrete words (due to emphasis on Stage 1 semantics) ***Hypothesis 4.2***: ▪ ***4.2a:*** Concrete words faster than abstract (due to emphasis is on Stage 1 semantics, and stronger activation for concrete words at Stage 1) ▪ ***4.2b:*** Greater effect of SND for abstract words (due to progression to Stage 2 semantics because of prolonging of visual word recognition)
5	Concrete/ Abstract Categorization Task	Indicate (with a key press) whether the word is a concrete or an abstract word.	▪ ***5a:*** Faster RTs for abstract words ▪ ***5b:*** An effect of SND for abstract words only (due to emphasis on Stage 2 processing, behavioural effects of Stage 1 – which show an advantage for concrete words – are masked)
6	Word Relatedness Task	Only respond (key press) when a word is related to the preceding word. Do not respond when a word is unrelated to the preceding word.	▪ Experiments 6 and 7 are exploratory studies to test the applicability of the Flexible Semantic Processing Hypothesis to contextualized or multi-word stimuli. No specific hypotheses are offered.
7	Sentence Relatedness Task	Only respond (key press) when a word is unrelated to the preceding sentence. Do not respond when a word is related to the preceding sentence.	

CHAPTER 2
DESIGN AND METHODOLOGY

Operational Definitions

Semantic Neighbourhood Density (SND). In accordance with previous investigations of SND conducted by Macdonald (2013) and Danguecan and Buchanan (2014), SND is defined in the current study as the average degree of similarity between a target stimulus word and all other words 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). Therefore, SND is meant to serve as an index of the distribution of neighbours within a given word's semantic space. Using hierarchical regression analyses, Macdonald (2013) demonstrated that using a standard score cutoff of 3.5 standard deviations best predicted lexical decision RT data from the Balota, Cortese, and Pilotti (1999) corpus. SND values range from 0 to 1[4], but to allow for factorial manipulation of SND within a stimulus set, words were categorized as being either low SND or high SND. Low and high SND words were selected from the bottom and top 33% of the words within the WINDSORS database, respectively. Low SND words (SND values equal to or less than 0.347) are those with smaller SND values (i.e., closer to 0) and have weakly related neighbours that are relatively distant. On the other hand, high SND words (SND values equal to or greater than 0.375) are those with higher SND values (i.e., closer to 1) and have closely related neighbours that are tightly clustered. See Figure 5 below for a simplified illustration of low versus high SND representations. Importantly, low and high SND words were controlled for semantic neighbourhood size

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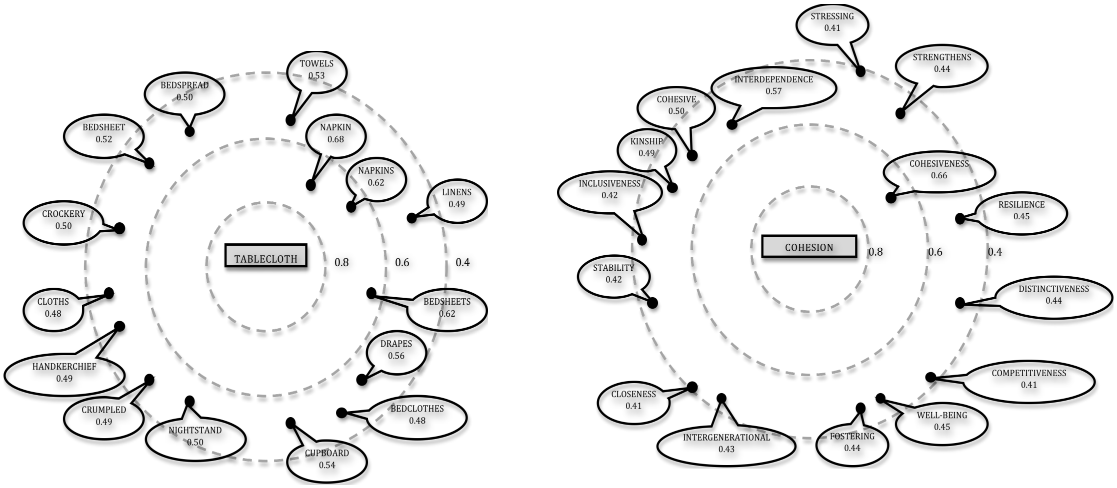
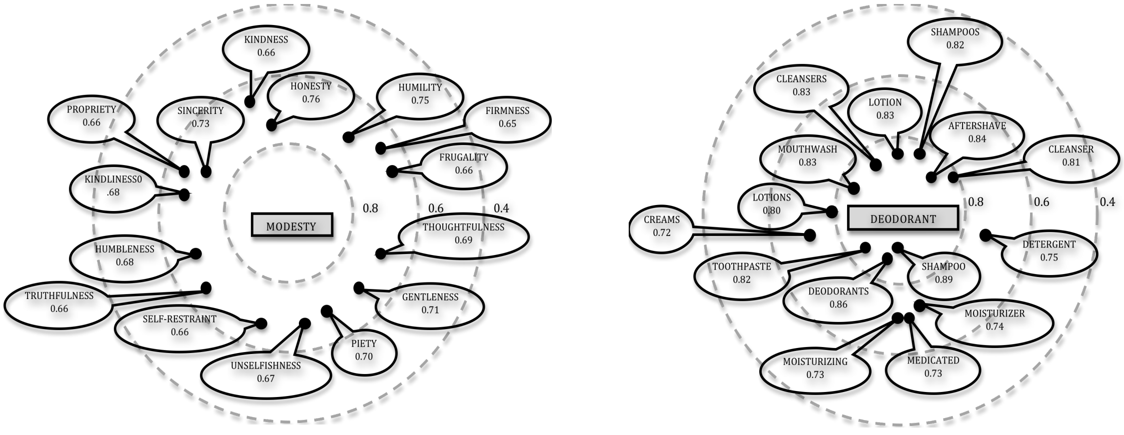
[4] SND values theoretically range from 0 to 1, although the vast majority of words within the WINDSORS database have SND values under 0.5.

and therefore had the same approximate number of neighbours, but the *distribution* of their semantic neighbours was manipulated.



Low SND: Neighbours are less related to
the target word (on average)



High SND: Neighbours are more related
to the target word (on average)

Figure 5. Two-dimensional theoretical representations of a low versus high SND words with their closest 15 neighbours.

Concreteness. Although words theoretically vary along a concreteness continuum (ranging from very concrete to very abstract), the existence of two distinct groups (i.e., concrete and abstract) is supported by the bimodal distribution of data from studies on human concreteness ratings, in which each mode is centered in each half of the concreteness scale (Nelson & Schreiber, 1992; Wiemer-Hastings, Krug, & Xu, 2001). Therefore, for the purposes of the present study, stimulus words were categorized as being concrete or abstract. Within the potential pool of low and high SND words, potential stimulus words were categorized qualitatively as being either concrete or abstract. Specifically, a word was labeled as "concrete" if it referred to a physically tangible entity, and a word was labeled as "abstract" if it referred to a non-physically tangible entity.

Stimulus Development

The current study made use of the experimental word list from Danguecan and Buchanan (2014) for all tasks. The stimulus set is composed of 44 concrete and 44 abstract common nouns. Half of the abstract words and half of the concrete words are low SND and half are high SND. The words are matched across conditions (i.e., concrete-low SND, concrete-high SND, abstract-low SND, abstract-high SND) on the following lexical/semantic variables as measured by WINDSORS (Durda & Buchanan, 2008): word length, frequency, number of syllables, and semantic neighbourhood size. All words have an orthographic neighbourhood[5] size of 0 or 1, with the exception of 4 words (*PACIFIER, LIPSTICK, MASTERY, CONCESSION)*, which have an orthographic neighbourhood size of 2. All of the words are low frequency (i.e., fewer than 10 per

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[5] Orthographic neighbourhood size refers to the number of words (of the same length) that differ from a target word by only 1 letter.

million). The difference between the mean SND values of the low and high SND conditions is statistically significant ($p < .05$), and the difference between the mean SND values of the concrete and abstract words within the low and high SND conditions is not statistically significant ($p > .05$). A summary of the experimental word characteristics is provided in Table 3 below. The full stimulus set is presented in Appendix A.

Table 3

Means and Standard Deviations for Word Length, Number of Syllables, Frequency (Freq), Orthographic Neighbourhood Size (ON), Semantic Neighbourhood Size (SN), and Semantic Neighbourhood Density (SND) Per Word Type

Word Type	Length	#Syllables	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)

Norming of Emotion Variables

Valence and arousal. Given the findings of Kousta et al. (2011) regarding the proposed importance of emotion-based information for abstract (but not necessarily concrete) words, emotional valence and arousal ratings were collected (see Appendix B for a detailed description of the norming procedures). The resulting valence and arousal ratings for all experimental words are presented in Appendix D.

Emotional Experience. Additionally, in a recent study, Newcombe, Campbell, Siakaluk, and Pexman (2012) introduced a new variable known as *emotional experience* (EE), which refers to the ease with which words evoke emotional experience. Interestingly, they found that higher EE ratings facilitated the semantic categorization of abstract words. Moreover, the effects of EE on abstract word processing have been shown in a naming (Moffat, Siakaluk, Sidhu, & Pexman, 2015), and stroop task (Siakaluk, Knol, & Pexman, 2014). There is also some indication that EE accounts for significant unique variability in lexical decision RTs over and above that of emotional valence and arousal (Newcombe, Duffels, Siakaluk, & Pexman, 2014). Given the potential impact of EE on the word recognition RTs in the present study, EE ratings were collected using the procedures outlined in Newcombe et al. (2014). The verbatim instructions provided to participants are presented in Appendix C, and the resulting EE ratings for all experimental words are presented in Appendix D.

Data analysis of emotion variables. The procedures for analyzing valence, arousal, and emotional experience ratings are provided in Appendix L. With rare exceptions, these emotion-based variables were non-significant predictors of RT. As such, they were not taken into account in the subsequent statistical analyses.

General Procedures for all Experiments

Participant recruitment and inclusion criteria. University of Windsor undergraduate students were recruited through the Undergraduate Psychology Participant Pool, and received partial course credit in exchange for their participation. Separate samples of participants were recruited for each experiment; that is, once a participant completed one of the experiments, he/she was not permitted to sign up for another experiment. All participants were required to be at least 18 years of age, report having learned English as a first language, and report normal or corrected-to-normal vision.

Task software and display details. All tasks were administered on a Dell PC using the Windows 7 operating system. The software program Direct RT (Version 2012.4.0.166; Empirisoft Corporation; New York, NY) was used to administer most tasks, with the exception of the progressive demasking task. Whenever Direct RT was used, words were presented in the middle of a black background in all capital letters, size 24, bold-faced font with turquoise-coloured letters. Due to the especially precise timing considerations necessary for the progressive demasking task, dedicated software was used to administer this task (Dufau, Stevens, & Grainger, 2008).

Task administration. To ensure proper understanding of task instructions, participants completed a series of practice trials supervised by a research assistant prior to each experiment. Correct/incorrect feedback was provided on all practice trials. If errors were made during the practice phase, the correct response was provided and task instructions were repeated. All participants received the same number of practice trials. For all experiments, trials were presented in random order.

Task Procedures

Experiment 1: Implicit Lexical Decision Task. For this task (see Figure 6 below), participants were presented with an experimental or control word for 500 ms, followed by the simultaneous presentation of two five-letter strings (one real word and one non-pronounceable non-word) on the left and right sides of the screen. They were instructed to indicate (as quickly and as accurately as possible) whether the real word appeared on the left or right side of the screen by pressing designated keys on a keyboard. The real word appeared on the left side of the screen in 50% of the trials, and appeared on the right side of the screen in the other 50% of the trials. RTs are collected from the lexical decision made from the pair of words in the latter part of each trial following the experimental or control word. These RTs are believed to reflect residual processing from the experimental or control word. Non-pronounceable non-words were used for the lexical decision portion of each trial in order to minimize/eliminate the need for explicit semantic processing, as is believed to occur when pronounceable non-words are used (Coltheart et al., 1977; Binder et al., 2003).

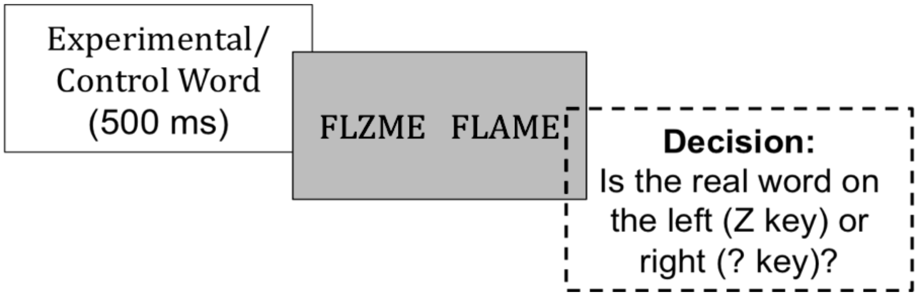

Figure 6. Trial components of the implicit lexical decision task.

Stimuli. In addition to the experimental words (see Appendix A) and control words (see Appendix F), five-letter words and five-letter non-pronounceable non-words were used for the lexical decision portion of each trial. One-syllable five-letter words were selected from the English Lexicon Project database (Balota et al., 2007). Semantic effects are maximal when stimulus words are low frequency (<10 per million; Buchanan et al., 2001). Because I intended to minimize semantic processing of the 5-letter word in the lexical decision portion of this task, I used high frequency (i.e., between 10 and 50 words per million) words for this portion of the task stimuli. The mean frequencies and orthographic neighbourhood sizes of the five-letter words were matched across conditions (see Table 4 below). The corresponding non-pronounceable non-words were created by replacing the first vowel of each five-letter real word with a consonant. The lexical decision stimuli for this task are presented in Appendix E.

Table 4

Means (and Standard Deviations) of Frequencies and Orthographic Neighbourhood Sizes (ON) of the 5-Letter Words Matched to the Experimental and Control Words in the Implicit Lexical Decision Task (Experiment 1)

Word Type	Frequency	ON	Word Type	Frequency	ON
Experimental			*Control*		
Concrete - Low SND	21.70(8.89)	3.95(2.57)	Concrete - Low SND	21.74(9.66)	4.00(3.10)
Abstract - Low SND	21.18(7.63)	3.95(2.15)	Abstract - Low SND	21.25(8.89)	3.95(2.63)
Concrete - High SND	21.68(7.60)	3.73(2.10)	Concrete - High SND	21.19(8.02)	3.95(2.90)
Abstract - High SND	21.91(9.04)	3.82(2.92)	Abstract - High SND	21.51(8.75)	3.82(2.24)

Experiment 2: Lexical Decision Task (with Non-Pronounceable Non-Words). Participants viewed each experimental word or non-pronounceable letter string one at a time. They were instructed to indicate with a key press (as quickly and as accurately as possible) whether the letter string formed a real English word or a non-word.

Stimuli. In addition to the experimental words, the non-words used in the Danguecan and Buchanan (2014) lexical decision task were made non-pronounceable by replacing the first vowel with a consonant (see Appendix G).

Experiment 3: Go/No-Go Lexical Decision Task. Participants viewed each experimental word or pronounceable letter string one at a time. They were instructed to press a key (as quickly and as accurately as possible) when presented with a real word. No action was required if presented with a non-word, and they waited 2500 ms for the next trial to begin.

Stimuli. The same stimulus set from Danguecan and Buchanan's (2014) lexical decision task was used for this experiment (see Appendix H).

Experiment 4: Progressive Demasking Task. PDT-specific software (Dufau et al., 2008) was used since the precise timing and sequencing considerations required for this task are not readily accommodated by existing commonly used experimental software (e.g., Direct RT). Each trial of the PDT (see Figure 7 below) consisted of an experimental word-mask pair that had a fixed combined duration of 233 ms. The masking stimulus was a series of 10 hash marks (##########), corresponding with the length of the longest experimental words. Within each trial, the ratio of the word-mask pair increased whereby the experimental word was initially presented for 1 display cycle (14 ms), and the mask was presented for the remainder of the trial (219 ms). As each trial progressed, the word presentation duration increased by one cycle each time (i.e., 28, 42, 56…ms), while the mask duration decreased by the same proportion (i.e., 205, 191, 177…ms). This resulted in the participants perceiving each word as "emerging" from the mask. They were instructed to press the spacebar as soon as they were able to read the word. The stimulus word disappeared once the spacebar was pressed, at which point they were prompted to type the word they just read. Participants' typed responses were manually checked for accuracy so that only correct RTs were statistically analyzed.

Responses provided after 3262 ms were excluded as the words were clearly presented without the masking stimulus at this point.

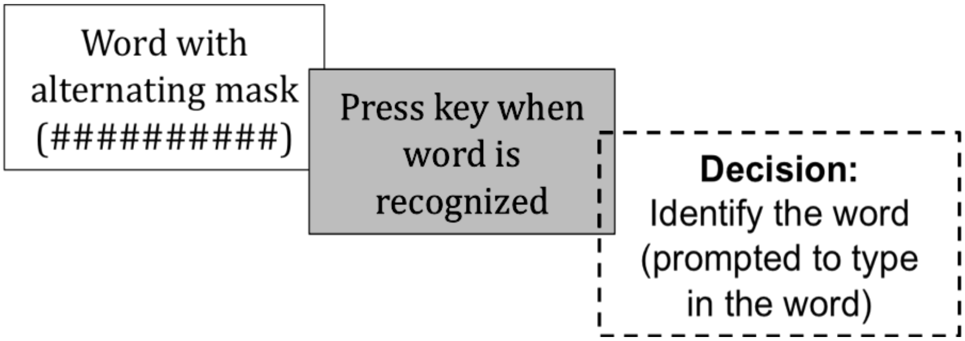

Figure 7. Trial components of the progressive demasking task.

Stimuli. Given that no matched non-words or control words were required, only the experimental words were used (see Appendix A).

Coding errors. In general, responses were considered incorrect if they formed a word that was semantically and orthographically different from an experimental word. For example, if the word "CULTURE" was provided instead of "CUTLERY" this was considered an error. If minor spelling mistakes were committed such that the pronunciation of the experimental word was not affected (e.g., "BAYONNETT" instead of "BAYONET"), these were still considered correct. However, if a spelling error changed the pronunciation of the corresponding experimental word in any way, these responses were considered incorrect (e.g., "ADOMEN" instead of "ABDOMEN").

Experiment 5: Concrete/Abstract Categorization Task. Participants viewed each of the experimental words one at a time, and were instructed to indicate (as quickly and as accurately as possible) whether the word represented a concrete or an abstract concept by pressing designated keys.

Stimuli. Only the experimental words were used for this task (See Appendix A).

Experiment 6: Word Relatedness Task. For this task (see Figure 8 below), participants were presented with a single word for 500 ms, followed by an experimental or control word. Participants were instructed to decide (as quickly and as accurately as possible) whether the two words within each trial were related by meaning or not. Specifically, they were instructed to press the space bar if they believed the words were related. No action was required if they believed the words were not related, and they waited 2500 ms for the next trial to begin. In this way, all experimental words should have produced a behavioural response because they were paired with related words. No response was required for control words because they were paired with unrelated words.

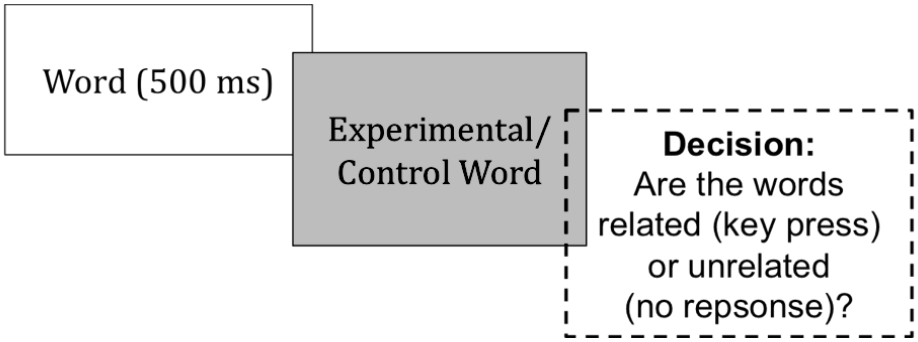

Figure 8. Trial components of the word relatedness task.

Stimuli. To identify words related to experimental words, the words comprising the semantic neighbourhoods of the experimental words were searched. The semantic neighbours were ordered according to their relatedness to the target word using a number from 0 to 1, with higher values indicating greater degrees of relatedness. I will refer to this value as the "relatedness coefficient." The semantic neighbour that was matched with each experimental word had the highest relatedness coefficient possible, while also fulfilling the following criteria, which are presented in rank order of importance:

1) Must be a noun in singular form (to match the experimental words).
2) Should be subjectively related to the experimental words.
3) Should be closely matched to the experimental word on length, frequency, and orthographic neighbourhood size.

For the control word pairs, unrelated words were selected that were matched to the control words on length, frequency, and orthographic neighbourhood size. The complete stimulus set for Experiment 6 is presented in Appendix I.

Experiment 7: Sentence Relatedness Task. For this task (see Figure 9 below), participants were presented with a short sentence, which remained on the screen for as long as needed for comprehension. They were then instructed to press the space bar, which prompted the presentation of a single (experimental or control) word. Participants were instructed to press the space bar (as quickly and as accurately as possible) if they believed the word was not related to the preceding sentence. They were instructed to do nothing if they believed the word was related to the preceding sentence, and the next trial began after 2500 ms. This way, all experimental words (corresponding to unrelated sentence-word pairs) should have produced a behavioural response, while the control words (corresponding to related sentence-word pairs) should have produced no response.

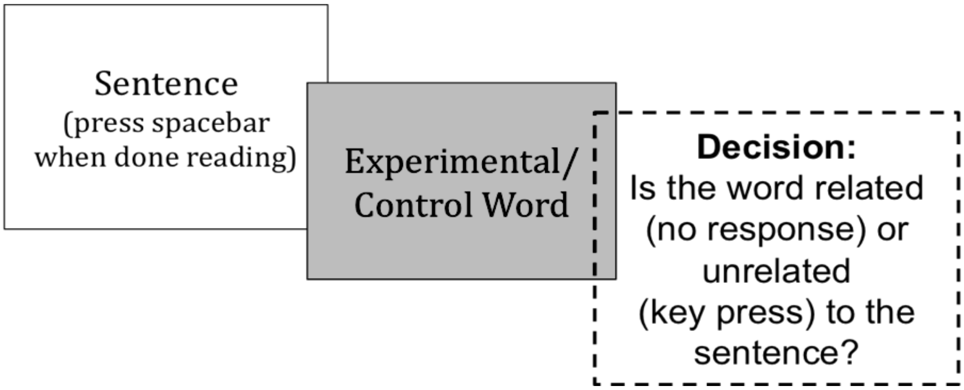

Figure 9. Trial components of the sentence relatedness task.

Stimuli. To maximize consistency between the sentences, each was formulated using the following template (see Table 5 below). Note that the subject, prepositions, and ending words for each pair of sentences are the same. Only the verbs and nouns changed in their relatedness to their matched experimental or control word. The full sentence stimulus set is presented in Appendix J.

Table 5

Template for the Go/No-Go Sentence Relatedness Task (Experiment 7) Sentence Stimuli

Sentence type	The **subject**	**related/ unrelated verb**	**preposition(s)**	**related/unrelated nouns**	**ending words**
Example sentence for control trial (matched word 'balloon')	The child	popped	the	party decorations	on the ground.
Example sentence for experimental trial (matched word: 'freezer')	The child	rolled	the	coloured marbles	on the ground.

CHAPTER 3

ANALYSIS OF RESULTS

Outlier Identification

The following procedure was used to identify outliers for all experiments. After removal of all incorrect responses, participants and stimulus items with less than 70% accuracy were excluded from subsequent statistical analyses. At this point outliers were excluded, which were defined as RTs deviating more than 2.5 standard deviations from the mean of a given word condition (i.e., concrete – low SND, concrete – high SND, abstract – low SND, abstract – high SND), after responses faster than 200 ms or slower than 3000 ms were excluded.

General Statistical Procedures

First, incorrect responses, participants and stimulus items with insufficient (<70%) accuracy rates, and outliers were removed. Then mean RTs per condition were calculated for each participant to conduct the subject analysis (F_1), and for each stimulus item to conduct the item analysis (F_2). As such, for all experiments, concreteness and SND were considered within-subject variables in the subject analysis, and as between-subject variables in the item analysis. RTs and error rates were analyzed separately. For the subject analyses, mean RTs and error rates for each condition across participants were analyzed using a within-subjects analysis of variance (ANOVA). For the item analyses, mean RTs and error rates for each condition across stimulus items were analyzed using a between-subjects ANOVA. Planned contrasts (t-tests) were also conducted to compare low and high SND means within the concrete and abstract word groups (i.e., low versus high SND concrete words; low versus high SND abstract words).

Experiment 1: Implicit Lexical Decision Task

42 University of Windsor undergraduate students participated in Experiment 1 (37 females, 4 males; mean age = 20.71 years). There were no participants or items excluded due to insufficient (<70%) accuracy rates. Using the previously described procedure for identifying outliers, 2.25% of the data were excluded across conditions. Experiment 1 mean RTs and number of errors across subjects and items per word type are displayed in Table 6 below.

Table 6

Number of Word Items, Mean RTs (with standard errors) for the Subject and Item Analyses, and Mean Number of Errors (with standard errors) for the Subject and Item Analyses in Experiment 1 (Final N=42, 0 participants excluded)

Word Type	# Word Items	Subject Mean RTs (ms)	Item Mean RTs (ms)	Subject Mean # of Errors	Item Mean # of Errors
CONCRETE					
Low SND	22	641 (14)	638 (6)	1 (0)	2 (0)
High SND	22	619 (15)	618 (5)	1 (0)	2 (0)
ABSTRACT					
Low SND	22	631 (14)	630 (6)	1 (0)	3 (0)
High SND	22	628 (14)	625 (5)	1 (0)	2 (0)

RT analysis. There was no statistically significant difference in RTs between concrete and abstract words [F_1 (1,41) = 0.01, $p = 0.93$; F_2 (1,84) = .01, $p = .92$]. However, there was a main effect of SND whereby high SND words produced faster RTs than low SND words [F_1 (1,41) = 10.72, $p < .05$, partial $\eta^2 = .21$; F_2 (1,84) = 5.12, $p < .05$, partial $\eta^2 = .06$]. There was also a significant concreteness by SND interaction [F_1 (1, 41) = 12.15, $p < .05$, partial $\eta^2 = .23$; F_2 (1, 84) = 2.00, $p < .05$, partial $\eta^2 = .06$]. Specifically, there were faster RTs for concrete – high SND words compared to concrete

– low SND words [$t_1(41) = 5.03, p < .05$; $t_2\ (42) = 2.64, p < .05$], though no such effect of SND was observed within the abstract word group [$t_1\ (41) = 0.64, p = .52$; $t_2\ (42) = 2.64, p < .05$]. Mean RTs from the subject analysis are presented in Figure 10 below.

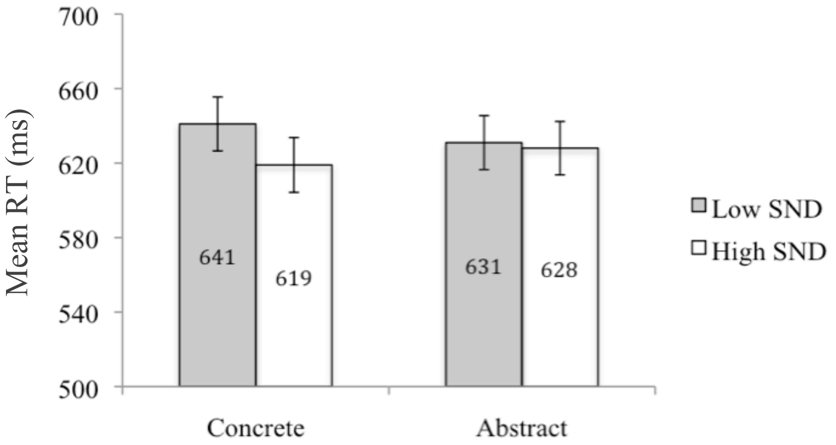

Figure 10. Experiment 1 mean RTs (subject analysis). Error bars represent standard error.

Error analysis. Analysis of mean errors rates per subject and per item indicated no statistical differences between concrete and abstract words [$F_{E1}\ (1,38) = 3.37, p = .07$; $F_{E2}\ (1,57) = 1.60, p = .21$], or between low and high SND words [$F_{E2}\ (1,38) = 0, p = 1.00$; $F_{E2}\ (1,57) = .59, p = .45$]. The interaction term was also non-significant [$F_{E1}\ (1,38) = 1.19, p = .28$; $F_{E2}\ (1,57) = .02, p = .88$].

Experiment 2: Lexical Decision Task (with Non-Pronounceable Non-Words)

40 University of Windsor undergraduate students participated in Experiment 2 (34 females, 6 males; mean age = 21.33 years). There were no participants excluded due to low accuracy rates, though responses from one abstract – low SND item (*FERVOUR*) were excluded from subsequent analyses due to low accuracy. Outliers were identified using the previously described procedure, resulting in the removal of 2.14% of the data

across conditions. Experiment 2 mean RTs and number of errors across subjects and items per word type are displayed in Table 7 below.

Table 7

Number of Word Items, Mean RTs (with standard errors) for the Subject and Item Analyses, and Mean Number of Errors (with standard errors) for the Subject and Item Analyses in Experiment 2 (Final N=40, 0 participants excluded)

Word Type	# Word Items	Subject Mean RTs (ms)	Item Mean RTs (ms)	Subject Mean # of Errors	Item Mean # of Errors
CONCRETE					
Low SND	22	691 (15)	693 (13)	1 (0)	3 (1)
High SND	22	704 (15)	706 (12)	1 (0)	2 (0)
ABSTRACT					
Low SND	21	677 (15)	679 (12)	1 (0)	2 (0)
High SND	22	749 (18)	749 (14)	1 (0)	3 (0)

RT analysis. A main effect of concreteness was obtained in the subject analysis, such that concrete words produced faster RTs than abstract words [F_1 (1, 39) = 4.82, $p < .05$, partial $\eta^2 = .11$], though this effect was not replicated in the item analysis [F_2 (1, 83) = 1. 30, $p = .26$]. Both the subject and item analyses revealed faster RTs for low SND compared to high SND words [F_1(1, 39) = 64.62, $p < .05$, partial $\eta^2 = .62$; F_2 (1, 83) = 11.01, $p < .05$, partial $\eta^2 = .12$]. There was also a significant interaction [F_1 (1, 39) = 40.00, $p < .05$, partial $\eta^2 = .51$; F_2 (1, 83) = 5.29, $p < .05$, partial $\eta^2 = .06$] whereby abstract – low SND words produced faster RTs than abstract – high SND words [t_1(39) = -10.10, $p < .05$; t_2 (41) = -3.84, $p < .05$], though there was no effect of SND within the concrete word group [t_1 (39) = -1.91, $p = .06$; t_2 (42) = -0.74, $p = .46$]. Mean RTs from the subject analysis are presented in Figure 11 below.

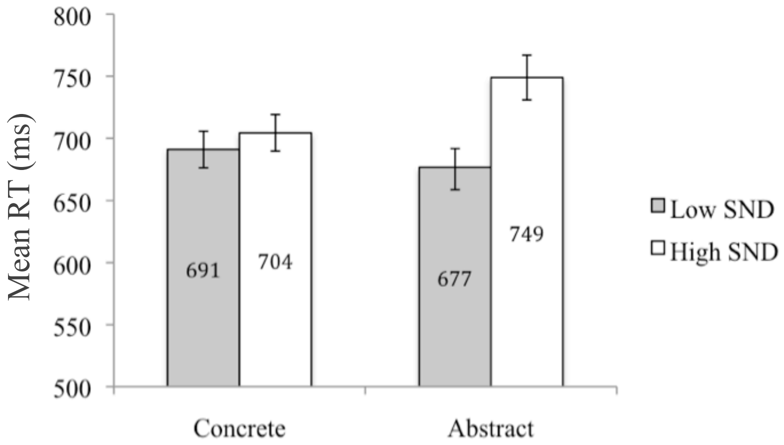

Figure 11. Experiment 2 mean RTs (subject analysis). Error bars represent standard error.

Error analysis. Analysis of mean error rates for subjects and items revealed no effect of concreteness [F_{E1} (1, 34) = 0.74, $p = .40$; F_{E2} (1, 56) = 0, $p = .99$]. Participants made more errors when responding to high SND compared to low SND words as indicated by the subject analysis [F_{E1} (1, 34) = 6.80, $p < .05$, partial $\eta^2 = .17$], though the effect was non-significant in the item analysis [F_{E2} (1, 56) = .004, $p = .95$]. Finally, the concreteness by SND interaction was non-significant [F_{E1} (1, 34) = 1.07, $p = .31$; F_{E2} (1, 56) = 2.46, $p = .12$].

Experiment 3: Go/No-Go Lexical Decision Task

41 University of Windsor undergraduate students participated in Experiment 3 (30 females, 11 males; mean age = 21.49 years). Although all participants performed with at least 70% accuracy overall, responses from one abstract – high SND word (*ACCOLADE*), one concrete – low SND word (*BAYONET*), and one abstract – low SND word (*FERVOUR*) were excluded due to insufficient accuracy. Outliers were identified using the aforementioned procedure, which resulted in the removal of 3.29% of the data

across conditions. Experiment 3 mean RTs and number of errors across subjects and items per word type are displayed in Table 8 below.

Table 8

Number of Word Items, Mean RTs (with standard errors) for the Subject and Item Analyses, and Mean Number of Errors (with standard errors) for the Subject and Item Analyses in Experiment 3 (Final N=41, 0 participants excluded)

Word Type	# Word Items	Subject Mean RTs (ms)	Item Mean RTs (ms)	Subject Mean # of Errors	Item Mean # of Errors
CONCRETE					
Low SND	21	828 (20)	827 (20)	1 (0)	3 (1)
High SND	22	840 (19)	840 (20)	1 (0)	3 (1)
ABSTRACT					
Low SND	21	829 (18)	829 (16)	1 (0)	3 (1)
High SND	21	968 (23)	966 (28)	3 (0)	5 (1)

RT analysis. Analysis of mean RTs revealed that participants responded more quickly to concrete words than to abstract words [F_1 (1, 40) = 48.24, $p < .05$, partial $\eta^2 = .55$; F_2 (1, 81) = 8.93, $p < .05$, partial $\eta^2 = .10$]. Faster RTs were also produced for low SND compared to high SND words [F_1 (1, 40) = 91.77, $p < .05$, partial $\eta^2 = .70$; F_2 (1, 81) = 12.37, $p < .05$, partial $\eta^2 = .13$]. Moreover, a significant interaction [F_1 (1, 40) = 73.87, $p < .05$, partial $\eta^2 = .65$; F_2 (1, 81) = 8.59, $p < .05$, partial $\eta^2 = .10$] revealed a differential effect of SND. For abstract words, participants responded more quickly to low SND than to high SND words [t_1 (40) = -10.32, $p <.05$; t_2 (31.839[6]) = - 4.30, $p < .05$], though no such effect of SND was evident for concrete words [t_1 (40) = -1.71, $p = .10$; t_2

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[6] Levene's test of equality of variances was significant for this comparison. As such, the degrees of freedom for the error term was adjusted accordingly.

(41) = - 0.44, p = .66]. Mean RTs from the subject analysis are presented in Figure 12 below.

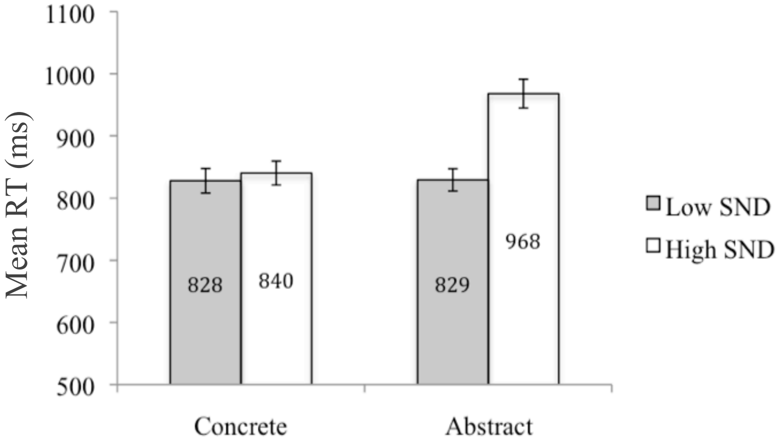

Figure 12. Experiment 3 mean RTs (subject analysis). Error bars represent standard error.

Error analysis. Analysis of mean error rates per participant revealed a pattern consistent with the RT results summarized above. Participants committed more errors when presented with abstract words than concrete words [F_{E1} (1, 33) = 23.38, $p < .05$, partial $\eta^2 = .42$], with this effect approaching significance in the item analysis [F_{E2} (1, 43) = 3.60, $p = .07$, partial $\eta^2 = .08$]. There were also more errors made in response to high SND words than to low SND words [F_{E1} (1, 33) = 14.79, $p < .05$, partial $\eta^2 = .31$], though this effect was not replicated in the item analysis [F_{E2} (1, 43) = 1.04, $p = .32$, partial $\eta^2 = .02$]. The subject error analysis revealed a significant concreteness by SND interaction [F_{E1} (1, 33) = 22.33, $p < .05$, partial $\eta^2 = .40$], whereby there were more errors for abstract - high SND words than abstract – low SND words [t_{E1} (33) = -5.01, $p < .05$], but no difference in errors between concrete – high SND and concrete – low SND words [t_{E1} (33) = -.30, $p = .77$]. However, the interaction term in the item analysis was non-significant [F_{E2} (1, 43) = 1.17, $p = .29$].

Experiment 4: Progressive Demasking Task

45 University of Windsor undergraduate students participated in Experiment 4. Complete demographic information is unavailable as some data was lost due to computer error. Two participants were excluded due to insufficient accuracy rates. Responses from one concrete – low SND word (*PRAIRIE*), one concrete – high SND word (*EMBROIDERY*), and one abstract – high SND word (*SUSTENANCE*) were excluded due to insufficient accuracy. Outliers were identified according to the previously described procedure, resulting in the removal of 2.46% of the data across conditions. Experiment 4 mean RTs and number of errors across subjects and items per word type are displayed in Table 9 below.

Table 9

Number of Word Items, Mean RTs (with standard errors) for the Subject and Item Analyses, and Mean Number of Errors (with standard errors) for the Subject and Item Analyses in Experiment 4 (Final N=43, 2 excluded)

Word Type	# Word Items	Subject Mean RTs (ms)	Item Mean RTs (ms)	Subject Mean # of Errors	Item Mean # of Errors
CONCRETE					
Low SND	21	1670 (31)	1674 (35)	1 (0)	5 (1)
High SND	21	1704 (35)	1703 (29)	2 (0)	4 (1)
ABSTRACT					
Low SND	22	1784 (37)	1784 (35)	1 (0)	4 (1)
High SND	21	1856 (42)	1852 (42)	2 (0)	4 (1)

RT analysis. Overall, concrete words were recognized more quickly than abstract words [F_1 (1, 42) = 81.14, $p < .05$, partial $\eta^2 = .66$; F_2 (1, 81) = 13.46, $p < .05$, partial $\eta^2 = .14$]. The subject analysis revealed faster RTs for low SND words compared to high SND words [F_1 (1, 42) = 22.86, $p < .05$, partial $\eta^2 = .35$], though this effect was non-significant in the item analysis [F_2 (1, 81) = 1.92,p = .17, partial η^2 = .02]. There was also a significant concreteness by SND interaction in the subject analysis [F_1 (1, 42) = 4.50, p < .05, partial η^2 =.10], whereby there was a larger effect of SND for abstract words [t_1 (42) = -4.88, p < .05] than for concrete words [t_1 (42) = -2.44, p < .05]; however, the interaction term was non-significant in the item analysis [F_2 (1, 81) = .31, p = .58]. Mean RTs from the subject analysis are presented in Figure 13 below.

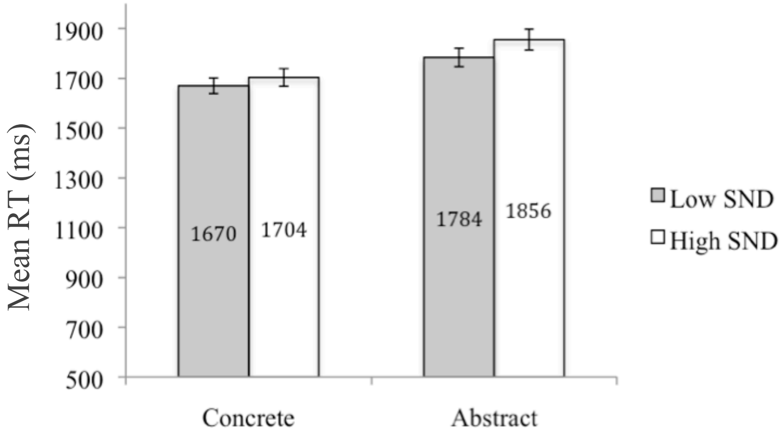

Figure 13. Experiment 4 mean RTs. Error bars represent standard error.

Error analysis. Analysis of mean error rates revealed that participants did not commit more errors as a function of concreteness [F_{E1} (1, 37) = .99, p = .33; F_2 (1, 54) = .86, p = .36]. Consistent with the slower observed RTs for high SND words, participants also made more errors in response to high SND words compared to low SND words [F_{E1} (1, 37) = 5.33, p < .05, partial η^2 = .13], though this was not observed in the item analysis [F_{E2} (1, 54) = .01, p = .93]. The concreteness by SND interaction term was non-significant in both the subject and item analyses [F_{E1} (1, 37) = 2.51, p = .12; F_{E2} (1, 54) = .36, p = .57].

Experiment 5: Concrete/Abstract Categorization Task

56 University of Windsor undergraduate students participated in Experiment 5 (46 females, 10 males; mean age = 21.46 years). All participants were at least 70% accurate in their overall performance, though responses from one abstract – low SND word (*CUISINE*), two concrete – high SND words (*AMMONIA, EMBROIDERY*), and one concrete – low SND word (*SUBTITLE*) were excluded from subsequent analyses due to insufficient accuracy rates. Outliers were identified using the previously described procedure, resulting in the removal of 5.46% of the data across conditions. Experiment 5 mean RTs and number of errors across subjects and items per word type are displayed in Table 10 below.

Table 10

Number of Word Items, Mean RTs (with standard errors) for the Subject and Item Analyses, and Mean Number of Errors (with standard errors) for the Subject and Item Analyses in Experiment 5 (Final N=56, 0 excluded)

Word Type	# Word Items	Subject Mean RTs (ms)	Item Mean RTs (ms)	Subject Mean # of Errors	Item Mean # of Errors
CONCRETE					
Low SND	21	893 (16)	900 (25)	1 (0)	5 (1)
High SND	20	937 (20)	940 (26)	1 (0)	4 (1)
ABSTRACT					
Low SND	21	1130 (28)	1116 (15)	2 (0)	6 (1)
High SND	22	1175 (31)	1158 (26)	1 (0)	4 (1)

RT analysis. Concrete words were categorized faster overall [F_1 (1, 55) = 159.9, $p < .05$, partial $\eta^2 = .74$; F_2 (1, 80) = 85.21, $p < .05$, partial $\eta^2 = .52$]. Categorization RTs were also faster for low SND words compared to high SND words in the subject analysis [F_1 (1, 55) = 18.08, $p < .05$, partial $\eta^2 = .25$] but not in the item analysis [F_2 (1, 80) =

3.05, $p = .09$, partial $\eta^2 = .04$]. The concreteness by SND interaction term was non-significant [F_1 (1, 55) = .002, $p = .96$; F_2 (1, 80) = .005, $p = .94$]. Mean RTs from the subject analysis are presented in Figure 14 below.

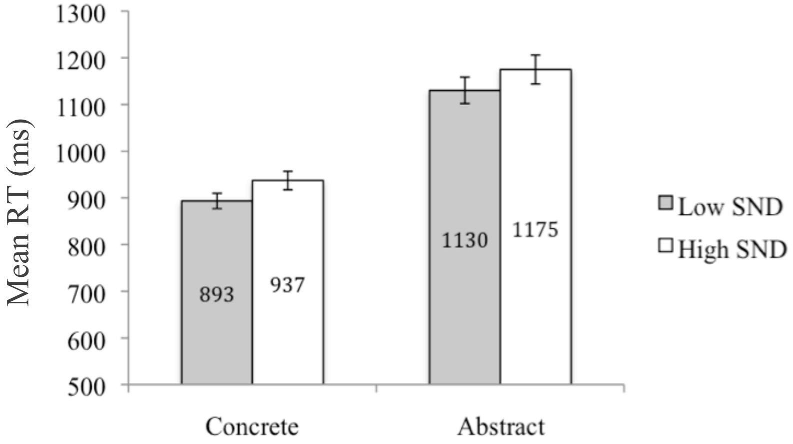

Figure 14. Experiment 5 mean RTs (subject analysis). Error bars represent standard error.

Error analysis. Consistent with the slower RTs for abstract compared to concrete words, participants also made more errors when categorizing abstract words [F_{E1} (1, 54) = 6.52, $p < .05$, partial $\eta^2 = .11$], though this finding was non-significant in the item analysis [F_{E2} (1,56) = .09, $p = .77$]. Participants made more errors in response to low SND words than high SND words as revealed by the subject error analysis [F_{E1} (1, 54) = 6.4, $p < .05$], but not the item error analysis [F_{E2} (1,56) = .58, $p = .45$]. Finally, the concreteness by SND interaction term was non-significant [F_{E1} (1, 54) = 2.50, $p = .12$; F_{E2} (1, 56) = .18, $p = .67$].

There is some indication of a speed-accuracy trade-off with the low SND words. As reported above, low SND words produced faster RTs than high SND words, though low SND words were more subject to error. As can be seen from Table 10, the abstract – low SND words are primarily driving the low SND error effect. Upon initial inspection of the abstract - low SND words that tended to generate the highest error rates (e.g., *ELEVATION, DIGESTION*), they seemed to be those that may have several close concrete semantic neighbours. It is possible that participants may have been tempted to make a speeded “concrete word” decision because of the activation of many concrete neighbors. To test this possibility, the closest 20 neighbours of the abstract – low SND words most frequently associated with error responses were examined. Indeed, these words tended to have several close concrete neighbours. For example, the word *ELEVATION* has close concrete neighbours such as *FOOTHILLS, MOUNTAINS,* and *GLACIER.* Conversely, the abstract word *COHESION,* which was only associated with a single error, has no close concrete neighbours. Examples of the closest 20 neighbours include other abstract words such as *KINSHIP, RESILIENCE,* and *STABILITY.* In sum, using this semantic categorization task, the ability to make inferences about concrete versus abstract words is complicated since participants may have been highly influenced by the presence of concrete semantic associates in making their “concrete” versus “abstract” word decisions.

Experiment 6: Word Relatedness Task

73 University of Windsor undergraduate students participated in Experiment 6 (52 females, 21 males; mean age = 21.21 years). Responses from 12 participants were excluded due to insufficient accuracy rates[7]. Additionally, responses from 12 abstract –

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[7] It should be noted that for Experiments 6 and 7, the terms ‘errors’ and ‘response accuracy’ will be discussed in a similar manner to the previous experiments. However, given that the stimulus sets used for these experiments were developed to study the relatedness judgments between words (or words and sentences), ‘errors’ on these tasks are more akin to differences in opinion between how I and the participants perceive the relationship between words. That is, I may judge two words as being related, but certain participants may not. Although I may refer to these differing participant responses as ‘errors’ for the purposes of this paper, they are not ‘errors’ in an absolute sense.

high SND words (*ACCOLADE, ANGUISH, ASYMMETRY, DETERRENT, DISCORD, EVICTION, FIXATION, GESTATION, IMPURITY, PENANCE, PRUDENCE, VACANCY*), 4 abstract – low SND words (*ACCLAIM, ADORATION, FERVOUR, FIDELITY*), 3 concrete – high SND words (*AMMONIA, BAZOOKA, FLAMINGO*) and 2 concrete – low SND words (*BAYONET, STYROFOAM*) were excluded due to low accuracy rates across participants. Outliers were identified using the previously described procedure, resulting in the removal of 3.44% of the data across conditions. Experiment 6 mean RTs and number of errors across subjects and items per word type are displayed in Table 11 below.

Table 11

Number of Word Items, Mean RTs (with standard errors) for the Subject and Item Analyses, and Mean Number of Errors (with standard errors) for the Subject and Item Analyses in Experiment 6 (Final N=61, 12 excluded)

Word Type	# Word Items	Subject Mean RTs (ms)	Item Mean RTs (ms)	Subject Mean # of Errors	Item Mean # of Errors
CONCRETE					
Low SND	20	748 (13)	748 (20)	1 (0)	3 (1)
High SND	19	766 (14)	776 (28)	1 (0)	7 (2)
ABSTRACT					
Low SND	18	844 (16)	855 (25)	2 (0)	6 (1)
High SND	10	884 (19)	886 (31)	1 (0)	8 (2)

RT Analysis. Participants responded more quickly to concrete than abstract words [F_1 (1, 60) = 167.26, $p < .05$, partial $\eta^2 = .74$; 16.50, $p < .05$, partial $\eta^2 = .21$]. RTs were also quicker for low SND than high SND words in the subject analysis [F_1 (1, 60) = 13.44, $p < .05$, partial $\eta^2 = .18$], though this effect was non-significant in the item analysis [F_2 (1, 63) = 1.24, $p = .27$]. The concreteness by SND interaction was non-significant [F_1

(1, 60) = 2.11, $p = .15$; F_2 (1, 63) = .01, $p = .95$]. Mean RTs from the subject analysis are presented in Figure 15 below.

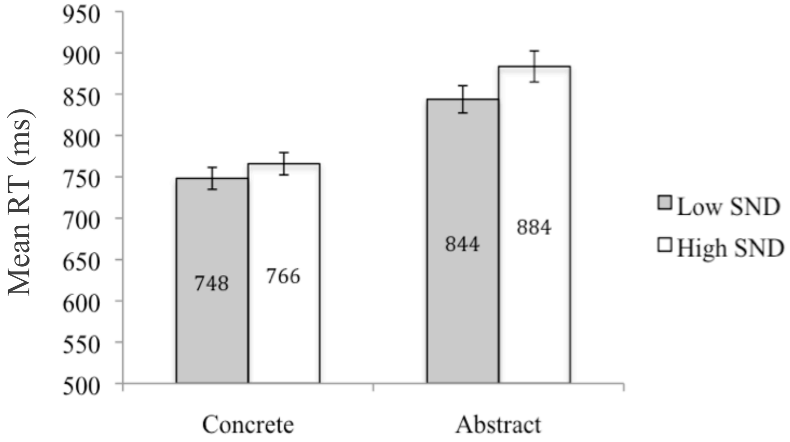

Figure 15. Experiment 6 mean RTs (subject analysis). Error bars represent standard error.

Error Analysis. Analysis of mean error rates revealed that participants did not commit errors as a function of concreteness [F_{E1} (1, 58) = 3.28, $p = .08$; F_{E2} (1, 49) = 2.80, $p = .10$] or SND [F_{E1} (1, 58) = .03, $p = .86$; F_{E2} (1, 49) = 3.74, $p = .06$]. The concreteness by SND interaction was significant in the subject error analysis [F_{E1} (1, 58) = 9.10, $p < .05$, partial $\eta^2 = .14$] but not in the item error analysis [F_{E2} (1, 49) = .55, $p = .46$]. Specifically, analysis of mean error rates per subject indicate that for concrete words, there were more errors for high SND than low SND words [t_{E1} (58) = -2.72, $p < .05$], though there was no such difference for abstract words [t_{E1} (58) = 1.74, $p = .09$].

Experiment 7: Sentence Relatedness Task

41 University of Windsor undergraduate students participated in Experiment 7 (35 females, 6 males; mean age = 20.12 years). Responses from one participant were excluded due to low overall accuracy. Across participants, all items had response

accuracy rates of at least 70%. Outliers were identified using the previously described procedure, resulting in the removal of 3.10% of the data across conditions. Experiment 7 mean RTs and number of errors across subjects and items per word type are displayed in Table 12 below.

Table 12

Number of Word Items, Mean RTs (with standard errors) for the Subject and Item Analyses, and Mean Number of Errors (with standard errors) for the Subject and Item Analyses in Experiment 7 (Final N = 40, 1 participant excluded)

Word Type	# Word Items	Subject Mean RTs (ms)	Item Mean RTs (ms)	Subject Mean # of Errors	Item Mean # of Errors
CONCRETE					
Low SND	22	892 (25)	888 (15)	1 (0)	3 (1)
High SND	22	885 (23)	883 (14)	0 (0)	1 (0)
ABSTRACT					
Low SND	22	952 (29)	946 (15)	1 (0)	2 (0)
High SND	22	994 (30)	986 (14)	1 (0)	3 (1)

RT Analysis. Participants responded more quickly to concrete than abstract words [F_1 (1, 39) = 84.26, $p < .05$, partial $\eta^2 = .68$; F_2 (1, 84) = 31.14, $p < .05$, partial $\eta^2 = .27$]. RTs were faster for low SND compared to high SND words in the subject analysis [F_1 (1, 39) = 5.04, $p < .05$, partial $\eta^2 = .11$], though this effect was non-significant in the item analysis [F_2 (1, 84) = 1.45, $p = .23$]. The concreteness by SND interaction was also significant in the subject analysis [F_1 (1, 39) = 7.92, $p < .05$, partial $\eta^2 = .17$] but not in the item analysis [F_2 (1, 84) = 2.51, $p = .12$]. The significant subject analysis interaction revealed that for abstract words, low SND words had faster RTs than high SND words [t_1 (39) = -3.40, $p < .05$], though there was no effect of SND for concrete words [t_1 (39) = .56, $p = .58$]. Mean RTs from the subject analysis are presented in Figure 16 below.

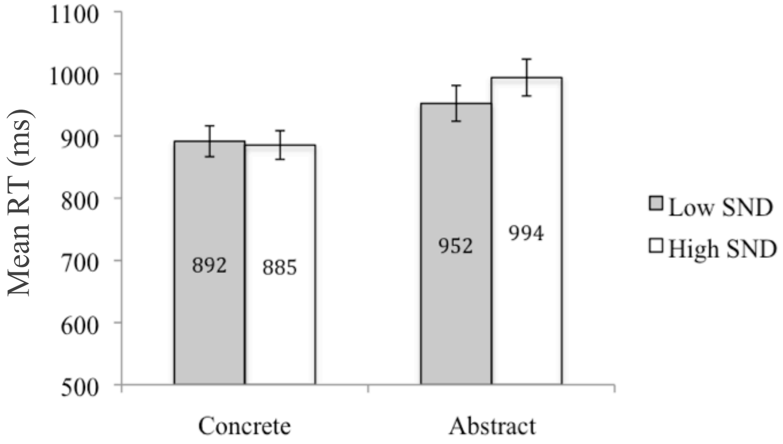

Figure 16. Experiment 7 mean RTs (subject analysis). Error bars represent standard error.

Error Analysis. Consistent with the finding that abstract words had slower RTs than concrete words, abstract words also produced higher error rates than concrete words overall in the subject analysis [F_{E1} (1, 28) = 6.65, $p < .05$, partial $\eta^2 = .19$] but not in the item analysis [F_{E2} (1, 41) = .65, $p = .43$]. There was no significant difference in error rates between low and high SND words [F_{E1} (1, 28) = 2.56, $p = .12$; F_{E2} (1, 41) = .17, $p = .68$). The subject analysis revealed a concreteness by SND interaction [F_{E1} (1, 28) = 7.12, $p < .05$, partial $\eta^2 = .20$], such that participants made more errors for concrete – low SND words than for concrete – high SND words [t_{E1} (28) = 3.54, $p < .05$], though there was no such effect for abstract words [t_{E1} (28) = -.70, $p = .49$]. However, the interaction term was non-significant in the item analysis [F_{E2} (1, 41) = 3.00, $p = .09$].

A summary of all subject RT results from Experiments 1 to 7 is provided in Table 13 below.

Table 13

Summary of Task Instructions, Hypotheses, and Results for All Experiments

Experiment		**Task Instructions**	**Hypotheses**	**Hypotheses Supported?**
1	Implicit Lexical Decision Task	After viewing a word, indicate (with a key press) which of two words (left or right) is the real word.	▪ ***1a:*** Slower RTs for concrete words (due to stronger inhibition of concrete relative to abstract representations) ▪ ***1b:*** Effect of SND for concrete words only (Stage 2 semantics necessary for full abstract word processing is inhibited)	▪ ***1a:*** Yes (no concreteness effect) ▪ ***1b:*** Yes
2	Lexical Decision task (non-pronounceable non-words)	Indicate (with a key press) whether the word is a real word or a non-word.	▪ ***2a:*** Concrete words faster than abstract (due to stronger Stage 1 activation for concrete words) ▪ ***2b:*** Effect of SND for concrete words only (or only minimal effect of SND for abstract words) because Stage 1 semantics should be sufficient without progression to Stage 2	▪ ***2a:*** Yes ▪ ***2b:*** No (There was a greater effect of SND for abstract words)
3	Go/No-Go Lexical Decision Task	Only respond (with a key press) when a real word is presented. Do not respond when presented with a non-word.	▪ ***3a:*** Concrete words faster than abstract (due to stronger Stage 1 activation for concrete words) ▪ ***3b:*** Larger effect of SND for abstract than concrete words (due to more effortful processing at Stage 2 semantics)	▪ ***3a:*** Yes ▪ ***3b:*** Yes
4	Progressive Demasking Task	Respond (with a key press) when you can recognize the word.	***Hypothesis 4a***: ▪ Concrete words faster than abstract (due to emphasis is on Stage 1 semantics, and stronger activation for concrete words at Stage 1) ▪ Greater effect of SND for concrete words (due to emphasis on Stage 1 semantics) OR	▪ ***4a:*** No

	Experiment	Task Instructions	Hypotheses	Hypotheses Supported?
4	Progressive Demasking Task	Respond (with a key press) when you can recognize the word.	***Hypothesis 4b***: ▪ Concrete words faster than abstract (due to emphasis is on Stage 1 semantics, and stronger activation for concrete words at Stage 1) ▪ Greater effect of SND for abstract words (due to progression to Stage 2 semantics because of prolonging of visual word recognition)	▪ ***4b:*** Yes
5	Concrete/ Abstract Categorization Task	Indicate (with a key press) whether the word is a concrete or an abstract word.	▪ ***5a:*** Faster RTs for abstract words	▪ ***5a:*** No (There were faster RTs for concrete words)
			▪ ***5b:*** An effect of SND for abstract words only (due to emphasis on Stage 2 processing, behavioural effects of Stage 1 – which show an advantage for concrete words – are masked)	▪ ***5b:*** No (There was no concreteness by SND interaction)
6	Go/No-Go Word Relatedness Task	Only respond (with a key press) when a word is related by meaning to the preceding word. Do not respond when a word is unrelated to the preceding word.	▪ Experiments 6 and 7 were exploratory tests conducted to test the applicability of the Flexible Semantic Processing Hypothesis to contextualized or multi-word stimuli. No specific hypotheses were offered.	
7	Go/No-Go Sentence Relatedness Task	Only respond (with a key press) when a word is related by meaning to the preceding sentence. Do not respond when a word is unrelated to the preceding sentence.		

CHAPTER 4

DISCUSSION

The main objective of this study was to chart the flexibility of semantic processing by comparing word recognition RTs of words varying in concreteness and SND across a series of tasks varying in their degree of explicit semantic demands. It has been suggested (Pexman et al., 2007; Yap et al., 2012) that semantic effects are more directly examined using tasks that explicitly require participants to process meaning compared to those for which the processing of semantics is not necessary (e.g., lexical decision task; Hino & Lupker, 1996). However, according to recent research by Danguecan and Buchanan (2014), semantic effects may be revealed using a range of tasks varying in the degree of explicit semantic processing required. Based on data from three tasks (letter detection task, lexical decision task, semantic categorization task), they developed a working model of semantic processing called the *Flexible Semantic Processing Hypothesis*, which proposes two stages of semantic processing: a task-independent stage followed by a task-dependent stage. Broadly speaking, this model proposes that semantic processing unfolds in a flexible and cascaded manner in different ways for concrete and abstract words. The behavioural effects of concreteness and SND were measured to examine different stages of semantic processing in the context of three different tasks (letter detection task, lexical decision task, semantic categorization task).

Examining the Flexible Semantic Processing Hypothesis

According to the initially hypothesized version of the Flexible Semantic Processing Hypothesis, there are at least two stages of semantic processing. Stage 1 was believed to measure task-independent semantic processes involving spreading activation of related concepts. At this stage, concrete words were believed to have an advantage over abstract words. Progression to Stage 2 semantics was believed to occur when explicit semantic processing is useful for the task, and involves more elaborated meaning processing than at Stage 1. Importantly, Stage 2 semantics may be inhibited when explicit meaning processing is not helpful for the task. Furthermore, it was hypothesized that abstract words have an advantage over concrete words at Stage 2. Progression through each of the stages within the Flexible Semantic Processing Hypothesis (as illustrated in Figure 2) occurs as a function of three different (task-dependent) paths, representing the results of the Danguecan and Buchanan (2014) experiments.

To more precisely test the hypothesis that semantic effects are better captured by “more semantic” tasks, as well as the tenets of the Flexible Semantic Processing Hypothesis, the present study used a greater range of tasks than those used in the Danguecan & Buchanan (2014) study. To test the potential impact of concreteness and SND in a presumably “non-semantic task”, the implicit lexical decision task (Experiment 1) involved directing attention away from semantic processing of the experimental words. Moreover, there were tasks for which semantics was presumed to be useful but not necessary (Experiment 2: lexical decision task with non-pronounceable non-words; Experiment 3: go/no-go lexical decision task), tasks for which word identification was required (Experiment 4: progressive demasking task), and tasks for which explicit meaning processing was required (Experiment 5: concrete/abstract categorization task; Experiment 6: word relatedness task; Experiment 7: sentence relatedness task). Importantly, the current study used both conventional tasks from previous psycholinguistic studies (lexical decision task, concrete/abstract categorization task, progressive demasking task), as well as novel tasks (implicit lexical decision task, word relatedness task, sentence relatedness task) that were designed to more precisely evaluate the behavioural effects of concreteness and SND.

Broadly speaking, the task-specific results of the present study can be grouped based on whether semantics was assumed to be useful for completing the task or not. Specifically, the implicit lexical decision task (Experiment 1) was the only task requiring direction of attention away from the experimental words to produce a response, whereas semantics was presumed to at least by somewhat (indirectly) useful for producing a response in the other tasks[8]. Indeed, Experiments 2 to 7 produced the same general RT pattern, whereas the implicit lexical decision task (Experiment 1) produced a different RT pattern. To capture this broad distinction in the data, I will refer to the Experiment 1 implicit lexical decision task as a “semantic-negative” task (to reflect the lack of usefulness of semantics), whereas the tasks from Experiments 2 to 7 will be referred to “semantic-positive” tasks (to reflect the usefulness of semantics). The general differences in RT patterns between semantic-negative and semantic-positive tasks are depicted in Figure 17 below.

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[8] Recall that semantics is hypothesized to facilitate responding in the lexical decision task through feedback activation from semantic to orthographic representations (e.g., Hino & Lupker, 1996). Therefore, the lexical decision task is not believed to directly evaluate semantic effects.

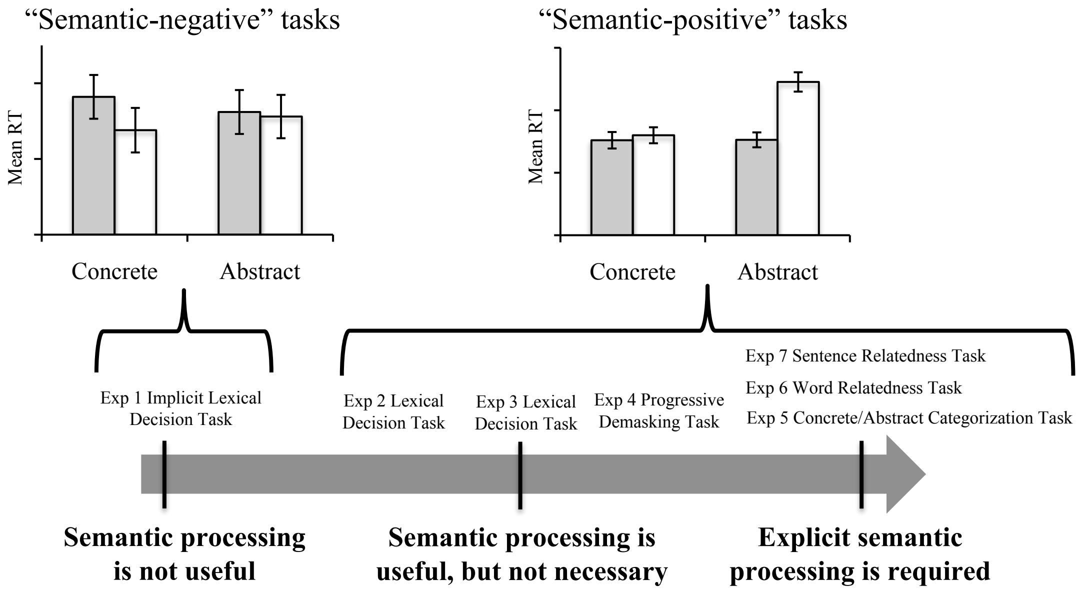

Figure 17. General subject RT patterns for semantic-negative versus semantic-positive tasks.

To aid in the following discussion, mean subject RTs for all experiments are presented in Figure 18 below. Within the semantic-positive tasks (Experiments 2 to 7), finer grained distinctions between tasks did not produce differences in RT patterns as initially hypothesized. That is, the pattern of RTs was the same for the lexical decision task (Experiment 2) and the sentence relatedness task (Experiment 7), even though the sentence relatedness task presumably required much more explicit semantic processing than the lexical decision task (for which participants only had to distinguish between real words and non-pronounceable non-words). The fact that the implicit lexical decision task (Experiment 1) was the only task to produce a different pattern of RTs suggests that this task employs semantics in a critically distinct manner relative to the other tasks in this study.

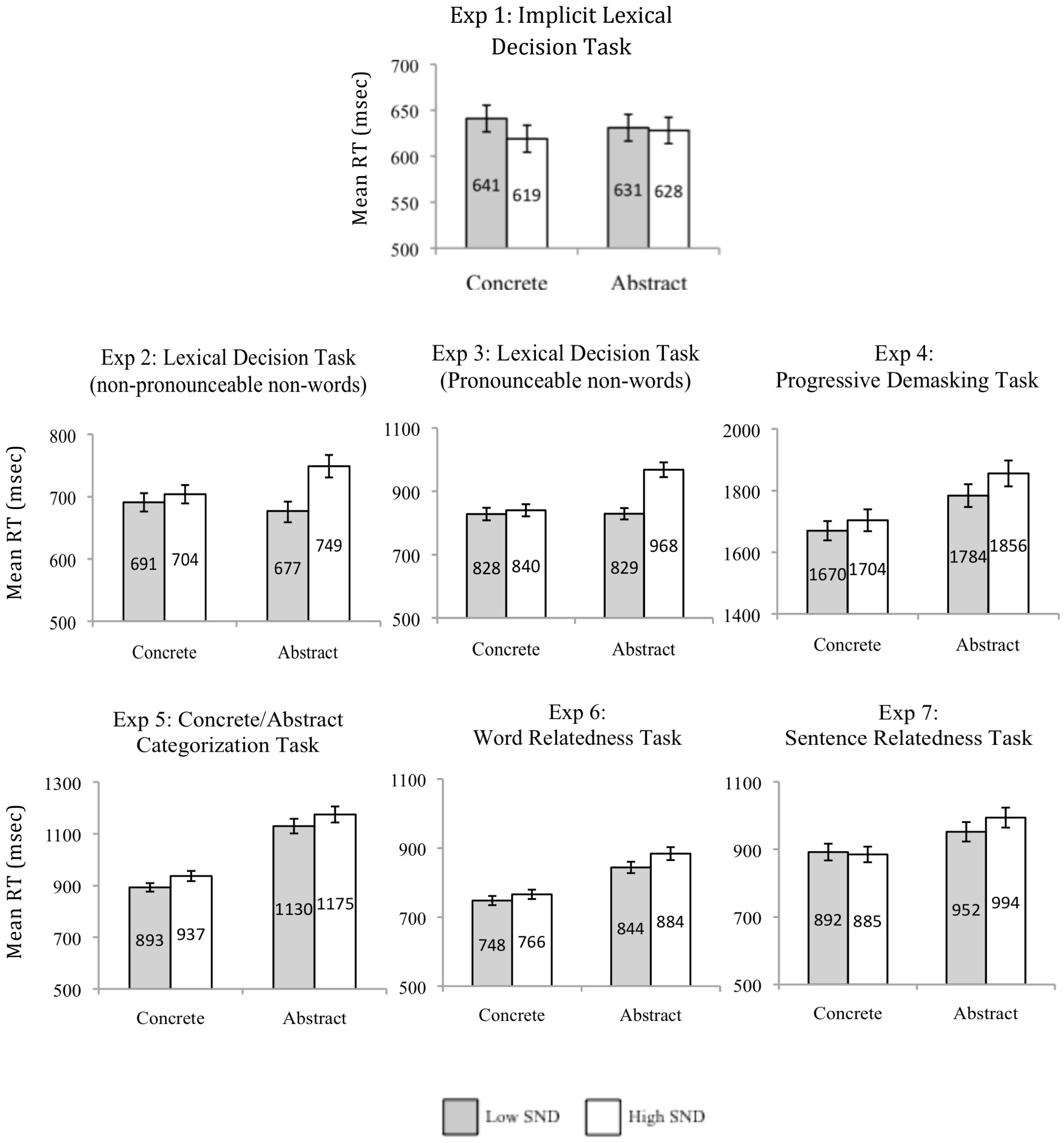

Figure 18. Subject mean RTs for experiments 1 to 7.

Based on the current study data, I propose that the number of pathways involved in the Flexible Semantic Processing Hypothesis can be reduced from three to two: one path to represent tasks for which semantics is not useful (i.e., semantic-negative tasks), and another path to represent tasks for which semantics is at least somewhat useful (i.e., semantic-positive tasks).

The proposal that Stage 2 semantics involves *explicit* meaning processing was challenged by the results of Experiment 2 (lexical decision task with non-pronounceable non-words). According to the initial tenets of the Flexible Semantic Processing Hypothesis, there should have been an effect of SND for concrete (but not abstract) words in Experiment 2 because explicit (Stage 2) semantic processing should not have been necessary to differentiate between non-pronounceable letter strings and real words. Recall that under such conditions, participants are believed to rely on orthographic information to make a real word or non-word decision (i.e. does this look like a word?). However, there was an effect of SND for abstract (but not concrete) words in Experiment 2, similar to the pattern seen in Experiment 3 for which at least some explicit semantic processing was required to differentiate real words from meaningless (but pronounceable) letter strings. This pattern of data suggests that Stage 2 semantics may be broader in scope, and not exclusive to *explicit* meaning processing. Rather, the processes involved in Stage 2 may reflect more elaborate, strategy-driven semantic processing that occurs when meaning processing of words is helpful *in any way*. Although the RT patterns from Experiments 2 and 3 were the same, overall RTs were faster for Experiment 2, suggesting that participants found this task easier. Therefore, the extent of processing within Stage 2 is believed to occur as a function of the depth of semantic processing required.

Another tenet of the originally proposed Flexible Semantic Processing Hypothesis is that abstract words should have an advantage over concrete words at Stage 2 semantics. This was hypothesized based on the (food/beverage) semantic categorization task used by Danguecan and Buchanan (2014), for which abstract words produced faster RTs than concrete words overall, and for which SND effects were only observed for abstract words. However, in the semantic categorization task used in the present study (Experiment 5; for which participants had to differentiate between concrete and abstract words), concrete words produced faster RTs overall, and SND effects were observed for both concrete and abstract words with no interaction. These divergent findings from the same task in different studies suggest that RT patterns from semantic categorization tasks are at least partly dependent on the decision category selected. Therefore, resulting RTs may be more of a reflection of strategy-driven processes rather than true semantic effects. Given the variability of results produced by the semantic categorization task in the current study versus that used by Danguecan & Buchanan (2014), a revised tenet of the Flexible Semantic Processing Hypothesis is that abstract words undergo more extensive processing than concrete words at Stage 2 semantics, though they do not have an *advantage* per se over concrete words.

The revised Flexible Semantic Processing Hypothesis may be summarized as per the following tenets, and is illustrated in Figure 19 below.

- There are (at least) two major stages of semantic processing. Stage 1 semantics involves task-independent conceptual activation of a target word, which includes automatic spread of activation to meaning-related concepts. Stage 2 processing is task-dependent and involves more elaborate semantic activation than at Stage 1. These more elaborate Stage 2 semantic processes may include retrieval of semantic dimensions (e.g., contextual information), and these processes are generally believed to be more effortful for abstract than concrete words

(Schwanenflugel & Shoben, 1983; Binder et al., 2005; Fiebach & Friederici, 2004; Jessen et al., 2000; Noppeney & Price, 2004; Perani et al., 1999).

- Complete progression from Stage 1 to Stage 2 semantics occurs for semantic-positive tasks but not semantic-negative tasks. A description of these different pathways is provided below:
    - <u>Semantic-negative tasks</u> (dotted line in Figure 19): There is initial (Stage 1) semantic activation, though these activated representations need to be suppressed in order to allow participants to focus on non-semantic task demands. In the case of Danguecan and Buchanan's (2014) letter detection task, participants were instructed to focus on letter-level features of words. In the implicit lexical decision task of the present study, participants were instructed to direct their attention away from the first word in each trial in order to make a lexical decision to semantically unrelated letter strings. This suppression is represented by the path diverting away from pre-Stage 2 semantics towards orthography.
    - <u>Semantic-positive tasks</u> (solid line in Figure 19): Following initial (Stage 1) semantic activation, participants proceed to Stage 2 semantics if at least some semantic processing is useful for the task. If the task *does not* require explicit semantic processing to make a decision (e.g., lexical decision task, progressive demasking task), then semantic information is believed to be only indirectly helpful through providing feedback to orthography. This semantic feedback is illustrated by the path from Stage 2 semantics to orthography. If the task *does* require explicit semantic processing to make a decision (e.g., sentence relatedness task), then feedback to orthography is not necessary, and the participant is able to make a response following Stage 2 semantics.
- Stage 1 semantics is believed to sufficient for linguistic processing of concrete words, whereas abstract words require the kind of elaborated semantic processing that occurs at Stage 2 semantics. SND effects are strongest for concrete words at Stage 1 and strongest for abstract words at Stage 2.

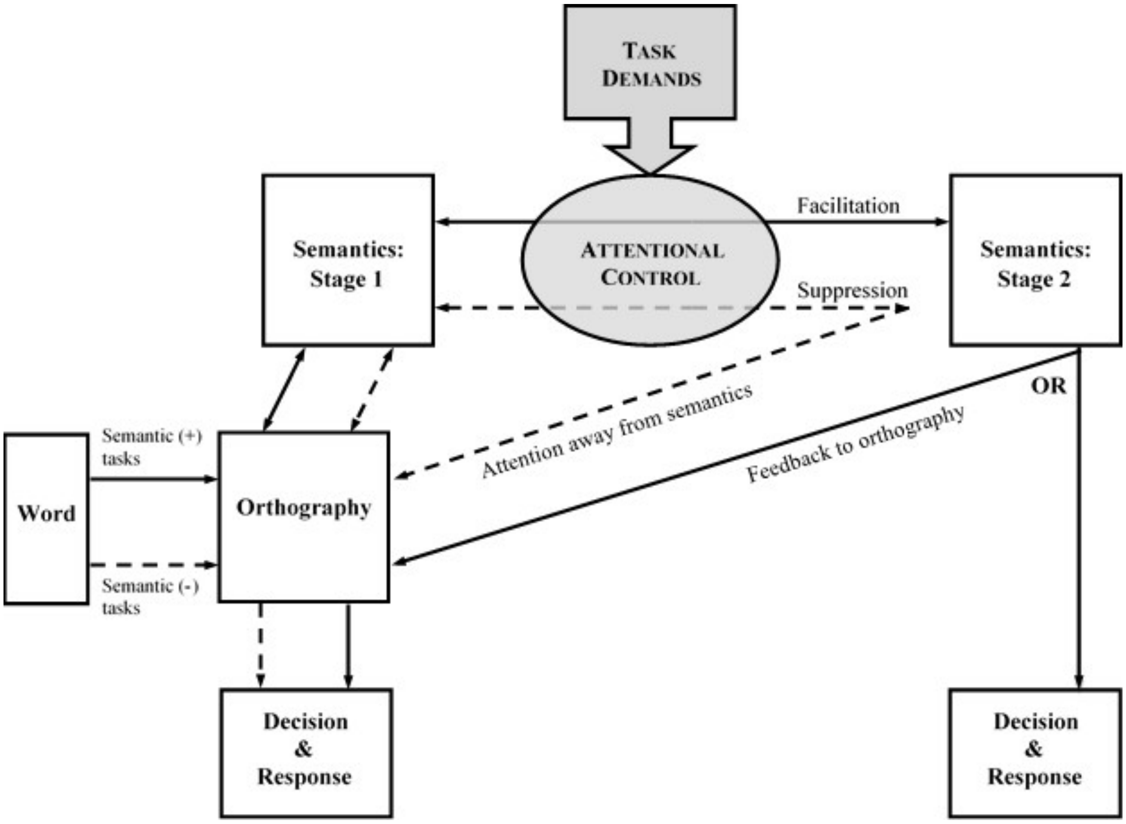

Figure 19. Revised Flexible Semantic Processing Hypothesis.

Semantic-Negative versus Semantic-Positive Tasks

The broad distinction in RT patterns for semantic-negative and semantic-positive tasks will form the basis of the following discussion.

Semantic-negative tasks. In Experiment 1 (implicit lexical decision task), the resulting RT pattern was similar to that produced by the letter detection task conducted by Danguecan and Buchanan (2014). Recall that in both the implicit lexical decision task and the letter detection task, semantic processing of the experimental words was not believed to be useful to the task decision. However, the implicit lexical decision task is believed to be a methodological improvement over the letter detection task in that there is no working memory component; that is, the participant did not have to keep the experimental word in mind in order to make a decision. In both of these tasks, the resulting RT main effects were contrary to those from previous investigations of concreteness and SND. Specifically, there was no concrete word advantage and low SND words were slower than high SND words. Interestingly, there was also a significant interaction whereby there was an effect of SND for concrete words only.

As briefly discussed in the *Introduction*, one plausible explanation for these findings is that the data from the letter detection task and the implicit lexical decision task are revealing suppression effects in semantic processing. Specifically, there may have been initial conceptual activation of the experimental words; however, because efficient performance on these tasks ultimately required attention away from the semantic features of the experimental words, participants were required to actively suppress any early semantic activation. This type of activation-suppression account is not new to psycholinguistics, and has previously been discussed in the semantic priming literature to explain the *Prime Task Effect* (Meyer, Schvaneveldt, & Ruddy, 1975; reviewed, e.g., Maxfield, 1997). Typically, in studies of semantic priming, word recognition (e.g., lexical decision) responses are facilitated for (target) words initially preceded by semantically related words (primes) as compared to when they are preceded by semantically unrelated primes. For example, the target word *DOCTOR* would be recognized faster if it were preceded by the prime word *NURSE* than if it were preceded by the prime word *BUTTER*. However, studies on the prime task effect have found that there is an absence of semantic priming (i.e., no response facilitation) when a letter search task is done on the prime word prior to lexical decision on the target word. The activation suppression account (Maxfield, 1997) proposes that initial semantic spread of activation occurs for the prime word, but that this activation is then actively suppressed due to the non-semantic nature of the prime task, resulting in null priming effects. These null or reduced priming effects are often observed in behavioural data, but ERP indices of semantic processing are preserved, lending support to the idea that semantic activation occurs during letter search in prime task effect studies (Mari-Beffa, Valdes, Cullen, Catena, & Houghton, 2005; Cinel, Avons, & Russo, 2010; Maxfield, 1997; Kuper & Heil, 2010).

Importantly, the activation-suppression explanation of the prime task effect suggests that there is an initial task-independent stage of semantics followed by a task-dependent stage, consistent with the proposed Flexible Semantic Processing Hypothesis. To apply an activation-suppression explanation to the letter detection task and the implicit lexical decision task, it is also necessary to assume that words require varying degrees of suppression depending on their ease of processing under conditions of normal reading. Said another way, words that are typically the easiest to process should require the most suppression. Based on previous research on the concreteness effect (reviewed, e.g., Paivio, 1991) and SND (Buchanan et al., 2001; Macdonald, 2013), it is reasonable to assume that concrete-low SND words should be the easiest to process because concrete words and low SND words are generally recognized faster than abstract words and high SND words, respectively. Assuming that concrete-low SND words required the most suppression, it makes sense that they produced the slowest RTs of all the word conditions in both the letter detection and implicit lexical decision tasks.

Generally speaking, in the psycholinguistic literature semantic effects are usually investigated using tasks for which semantic processing is at least somewhat useful.

However, using semantic-negative tasks can be useful for studying the dynamic and flexible nature of semantic processing. Indeed, data from both the letter detection and implicit lexical decision tasks show how the direction of semantic effects may be impacted by task demands.

Semantic-positive tasks. Examination of the tasks for which semantics was presumed to be useful (Experiment 2 to 7) revealed that concrete words consistently produced faster RTs than abstract words. This finding is in keeping with most research comparing these two word types (reviewed, e.g., Paivio, 1991) and suggests that concrete word representations possess qualities that make them easier to process compared to abstract words. However, it is unlikely that this difference can be attributed to abstract words having relatively impoverished semantic representations (as dual coding theory or context availability theory would suggest). In most cases (Experiments 2, 3, 4, 7), there was also a significant interaction whereby abstract (but not concrete) words produced an effect of SND such that abstract-low SND words were recognized faster than abstract-high SND words. If abstract concepts were simply less semantically rich than concrete concepts, one might expect that concrete (but not abstract) words would show effects of SND. Consistent with the results from the present study, Recchia and Jones (2012) found that a variable similar to SND was also able to significantly predict RTs in a lexical decision task. This finding was replicated in the current lexical decision data (Experiments 2 and 3), as well as extended within the context of several other tasks requiring varying amounts of semantic processing (i.e., Experiment 4: progressive demasking task; Experiment 7: sentence relatedness task).

In Experiments 5 and 6 there were SND effects for both concrete and abstract words. However, it is argued that task-related biases (Experiment 5) and disproportionately high error rates (Experiment 6) may account for these findings. In the concrete/abstract categorization task (Experiment 5), participants were instructed to decide whether a word was concrete or abstract. Although this decision appears neutral (unbiased towards concrete or abstract words), abstract words are more easily defined in relation to concrete words. Therefore, in the instructions for this task, participants were told that abstract words are concepts that lack tangible visual-spatial properties. As such, it is likely that participants' task decisions were slightly biased towards making a "concrete" versus "not concrete" decision, possibly making the concrete word category especially sensitive to detecting SND effects as compared to the other experiments. Moreover, there was a speed/accuracy trade-off detected in Experiment 5, which make the data complicated to interpret. In Experiment 6 (word relatedness task), it is possible that the effects of SND for abstract words may have been somewhat masked or attenuated because many abstract words were excluded from statistical analyses due to poor accuracy rates.

The Linguistic Complexity of Abstract Concepts

Abstract words and linguistic associations. The general finding that abstract (but not concrete) words often produced effects of SND suggests that linguistic associative information is more critical for abstract than for concrete concepts[9]. This conclusion is consistent with the theory of embodied abstract semantics (Vigliocco et al.,

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[9] Recall that SND values for words are calculated based on co-occurrence statistics between words in large samples of printed text, and thus captures linguistic associative information.

2009; Kousta et al., 2011), which states that linguistic associative information (of the type captured by SND) primarily underlies abstract representations, whereas sensorimotor information is more important for concrete representations. The different representational framework hypothesis (Crutch & Warrington, 2005) makes a similar argument regarding the abstract/concrete distinction in that it states that shared linguistic context (semantic association) is more important for abstract concepts, whereas concrete concepts are primarily organized by semantic similarity (i.e., same category, shared physical features). By virtue of the fact that SND captures large-scale co-occurrence patterns from human samples of language usage, it is able to reflect the semantic complexity of a concept beyond that which can be reflected based on sensorimotor properties alone. Therefore, I propose that the SND effects typically demonstrated by abstract (but not usually concrete) words in the present study are indicative of the greater semantic complexity of abstract words relative to concrete words.

Neuroimaging evidence of abstract concept complexity. Recent neuroimaging studies support the idea that abstract representations are more semantically diverse than concrete ones. For example, using fMRI, Pexman et al. (2007) found that abstract words produced more extensive cortical activation than concrete words in the context of a semantic categorization task. Moreover, using a combination of EEG and MRI methods, Moseley et al. (2013) found that in multi-modal/associative brain regions (i.e., dorsolateral prefrontal cortex, temporal pole, angular gyrus) abstract words evoked similar levels of activation to action and object (concrete) words. Furthermore, although action and object words were primarily linked to specific brain regions (the frontal motor/pre-motor areas and the posterior visual cortex, respectively), abstract words were not associated with activation in any singular brain region. The findings from these investigations suggest that abstract representations are neurologically represented by widespread connections between an array of regions. In fact, by looking at the neighbours of concrete versus abstract words generated by WINDSORS, one can imagine why abstract concepts would require more extensive cortical activation than concrete ones. For example, the nearest neighbours for the concrete stimulus word *DEODORANT* are other concrete words with circumscribed meanings such as *SHAMPOO* and *AFTERSHAVE*. In contrast, the nearest neighbours for the abstract stimulus word *MASTERY* include other abstract words such as *SKILL* and *DEXTERITY*, whose meanings would conceivably require complex associations with a network of other concepts. The above-summarized neuroimaging findings are also consistent with the idea that abstract representations are typically acquired by generalizing across divergent examples illustrating a given concept (Moseley et al., 2013). For example, the meaning of the word *BRAVERY* may be represented by a combination of exemplars (e.g., a firefighter, someone battling cancer, a war veteran), all of which are associated with a wide variety of object-based and language-based features that contribute to the meaning of the abstract concept *BRAVERY.*

Theoretical support for abstract concept complexity. The proposed relative complexity of abstract representations is also supported by theoretical frameworks such as perceptual symbol systems (Barsalou, 1999; Barsalou & Wiemer-Hastings, 2005). Recall that this theory advocates for a common semantic system for concrete and abstract representations, given that both are activated by means of sensorimotor simulations. Although situational content is believed to be a feature of both word types, the situational content of concrete words primarily involves physically circumscribed objects within a specific context, whereas a diverse array of physical, introspective, and social events often characterizes abstract words. Given the extent of integration across content areas that would be necessary for a coherent abstract representation, it seems reasonable that widespread activation across various association areas would also be necessary at a neuroanatomical level to activate these words. Furthermore, adaptations of the hub and spoke model may explain the imaging findings of Pexman et al. (2007) and Moseley et al. (2013). For example, Binder and Desai (2011) propose that there are lower-level modal convergence zones (association areas) and higher-level convergence zones that store semantic representations in a hierarchical manner. Lower level convergence zones are believed to store information about the sensorimotor features of concepts, whereas higher-level convergence zones bind information from lower level convergence zones to form supramodal representations. Although this view is similar to the hub and spoke model (Patterson, Nestor, & Rogers, 2007; Lambon Ralph et al., 2008, 2010), Binder and Desai (2011) advocate for several critical semantic hubs (throughout the lateral and ventral temporal cortex as well as the inferior parietal lobe) rather than a single semantic hub in the anterior temporal lobe.

Abstract Concepts and Emotion-Based Information

Recent research has also focused on the greater involvement of emotion-based information in the representation of abstract relative to concrete words (Kousta et al., 2011; Vigliocco et al., 2009; Vigliocco et al., 2013). Therefore, to examine the potential impact of emotion-based variables on RT patterns, ratings of valence, arousal, and emotional experience were collected as these variables have demonstrated behavioural effects in previous research (e.g., Kousta et al., 2009; Newcombe et al., 2014). Using crossed random effects modeling (see Appendix L), the data revealed that the aforementioned emotion-based variables were generally non-significant predictors of RTs, with a couple of exceptions[10]. Although emotion-based information may be important for some abstract concepts in the context of certain task demands, it is likely that the relative importance of emotion and linguistic associative information varies within the large scope of content represented by abstract concepts. For example, there is intuitively more emotional salience for the abstract word *CRISIS* than for the abstract word *SIMILARITY*. As can be seen in the mean ratings of arousal, valence, and emotional experience in Table 14 below, the stimulus words in the present study were not particularly emotionally charged overall. Therefore, it is not surprising that emotion-based variables often did not arise as significant predictors of RT.

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[10] In the implicit lexical decision task (Experiment 1) higher emotional experience ratings were associated with faster RTs, and in the word relatedness task (Experiment 6) higher ratings of arousal were associated with faster RTs.

Table 14

Means and Standard Deviations of Valence, Arousal, and Emotional Experience (EE) Ratings per Word Type

Word Type	Valence (9-point scale)	Arousal (9-point scale)	EE (5-point scale)
Concrete – Low SND	5.68 (0.88)	4.45 (1.34)	2.14 (0.64)
Concrete – High SND	5.10 (1.78)	4.70 (1.15)	2.62 (0.98)
Abstract – Low SND	5.58 (1.47)	4.80 (0.75)	3.31 (0.76)
Abstract – High SND	4.67 (1.39)	4.79 (0.72)	3.62 (1.05)

Future Directions

The present study provides evidence for the relative importance of linguistic associative information for abstract as compared to concrete words. However, it is also important to acknowledge that both object-based and language-based semantic variables have shown behavioural effects in visual word recognition studies (Buchanan et al, 2001; Hargreaves & Pexman, 2014; Yap et al., 2012), consistent with Dove’s (2009) theory of representational pluralism discussed earlier. The current findings contribute to our understanding of how adults use certain types of semantic information to dynamically construct meaning from printed words. However, a complete understanding of semantic processing also requires knowledge of how such dynamic processing develops over the course of childhood. To date, there has been more of a focus on how children acquire concrete concepts, which mainly involves sensorimotor experiences and interactions with tangible objects (reviewed by Wellsby & Pexman, 2014). To date, relatively little is known about how children acquire abstract concepts. Therefore, a potentially fruitful area of future research would be to examine the relative impact of language-based variables (e.g., SND) and object-based variables (e.g., ease of body-object interaction) on word recognition RTs in children of different ages using various psycholinguistic tasks.

Clinical Applications. The current findings may also be used to inform clinical practice in treating adults with aphasia. Anomia (word findings difficulties) is a pervasive and chronic symptom in persons with aphasia, and often causes significant impairments in communication and quality of life (Davis, 2000; Goodglass & Wingfield, 2007). Given that the integrity of the semantic system is critical for word comprehension and retrieval, rehabilitation of the semantic system is believed to facilitate word retrieval (Raymer et al., 2000), and possibly other aspects of language functioning (Nickels, 2002). In this regard, the goal of one increasingly popular language rehabilitation strategy, Semantic Feature Analysis (Ylvisaker & Szekeres, 1985), aims to systematically restore semantic networks impaired by neurological insult to improve word retrieval abilities, and thus functional communication. SFA is based on the idea that semantic processing involves spreading activation between meaning related concepts (i.e., semantic features) that include physical characteristics (e.g., shape, texture), functional characteristics (e.g., used for writing), or associated concepts (e.g., *PENCIL* is often associated with the words *PAPER* or *PEN*) (Boyle, 2010). Therefore, an assumption of SFA is that if a patient is trained to identify semantic features for a given set of concepts, lexical retrieval of targeted words will improve through the strengthening of affected semantic networks. SFA may also aid more directly in functional communication because it is believed to promote semantic self-cueing skills and semantically appropriate circumlocution, which are strategies that aid in communication even when lexical retrieval of specific words fail.

Several studies have found that most individuals with aphasia experience greater difficulties with retrieving abstract as compared to concrete words (e.g., Martin, Saffran, & Dell, 1996; Newton & Barry, 1997; Nickels & Howard, 1995). Although concrete words are most often trained in language rehabilitation programs, Renvall, Nickels, and Davidson (2013) question the functional utility of this strategy since patients can physically point to concrete word referents. Therefore, they propose that training patients on a greater number of abstract words can improve the functional utility of language rehabilitation, since abstract words refer to a range of concepts and ideas that cannot be physically identified, but are often important in communicating emotional needs or opinions. In keeping with the proposed usefulness of including abstract words in language rehabilitation, recent evidence suggests that training patients on abstract words results in better generalization to untrained items within a semantic category compared to when patients are trained on concrete words (Kiran, Sandberg, & Abbott, 2009). Therefore, another important direction for future research could involve a thorough investigation of language rehabilitation strategies that train patients on abstract word retrieval. In this regard, large-scale linguistic co-occurrence models, such as WINDSORS, could be useful in identifying the semantic associates most beneficial for training.

Conclusions

The present study contributes to the growing literature on the multi-dimensional and dynamic nature of semantic processing. Although researchers in psycholinguistics most often use tasks for which semantic processing is at least somewhat helpful, examining semantic effects using tasks that direct attention away from semantics may aid in investigating these effects more fully. Finally, the current findings highlight the importance of examining interactive semantic effects, as these can reveal important insights into the underlying semantic structure of various types of representations, including concrete and abstract concepts.

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Appendix A

Experimental Stimulus Words with their Lengths, Frequencies (Freq), Orthographic Neighbourhood Sizes (ON), Number of Syllables, Semantic Neighbourhood Sizes (SN), and Semantic Neighbourhood Densities (SND)

Word Type		Word	Length	#Syllables	Freq	ON	SN	SND
Concrete – Low SND	1	FREEZER	7	2	2.288	1	277	0.347
	2	WOODPECKER	10	3	0.253	0	221	0.344
	3	NOSTRIL	7	2	0.285	0	240	0.335
	4	SUBTITLE	8	3	0.757	0	183	0.332
	5	CROCODILE	9	3	1.215	0	168	0.336
	6	KANGAROO	8	3	1.372	0	154	0.322
	7	BAYONET	7	3	0.923	1	215	0.345
	8	VOLCANO	7	3	1.916	0	183	0.342
	9	CHANDELIER	10	3	0.267	0	177	0.323
	10	AQUARIUM	8	4	1.157	1	251	0.351
	11	MICROPHONE	10	3	3.643	0	221	0.354
	12	CUTLERY	7	3	0.243	1	217	0.343
	13	CALCULATOR	10	4	2.612	0	207	0.339
	14	GYMNASIUM	9	4	0.355	0	179	0.344
	15	TABLECLOTH	10	3	0.201	0	153	0.323
	16	STYROFOAM	9	3	0.339	0	245	0.354
	17	CANISTER	8	3	0.797	1	295	0.346
	18	ALLIGATOR	9	4	0.6	0	198	0.328
	19	PACIFIER	8	4	0.201	2	169	0.345
	20	CONTAINER	9	3	5.401	1	223	0.343
	21	PRAIRIE	7	2	1.138	0	257	0.334
	22	LIPSTICK	8	2	1.209	2	243	0.335

Appendix A (continued)

Word Type		Word	Length	#Syllables	Freq	ON	SN	SND
Concrete – High SND	1	BOOKLET	7	2	2.58	0	227	0.378
	2	TABLESPOON	10	3	2.092	0	248	0.399
	3	TADPOLE	7	2	0.292	0	159	0.384
	4	FLAMINGO	8	3	0.27	0	172	0.383
	5	GUNPOWDER	9	3	1.209	0	218	0.383
	6	MOSQUITO	8	3	1.669	0	228	0.391
	7	GORILLA	7	3	1.898	0	156	0.385
	8	BAZOOKA	7	3	0.231	0	212	0.386
	9	SKYSCRAPER	10	3	0.734	0	254	0.398
	10	AMMONIA	7	4	1.38	0	258	0.431
	11	MICROSCOPE	10	3	3.664	0	246	0.385
	12	ABDOMEN	7	3	1.816	0	286	0.379
	13	EMBROIDERY	10	4	0.237	1	174	0.386
	14	INCUBATOR	9	4	0.376	0	126	0.365
	15	CHIMPANZEE	10	3	1.319	0	268	0.406
	16	INTESTINE	9	3	0.861	0	266	0.438
	17	BUNGALOW	8	3	0.198	0	222	0.365
	18	DEODORANT	9	4	0.287	0	237	0.383
	19	CEMETARY	8	4	0.306	0	217	0.381
	20	CIGARETTE	9	3	5.436	0	216	0.389
	21	EARDRUM	7	2	0.374	0	198	0.378
	22	NECKLACE	8	2	1.122	0	205	0.378

Appendix A (continued)

Word Type		Word	Length	#Syllables	Freq	ON	SN	SND
Abstract – Low SND	1	FERVOUR	7	2	0.357	0	188	0.335
	2	CONCESSION	10	3	2.569	2	110	0.34
	3	ACCLAIM	7	2	0.966	0	235	0.345
	4	INFUSION	8	3	0.838	0	210	0.339
	5	DIGESTION	9	3	0.821	0	254	0.339
	6	COHESION	8	3	1.322	0	180	0.355
	7	ALLERGY	7	3	1.52	0	220	0.335
	8	POTENCY	7	3	1.241	0	212	0.339
	9	ABSORPTION	10	3	2.428	0	225	0.338
	10	FIDELITY	8	4	2.376	0	278	0.351
	11	TURBULENCE	10	3	0.914	1	206	0.354
	12	MASTERY	7	3	3.271	2	255	0.346
	13	SATURATION	10	4	1.335	1	190	0.34
	14	ELEVATION	9	4	2.67	0	185	0.344
	15	CONDUCTION	10	3	1.109	0	265	0.352
	16	HYDRATION	9	3	0.403	0	173	0.329
	17	ELEGANCE	8	3	0.862	0	157	0.344
	18	ADORATION	9	4	0.887	0	200	0.345
	19	SORORITY	8	4	0.361	1	164	0.347
	20	SENSATION	9	3	3.996	0	281	0.346
	21	CUISINE	7	2	0.987	0	229	0.345
	22	DAMPNESS	8	2	0.279	0	220	0.327

Appendix A (continued)

Word Type		Word	Length	#Syllables	Freq	ON	SN	SND
Abstract – High SND	1	DISCORD	7	2	2.015	1	234	0.38
	2	BANISHMENT	10	3	0.839	0	215	0.372
	3	PENANCE	7	2	0.701	0	222	0.367
	4	EVICTION	8	3	0.732	0	215	0.378
	5	CREMATION	9	3	0.992	0	186	0.405
	6	FIXATION	8	3	1.806	0	162	0.397
	7	VACANCY	7	3	0.884	0	157	0.382
	8	SORCERY	7	3	1.372	0	205	0.379
	9	DECRYPTION	10	3	0.218	0	202	0.367
	10	NOBILITY	7	4	2.197	1	245	0.381
	11	SUSTENANCE	10	3	1.453	0	191	0.408
	12	MODESTY	7	3	1.254	0	299	0.401
	13	ACTIVATION	10	4	2.017	0	249	0.385
	14	ASYMMETRY	9	4	0.41	0	185	0.371
	15	ABSTINENCE	10	3	6.105	0	221	0.378
	16	EXCRETION	9	3	0.233	0	255	0.366
	17	ACCOLADE	8	3	0.25	0	217	0.375
	18	STERILITY	9	4	0.312	0	245	0.367
	19	IMPURITY	8	4	0.569	1	157	0.378
	20	DETERRENT	9	3	2.774	1	170	0.376
	21	ANGUISH	7	2	2.168	0	280	0.389
	22	PRUDENCE	8	2	1.024	0	216	0.382

Appendix B

Instructions for Emotional Valence and Arousal Ratings Task

You will be presented with a series of words on the computer screen. You will be asked to rate how you *feel* about each of these words according to 2 different dimensions.

First, you'll be asked to rate how NEGATIVELY or POSITIVELY you feel about a word on a scale ranging from 1 (completely negative) to 9 (completely positive). For example, you may give a rating of 1 if a word makes you feel completely sad, annoyed, despaired, or any other negative emotion. Ratings between 2 and 4 may also be given for intermediate levels of negative feelings. At the other extreme, you may give a rating of 9 if a word makes you feel completely happy, joyous, contented, or any other positive emotion. Ratings between 6 and 8 may also be given for intermediate levels of positive feelings. A 'neutral' rating (5) should be given if a word does not make you feel either negative or positive.

Secondly, you'll be asked to rate how CALM or AROUSED you feel about a word on a scale ranging from 1 (completely calm) to 9 (completely aroused). For example, you may give a rating of 1 if a word makes you feel completely calm, relaxed, or unaroused. Ratings between 2 and 4 may also be given for intermediate feelings of calmness. At the other extreme, you may give a rating of 9 if a word makes you feel completely aroused, stimulated, or wide-awake. Ratings between 6 and 8 may also be given for intermediate feelings of arousal. A 'neutral' rating (5) should be given if a word does not make you feel either calm or aroused.

Do not spend too much time thinking about each word. Rather, base your ratings on your first and immediate reactions to each word.

Appendix C

Instructions for Emotional Experience Ratings Task

Words differ in the extent to which they elicit or evoke an emotional experience. Some words elicit or evoke strong emotional experiences (e.g., JUSTICE), whereas other words elicit or evoke weaker emotional experiences (e.g., MOMENT).

The purpose of this experiment is to rate words as to the ease with which they elicit or evoke emotional experience. For example, the word “justice” refers to a concept that is associated with high levels of emotional experience (e.g., think of the emotional conditions that arise when a jury verdict is delivered, such as joy, dismay, anger, frustration), whereas the word “moment” refers to a concept that is associated with low levels of emotional experience (i.e., it is difficult to think of any kind of emotional experience to which this word is related).

Any word (e.g., “justice”) that in your estimation elicits or evokes high levels of emotional experience should be given a high emotional experience rating (at the upper end of the numerical scale).

Any word (e.g., “moment”) that in your estimation elicits or evokes low levels of emotional experience should be given a low emotional experience rating (at the lower end of the scale).

Because words tend to make you think of other words as associates, it is important that your ratings NOT be based on this and that you judge only the ease with which a word elicits or evokes emotional experience. Remember, all the words are nouns and you should base your ratings on this fact.

Your emotional experience ratings will be made on a 1-7 scale. A value of 1 will indicate a low emotional experience rating, and a value of 7 will indicate a high emotional experience rating. Values of 2-6 will indicate intermediate ratings. Please feel free to use the whole range of values provided when making your ratings. You will be making your ratings on the button bar in front of you.

When making your ratings try to be as accurate as possible, but do not spend too much time on any one word.

Please ask the experimenter any questions you may have at this time.

Appendix D

Ratings of Valence, Arousal, and Emotional Experience (EE) for Experimental Words

Concrete-Low SND Word	Valence (1-9)	Arousal (1-9)	EE (1-5)	Concrete- High SND Word	Valence (1-9)	Arousal (1-9)	EE (1-5)
FREEZER	5.18	3.89	2.28	BOOKLET	5.40	3.29	1.39
WOODPECKER	6.22	4.64	1.94	TABLESPOON	5.40	3.09	1.28
NOSTRIL	4.93	3.93	1.50	TADPOLE	6.09	3.27	2.08
SUBTITLE	5.58	3.29	1.89	FLAMINGO	7.31	5.00	1.75
CROCODILE	4.27	5.96	2.75	GUNPOWDER	2.93	6.51	3.64
KANGAROO	7.16	6.42	1.86	MOSQUITO	1.47	6.47	3.25
BAYONET	4.87	4.42	2.72	GORILLA	5.98	6.00	2.17
VOLCANO	4.87	7.09	3.53	BAZOOKA	4.47	6.38	3.72
CHANDELIER	6.53	3.76	2.06	SKYSCRAPER	5.73	6.07	2.75
AQUARIUM	6.89	5.20	2.42	AMMONIA	2.89	5.42	3.50
MICROPHONE	5.89	5.64	2.31	MICROSCOPE	5.58	3.62	1.75
CUTLERY	5.47	3.11	1.61	ABDOMEN	5.78	4.44	2.42
CALCULATOR	5.29	3.24	1.53	EMBROIDERY	6.11	3.51	2.22
GYMNASIUM	7.20	6.42	3.31	INCUBATOR	5.00	4.58	2.94
TABLECLOTH	5.40	2.71	1.11	CHIMPANZEE	6.98	5.73	2.14
STYROFOAM	5.09	4.18	1.75	INTESTINE	4.71	4.24	2.86
CANISTER	5.24	3.36	1.69	BUNGALOW	6.33	3.89	1.69
ALLIGATOR	4.31	6.24	3.03	DEODORANT	7.24	3.27	2.39
PACIFIER	6.49	3.62	2.33	CEMETERY	2.40	4.73	5.22
CONTAINER	5.31	2.93	1.22	CIGARETTE	1.60	5.40	4.22
PRAIRIE	5.91	2.93	2.00	EARDRUM	5.58	3.80	2.00
LIPSTICK	6.91	4.87	2.22	NECKLACE	7.27	4.60	2.33

Appendix D (continued)

Abstract - Low SND Word	Valence (1-9)	Arousal (1-9)	EE (1-5)	Abstract - High SND Word	Valence (1-9)	Arousal (1-9)	EE (1-5)
FERVOUR	4.84	5.00	2.75	DISCORD	4.49	4.49	2.78
CONCESSION	5.82	4.20	2.39	BANISHMENT	2.24	6.11	5.92
ACCLAIM	5.56	4.36	3.42	PENANCE	5.13	4.20	3.28
INFUSION	5.29	4.60	2.83	EVICTION	2.09	6.31	5.06
DIGESTION	5.73	3.80	2.61	CREMATION	2.47	5.40	5.00
COHESION	5.60	4.27	3.28	FIXATION	4.56	4.80	3.03
ALLERGY	2.33	5.69	3.31	VACANCY	4.96	3.89	2.58
POTENCY	5.22	4.78	3.25	SORCERY	5.18	5.80	3.19
ABSORPTION	5.38	4.04	2.64	DECRYPTION	5.13	4.82	2.67
FIDELITY	5.02	4.76	4.50	NOBILITY	7.13	4.02	4.50
TURBULENCE	3.09	6.73	4.72	SUSTENANCE	5.60	4.40	3.11
MASTERY	6.73	4.78	3.81	MODESTY	7.27	3.78	4.17
SATURATION	5.13	4.04	2.61	ACTIVATION	6.40	5.60	3.25
ELEVATION	6.11	5.22	3.08	ASYMMETRY	4.73	4.31	1.94
CONDUCTION	5.20	4.24	2.44	ABSTINENCE	5.38	4.20	4.19
HYDRATION	7.53	3.96	3.89	GESTATION	5.20	4.42	2.39
ELEGANCE	8.04	4.36	3.89	ACCOLADE	5.40	4.82	2.36
ADORATION	7.04	5.11	4.67	STERILITY	4.36	5.00	3.72
SORORITY	4.80	5.44	2.86	IMPURITY	3.89	4.69	4.78
SENSATION	7.36	6.09	4.44	DETERRENT	4.07	4.58	3.14
CUISINE	7.64	5.60	2.86	ANGUISH	2.93	5.62	4.64
DAMPNESS	3.22	4.56	2.58	PRUDENCE	4.22	4.20	3.94

Appendix E

Implicit Lexical Decision Task (Experiment 1) 5-Letter Words and Non-Words matched on Frequency (Freq) and Orthographic Neighbourhood Size (ON)

5-Letter Real Word	Freq	ON	5-Letter Non-word	5-Letter Real Word	Freq	ON	5-Letter Non-word
SHAWL	10.12	2	SHBWL	TWIST	10.70	0	TWBST
BLUSH	10.14	4	BLCSH	GLARE	11.31	5	GLCRE
QUOTE	12.48	2	QUDTE	PEARL	11.98	1	PXARL
LEASE	12.64	5	LXASE	FRAUD	12.09	1	FRFUD
SOLVE	13.66	1	SFLVE	BRUTE	13.96	0	BRGTE
PURSE	13.85	7	PGRSE	REALM	12.67	2	RXALM
SWEAT	15.46	3	SWXAT	BLAZE	12.93	6	BLHZE
DWELL	15.95	2	DWHLL	FLUSH	13.65	5	FLJSH
RIDGE	19.11	1	RJDGE	STEAL	16.75	4	STKAL
LODGE	19.26	2	LKDGE	GRADE	16.95	7	GRLDE
BURNT	19.40	2	BLRNT	STARE	18.12	13	STMRE
CHASE	19.53	5	CHMSE	SWING	18.40	6	SWQNG
STIFF	25.23	4	STNFF	SPELL	29.26	5	SPRLL
YIELD	25.64	2	YXELD	STEAM	29.62	3	STXAM
SHELL	28.52	5	SHPLL	DEPTH	29.79	1	DRPTH
STOUT	20.19	7	STXUT	CRAFT	23.02	3	CRSFT
SCOPE	20.29	3	SCQPE	FLEET	23.44	2	FLTET
ROUTE	36.94	3	RXUTE	WAIST	23.62	2	WXIST
SHEET	35.20	6	SHXET	SKILL	37.19	5	SKWLL
SHIRT	35.43	6	SHSRT	SMELL	37.51	5	SMVLL
JOINT	36.75	3	JXINT	NURSE	38.51	3	NZRSE
SHAKE	31.51	12	SHRKE	TIGHT	36.72	9	TBGHT

Appendix E (continued)

5-Letter Real Word	Freq	ON	5-Letter Non-word	5-Letter Real Word	Freq	ON	5-Letter Non-word
TRAMP	11.52	3	TRHMP	STOOL	10.52	3	STXOL
QUEST	11.55	1	QXEST	BLISS	10.53	2	BLRSS
SWELL	12.14	5	SWKLL	TREND	12.96	2	TRSND
SQUAD	12.28	4	SQXAD	HEDGE	13.00	3	HTDGE
SKULL	14.16	3	SKMLL	WIDTH	13.32	0	WVDTH
NERVE	19.08	3	NPRVE	SLIDE	13.56	5	SLWDE
CLOAK	19.08	2	CLXAK	CHEER	16.26	3	CHZER
CREEK	19.58	6	CRXEK	COUCH	16.43	6	CXUCH
DRAFT	16.96	3	DRQFT	BREED	18.80	6	BRXED
BLOOM	17.21	3	BLXOM	BLOWN	18.98	5	BLBWN
PATCH	17.95	9	PRTCH	STOLE	19.88	8	STCLE
DRIFT	18.06	1	DRSFT	CEASE	19.94	4	CXASE
BRIDE	20.76	3	BRTDE	FENCE	26.10	2	FDNCE
BRASS	20.02	8	BRVSS	SLOPE	26.31	3	SLFPE
TRIBE	22.60	5	TRWBE	CLIMB	24.35	1	CLGMB
GLOOM	22.71	2	GLXOM	DRIED	22.27	6	DRXED
BLANK	23.70	6	BLBNK	STRAW	22.56	4	STRHW
KNOCK	24.09	1	KNDCK	PRIZE	27.72	3	PRJZE
WHEEL	32.19	0	WHXEL	VAGUE	33.57	2	VKGUE
TREAT	35.13	2	TRXAT	SHADE	33.82	8	SHLDE
SPARE	36.08	12	SPCRE	CHARM	32.62	5	CHMRM
TEACH	39.40	5	TXACH	PAINT	32.57	6	PXINT

Appendix E (continued)

5-Letter Real Word	Freq	ON	5-Letter Non-word	5-Letter Real Word	Freq	ON	5-Letter Non-word
CREST	11.76	5	CRCST	PROSE	10.22	6	PRBSE
PULSE	11.81	1	PDLSE	SIEGE	10.22	3	SXEGE
BLAST	12.28	3	BLFST	SCENT	17.51	3	SCDNT
SPOIL	12.31	1	SPXIL	BUNCH	17.57	6	BCNCH
THUMB	14.34	1	THPMB	PORCH	17.68	6	PFRCH
BORED	14.64	10	BJRED	WRIST	13.65	4	WRGST
BLADE	14.96	5	BLKDE	GUILT	15.95	4	GXILT
FROST	14.99	1	FRLST	GLOBE	15.96	2	GLHBE
SKIRT	17.22	3	SKMRT	GROSS	20.92	6	GRJSS
HARSH	17.31	1	HNRSH	SHAFT	15.17	2	SHKFT
WRATH	17.76	1	WRPTH	CHILL	15.22	2	CHMLL
CURSE	17.83	5	CQRSE	FLOOD	25.10	2	FLXOD
STAMP	14.18	4	STRMP	STERN	25.72	1	STLRN
STEEP	21.64	7	STXEP	SWEAR	25.94	4	SWXAR
BRUSH	24.42	3	BRTSH	COACH	27.77	4	CXACH
DRUNK	31.34	3	DRWNK	MOUNT	28.15	4	MXUNT
GUEST	31.34	2	GXEST	CLERK	30.08	0	CLMRK
SHOOT	27.73	6	SHXOT	TRACE	31.31	7	TRNCE
FLAME	31.80	5	FLZME	CHEEK	34.97	4	CHXEK
BEAST	31.92	6	BXAST	THEME	22.97	3	THPME
SCORE	37.76	9	SCFRE	MOUSE	18.79	8	MXUSE
BLAME	38.26	5	BLGME	MIDST	36.13	1	MQDST

Appendix E (continued)

5-Letter Real Word	Freq	ON	5-Letter Non-word	5-Letter Real Word	Freq	ON	5-Letter Non-word
WRECK	11.88	2	WRFCK	TREAD	10.54	6	TRXAD
PUNCH	11.93	5	PGNCH	SPRAY	10.66	3	SPRNY
NIECE	12.32	1	NXECE	WEIRD	13.13	1	WXIRD
GROVE	12.36	6	GRHVE	FLOCK	13.16	5	FLPCK
DENSE	14.62	3	DJNSE	SEIZE	13.17	1	SXIZE
GLEAM	14.69	1	GLXAM	RANCH	13.22	1	RQNCH
BROOK	14.79	3	BRXOK	BRAND	16.60	3	BRSND
SPEAR	14.80	4	SPXAR	SLAIN	16.63	4	SLZIN
STRIP	17.34	4	STRKP	CURVE	18.65	2	CTRVE
CLIFF	20.78	0	CLMFF	WOUND	36.31	8	WXUND
TRUNK	20.10	2	TRLNK	SHELF	14.06	2	SHVLF
BEARD	26.34	3	BXARD	WITCH	15.32	7	WZTCH
SHOUT	21.38	6	SHXUT	SHINE	15.33	11	SHWNE
SMART	21.38	1	SMPRT	GHOST	26.74	0	GHBST
DREAD	21.94	5	DRXAD	DRANK	27.00	5	DRCNK
PITCH	22.26	7	PRTCH	PLANE	27.61	6	PLDNE
BENCH	24.97	6	BSNCH	CHEAP	31.45	2	CHXAP
CRASH	19.68	5	CRTSH	PHASE	32.71	1	PHFSE
SAINT	37.60	5	SXINT	SWIFT	33.00	1	SWGFT
CHAIN	37.92	1	CHXIN	CLOCK	33.19	8	CLHCK
BEACH	37.02	7	BXACH	CLOTH	31.71	2	CLJTH
SLAVE	37.11	7	SLWVE	SPORT	31.77	5	SPKRT

Appendix F

Implicit Lexical Decision Task (Experiment 1) Control Words

Matched Word Type		Control Word	Matched Word Type		Control Word
Concrete – Low SND	1	BALLOON	Concrete – High SND	1	COTTAGE
	2	TRAMPOLINE		2	MOUNTAINTOP
	3	TOASTER		3	SEASHORE
	4	SOUVENIR		4	PONYTAIL
	5	BODYGUARD		5	APPLIANCE
	6	DINOSAUR		6	SYMPHONY
	7	NUMERAL		7	GASOLINE
	8	STADIUM		8	SPATULA
	9	HOUSEKEEPER		9	WASTEBASKET
	10	AMPHIBIAN		10	UNICYCLE
	11	QUARTERBACK		11	BASKETBALL
	12	ANTENNA		12	ACROBAT
	13	EXHIBITION		13	MOISTURIZER
	14	ORANGUTAN		14	DORMITORY
	15	LAUNDROMAT		15	BARTENDER
	16	GLOSSARY		16	ASTRONAUT
	17	MOTORBIKE		17	INCISION
	18	GLADIATOR		18	METEORITE
	19	BALLERINA		19	ELEVATOR
	20	DETECTIVE		20	CATHEDRAL
	21	BANQUET		21	SWIMSUIT
	22	BALLROOM		22	BACKPACK

Appendix F (continued)

Matched Word Type		Control Word	Matched Word Type		Control Word
Abstract – Low SND	1	SUNBURN	Abstract – High SND	1	SANDBOX
	2	PHARMACIST		2	MAGICIAN
	3	BILLBOARD		3	PERFUME
	4	SCORPION		4	SANDPAPER
	5	SAXOPHONE		5	DETERGENT
	6	ORNAMENT		6	UMBRELLA
	7	TORNADO		7	JANITOR
	8	PODIUM		8	GRAFFITI
	9	SUBMARINE		9	SILVERWARE
	10	TITANIUM		10	LIBRARIAN
	11	POTPOURRI		11	SONGWRITER
	12	CINEMA		12	BICYCLE
	13	THERMOMETER		13	ADOLESCENT
	14	CUSTODIAN		14	TARANTULA
	15	HANDKERCHIEF		15	CHEERLEADER
	16	STORYBOOK		16	REPAIRMAN
	17	SKELETON		17	SEAWATER
	18	SUPERHERO		18	DANDELION
	19	ESCALATOR		19	POLYESTER
	20	MICROWAVE		20	AMBULANCE
	21	SHAMPOO		21	POSTCARD
	22	HOSTESS		22	RAINFALL

Appendix G

Lexical Decision Task (Experiment 2) Stimulus Set

Experimental Word (Concrete – Low SND)	Matched Non-Pronounceable Non-word	Experimental Word (Concrete – High SND)	Matched Non-Pronounceable Non-word
FREEZER	RBSSALS	BOOKLET	MFRMUMS
WOODPECKER	PCRTONENCE	TABLESPOON	GLVERNATOR
NOSTRIL	SPDUSEK	TADPOLE	BHSLIER
SUBTITLE	BRFWLIER	FLAMINGO	GJMESMEN
CROCODILE	PGRBARIZE	GUNPOWDER	PKTBOALER
KANGAROO	CRHCTISE	MOSQUITO	LNLIRTED
BAYONET	DJBBIES	GORILLA	CRMSSTY
VOLCANO	BKRBLES	BAZOOKA	CNRPSEY
CHANDELIER	TLNSALLING	SKYSCRAPER	SPMPATHIBE
AQUARIUM	BRMAKIER	AMMONIA	WQSBING
MICROPHONE	WNSHITTING	MICROSCOPE	DRSNERSALS
CUTLERY	BRPFLES	ABDOMEN	XQUAVIP
CALCULATOR	CRQSSWALKS	EMBROIDERY	TNDERWRATE
GYMNASIUM	SQSEAWISH	INCUBATOR	CLSARNESH
TABLECLOTH	BTRDERLAND	CHIMPANZEE	CRVNOMINES
STYROFOAM	VSGALANTE	INTESTINE	YWSTERDAT
CANISTER	TLLUSIVE	BUNGALOW	LXAPFRON
ALLIGATOR	CVNTARIES	DEODORANT	RZTRIEFER
PACIFIER	SWNTABLE	CEMETERY	RBNVERSE
CONTAINER	CHXSTIEST	CIGARETTE	PCCKETIRG
PRAIRIE	SLZBBAR	EARDRUM	HDDDUPS
LIPSTICK	STBAVIER	NECKLACE	XAPMARKS

Appendix G (continued)

Experimental Word (Abstract – Low SND)	Matched Non-Pronounceable Non-word	Experimental Word (Abstract – High SND)	Matched Non-Pronounceable Non-word
FERVOUR	MCLINGE	DISCORD	PLFNRED
CONCESSION	CDNVOCTION	BANISHMENT	DGSMOCATED
ACCLAIM	DFMPERG	PENANCE	PHRTOIL
INFUSION	WGNDFOUS	EVICTION	THJMBING
DIGESTION	FHSTIVATS	CREMATION	CKWPANILE
COHESION	JMEKETTE	FIXATION	DRLNKARK
ALLERGY	KVOISED	VACANCY	SNMCTED
POTENCY	GLNTILE	SORCERY	PNNTIAS
ABSORPTION	MNNERWATED	DECRYPTION	KPSDATCHES
FIDELITY	BRNCCOYI	NOBILITY	PRQXENDS
TURBULENCE	RPSEMPTION	SUSTENANCE	SRPERCARHO
MASTERY	TQACHER	MODESTY	SSDRESS
SATURATION	NSRABILITY	ACTIVATION	TRTECLIEST
ELEVATION	TXIDEBOOK	ASYMMETRY	DVSPERMED
CONDUCTION	SNTERWEAPE	ABSTINENCE	WNVINDLING
HYDRATION	TVNGERIRA	GESTATION	PXPULATED
ELEGANCE	GLWMCESS	ACCOLADE	RZMPOGES
ADORATION	BXNDERIES	STERILITY	LBARWAYS
SORORITY	FLZTNEST	IMPURITY	TRCTHING
SENSATION	BSOLUTING	DETERRENT	SCDTCHING
CUISINE	FCSTEMS	ANGUISH	STRFKID
DAMPNESS	DLLUMISE	PRUDENCE	RGSHNOSS

Appendix H

Go/No-Go Lexical Decision Task (Experiment 3) Stimulus Set

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

Appendix H (continued)

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

Appendix I

Word Relatedness Task (Experiment 6) Stimulus Set

Experimental Word (Concrete – Low SND)	Related Word	Experimental Word (Concrete – High SND)	Related Word
FREEZER	IGLOO	BOOKLET	HARDCOVER
WOODPECKER	NEST	TABLESPOON	SAUCEPAN
NOSTRIL	SINUS	TADPOLE	LARVA
SUBTITLE	CAPTION	FLAMINGO	PARADISE
CROCODILE	CARNIVORE	GUNPOWDER	DYNAMITE
KANGAROO	OUTBACK	MOSQUITO	PARASITE
BAYONET	SNIPER	GORILLA	JUNGLE
VOLCANO	ERUPTION	BAZOOKA	SHRAPNEL
CHANDELIER	CEILING	SKYSCRAPER	LANDMARK
AQUARIUM	GOLDFISH	AMMONIA	OXIDATION
MICROPHONE	LOUDSPEAKER	MICROSCOPE	LENS
CUTLERY	DISHWASHER	ABDOMEN	HERNIA
CALCULATOR	KEYPAD	EMBROIDERY	QUILT
GYMNASIUM	FITNESS	INCUBATOR	BIOTECHNOLOGY
TABLECLOTH	NAPKIN	CHIMPANZEE	PRIMATE
STYROFOAM	CARTON	INTESTINE	STOMACH
CANISTER	DISPENSER	BUNGALOW	GUESTHOUSE
ALLIGATOR	SWAMP	DEODORANT	FRAGRANCE
PACIFIER	NEWBORN	CEMETERY	GRAVESTONE
CONTAINER	SHIPMENT	CIGARETTE	TOBACCO
PRAIRIE	MEADOW	EARDRUM	WINDPIPE
LIPSTICK	SUPERMODEL	NECKLACE	PENDANT

Appendix I (continued)

Experimental Word (Abstract – Low SND)	Related Word	Experimental Word (Abstract – High SND)	Related Word
FERVOUR	VIGOUR	DISCORD	STRIFE
CONCESSION	SNACK	BANISHMENT	EXILE
ACCLAIM	REVIEWER	PENANCE	SINNER
INFUSION	SYRINGE	EVICTION	TENANCY
DIGESTION	NUTRIENT	CREMATION	URN
COHESION	TEAMWORK	FIXATION	EYEBALL
ALLERGY	HIVES	VACANCY	RESIGNATION
POTENCY	DOSAGE	SORCERY	WIZARD
ABSORPTION	VITAMIN	DECRYPTION	PASSWORD
FIDELITY	VIRTUE	NOBILITY	MONARCHY
TURBULENCE	JET	SUSTENANCE	NOURISHMENT
MASTERY	BRILLIANCE	MODESTY	SIMPLICITY
SATURATION	DIFFUSION	ACTIVATION	STIMULATION
ELEVATION	PLATEAU	ASYMMETRY	ANOMALY
CONDUCTION	VOLTAGE	ABSTINENCE	CHASTITY
HYDRATION	ELECTROLYTE	GESTATION	TRIMESTER
ELEGANCE	POISE	ACCOLADE	EXCELLENCE
ADORATION	SAVIOUR	STERILITY	MENOPAUSE
SORORITY	SISTERHOOD	IMPURITY	FLUORIDE
SENSATION	STIMULATION	DETERRENT	SAFEGUARD
CUISINE	MENU	ANGUISH	SOLITUDE
DAMPNESS	MOISTURE	PRUDENCE	TACT

Appendix I (continued)

Control Word (Concrete-Low SND)	Unrelated Word	Control Word (Concrete-High SND)	Unrelated Word
BALLOON	GRANITE	COTTAGE	PALETTE
TRAMPOLINE	WARDROBE	MOUNTAINTOP	MATTRESS
TOASTER	CONFETTI	SEASHORE	BOUTIQUE
SOUVENIR	MOCKERY	PONYTAIL	CLEARANCE
BODYGUARD	PEACOCK	APPLIANCE	TORTOISE
DINOSAUR	CUSHION	SYMPHONY	COCOON
NUMERAL	LADLE	GASOLINE	CLASSROOM
STADIUM	HATCHET	SPATULA	FOUNTAIN
HOUSEKEEPER	METEOR	WASTEBASKET	CHARCOAL
AMPHIBIAN	ARTISTRY	UNICYCLE	CHIVALRY
QUARTERBACK	SNOWMAN	BASKETBALL	BUTCHER
ANTENNA	TOLERANCE	ACROBAT	INFANCY
EXHIBITION	LIFEGUARD	MOISTURIZER	QUOTATION
ORANGUTAN	APOLOGY	DORMITORY	DURATION
LAUNDROMAT	TOOTHPICK	BARTENDER	VACCINE
GLOSSARY	BOUQUET	ASTRONAUT	GARAGE
MOTORBIKE	SCALLOP	INCISION	PLUMBER
GLADIATOR	ARMCHAIR	METEORITE	MUSTACHE
BALLERINA	SCARECROW	ELEVATOR	DIAPER
DETECTIVE	PARROT	CATHEDRAL	SHUTTLE
BANQUET	LUMBER	SWIMSUIT	CUBICLE
BALLROOM	HAMMER	BACKPACK	FUNNEL

Appendix I (continued)

Control Word (Abstract-Low SND)	Unrelated Word	Control Word (Abstract-High SND)	Unrelated Word
ADULTHOOD	INDULGENCE	AUTOPSY	CYBERSPACE
PROFANITY	ROCKET	CAUSATION	ELITE
APTITUDE	CANTEEN	DRAWBACK	SHRUB
AUDITION	SHINGLE	GETAWAY	OPPRESSION
CHARISMA	BAGGAGE	MONOGAMY	TEAPOT
COGNITION	OUTRAGE	PATERNITY	PICKLE
DEFORMITY	HOSTEL	LONGEVITY	SECRECY
DRAWBACK	ANALOGY	NIGHTLIFE	DIPLOMAT
ECOSYSTEM	FLASHLIGHT	PARAGON	HELMET
EUPHORIA	VERDICT	PERIPHERY	HOMICIDE
FORMALITY	MISSILE	PORTRAYAL	EROSION
MILESTONE	RANSOM	NUANCE	INNOCENCE
GEOMETRY	CENSORSHIP	DEVIATION	RETIREMENT
GLAMOUR	STAMINA	INTRICACY	SANITY
HEREDITY	TAVERN	PESSIMISM	GREED
RAMPAGE	PAMPHLET	AVOIDANCE	HOAX
IMMUNITY	DECADENCE	COMMOTION	LIFETIME
PATHOLOGY	BRIEFCASE	TIRADE	EMERGENCE
NUTRITION	FRICTION	DISPARITY	TREADMILL
LAWSUIT	PARADOX	BETRAYAL	PRESTIGE
UNDERDOG	CROWBAR	MATERNITY	DIVERSION
MENTALITY	BLADDER	SOBRIETY	FEUD

Appendix J

Sentence Relatedness Task (Experiment 7) Stimulus Set

Experimental Word (Concrete – Low SND)	Unrelated Sentence
FREEZER	The child rolled the coloured marbles on the ground.
WOODPECKER	The child hummed while doing chalk drawings in the yard.
NOSTRIL	The man bought some roast beef for his lunch.
SUBTITLE	The woman wanted the expensive sweater at the shop.
CROCODILE	The man visited the art gallery on his trip.
KANGAROO	The woman photographed the large cactus in the desert.
BAYONET	The student finished a science project on his own.
VOLCANO	The people ate at the birthday party in the afternoon.
CHANDELIER	The woman knitted the colourful blanket all day long.
AQUARIUM	The child grabbed the candy bar at the store.
MICROPHONE	The man slept at the cheap motel in the afternoon.
CUTLERY	The woman replaced the old carpeting in the room.
CALCULATOR	The student organized the group events on his trip.
GYMNASIUM	The student browsed the downtown stores on her trip.
TABLECLOTH	The man repaired his broken computer on the table.
STYROFOAM	The child memorized the major theories for the test.
CANISTER	The man whistled as he walked quickly down the street.
ALLIGATOR	The man ran like a speeding bullet on the field.
PACIFIER	The girl competed at the talent show in the evening.
CONTAINER	The woman completed the clay sculpture after several years.
PRAIRIE	The man presented at the business conference in the evening.
LIPSTICK	The woman screamed at the noisy teenagers in the evening.

Appendix J (continued)

Experimental Word (Concrete – High SND)	Unrelated Sentence
BOOKLET	The woman tanned at her private beach in the summer.
TABLESPOON	The man sprinted to the post office in the morning.
TADPOLE	The woman drove along the corn fields in the evening.
FLAMINGO	The woman mended her daughter's ripped shirt in the morning.
GUNPOWDER	The man painted using the art supplies at his home.
MOSQUITO	The man responded to emergency calls in the evening.
GORILLA	The woman ironed her wrinkled shirt in the morning.
BAZOOKA	The man shaved his thick beard in the morning.
SKYSCRAPER	The woman placed the winter boots in the corner.
AMMONIA	The man strutted around the auditorium stage for the audience.
MICROSCOPE	The man wound-up and threw a perfect curveball to his friend.
ABDOMEN	The performer spun on a rotating stage for the audience.
EMBROIDERY	The woman scratched the mosquito bite on her body.
INCUBATOR	The man napped in his home office in the evening.
CHIMPANZEE	The woman baked many chocolate cookies for the guests.
INTESTINE	The man investigated the wonders of underwater caves for a living.
BUNGALOW	The doctor injected a trial vaccine into the patient.
DEODORANT	The object ignited forming a burning pit into the ground.
CEMETERY	The woman wandered up to the rooftop patio of the building.
CIGARETTE	The man parked in the neighbour's driveway in the morning.
EARDRUM	The woman cruised around in the red convertible in the afternoon.
NECKLACE	The man brought many extra pens to his classes.

Appendix J (continued)

Experimental Word (Abstract-Low SND)	Unrelated Sentence
FERVOUR	The man painted his front driveway in the morning.
CONCESSION	The woman advised a client on paint selection at the store
ACCLAIM	The man hit the small squirrel on the road.
INFUSION	The woman enjoyed the warm sunshine on her hike.
DIGESTION	The man dated the prettiest girl in the group.
COHESION	The woman roasted the large turkey in the evening.
ALLERGY	The town was stunned by the store robbery on the weekend.
POTENCY	The man jumped on a dinner table at the event.
ABSORPTION	The woman crawled in a dark cave in the morning
FIDELITY	The man created a structure using brown bricks from the store.
TURBULENCE	The woman killed a small insect in the room
MASTERY	The man interviewed a potential employee in the city.
SATURATION	The woman admired the cozy atmosphere of the room.
ELEVATION	The man watered the many plants in the building.
CONDUCTION	The woman wrote her project notes at her desk.
HYDRATION	The man showed some educational videos to his class.
ELEGANCE	The woman looked in search of lost tools in the field.
ADORATION	The man dressed himself as a mime artist in the evening.
SORORITY	The woman rushed to the front door of the building.
SENSATION	The man rehearsed his formal presentation in the afternoon.
CUISINE	The woman organized her messy closet in the morning.
DAMPNESS	The man opened the expensive wine upon their arrival.

Appendix J (continued)

Experimental Word (Abstract-High SND)	Unrelated Sentence
DISCORD	The child squished the green playdough with his hands.
BANISHMENT	The man told many funny jokes on the stage.
PENANCE	The woman hired an event planner for the party.
EVICTION	The man painted the old furniture in the shed.
CREMATION	The woman opened the front door in the morning.
FIXATION	The man secluded himself from the noisy kids in the afternoon.
VACANCY	The woman sorted the client files in the building.
SORCERY	The boy guided the study session in the evening.
DECRYPTION	The man sketched using the coloured pencils at the table.
NOBILITY	The woman trained with student athletes at the school.
SUSTENANCE	The man promoted many good employees in his career.
MODESTY	The woman fell down the steep stairwell in the morning.
ACTIVATION	The boy rested before starting football training in the Fall.
ASYMMETRY	The man captured the small rodent in the cage.
ABSTINENCE	The girl smiled for the news cameras in the afternoon.
GESTATION	The man drank the orange juice in the morning.
ACCOLADE	The woman sailed in the fishing boat on her trip.
STERILITY	The man installed the sprinkler system in his yard.
IMPURITY	The woman made a pecan pie in the afternoon.
DETERRENT	The man went to the hockey tournament across the city.
ANGUISH	The woman gave the fresh vegetables to her family.
PRUDENCE	The man planned a day of family fun in the city.

Appendix J (continued)

Control Word	Related Sentence
BALLOON	The child popped the party decorations on the ground.
TRAMPOLINE	The child bounced while doing high backflips in the yard.
TOASTER	The man warmed some sliced bread for his lunch.
SOUVENIR	The woman purchased the special momento at the shop.
BODYGUARD	The man protected the famous celebrity on his trip.
DINOSAUR	The woman excavated the ancient fossils in the desert.
NUMERAL	The student solved a math equation on his own.
STADIUM	The people cheered at the soccer game in the afternon.
HOUSEKEEPER	The woman cleaned the dirty residence all day long.
AMPHIBIAN	The child petted the slimy frog at the store.
QUARTERBACK	The man fumbled at the football game in the afternoon.
ANTENNA	The woman adjusted the television reception in the room.
EXHIBITION	The student visited the museum displays on his trip.
ORANGUTAN	The student toured the primate exhibit on her trip.
LAUNDROMAT	The man folded his clean clothing on the table.
GLOSSARY	The child learned the word meanings for the test
MOTORBIKE	The man speeded as he raced riders down the street.
GLADIATOR	The man fought like a mighty warrior on the field.
BALLERINA	The girl performed at the dance recital in the evening.
DETECTIVE	The woman solved the murder mystery after several years.
BANQUET	The man feasted at the dinner buffet in the evening.
BALLROOM	The woman danced at the elegant gala in the evening.

Appendix J (continued)

Control Word	Related Sentence
SUNBURN	The man soothed his red skin in the morning.
PHARMACIST	The woman educated a client on medication risks at the store.
BILLBOARD	The man read the large advertisement on the road.
SCORPION	The woman avoided the exotic insect on her hike.
SAXOPHONE	The man played the brass instrument in the group.
ORNAMENT	The woman decorated the Christmas tree in the evening.
TORNADO	The town was destroyed by the raging storm on the weekend.
PODIUM	The man spoke on a raised platform at the event.
SUBMARINE	The woman descended in a water vehicle in the morning.
TITANIUM	The man built a structure using strong metal from the store.
POTPOURRI	The woman smelled a flowery fragrance in the room.
CINEMA	The man attended a movie screening in the city.
THERMOMETER	The woman measured the hot temperature of the room.
CUSTODIAN	The man mopped the filthy floors in the building.
HANDKERCHIEF	The woman wiped her runny nose at her desk.
STORYBOOK	The man read some children's tales to his class.
SKELETON	The woman dug in search of old bones in the field.
SUPERHERO	The man disguised himself as a caped crusader in the evening.
ESCALATOR	The woman walked to the upper level of the building.
MICROWAVE	The man heated his cold food in the afternoon.
SHAMPOO	The woman washed her oily hair in the morning.
HOSTESS	The man greeted the restaurant guests upon their arrival.

Appendix J (continued)

Control Word	Related Sentence
COTTAGE	The woman relaxed at her country cabin in the summer.
MOUNTAINTOP	The man climbed to the rocky peak in the morning.
SEASHORE	The woman strolled along the sandy waterfront in the evening.
PONYTAIL	The woman tied her daughter's long hair in the morning.
APPLIANCE	The man cooked using the kitchen tools at his home.
SYMPHONY	The man listened to classical music in the evening.
GASOLINE	The woman filled her empty tank in the morning.
SPATULA	The man flipped his hot pancakes in the morning.
WASTEBASKET	The woman tossed the cluttered garbage in the corner.
UNICYCLE	The man rode around the circus tent for the audience.
BASKETBALL	The man dribbled and threw a bounce pass to his friend.
ACROBAT	The performer balanced on a swinging trapeze for the audience.
MOISTURIZER	The woman spread the thick lotion on her body.
DORMITORY	The man studied in his college bedroom in the evening.
BARTENDER	The woman poured many vodka cocktails for the guests.
ASTRONAUT	The man explored the wonders of outer space for a living.
INCISION	The doctor cut a precise opening into the patient.
METEORITE	The object crashed forming a deep crater in the ground.
ELEVATOR	The woman rode up to the top floor of the building.
CATHEDRAL	The man prayed in the historic cathedral in the morning.
SWIMSUIT	The woman splashed around in the backyard pool in the afternoon.
BACKPACK	The man carried many heavy books to his classes.

Appendix J (continued)

Control Word	Related Sentence
SANDBOX	The child scooped the golden granules with his hands.
MAGICIAN	The man performed many magnificent tricks on the stage.
PERFUME	The woman wore an elegant scent for the party.
SANDPAPER	The man smoothed the rough wood in the shed.
DETERGENT	The woman washed the stained clothing in the morning.
UMBRELLA	The man shielded himself from the pouring rain in the afternoon.
JANITOR	The woman scrubbed the dirty toilets in the building.
GRAFFITI	The boy vandalized the abandoned building in the evening.
SILVERWARE	The man dined using fancy utensils at the table.
LIBRARIAN	The woman assisted with locating books at the school.
SONGWRITER	The man produced many musical numbers in his career.
BICYCLE	The woman pedaled down the narrow lane in the morning.
ADOLESCENT	The boy grew before starting high school in the Fall.
TARANTULA	The man feared the hairy spider in the cage.
CHEERLEADER	The girl danced for the pep rally in the afternoon.
REPAIRMAN	The man fixed the broken machine in the morning.
SEAWATER	The woman floated in the salty ocean on her trip.
DANDELION	The man pulled the yellow weeds in his yard.
POLYESTER	The woman mended a fabric garment in the afternoon.
AMBULANCE	The man raced to the medical emergency across the city.
POSTCARD	The woman mailed the vacation picture to her family.
RAINFALL	The man predicted a day of wet weather in the city.

Appendix K

Task Instructions for All Experiments

Experiment		Instructions
1	Progressive Demasking Task	You will be presented with single words one at a time on the screen. Each word will be preceded by a fixation cross (+) to focus your attention to the middle of the screen. At first, the word will be difficult to read because it will be hidden by a visual ‘mask’ that looks like a series of hash marks (##########). The word will become increasingly clear with the gradual fading of the mask. You are asked to press the SPACEBAR at the EARLIEST MOMENT that you are able to read the word. You will then be prompted to type the word that you just read by using the keyboard in front of you. Once you have typed the word, press the ENTER key to proceed to the next trial. It is important that you press the spacebar AS SOON AS YOU ARE ABLE TO READ THE WORD because we will be measuring response times. However, we cannot use your data if you make too many errors, so do not respond until you are able to read to word accurately.
2	Implicit Lexical Decision Task	A word will appear briefly in the middle of the screen. Then you will see two letter strings on either side of the screen: one real word and one nonsense word (e.g., “nolstad”, “wuggins”). Your task is to decide which of the two letter strings is a real word. If the real word appears on the left side of the screen, press the “Z” key. If the real word appears on the right side of the screen, press the “?” key. We will be looking at the time it takes you to make this decision, so you should respond as quickly as possible. However, we cannot use your data if you make too many errors, so you should also respond as accurately as possible.
3	Lexical Decision task (non-pronounceable letter strings)	You will be presented with letter strings that will either form real English words or nonsense words (e.g., GRXFELG). For each letter string, you must decide if it is a real word or a nonsense word. If you see a nonsense word, press the ‘Z’ key. If you see a real word, press the ‘?’ key. We will be looking at response times, so please make your decision as quickly as possible. However, we cannot use your data if you make too many errors, so it is also important that you respond as accurately as possible.
4	Go/No-Go Lexical Decision Task	You will be presented with a series of letter strings that will either form real English words or nonsense words (pronounceable groups of letters that do not form real English words; e.g., wuggy). For each letter string, you must decide if it is a real word or a nonsense word. If you see a real word, press the spacebar. If you see a nonsense word, do nothing and wait for the next trial to begin. It is important that you make this decision as quickly as possible because we will be looking at response times. However, we cannot use your data if you make too many errors, so it is also important that you respond as accurately as possible.

Appendix K (continued)

Experiment		Instructions
5	Concrete/ Abstract Categorization Task	You will be presented with a series of words one at a time on the screen. For each word, your task is to decide if the word is concrete or abstract. A word is considered concrete if you can physically sense it. Examples of concrete words include *jacket, building,* and *truck.* A word is considered abstract if you cannot physically sense it. Examples of abstract words include *democracy, suitability,* and *crime.* If you think a word is concrete, press the 'Z' key. If you think the word is abstract, press the '?' key. It is important that you make this decision as quickly as possible because we will be looking at response times. However, we cannot use your data if you make too many errors, so it is also important that you respond as accurately as possible.
6	Go/No-Go Word Relatedness Task	In this experiment you will be presented with a series of words, each followed by another word. Your task is to decide whether or not the second word in each trial is related by meaning to the word that came before it (the first word). Once you finish reading the first word, press the spacebar. You will then be presented with another word. If you think the second word is related to the first word, press the spacebar. If you do not think the second word is related to the first word, press nothing and wait for the next trial to begin. You must make this decision as quickly as possible. However, we cannot use your data if you make too many errors, so it is also important that you respond as accurately as you can.
7	Go/No-Go Sentence Relatedness Task	In this experiment you will be presented with a series of sentences, each followed by a single word. Your task is to decide whether or not the word is related by meaning to the sentence that came before it. Once you finish reading a sentence, press the spacebar. You will then be presented with a single word. If you think the word is related to the previous sentence, press nothing and wait for the next sentence to appear. If you do not think the word is related to the previous sentence, press the spacebar. You must make this decision as quickly as possible. However, we cannot use your data if you make too many errors, so it is also important that you respond as accurately as you can.

Appendix L

Supplementary Statistical Analyses: Crossed Random Effects Modeling

Initially, the potential impact of various emotion-based variables (i.e., valence, arousal, emotional experience) was to be examined using an Analysis of Covariance (ANCOVA). However, this would only allow for an item-level (not a subject-level) analysis of the data because mean emotion ratings could only be analyzed on an item-by-item (not a subject-by-subject) basis. A similar problem would occur with a multiple regression analysis. Since both an ANCOVA and multiple regression would require aggregated data (i.e., mean RTs and emotion ratings for each word across participants), power is relatively low because there are not a large number of items in each condition (22). To circumvent these concerns, the data was analyzed using crossed random effects modeling (CREM).

CREM (also known as linear mixed effects modeling) is a form of multi-level modeling that has become an increasingly popular method of analyzing repeated measures data in psycholinguistics (Baayen, Davidson, & Bates, 2008). Importantly, data need not be aggregated, and the subject and item analyses are conducted within the same model. Since individual differences due to both subjects and items are taken into account simultaneously, there is more variability accounted for in the error term, resulting in increased power.

The proposed analysis will model RT as a function of various fixed and random effects. Fixed effects (also known as explanatory variables) are those that may influence the data in some systematic way. In this way, valence, arousal, and emotional experience were entered into the model as fixed effects. Random effects refer to subjects and items, since it is assumed that the group of subjects and items included in the experiment are taken from a random pool within the general population of subjects and items. Essentially, CREM is a more sophisticated extension of multiple regression in that it allows for both random and fixed effects (as opposed to only fixed effects in multiple regression). The proposed model may be expressed as a function in the following way:

RT ~ valence + arousal + emotional experience + concreteness + SND +
concreteness * SND + (1|subjects) + (1|items) + random error

Translated into everyday language, RT was modeled as a function of various fixed effects (valence, arousal, emotional experience, concreteness, SND, concreteness by SND interaction), random effects (subjects, items), as well as other error that cannot be accounted for by either random or fixed effects. Note that there is specific notation for both subjects (1|subject) and items (1|items). This means that the model should expect multiple responses for each subject and item, and that intercepts should be allowed to vary by subjects and items. As such, this analysis resolves the non-independence within the data. In sum, the following CREM analysis tested whether the variables of interest (concreteness, SND, concreteness by SND interaction) were significant predictors of RT when additional variables of interest (emotion-based variables) were also taken into account.

All fixed effects were grand mean centered to avoid potential problems resulting from multicollinearity (e.g., concreteness by SND interaction being correlated with its constituent variables) and the inclusion of variables measured on different scales (e.g., ratings of valence and arousal versus emotional experience). The CREM analysis was conducted using syntax through the MIXED procedure in SPSS version 21 as per the tutorial provided by Carson and Beeson (2013).

The results of the CREM analysis are presented in the below table with respect to the significance of each fixed factor across experiments. Generally, the emotion-based variables were non-significant predictors of RT, with a couple of exceptions[11]. This finding suggests that emotion-based variables are not especially helpful for explaining concreteness and SND effects in the current data. Therefore, the primary ANOVA analyses are believed to be sufficient to examine concreteness and SND effects.

Estimates of fixed effects parameters and their p-values based on the t-statistic

Fixed Effects	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6	Exp 7
Valence	-1.61	-1.07	-1.46	-1.98(*)	-1.85(*)	-.48	-.31
Arousal	.82	-1.38	-1.49	-1.11	-1.26	-2.39*	-1.86(*)
Emotional Experience	-2.08*	.33	.23	-.78	-1.08	-.91	-.36
Concreteness	-1.15	-.75	-2.11*	-3.34*	-8.14*	-4.14*	-5.01*
SND	-2.40*	3.19*	2.40*	.77	1.32	1.05	1.54
Concreteness X SND	-1.61	-1.45	-1.85(*)	.44	.14	-.78	-2.04*

* $p < .05$

(*) indicates a trend with $p \leq .07$

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[11] In Experiment 1 (implicit lexical decision task) emotional experience was a negative predictor of RT (i.e., higher ratings of EE were associated with faster RTs), and in Experiment 6 (word relatedness task) arousal was a negative predictor of RT (i.e., higher ratings of arousal were associated with faster RTs).

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