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The Meaning of Words: For Richer or For Poorer

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By

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ABSTRACT

The current study operationally defined semantic richness as the depth and breadth of meaning associated with words. It also examined the relationship between known language variables and their relative contribution to semantic richness as a construct. A total of 60,000 subjective word ratings were explicitly collected from adult participants across 39 different countries who identified as speaking English as a first language. These ratings were compared to other known language variables to investigate the individual and collective relationships among them and determined their predictive influence on the collected ratings. It was found that although most variables were significantly related to the collected ratings and to other variables, together, 5 language metrics combined were significantly influential in predicting the variance in semantic richness, with sensorimotor contributing the most weight, followed by emotional arousal, body-object interaction, emotional valence, and association types. The findings from this study aim to bring awareness to the importance of using a scientific framework to understand the underlying components of semantic processing in order to better inform language interventions.

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CHAPTER 1

REVIEW OF THE LITERATURE

Investigating individual characteristics of words is important for understanding the foundational processes involved in language development. Understanding these foundations has implications for normal acquisition of productive and receptive language processes across the lifespan, and for educating and assisting people who are challenged to develop or reacquire language due to disability, disease, or trauma. Although many variables contribute to language processing, this study seeks to investigate the unique word-level characteristic known as *semantic richness* in order to understand how semantic (i.e., meaning) processing relates to word recognition. This science-based approach to the investigation of word-level metrics and their role in semantic processing may contribute to the development of effective treatment techniques for the development of language in young learners and to facilitate the return of language in clinical populations (e.g., patients with aphasia).

Introduction to Language Acquisition

The processes related to language acquisition are of interest in psycholinguistic and neurolinguistic research for many reasons. For instance, language ability is associated with academic success (Neumann et al., 2019; Nyarko et al., 2018) and performance on language related research tasks (e.g., verbal fluency tasks; Pexman et al., 2013; Rabovsky et al., 2016), across the lifespan (Klooster et al., 2020; O'Connor et al., 2019). For example, the reading proficiency of students in grades 1 to 3 was assessed by Nyarko and colleagues (2018) using the Wide Range Achievement Test 4 (WRAT4) word reading and sentence comprehension subtests. After controlling for demographic characteristics, reading proficiency was found to be positively correlated with academic success. Further, Klooster and colleagues (2020) have demonstrated that language acquisition is a continually evolving and lifelong process that takes place over time, as word knowledge expands and the richness of meaning increases.

In addition to the importance of language development, the process of acquisition has unique implications for each individual learner. For example, the process of language development has been shown to be different for first language learners and normal hearing learners (Hirshorn et al., 2015; O'Connor et al., 2019) when compared to second language learners, hearing impaired learners, and people who are reacquiring language skills after varying degrees of brain trauma (e.g., aphasia due to stroke; Madden et al., 2018; O'Connor et al., 2019). Understanding differences in how language is acquired may help to inform learning strategies that will compliment the unique strengths and weaknesses of all learners. Theories of language development including the lexical quality hypothesis (Perfetti & Hart, 2002) and the triangle model of word knowledge (DVC; Perfetti, 2010) are central to this discussion and will be described below.

Theories of Language Development

The Lexical Quality Hypothesis

The lexical quality hypothesis (LQH; Perfetti & Hart, 2002) states that language development takes place over time, through the interdependent relationship between lexical skill development, language comprehension, and reading practice. *Lexical quality* refers to the quality of the orthographic, semantic, and phonetic representation in the mental lexicon. *Representation*s are acquired through repeated exposure in multiple contexts. Perfetti and Hart (2002) found that a positive relationship exists between the strengthening of representations of lexical components and the subsequent development of increased comprehension. *Component*s can be whole words, or they can be parts of words that are recognized as pieces that form words (e.g., the letters *g, a, t,* and *e* are parts of the whole word recognized as *gate*). This theory suggests that as children develop, they are exposed to increasing linguistic content over time. This exposure can take place through listening, speaking, reading, and writing. Higher levels of exposure results in a higher degree of skill development (i.e., lexical quality). As language skills develop, comprehension increases, leading to better performance on reading exercises. As reading skills increase, further development of language comprehension occurs. Therefore, the development and strength of each component of the LQH is predicated on the development of the other components. More simply, comprehension is enhanced through repeated exposure to language skills over time and level of comprehension relies on the level of word knowledge.

According to this theory, word knowledge involves a three-part process (Perfetti & Hart, 2002) that includes a combination of orthography, phonology, and semantics. *Orthography* is the visual representation of the symbolic (i.e., written) form of language. *Phonology* refers to the auditory sounds that string together to form words. *Semantics* refers to the way in which meaning is conveyed or derived from words. For example, the word *gate* appears in its orthographic form (i.e., symbolic representation), made up of the letters *g*, *a*, *t*, and *e*. The visual representation of the sound (i.e., phonetic form of the word) is represented as {*geyt*}. The semantic representation of the word sound in this case is not unique because in this instance, it has more than one meaning (i.e., gate versus gait).

These multiple meanings are viewed by Perfetti and Hart (2002) as a potential threat to lexical quality. In other words, multiple meanings may interfere with the development of comprehension that is dependent on the skill of the learner. Using a similar example of the word *gait*, skilled readers will recognize the correct meaning by the visual representation of the word and the context in which it appears and understand it to be the way in which a person is standing or walking. Nonskilled readers may interpret the meaning correctly, or they may interpret it as something that refers to the physical barrier meant to control the flow of something going in and out. An understanding of the context from previous (and repeated) exposure is required to fully comprehend the word in the appropriate way. This lexical quality hypothesis was later extended to include the triangle model of language (i.e., DVC; Perfetti, 2010).

The Triangle Model of Language Development

Perfetti (2010) illustrates this model using a triangular visual representation of the cognitive-linguistic mechanisms that represent the interdependent relationship between *decoding* (D), *vocabulary* (V), and *comprehension* (C). Perfetti believes that taken together this model forms the overarching skill of *general reading*. This is similar to the LQH in that it recognizes orthography, phonology, and semantics are the foundation of reading. It differs from LQH in that it also recognizes that there is a dynamic relationship between these that contribute to language development over time. For example, this theory posits that *decoding* includes an understanding of the orthographic and phonological components of word knowledge, *vocabulary* represents knowledge of specific words in addition to the total number of words known, and *comprehension* is representative of knowledge based on larger sets of words (i.e., sentences) as they are used in various contexts.

Learning how to decode is pivotal to building vocabulary and vocabulary in turn facilitates comprehension. This model suggests that deficits in one area may hinder development of the other components (Perfetti, 2010). In addition, word meaning has been found to mediate the relationship between decoding and comprehension. This highlights the importance of understanding the role of the word-level characteristic of language known as semantic richness for its role in language acquisition.

Individual Differences

In addition to the various mechanisms underlying the language acquisition theories, individual differences in abilities influence language development (Hirshorn et al., 2015). For example, phonology is the most important component of language for reading comprehension among hearing children (Hirshorn et al., 2015) and second language learners (L2; O'Connor et al., 2019), and semantic processing is associated with faster recognition of words on language related tasks (Pexman et al., 2013). Importantly, whereas psychology research uses semantics as a measure of proficiency on verbal fluency tasks (König et al., 2018; Li et al., 2017), semantic processing has been found to be the most significant predictor of reading comprehension among deaf children (Sevcikova Sehyr et al., 2018) and is crucial in the retrieval of language in patients with aphasia (Madden et al., 2018). Thus, investigating the underlying structure of semantic processing will aid in the understanding of how meaning influences language development.

Introduction to Semantic Richness

The above clearly indicate that the written, auditory, and semantic representations of words are important in language acquisition; but the processes related to the development and use of semantic representations are not yet fully understood. Newer research offers insight into these processes, with researchers examining the characteristic of words known as *semantic richness* to establish the extent to which meaning plays a role in reading (e.g., Yap et al., 2011). For example, higher levels of semantically rich input have been found to increase learning among children with autism spectrum disorder (ASD; Gladfelter & Goffman, 2018). But what exactly is semantic richness?

The approach of previous research has focused on understanding linguistic processing through the examination of multiple, well studied variables of language. Semantic processing, and in particular, the variable known as semantic richness has only been studied as a construct that is estimated through the analysis of other characteristics of language. For example, Muraki and colleagues (2019) examined the effects of semantic richness through a single word level variable (i.e., number of features). Their research demonstrated that participants respond faster and more accurately to words with a higher number of features (e.g., legs, arms) than to words that are associated with fewer features (e.g., moo, bark). A higher number of features is associated with a higher degree of meaning (i.e., as a measure of semantic richness; Pexman et al., 2008; Yap et al., 2011).

In another example, Pexman and colleagues (2008) measured semantic richness by analyzing the number of semantic neighbours (NSN), number of features (NF), and context dispersion (CD). Other studies have analyzed body-object interaction (BOI;

Tousignant & Pexman, 2012; Yap et al., 2011), imageability (Taler et al., 2016; Yap et al., 2012), and number of senses (NoS; Taler et al., 2016; Yap et al., 2015) to estimate their own assumptions of the variables that contribute to semantic richness.

To understand how these variables might work together to instantiate something that could be called semantic richness it is important to first define them here. The number of features can vary depending on a target word. In one example, the word *chair* is known to have a seat, two arms, a back, and legs. It may be understood by additional features, but the concept of a chair is understood to be such by nature of its associated features (Tousignant & Pexman, 2012; Hargreaves et al., 2012; McRae et al., 1999).

In another example, the number of semantic neighbours (Buchanan et al., 2001) refers to how closely words tend to be related in semantic space (Danguecan, n.d.; Pexman et al., 2008). More specifically, when the word *hair* appears in a body of written text, the word *face* is more likely to be found in the same text when compared to the word *toe* (Danguecan, n.d; Lutfallah et al., 2018). Computational models examine the relationships between words and the rate at which those words tend to appear with other words. Some examples of these models include the *Windsor improved norms of distance and similarities* (WINDSORS), the *bound encoding of the aggregate language environment* (BEAGLES), and the *hyperspace analog to language* (HAL). The WINDSORS model uses an algorithm to determine the number of times a word is likely to appear near another word while controlling for the effect of word frequency (Durda & Buchanan, 2008). BEAGLES similarly examines the relationship of words to other words that share common neighbours in semantic space (Jones & Mewhort, 2007). The HAL model examines the relationship of words in semantic space using an algorithm to determine the context in which words can be expected to be present along side their contextual neighbours (Burgess, 1998). Context dispersion refers to the many contexts in which a word might be used (Taler, 2016; Tousignant & Pexman, 2012; Yap et al., 2012). For example, the word *table* is understood to have the potential to be found in a kitchen, a living room, a restaurant, or in a retail store or even in the context of a vote in a boardroom. Words may also evoke mental images, and the extent to which this is true for a particular word is known as that word's imageability (Keiffer & Trumpp, 2012; Taler et al., 2012; Yap et al., 2012).

Number of senses refers to the ways in which a single word can have multiple representations (Lau et al., 2018; Taler et al., 2016; Yap et al., 2012). For example, a *date* can be some fruit, a specific day on a calendar, or an outing with a friend or romantic partner. Words with more senses are considered to be more semantically rich than words with fewer senses (Lau et al., 2018). Body-object interaction refers to the way that a person is able to physically interact with an object's referent (Tillotson et al., 2008). For example, one is more likely to interact with a *couch* than a *cliff*, meaning *couch* would rate higher on a BOI scale than *cliff* (Siakaluk et al., 2006; Tillotson et al., 2008). Although the above are all measures that researchers have either explicitly or implicitly linked to the concept of semantic richness the actual relationship between those variables and the concept has not yet been explored.

Defining Semantic Richness

Researchers tend to agree that semantic richness is a measure of the degree of meaning associated with words. For example, it is Pexman's belief that "meaning is multidimensional" (Pexman et al., 2013) and semantic richness is "a multidimensional construct that encompasses a word's number of semantic neighbors (NSN), the number of features (NF) associated with its referent, and its contextual dispersion (CD)" (Pexman et al., 2008). More recently, Pexman's research has focused on the principles underlying semantic processing (Pexman, 2020), namely word form, semantic representations, abstract concepts, and experience. However, a single definition of semantic richness has not yet been recorded.

In an attempt to highlight the variations in definitions among current research, for the purpose of this study, other leading researchers in the field were asked to define semantic richness in their own words as displayed in Table 1. Together with current published studies and the opinions of researchers in the field, this study will operationally define semantic richness using the collective opinion that it refers to *the depth and breadth of meaning* of words. However, in addition to the lack of a standardized definition of semantic richness, challenges are present in the techniques previously used to measure this unique characteristic of language.

Table 1

Definitions of semantic richness according to researchers in the field

Researcher	Quote
Marc Brysbaert	"One element is links to other words (number and strength). I am convinced that early acquired words form the core (hubs) of the semantic network. So, they tend to be very rich. Another element is the relationship to embodied experiences. This is captured by the new Lancaster sensorimotor norms."
Chris Westbury	"Semantic richness is the depth of meaning and the degree to which it matters."

Current Metrics and Limitations

Some techniques used to analyze characteristics of language include the collection of reaction times to target words (Tillotson et al., 2008), the development of large corpora through the use of Likert-type rating scales (Tousignant & Pexman, 2012), and through the analysis of regression equations that are used to illustrate how each language variable contributes to the constructs such as semantic richness (Pexman et al., 2008). For example, words that are perceived as more likely to interact with one's body are recognized faster than words rated lower for body-object interaction (Tillotson et al., 2008). Similarly, words have been rated along Likert-type scale continuums to determine how they are perceived in relation to their action potential (Tousignant & Pexman, 2012). In this example, words (e.g., *jump*) were rated from 1 to 6 such that the range of 1 to 3 more closely represented an *entity* (i.e., an inanimate object) and the range of 4 to 6 more closely represented an *action*. In Likert-type scale studies, the resultant ratings are often compared to norms from larger (i.e., big data) studies that collect language variable data such as word frequencies, reaction time norms, or concreteness ratings (e.g., Brysbaert & Kuperman, 2013). The findings can then be used to calculate averages that form the basis of each corpus.

The use of Likert-type rating scales also presents a unique challenge, in the way that each individual word is rated on a single continuum. Data collected in this way are susceptible to *floor* and *ceiling effects* meaning raters may be more likely to consistently rate items at the low or high end of a continuum which can contribute to skewed findings. One way to mitigate these effects is to label every value on the response scale (Chyung, 2020). For example, this would change a task that would normally be ranked from

Disagree to *Agree* on a scale that ranges from 1 to 6, to being ranked on a scale where each number on the scale represents an explicit response (e.g., *Strongly Disagree, Disagree, Somewhat Disagree, Somewhat Agree, Agree, Strongly Agree*).

One solution is to rate individual responses in relation to every other response in a response set. This is arguably more useful, providing a nuanced understanding of the rated stimulus items using a forced choice study design. For example, in early psycholinguistic research, Anderson (1968) used Q-Methodology to force participants to rate words on the characteristic of *likableness*. This study design was unique at the time and forced the rating of individual words against all of the other words in the stimulus set. More recently, Lutfallah and Buchanan (2018) used a similar study design, developing a stimulus set that was generated from a corpus of 40,000 English lemmas (i.e., the base form of a word) that had previously been rated for *concreteness* (Brysbaert & Kuperman, 2013). Participants then rated the words in relation to all of the other words in the Q-Set. The findings were highly correlated with the original corpus (r = .93), with the additional benefit of rank ordering the findings relative to all of the other words in the newly generated list.

This technique is useful in obtaining more fine-grained differences between words in a previously rated corpus; however, Q-Methodology for corpus *development* is limited by the vast number of Q-sets that would be required to achieve an adequate sample rating for a large number of words. For these reasons, this study will use a Likert-type rating scale for each individual word and mitigate the challenges of this study design by explicitly labeling each number on the scale.

Exploratory factor analysis has been used to examine the relative weight that each characteristic of language (i.e., BOI, concreteness, imageability) contributes to semantic richness (Muraki et al., 2019). Regression analysis is another way to examine how individual characteristics of language contribute to semantic richness. Goh and colleagues (2016) analyzed the contributions of six language variables (i.e., concreteness, valence, arousal, number of features, semantic neighbourhood density, and semantic diversity) to understand their role in semantic richness. This study was modelled after the Pexman et al. (2008) study that examined how the unique variance from visual and auditory word recognition timed tasks using NSN, NF, and CD were used to explain semantic richness. The current study also employed a multiple regression analysis to look at the overall relationship between multiple corpora of language variables and the collected semantic richness ratings; however, this is the first known study to explicitly collect values for semantic richness on a set of monomorphemic words. A model to predict semantic richness values from a set of predictor variables (see list of predictor variables below) was built by optimizing the multiple regression analysis. The model was then cross validated to ensure that the model performed similarly in randomly generated groups within the sample.

Finally, limitations also exist in various methods used in the collection of data. Language variable data have been collected through a variety of study designs, including small (Robovsky et al., 2016; Taler et al., 2016), medium (Lau et al., 2018), and large-scale studies (Brysbaert et al., 2013 For example, Brysbaert and colleagues' (2013) collected ratings for 40,000 English lemmas using a large-scale (i.e., big data) technique using an online participant recruitment platform called Amazon Mechanical Turk

(MTurk; www.mturk.com). This type of recruitment service allows for a larger sample of North American respondents (Kennedy et al., 2020) to participate in research studies without consideration for constraints such as location or travel. Although larger scale studies may provide data that are more representative of the population as a whole, MTurk is not without its flaws. For example, Kennedy et al. (2020) discovered that data quality is a concern when bots fraudulently access and participate in studies that are aimed at collecting human participant data. In addition, they found that such MTurk data fraud has been increasing since 2018.

Prolific (www.prolific.co) is an alternative participant recruitment software to MTurk. Some research has shown it to be comparable to MTurk in terms of data quality, meaning participants were adequately attentive during the task, lending to reliability of the data (Peer et al., 2017); however, Prolific allows for participant surveys and offers a more diverse participant base than similar software platforms. In addition, Prolific software allows researchers to confirm the validity of the data before approving it for use in the study and paying the participant (Peer et al., 2017). More importantly, Prolific participant responses were found to be more honest compared to other participant recruitment sites (Peer et al., 2017).

The downside to online participant recruitment sites involves the potentially high cost of collecting data from large numbers of participants and potentially restricting the pool of participants to those who sign up to participate in paid research studies and those who participate for personal interest reasons. Using a viral based online data collection approach, the current study used a social media campaign to engage participants to collect large amounts of data. The study was shared virally across social media platforms such as Facebook, Instagram, Twitter, and Reddit. One obvious advantage to this approach is that the data are collected without charge but another even more important benefit is that the participants have no reason to participate other than interest in the study. The results are consequently likely to reflect good-faith participation.

Research Objectives

The purpose of the current study was three-fold. The first objective was to operationally define *semantic richness* as its own variable of language based on definitions provided in prior research and by assessing the opinions of current researchers in the field. The second aim of this study was to create a corpus of monomorphemic words normed on this semantic richness variable. The norms were collected using an online word rating tool described below. The third objective of the study was to determine how these norms relate to other semantic norms to successfully predict the norms of unrated words using an equation developed using a multiple regression analysis in SPSS with the predictor variables described in the Methods section below. It was hypothesized, based on prior research, that all of the predictor variables used in this study would be significant contributors to the underlying construct of the newly collected semantic richness norms.

CELEX

The Centre for Lexical Information (CELEX; (Baayen & Piepenbrock, 1996) is a lexical database of Dutch, English, and German words that is used in a wide range of linguistics research (Crossley et al., 2010; Gagné et al., 2019; Hathout, 2014). The English words found in the database were taken from two dictionaries (Keuleers, 2015) and have been rated for various characteristics of language such as frequency, orthography, phonology, and morphology. This database formed the basis from which the final stimulus set for this study originated (Baayen & Piepenbrock, 1996).

CHAPTER 2

DESIGN AND METHODOLOGY

Study Design

The study used a web-based word rating app (i.e., wordraterapp.ca) that allowed participants to rank words on one of six labels along a continuum according to how meaningful each word was to the individual (i.e., *non-word, not at all, slightly, somewhat, moderately,* and *extremely*). The words that were rated were chosen from the CELEX database and compared against Brysbaert and colleagues' 62,000 English lemmas (Brysbaert et al., 2018) to find a list of words that are known to 97.5% of the population (See Appendix A). These words were randomly divided into sets of 50 words that appeared to participants one at a time. Additionally, a list of non-words (See Appendix B) was generated from the WUGGY database (Keuleers & Brysbaert, 2010). A total of 10 nonwords were randomly selected to be shown with the 50 real words. The non-words were intended to be used as a measure of attention and effort in the rating procedure.

Stimulus Development

The stimulus set was developed from a list of unique monomorphemic words taken from the CELEX database (Baayen & Piepenbrock, 1996). This list was then compared to Brysbaert and colleagues’ (2018) 62,000-word prevalence norms to remove words that are known to fewer than 97.5% of the population in both the United States and the United Kingdom. This cut-off was chosen because it has been shown that this number reflects a point at which word knowledge is not affected by word frequency effects (Brysbaert et. al., 2018) and because maintaining only words with higher prevalence norms would increase the likelihood that all words in the stimulus set would be known to most participants. After all of these considerations, a final list of 4,026 words was generated.

Predictor Variables

The predictor variables were derived from a variety of sources including the English Lexicon Project (Balota et al., 2007), the Word Pair App (Lutfallah et al., 2018), the Lancaster Sensorimotor Norms: Multidimensional measures of Perceptual and Action Strength for 40,000 English words (Lynott, et al. 2019), and the Glasgow norms (Scott et al., 2018). Each variable and its source are described in Table 2.

Table 2

Predictor Variables

Log-frequency (LF)	This refers to word log or word frequency ratings collected from the Hyperspace Analogue Language (HAL) norms collected by Lund and Burgess (1996). These norms relate to the number of times a word presents itself relative to other words (i.e., the global word co-occurrence rate). The words were rated on a scale from 0-17 with an average of 4.49 and SD = 2.89 (Balota et al., 2007).
Semantic neighbourhood density (SND	This refers to the relative distance of a relationship between words in multidimensional semantic space. For example, words with closer neighbours (e.g., sock and shoe) are more related than words with distant neighbours (e.g., sock and fork). The closer the words are within their neighbourhoods, the more

	likely the words are to appear together within a block of text (Durda & Buchanan, 2008). These word values were taken from the Word Pair App site (Lutfallah et al., 2018).
Context dispersion (CD)	This refers to the SUBTLEX contextual diversity corpus that was derived by evaluating the percent of films that contain specific target words in their subtitles (Balota et al., 2007). The words were rated on a scale from 0-100 with an average of 2.85 and *SD* = 10.16.
Concreteness (Con)	This refers to the relatively tangibility of a word's referent. These ratings were collected by Bysbaert et al. (2013, BRM) on a set of 40 thousand English word lemmas. The words were rated on a scale from 1.04-5.00 with an average of 3.11 and SD = 1.03.
Age of acquisition (AoA)	This refers to the average age that individuals acquire words across the lifespan. These ratings were collected by Kuperman et al. (2012, BRM)). The words were rated on a scale from 1.58-18.92 with an average of 9.71 and SD = 2.96.
Body-object interaction (BOI)	This refers to the degree to which a word's referent has the ability and chance to interact with one's body. For example, the word couch would be more highly rated on this variable than the word cliff (Pexman et al., 2018, BRM). The words were rated on a scale from 1.12-6.88 with an average of 3.54 and SD = 1.38.
Emotional valence (EV)	This refers to the positive or negative emotion associated with a word. (e.g., love and intruder; Warriner et al., 2013, BRM). The words were rated on a scale from 1.30-8.53 with an average of 5.08 and SD = 1.28.
Emotional arousal (EA)	This refers to the relative intensity of emotion that is attributed to a word. For example, words can be rated based on high or low intensity (Warriner et al., 2013,

	BRM). The words were rated on a scale from 1.6-7.79 with an average of 4.21 and SD = 0.90.
Association frequency (AF)	This refers to the number of times a word appears within three words of a target word (De Deyne, et al., 2018, BRM). The words were rated on a scale from 1-13,771 with an average of 102.80 and SD = 368.97.
Association types (AT)	This refers to the number of words that produce a target word as one of the first three associate words (De Deyne, et al., 2018, BRM). The words were rated on a scale from 2-2,177 with an average of 38.85 and SD = 101.56.
Imageability (Img)	This refers to the degree to which a word's referent can produce an image in the mind. The words were gathered from the Glasgow Norms and were rated on a scale from 1.74-6.94 with an average of 4.79 and SD = 1.35 (Scott et al., 2018).
Semantic diversity (SD)	This refers to the number and contexts of meaning that can be given to one particular word of the same spelling. The words were rated on a scale from 0.18-2.41 with an average of 1.56 and SD = 0.34 (Hoffman et al., 2012, BRM).
Sensorimotor information (SI)	These norms refer to a multidimensional measure of the strength of connection between a word and sensory (e.g., taste, sound) and motoric or action parts of the body (e.g., foot, hand; Lynott, et al., 2019).

Participant Recruitment and Inclusion Criteria

Participants were recruited through an online social media campaign using Facebook, Twitter, Instagram, and Reddit. It was estimated that it would take between 5 and 10 minutes to complete the ratings for one list of words, including the initial demographic questionnaire, consent, and instruction video. There were two criteria for inclusion in the study. The first requirement was that each participant identified that English was their first language. The second was that participants must have identified as 18 years old or older at the time of sign up. Based on the number of words in the stimulus set (4,026) and the number of times each word needed to be rated (using criteria similar to that used to collect the Brysbaert et al. [2013] concreteness ratings), it was estimated that a total of 2,000 lists of words needed to be rated. Participants were able to rate more than one list of words if they were interested.

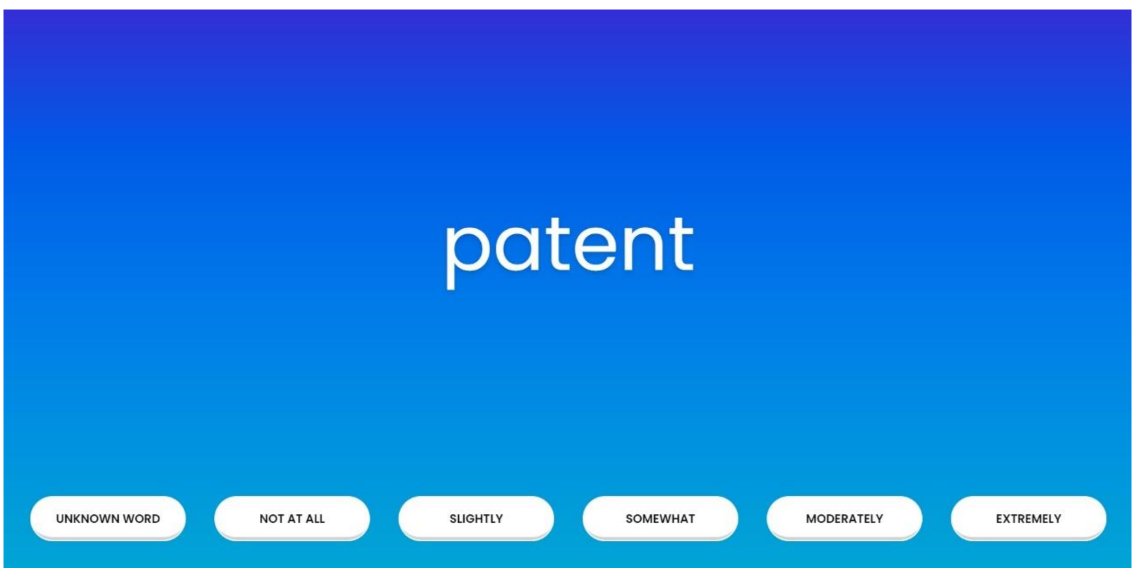
Participants were asked if English was their first language, their current age, and their country of residence. Identifying information was not recorded so there was no way for a participant to opt out of the study once they completed the sorting task. Demographic information was collected as a screener to begin the study process. Age and country of residence was tied to the data collection for the purposes of providing demographic information of the respondents. The data were separated from the participant information after the initial data cleaning step. It is difficult to determine the total number of participants recruited because some participants rated more than one list of words. Data were not collected on individual participants to comply with the de-identification approved in the study's ethics. Only participants who identified English as a first language and were 18 years of age or older were approved to participate in the study. Participants ranged in age from 18 to 65 (M = 35.71). Participants self-identified as living in a combined total of 39 countries (see Appendix C). The study was gamified to the extent that the task was fast and enjoyable. In exchange for participation in the rating of each list of words, participants were given a value representing their relative rating of their unique set of words compared to all other participants ratings of the same words.

Software and Computer Requirements

Participants used either a cell phone, a PC or MAC desktop, or a lap top computer to complete the study at www.wordrater.ca. For each participant, a sorting algorithm gathered the least rated 500 words in the list and randomly sorted to generate a unique 60-word stimulus set for each participant. This method ensured that each word in the stimulus set had an equal chance of being sorted over time. The study design included a home page that created a unique session ID to capture each user's country of residence, age, and whether English was their first language. No other participant data were collected. This page was followed by a consent form and an instruction page. The study itself consisted of a word rating activity (See Figure 1).

Figure 1

Word rating activity in wordrater.ca



Note. This figure is an example of the presentation of words in the online rating task at wordrater.ca.

Procedure

Upon signing up for the study, participants clicked a link directing them to the study page. Upon entering the study's web address, participants were asked to provide their consent. If consent was not granted the user was unable to advance through the study and could exit the page at any time by closing the browser window. After granting consent, participants were directed to a demographic questionnaire (See Appendix D) followed by an instruction page with a video, detailing how to complete the study. The video asked the participants to rate each word according to how meaningful they found each word, noting there were no right or wrong answers. The participants were then instructed that if they were presented with a word that they have never seen before, they should rate the word as an "*unknown word.*"

After reviewing the instructions and advancing to the study by clicking on the *Next* button, participants were presented with a word in the center of the screen and a 6-point rating scale that was labelled *non-word, not at all, slightly, somewhat, moderately,* and *extremely* (See Figure 1). The scale item called *non-word* was included as a validity check for the six non-words that were presented randomly throughout the activity. These non-words served both as a measure of attention and effort. Participants were asked to make a decision about each of the 60 words plus the six non-words as they appeared in the center of the screen, one after the other. The choice of which button to click was determined based on their individual perception of the degree of semantic richness (i.e., *meaning*) of each word. They did this by clicking the label they felt most closely matched their opinion about the word. That is, they clicked on *non-word, not at all, slightly, somewhat, moderately,* or *extremely,* for each word.

Once all the words were sorted, participants who incorrectly rated any of the non-words as words were directed to a page that asked them to identify whether they had rated any non-words incorrectly, and if so, how many. Participants who rated all non-words correctly did not have to complete this step. The final screen presented to all participants was a page that thanked them for their participation in the word rating task and gave them information about how their ratings compared to others who had rated the same words. This page also provided instructions on how to contact the researcher with any questions relating to the study.

CHAPTER 3

STATISTICAL ANALYSIS AND RESULTS

Data Cleaning and Preparation

For each session, participants rated 50 words and 10 non-words. In total, 4,026 words (See Appendix A) were rated from 3-34 times each (M = 18.32). The 10 non-words (See Appendix B) were added to the task as a measure of each participant's attention and effort. Data collected on each task was rated out of 60, with 50 points being awarded for each real word rated and one point for every non-word that was correctly rated as an unknown word. The total value was then compared to the number of words a participant identified as being incorrectly rated for a total score that was only visible to the researcher. For example, if a participant incorrectly rated two non-words as words, their score at the end of the rating task was 58 out of a total of 60 points. If they identified that they had incorrectly rated one or two words, the score would increase to 59 or 60 points respectively. Any ratings of words that were incorrectly rated as non-words (n = 310) were excluded from the analysis.

A tolerance of +/- 2 was allowed for participants to incorrectly identify non-words as words or incorrectly identifying an error when a word was correctly identified. Thus, individually rated lists with scores ranging from 58 to 62 were maintained in the dataset. Lists with scores outside of this range were deleted, accounting for 103 participants' data (i.e., 5,150 data points) being removed (i.e., 100 participants scored 57 or less out of 60 and 3 participants scored 63 or higher, meaning they incorrectly identified having rated non-words as words when they had been correctly rated). Thus, 60,000 individual ratings remained in the dataset as correctly rated.

The words in the stimulus set were matched to their values from various data bases containing word-level variables relevant to measuring lexical processing. These values were used as predictor variables in the current study's data analysis, and they include word frequency, semantic neighbourhood density, context dispersion, age of acquisition, body-object-interaction, emotional valence, emotional arousal, emotional dominance, association frequency, imageability, semantic diversity, association type, and sensorimotor strength. Each variable was described above with a reference to the available corpora. Words with associated values on all of the variables were kept in the final stimulus set. Words with missing values for any of the variables were excluded, resulting in the loss of 2,436 words. Thus, the final stimulus set contained 1,590 words.

Statistical Analysis

After entering the data into SPSS Version 28, a correlation analysis was conducted (See Table 3) to determine the extent to which all of the variables correlated with one another and to assess for multicollinearity among the variables. Then a multiple regression analysis was conducted to evaluate the extent to which participant ratings of semantic richness can be predicted by a set of well studied variables of language. Finally, the model was cross validated by splitting the data randomly into two groups, with each group retaining approximately 50% of the data.

Decisions about the specific variables entered into the regression analysis were made based on prior research referring to semantic richness (e.g., Pexman et al., 2008; Yap & Pexman, 2016). Descriptive statistics for these variables can be found in the "Predictor Variables" in Table 2. An examination of the correlations (See Table 3) revealed that all variables except semantic neighbourhood density ($p = -.04$) were significantly correlated with rated semantic richness at the $p < .001$ level. *Concreteness* was removed from the analysis because of its high correlation with body-object interaction ($r = .78$). Although it is typical to maintain the variable that is more highly correlated with the criterion variable, the decision to retain body-object interaction ($r = .22$) and eliminate concreteness ($r = .32$) was made because concreteness tends to be more highly correlated across many of the other variables in the current dataset. This decision was meant to eliminate any masking effects that the inclusion of the variable might cause. Context *dispersion* was highly correlated with log frequency ($r = .71$), so context dispersion was maintained in the dataset because of its higher correlation with semantic richness ($r = .30$). Emotional dominance was removed due to its high correlation with emotional valence ($r = .67$) and lower correlation with semantic richness ($r = .10$). Association frequencies and association types were almost perfectly correlated ($r = .95$) so the association types variable was maintained in the dataset because of its higher correlation with semantic richness ($r = .35$). The variables maintained in the analysis included semantic neighbourhood density ($r = -.04$), age of acquisition ($r = -.16$), body-object interaction (r = -.22), emotional valence (r = .15), emotional arousal (r = .21), semantic diversity (r = .20), imageability (r = -.09), context dispersion (r = .30), association types (r = .35), and sensorimotor (r = -.21).

After entering the chosen variables into the regression model, the *Enter* method was used to regress the 10 predictor variables onto the criterion variable to assess the extent of each predictor variable's unique contribution to semantic richness (Pituch & Stevens, 2016). The first step in the analysis was to test the assumptions for multiple regression and clean the data.

On examination of the initial output, it was observed that four cases were missing from the body-object interaction dataset, and five cases from the imageability dataset. Thus, the sample size (N = 1,573) for this analysis was deemed to be large enough based on the equation ($df = N\text{-}k\text{-}1$ or 1,562), and the generally accepted ratio of 15 observations for each predictor variable in the regression equation (Pituch & Stevens, 2016). Outliers on x (predicted) were checked using Mahalonobis Distance using a Chi^2 cut-off value of 18.31 (Field, 2018; k = 10, p = .05). This resulted in 133 observations being outside of the cut-off value. Outliers on y (residuals) were checked using the Standardized Residuals. Using the acceptable cut-off of +/- 2.5 for a large sample size (Pituch & Stevens, 2016), 18 outliers were outside of the acceptable range. The data was initially analyzed with these observations removed; however, the decision was made to maintain the outlier variables in the model because they did not affect the regression due to the large sample size. Additionally, their inclusion reflects the unique opinions of a small group of participants that may help to explain subtle differences in the data. The Cook's Distance scores and DFBeta scores were within the acceptable range of +/-1, indicating that no cases were creating undue influence on the model. A visual inspection of the regression standardized residuals histogram suggests the data approximated a normal distribution. A graph of the observed and predicted scores on a P-P Plot of Regression Standardized Residuals indicated that the relationship was normally distributed and thus could be explained by a linear model. Further, the Shapiro Wilks test indicated that the residuals were normally distributed ($SW = 1.0$, $p = .27$). The constant variance of the residual terms meant that homoscedasticity was intact, and the Durbin-Watson test (2.07) of independent observations was in the acceptable range, indicating the residual errors were uncorrelated.

The model was cross validated by splitting the original dataset into two randomly divided groups, resulting in each group retaining approximately 50% of the full dataset (Group1 $n = 763$; Group2 $n = 810$). As with the original dataset, the assumptions of both groups were met. All models were found to be significant.

Table 3

Correlation Table of 12 Predictors, Including the 10 Final Predictors

	SR	SND	LF	CD	Con	AoA	BOI	EV	EA	AF	AT	SD	Img	SM
SR	--	-0.04	.29**	.30**	-.32**	-.16**	-.21**	.15**	.21**	.30**	.35**	.20**	-.09**	-.21**
SND	-0.04	--	-.14**	-.09**	.12**	0.04	.12**	-0.01	-0.02	0.00	-0.03	-.17**	.28**	.05*
LF	.29**	-.14**	--	.71**	-.23**	-.41**	-.12**	.23**	-0.01	.46**	.55**	.55**	-.09**	-.10**
CD	.30**	-.09**	.71**	--	-.26**	-.46**	-.15**	.19**	0.02	.49**	.58**	.48**	-.08**	-.16**
Con	-.32**	.12**	-.23**	-.26**	--	-.25**	.78**	.14**	-.16**	0.04	-0.04	-.40**	.29**	.19**
AoA	-.16**	0.04	-.41**	-.46**	-.25**	--	-.26**	-.28**	.08**	-.43**	-.47**	-.25**	-.11**	.01
BOI	-.21**	.12**	-.12**	-.15**	.78**	-.26**	--	.21**	-.16**	.10**	0.04	-.34**	.23**	-.02
EV	.15**	-0.01	.23**	.19**	.14**	-.28**	.21**	--	-.21**	.17**	.18**	0.05	0.02	0.01
EA	.21**	-0.02	-0.01	0.02	-.16**	.08**	-.16**	-.21**	--	.10**	.10**	-0.03	-0.03	.18**
AF	.30**	0.00	.46**	.49**	0.04	-.43**	.10**	.17**	.10**	--	.95**	.20**	0.02	.12**
AT	.35**	-0.03	.55**	.58**	-0.04	-.47**	0.04	.18**	.10**	.95**	--	.28**	0.01	-.14**
SD	.20**	-.17**	.55**	.48**	-.40**	-.25**	-.34**	0.05	-0.03	.20**	.28**	--	-.13**	-.07**
Img	-.09**	.28**	-.09**	-.08**	.29**	-.11**	.23**	0.02	-0.03	0.02	0.01	-.13**	--	.06**
SM	-.21**	.05*	-.10**	-.16**	-.19**	.01	-.02	.01	.18**	.12**	-.14**	-.07**	.06**	--

Note. SR = semantic richness; SND = semantic neighbourhood density; LF = log frequency; CD = context dispersion; Con = concreteness; AoA = Age of Acquisition; BOI = body-object interaction; EV = emotional valence; EA = emotional arousal; AF = association frequency; AT = association types, SD = semantic diversity; Img = imageability; SM = sensorimotor. *$p < .05$. **$p < .01$.

Results

To determine the impact of current language metrics on semantic richness, a multiple regression analysis was performed. The *Enter* method was used in SPSS version 28 and the *F* was set to correspond to an *alpha* of .05. The combination of the chosen set of language variables explained 25.3% of the variance in semantic richness (See Table 4). The model was found to be significant, $F(10, 1562) = 52.97$, $p < .001$, with an $R^2 = .25$. The current model predicted semantic richness was equal to $3.05 + .13_{(SND)} + .00_{(CD)} - .01_{(AoA)} - .08_{(BOI)} + .06_{(EV)} + .08_{(EA)} + .00_{(AT)} + .02_{(SD)} - .02_{(Img)} – 1.07_{(SM)}$.

Table 4

Model 1 Summary

Model	*R*	R^2	Adj. R^2	SEE	R^2 Change	*F* Change
1	0.50	0.25	0.25	0.42	0.25	52.97

Of the 10 variables analyzed in the model, five were found to be significant contributors to the variance explained in semantic richness. Body-object interaction (β = -.24, t = -8.91, p < .001) and sensorimotor (β = -.15, t = -6.49, p < .001), were significant negative predictors of semantic richness, meaning that for every 1 unit of change in BOI or SM, semantic richness decreased by their corresponding *t* value. Emotional valence (β = .16, t = 6.85, p < .001), emotional arousal (β = .16, t = 6.89, p < .001), and association types (β = .25, t = 8.92, p < .001) were significant positive predictors of semantic richness. This means that for every 1 unit increase in a predictor variable, semantic richness increased by the value that was reflective of its associated *t* value. Semantic neighbourhood density, context dispersion, age of acquisition, semantic diversity, and imageability were not found to be significant predictors of semantic richness in this model (See Table 5).

Table 5

Coefficients and Correlations of Final Total Sample Predictors

Variable	*b*	Std. Error	Structure	*t*	Sig.	Zero-order	Partial	Semi
(Constant)	3.05	0.16		18.75	<.001			
SND	0.13	0.11	0.03	1.23	0.22	-0.04	0.03	0.03
AoA	-0.01	0.01	-0.05	-1.88	0.06	-0.16	-0.05	-0.04
BOI	-0.08	0.01	-0.24	-8.91	<.001	-0.22	-0.22	-0.19
EV	0.06	0.01	0.16	6.85	<.001	0.14	0.17	0.15
EA	0.08	0.01	0.16	6.89	<.001	0.21	0.17	0.15
SD	0.02	0.04	0.01	0.44	0.66	0.2	0.01	0.01
Img	-0.02	0.01	-0.04	-1.86	0.06	-0.09	-0.05	-0.04
CD	0.00	0.00	0.03	1.02	0.31	0.3	0.03	0.02
AT	0.00	0.00	0.25	8.92	<.001	0.36	0.22	0.19
SM	-1.07	0.16	-0.15	-6.49	<.001	-0.21	-0.16	-0.14

Note. SR = semantic richness; SND = semantic neighbourhood density; CD = context dispersion; Con = concreteness; AoA = Age of Acquisition; BOI = body-object interaction; EV = emotional valence; EA = emotional arousal; AF = association frequency; AT = association types, SD = semantic diversity; Img = imageability; SM = sensorimotor.

To cross validate the model, the dataset was split into two groups. The model for Group 1 (n = 763) was found to be significant, $F(10, 752) = 22.62$, $p < .001$, with an R^2 = .23. This model found that 23.1% of the variance in semantic richness could be accounted for by the 10 predictor variables (See Table 6). The model predicted semantic richness was equal to 3.03 + $.04_{(SND)}$ + $.00_{(CD)}$ - $.01_{(AoA)}$ - $.07_{(BOI)}$ + $.06_{(EV)}$ + $.09_{(EA)}$ + $.00_{(AT)}$ - $.02_{(SD)}$ - $.02_{(Img)}$ - $.95_{(SM)}$. In this model, 5 variables were found to be significant predictors of semantic richness. Body-object interaction (β = -.23, t = -5.69, p < .001) and sensorimotor (β = -.12, t = -3.66, p < .001) were significant negative predictors of semantic richness. Emotional valence (β = .16, t = 4.52, p < .001), emotional arousal (β = .17, t = 4.90, p < .001), and association types (β = .25, t = 5.83, p < .001) were found to be significant positive predictors of semantic richness. This meant that for every 1 unit increase in a predictor variable, semantic richness increased by the value that was reflective of its associated t value. Imageability, semantic neighbourhood density, age of acquisition, context dispersion, and semantic diversity were not found to be significant predictors of semantic richness in this model (See Table 7).

Table 6

Model Summary for Group 1 Split Data

Model	R	R^2	Adj. R^2	SEE	R^2 Change	F Change
1	0.48	0.23	0.22	0.44	0.23	22.62

Table 7

Coefficients and Correlations of Final Group 1 Predictors

Variable	b	Std. Error	Structure	t	Sig.	Zero-order	Partial	Semi
Constant	3.03	0.24		12.46	0.00			
SND	0.03	0.16	0.01	0.21	0.83	-0.05	0.01	0.01
AoA	-0.01	0.01	-0.03	-0.76	0.45	-0.14	-0.03	-0.02
BOI	-0.07	0.01	-0.23	-5.69	0.00	-0.22	-0.20	-0.18
EV	0.06	0.01	0.16	4.52	0.00	0.11	0.16	0.14
EA	0.09	0.02	0.17	4.90	0.00	0.21	0.18	0.16
SD	-0.02	0.07	-0.01	-0.25	0.80	0.19	-0.01	-0.01
Img	-0.02	0.02	-0.03	-0.87	0.38	-0.09	-0.03	-0.03
CD	0.00	0.00	0.04	0.97	0.33	0.29	0.04	0.03
AT	0.00	0.00	0.25	5.83	0.00	0.35	0.21	0.19
SM	-0.95	0.26	-0.12	-3.66	0.00	-0.20	-0.13	-0.12

Note. SR = semantic richness; SND = semantic neighbourhood density; CD = context dispersion; Con = concreteness; AoA = Age of Acquisition; BOI = body-object interaction; EV = emotional valence; EA = emotional arousal; AF = association frequency; AT = association types, SD = semantic diversity; Img = imageability; SM = sensorimotor.

The model built for Group 2 (n = 810) was also found to be significant, $F(10, 799) = 31.12$, $p < .001$, with an $R^2 = .28$, meaning 28.0% of the variance in the criterion variable was accounted for by the predictors (See Table 8). Group 2's model predicted semantic richness was equal to $3.06 + .23_{(SND)} + .00_{(CD)} - .02_{AoA)} - .08_{(BOI)} + .07_{(EV)} + .08_{(EA)} + .00_{(AT)} + .05_{(SD)} - .03_{(Img)} - 1.15_{(SM)}$. As found in Group 1, Group 2's model found five variables to be significant predictors of semantic richness. Body-object interaction ($\beta = -.25$, $t = -6.91$, $p < .001$) and sensorimotor ($\beta = -.17$, $t = -5.44$, $p < .001$) were significant negative predictors of semantic richness. Emotional valence ($\beta = .17$, $t = 5.12$, $p < .001$), emotional arousal ($\beta = .16$, $t = 4.85$, $p < .001$), and association types ($\beta = .26$, $t = 6.87$, $p < .001$) were found to be significant positive predictors of semantic richness. This meant that for every 1 unit increase in a predictor variable, semantic richness increased by the value that was reflective of its associated *t* value. Imageability, semantic neighbourhood density, age of acquisition, context dispersion, and semantic diversity were not found to be significant predictors of semantic richness in this model (See Table 9).

Table 8

Model Summary for Group 2 Split Data

Model	*R*	R^2	Adj. R^2	SEE	R^2 Change	*F* Change
1	0.50	0.25	0.24	0.42	0.25	26.20

Table 9

Coefficients and Correlations of Final Group 2 Predictors

Variable	*b*	Std. Error	Structure	*t*	Sig.	Zero-order	Partial	Semi
Constant	3.06	0.22		13.86	0.00			
SND	0.23	0.15	0.05	1.54	0.12	-0.03	0.05	0.05
CD	-0.02	0.01	-0.07	-1.90	0.06	-0.18	-0.07	-0.06
AoA	-0.08	0.01	-0.24	-6.91	0.00	-0.21	-0.24	-0.21
BOI	0.06	0.01	0.17	5.12	0.00	0.18	0.18	0.15
EV	0.08	0.02	0.16	4.85	0.00	0.21	0.17	0.15
EA	0.05	0.06	0.03	0.89	0.37	0.22	0.03	0.03
AT	-0.03	0.02	-0.05	-1.69	0.09	-0.10	-0.06	-0.05
SD	0.00	0.00	0.02	0.44	0.66	0.32	0.02	0.01
Img	0.00	0.00	0.26	6.87	0.00	0.37	0.24	0.21
SM	-1.15	0.21	-0.17	-5.44	0.00	-0.23	-0.19	-0.16

Note. SR = semantic richness; SND = semantic neighbourhood density; CD = context dispersion; Con = concreteness; AoA = Age of Acquisition; BOI = body-object interaction; EV = emotional valence; EA = emotional arousal; AF = association frequency; AT = association types, SD = semantic diversity; Img = imageability; SM = sensorimotor

CHAPTER 4

DISCUSSION

General Discussion

The current study examined the predictive value of a set of word-level metrics on the construct of semantic richness after operationally defining the term as the depth and breadth of meaning associated with words. Moreover, the study aimed to create the first known corpus of ratings explicitly collected for semantic richness. Together, these procedures were meant to inform the understanding of semantic richness and its underlying constructs and to identify the degree to which the collected ratings might be used in future studies to examine the effect of semantic processing.

Although it was expected that a relationship would exist between all of the variables in the study, specifically in how they would relate to and explain semantic richness, it came as a surprise to find that some variables did not correlate with the predicted outcome variable and did not predict the underlying construct. For example, semantic neighbourhood density was shown to be related to many of the predictor variables (See Table 3) at the bivariate level; however, findings from this study indicated that semantic neighbourhood was not related to the objectively measured semantic richness ratings of meaningfulness when entered into the multiple regression analysis. This means that the relative closeness of words in semantic space was not found to be an important consideration in individual ratings of words in this study. One explanation for this may be due to the SND values used in this study (Lutfallah et al., 2018) being based on time to recognition. Another consideration for this finding may be related to the limited number of words available across all corpora.

The most influential contributors to semantic richness found in this model included body-object interaction, emotional valence, emotional arousal, association types, and sensorimotor. Body-object interaction and sensorimotor variables were found to be negative predictors of semantic richness. This suggests that the more likely a person is to interact with an object, either with their body or their senses, the less meaning they tended to associate with its word's referent. This is supported by the negative relationship found between the collected semantic richness values and the concreteness ratings. Words scoring higher on the variable concreteness tended to score lower on meaningfulness. Put another way, abstract words were found to hold more meaning and thus scored higher on the semantic richness scales.

Surprisingly, association types and semantic richness are two variables that represent the relative closeness of words in semantic space, yet they had vastly different contributions to the prediction equation in this study. Words that tended to be closely related by virtue of the likelihood of being found (i.e., spoken or heard) after other words (i.e., association types) were rated higher on meaningfulness. This variable contributed the most weight to the prediction equation relative to the other variables entered into the analysis. In contrast, words that tended to have more relatives (i.e., semantic neighbourhood density) did not contribute to the relative meaningfulness of the words in this study. Not surprisingly, the relationship between emotions and semantic richness indicates that words associated with higher levels and intensity of emotions tended to be rated as more meaningful.

Limitations and Future Research

This study is not without some limitations. For example, one limitation is related to the number of times each of the words were rated. Some words were rated only three times whereas others were rated up to 24 times. It could be assumed that a larger number of ratings would more closely approximate a true population level rating for each word. Future research could examine a smaller list of words to ensure more ratings. Alternatively, future research should focus on collecting data for a longer period of time to optimize the number of words rated and the number of ratings per word.

Another limitation is related to the corpora used in this study. The individual words and the types of words used (e.g., monomorphemic, concrete, noun, etc.) along with the way in which the ratings were collected render the corpora inherently different. For example, many of the corpora ratings (e.g., SND, BOI, Img) were based on reaction time data that has the potential to measure other constructs than meaning (i.e., processing speed). The semantic richness values in this study were rated subjectively, thereby controlling for the effect of processing speed on the values. Moreover, a wide range of rating availability exists between corpora. For example, the corpus of concreteness ratings (Bysbaert et al., 2013, BRM)) contained 40,000 words whereas the imageability (Scott et al., 2018) corpus contained only 5,500 words. This was further complicated by the requirement of all words in this study to have ratings across all corpora. Future research could focus on developing an optimized list of words that match across a range of corpora while ensuring the list is large enough to maintain a reliable effect size in the analysis process and while also controlling for word level effects. For example, a lemma is the smallest form of a word (e.g., *help*) whereas a lexeme is one of many forms that a word can take (e.g., *helps*, *helped*, *helping*).

Finally, semantic richness as it relates to the depth and breadth of meaning associated with words may forever fall short of encompassing all of the potential underlying constructs without the confounds of geographical, cultural, societal, and generational differences. Moreover, all of these potential areas of difference are compounded by the ever-changing zeitgeist across time and most important, by the idiosyncratic differences among individual raters.

Another area of focus for future research would be to examine other constructs of language and to employ other statistical analyses. For example, the variables could be examined for the existence of a mediation and/or a moderation effect within the relationships among variables. Further research could also investigate the ways in which the lexicon, semantics, and syntax of both oral and written language might contribute to the relative importance of the underlying structure of semantic richness and whether that might change as a function of the method of language expression/reception.

Implications

The implications of this study could be used to inform language acquisition/reacquisition strategies for people who learn best in ways that are outside of a standardized format. For example, prior research indicates that children with autism, deaf children, and patients with aphasia perform better when presented with information that is more semantically rich (Gladfelter & Goffman, 2018; Madden et al., 2018; Sevcikova Sehyr et al., 2018). Treatment programs traditionally developed with audio and visual spaced retrieval and cueing (Marshall & Freed, 2006; Schuell & Jenkins, 1974) often use concrete words as a stimulus. Knowing abstract words tend to be rated as more semantically rich than concrete words, the restructuring of treatment stimuli to reflect more semantically rich information may render language acquisition/reacquisition treatment programs more effective. This highlights the importance of taking a science backed approach to investigating word-level metrics and their effects on semantic processing and their role in the development and reacquisition of language.

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APPENDICES

APPENDIX A

Complete word list of all words used in the randomly generated stimulus set

thorn	other	arrow	touch	break	wig
exact	brash	senate	bird	coarse	surrogate
guess	youth	snout	compliment	shed	compound
biscuit	doubt	polite	willow	dough	citrus
verdict	thermostat	wrangle	clove	guide	groin
fake	damsel	struggle	hoe	blonde	fact
disgust	create	bend	acoustic	sad	melon
catalogue	flea	rebel	fence	project	vagina
fortune	drama	regard	realm	pancreas	spite
aloe	diffuse	talent	bandit	pooch	shoot
cheap	barge	shred	bee	fickle	husky
curse	prick	Capricorn	together	code	preface
flint	sweat	felt	gossip	globe	limit
reply	paraphrase	mortar	accord	llama	gene
tomato	barn	raid	keep	correct	tendon
hinge	us	trespass	gang	steel	shrewd
nourish	lurk	leopard	cougar	imperative	giggle
bankrupt	sworn	couch	sleep	lame	domain
pose	dent	grammar	contract	shade	fur
scarf	sprawl	foam	sperm	cyclone	lab
volley	bat	eclipse	harsh	antics	and
ink	fang	torrent	reef	none	blank
twit	loom	poll	crutch	prance	difficult
lung	vertigo	give	infringe	hip	car
goose	phenomenon	formula	wrap	bishop	quirk
cover	slang	evil	loin	letter	fret
surprise	tune	coy	swap	loot	grind
ghetto	port	gnome	murmur	treat	loaf
serve	muck	Scotch	marine	erotica	duplex
kangaroo	quarantine	squeak	blade	mean	asphalt
decline	nose	ripple	strut	twitch	heat
sleigh	fountain	lay	sign	affluent	flask
emerald	row	pocket	rowdy	trick	wire
confide	padlock	exhibit	robot	smart	gallon
technique	twist	intact	horse	twenty	odd
seat	tinkle	scope	junk	lend	print
silicon	yearn	igloo	track	shovel	hour
moss	tranquil	dish	standard	kettle	drive
tackle	crook	fart	have	tame	orange
every	dictate	cereal	ransom	scold	press
habit	cube	self	attempt	charm	bullet

stun	gush	edit	mafia	desire	buckle
gram	tomb	nail	news	leave	rush
sweet	nut	sir	badger	world	poor
cardigan	iguana	spike	should	stick	encore
assert	roach	annual	crust	promise	suit
gas	maple	squirm	balance	cue	college
garden	hive	treasure	breed	boob	hygiene
grunt	friend	ice	claim	frog	raise
bogus	bold	absent	alcohol	falcon	seven
pike	fondle	hoop	decrease	poet	hundred
babble	rim	thirst	exterior	hostel	wrong
anus	thong	cone	wallet	cramp	coach
intrigue	biceps	avocado	anchor	creed	credit
club	chip	smell	shape	demand	parallel
bats	flight	quest	brute	torch	prom
chocolate	faucet	little	brass	antique	ditto
open	fringe	bare	subordinate	dilute	puncture
box	reserve	pilgrim	flux	equivalent	factor
parliament	mellow	ivy	until	knot	snarl
glass	ignite	nip	stale	knife	drop
turquoise	campaign	condone	fizz	smoke	brook
toss	repair	chorus	ten	exhaust	funnel
alone	gloom	hold	see	theme	nutrient
gear	crimson	howl	mate	so	address
pledge	Zen	crisis	Yankee	throne	havoc
vow	ditch	cement	decadent	dive	slime
draft	road	wheel	eagle	surge	gauze
shield	pigeon	area	mute	any	scatter
melancholy	shift	auto	girl	pasty	weasel
ruin	platypus	hero	sigh	award	cargo
soil	ache	comfort	grope	blend	ridicule
wrench	stitch	jolly	nymph	earth	skin
whine	meal	troop	tough	square	hello
superior	major	elite	process	wife	tailor
pour	grit	ground	enigma	neglect	knit
from	fuse	scoundrel	camouflage	priest	tile
despair	sprinkle	pulse	roof	crisp	pad
chin	saloon	spook	scramble	not	cashmere
seesaw	deviate	direct	elastic	strike	nope
succumb	alias	corridor	haunt	china	challenge
chuck	molecule	grain	corrupt	thimble	sheer
part	cashew	smother	stock	pinch	tarantula
summary	rival	piss	pedestal	lament	slumber
soon	starch	canal	too	dazzle	digest
grotesque	buffalo	incest	wagon	aunt	suggest

trip	conserve	reject	kilo	shimmer	often
pastor	bolt	bulge	wonder	helmet	poach
belch	fade	bed	turnip	spawn	gel
stubborn	royal	lucid	dire	impact	serenade
funk	mingle	convoy	drool	case	council
apprentice	year	drove	age	side	custom
decoy	audio	style	tart	spout	frigid
constant	introvert	time	vote	victim	elect
busy	stamp	spark	cod	me	current
deaf	liquor	massacre	quick	law	weapon
appetite	just	repeat	humid	whale	rain
else	slob	bluff	tango	stifle	scowl
grip	fit	coke	boar	forest	japan
sail	bubble	govern	roost	shore	tug
awe	morning	five	class	quartz	ghost
pinnacle	chew	frown	ebony	freight	cliche
bar	bomb	splinter	counterfeit	oat	hell
charge	goggle	ban	caramel	gorilla	clump
seal	super	stash	separate	big	crumb
hustle	spy	scoot	strong	tower	terrace
dimple	haggle	cathedral	course	musket	solid
clown	article	forge	motion	pole	bland
preserve	punch	paper	temple	donkey	pepper
cyst	buffet	still	weather	result	by
money	travel	tan	smooth	pretend	angle
fawn	curb	plastic	twig	scroll	child
hospital	thistle	merchant	crush	social	pea
arch	epidemic	skip	spit	assist	if
routine	capture	stupid	testament	weird	tinsel
shrew	they	relic	cubicle	waist	oil
compost	poison	whore	anthrax	her	furnace
bin	decide	reptile	vase	seldom	beetle
window	tense	sophomore	tampon	gnaw	rust
duplicate	rug	thud	almond	coyote	nausea
battle	latex	pilot	lack	robe	motto
polo	raisin	peer	budge	avalanche	defeat
bucket	maid	vary	staff	reproach	grape
prize	corner	attack	spasm	panel	wave
connect	pest	crime	nap	ass	rummage
diesel	soul	belief	tortilla	prism	raft
gargoyle	twelve	let	lie	cannon	secret
bass	meet	settle	catastrophe	caress	planet
short	hint	mutt	vast	holy	raccoon
screech	strange	grease	drill	son	many
conflict	determine	wheat	practice	paramount	prude

middle	bring	task	kid	chain	pawn
slack	pan	import	loud	stag	siren
shiver	caviar	crotch	tingle	fort	ooze
fry	bias	note	lift	kilt	panic
sublime	bliss	format	commute	hollow	fiddle
incident	yahoo	use	large	lumber	lady
freak	court	front	peel	craze	bead
half	dust	hub	ramp	conceal	remedy
dynamic	demon	pastel	enzyme	public	wedge
sour	avid	bungalow	umbrella	lesson	wrist
cruel	weak	chuckle	gentle	to	strip
drain	dye	corporal	rabbit	dandruff	escort
sheet	key	barrel	slump	noon	nun
head	mule	orthodox	vertical	broccoli	nod
about	small	ticket	massage	swan	rock
tell	auction	clutter	cost	pursue	hunt
mayhem	baby	pollen	pill	empty	spleen
booth	web	insult	fill	raw	locomotive
equal	send	bitter	these	trouble	conquer
dodge	trim	famine	brand	swipe	tie
cape	mundane	stout	prelude	tweet	proper
sew	tight	stigma	cellar	baron	spunk
voice	ration	wide	lagoon	phrase	fell
link	ranch	tweak	chimp	with	instinct
husk	problem	level	rustic	turn	implement
solve	brick	think	check	hair	hoist
protect	flesh	advance	honk	reason	advice
jig	womb	more	rogue	insert	fate
jungle	hood	papaya	hawk	barbecue	pub
liberal	dad	mini	low	rubble	report
deliberate	premiere	stiff	influence	pupil	tongue
jingle	art	sort	lace	revenue	mature
rise	bore	quiet	wand	moon	sage
million	supplement	solace	purge	duke	dean
groan	citizen	mouth	book	handicap	spare
grade	lair	porn	fun	scaffold	bowl
nipple	maiden	spore	save	crouch	chance
glide	trickle	ready	blur	lead	posh
stool	repulse	possess	grey	ant	roll
summer	mistake	produce	under	lust	clerk
spree	cause	grimace	hence	folk	contrary
scandal	great	success	sin	pant	knickers
request	lemon	grouch	launch	stand	hut
effect	placebo	tire	glimpse	snatch	broke
cameo	Lent	frame	verse	pride	toil

pine	jest	expert	fragment	thief	ferment
wind	plight	be	jumble	genius	eat
blood	blossom	doom	left	stall	interior
toffee	campus	bow	wild	signature	plasma
quarrel	manifest	bank	studio	chronicle	grace
autumn	kudos	fidget	olive	people	swell
ponder	harvest	sanction	hog	precious	at
debut	mildew	flicker	over	finish	suck
build	dock	shirt	he	cabin	papa
seize	fog	ripe	poke	shrink	nozzle
soap	quota	here	terminate	snot	kite
fault	contest	record	zoo	employ	plug
mattress	faggot	pass	mound	lever	waddle
barbarian	embarrass	dismay	fossil	lavender	soy
stance	boat	this	saddle	know	cola
compile	red	inn	water	amp	sling
hallelujah	utilize	bunch	groove	brisket	spank
plant	ace	wheeze	billion	ask	even
deceit	stamina	cabinet	spent	spa	straddle
hose	act	vintage	graffiti	institute	spur
pond	lard	skipper	soothe	beach	human
escape	bob	carbon	distress	confront	drone
canvas	tray	grudge	black	indulge	force
infinitive	saint	shrimp	scrabble	pedigree	coral
beam	cheese	maverick	dwell	ozone	applaud
seminar	button	advocate	domestic	barter	gloss
rustle	moustache	guy	slant	leap	bait
heel	voyage	copy	spine	bake	partner
pelican	trot	appeal	screen	clock	meek
maze	mushroom	bang	speech	fondue	invite
arsenal	urge	pier	motive	twitter	desolate
hermit	argue	steward	hoof	clap	ratio
clay	compact	magnet	hash	cope	fear
flu	father	near	except	damn	focus
vogue	forth	mail	quench	jelly	cycle
pause	squabble	putty	spell	soup	reed
ray	gin	cob	tunic	prospect	verb
register	aspirin	affair	roast	boost	stunt
tail	scribble	raven	sake	plus	clarinet
slide	vampire	among	quilt	kneel	cab
opera	mild	Muslim	mistress	artifact	tavern
ring	smile	feature	sorry	gulp	humane
matter	bloat	flare	music	three	Frisbee
an	immense	frail	literal	vinyl	shackle
cancel	dim	elder	delay	radar	event

ambush	master	mole	ferry	ignore	Wimpy
concrete	dew	balm	dot	pedal	clan
stern	grid	volume	milk	claw	parsley
hit	crescent	musk	trail	card	final
avenue	June	perplex	then	apparatus	goblin
but	fork	bull	scum	flaw	fleet
snail	gift	blast	journey	dull	zebra
hyphen	sculpt	plaid	hail	present	arm
delta	murder	crown	dinosaur	oracle	membrane
daft	rinse	puzzle	measure	or	bump
buzz	gag	possible	proportion	steak	hide
pouch	fleece	daze	dispute	throttle	size
intimate	hen	construct	rifle	text	dragon
noodle	food	snack	collar	cannibal	lighter
person	waltz	ocean	epic	bust	slight
juice	leaf	engine	athlete	cardinal	beep
barnacle	lounge	noun	hulk	trigger	rave
cord	home	ostrich	toad	brain	clash
brace	parrot	pebble	rose	wet	wise
organ	my	fair	decor	basin	albino
deuce	silicone	warp	trauma	idol	cedar
essay	dude	weary	threat	draw	aspect
role	group	install	fashion	pact	mystic
succeed	comrade	banana	cloak	rod	name
flee	hooray	devout	spill	king	salt
junior	castle	bloom	bleep	stove	covert
vein	pen	pint	snake	permit	machine
minister	leash	mass	spindle	chest	profile
embargo	team	rank	waffle	air	infest
match	diary	dine	rule	slot	scrape
swindle	recruit	slab	handle	barracuda	grub
grove	primitive	belt	bother	lick	compass
which	patrol	slave	through	mall	sport
now	push	mustard	aerial	seek	lint
timid	dessert	sinister	price	eleven	obese
jasmine	turf	woman	ill	desert	pack
host	filth	shout	decay	alley	thorough
rumble	flamingo	meteor	null	butch	test
arena	what	curl	Easter	dandy	bellow
tract	below	command	hang	pimple	duct
tender	kindle	poop	preach	cry	retail
terrain	neutral	tunnel	town	private	shadow
work	manor	pop	mess	weave	bottom
forfeit	plea	steal	sack	peach	steroid
sovereign	galore	outcry	void	colon	caravan

week	splash	flip	shock	clause	budget
bottle	cult	cash	bound	good	manure
premier	dug	menu	stretch	sly	tremble
able	captain	limp	mop	mist	spoon
fuzz	fold	jazz	excess	pillar	tidy
idle	approach	bully	stone	crap	guarantee
drink	chair	aurora	goal	drench	chimpanzee
woe	bark	cherry	mob	couple	cologne
robin	cattle	agenda	python	stare	perch
pudding	orient	vest	incline	crude	halt
well	before	ski	clench	dilemma	greed
gum	scheme	least	shallow	saw	shove
system	complement	bargain	combo	cuff	marijuana
trout	cinnamon	cable	old	flannel	grass
baboon	coal	burst	exercise	extract	hockey
oath	provoke	funeral	fond	parish	fame
convey	rap	circuit	reap	crest	yam
proton	day	overture	slit	inch	bunk
grave	soprano	fern	log	brawl	chump
share	hug	reign	design	sex	vain
for	mace	crash	temper	shit	scrub
ointment	bingo	diagonal	quit	third	muffin
same	condense	humble	arc	mustang	trend
feed	coat	scan	trash	above	sacrifice
moose	winter	culprit	sleet	clamp	bell
brat	thrash	sway	oblique	fellow	glare
strict	urn	percent	skirt	retract	stay
chameleon	shrill	general	wage	gorge	prune
taste	dime	jersey	false	only	savage
mummy	beyond	slick	title	blitz	spruce
precipitate	shuffle	hurricane	duel	crease	mouse
mascara	store	breath	cave	potent	domino
fare	schedule	satin	regular	cradle	watch
blunder	jumbo	violin	hard	whimper	elephant
coupon	copper	pecan	vehicle	cove	moral
swivel	please	value	loose	sphere	ease
mongoose	firm	nephew	bruise	step	slush
rice	enough	yell	species	razor	trace
prophet	fright	pillow	bash	perfect	finger
function	dip	minor	zone	weight	flower
sprout	quite	carry	flood	prostitute	hook
growl	chill	rally	last	kiss	oven
sneer	scout	annoy	salad	run	room
prone	table	gate	feather	weep	camera
silhouette	potter	rather	counter	severe	hole

fire	crusade	that	bum	rift	say
forward	rotary	cricket	hate	debate	veil
soldier	comma	pick	crib	summon	poker
vanilla	swear	calorie	quake	erect	lash
plush	bite	basis	smith	drip	lettuce
ordinance	party	broad	nudge	suckle	queer
orchid	rhythm	valid	heir	native	stork
item	toast	hypodermic	plank	insignia	delegate
instant	cartridge	early	achieve	bleach	monitor
crop	cordial	visit	hurl	tremor	hue
thank	wrath	steady	on	pit	scone
manual	take	degree	thumb	parade	foreign
stalk	drug	lyric	quote	locust	calendar
muscle	peace	green	innocent	sweep	hope
frisk	fanfare	vet	boom	saliva	shop
exempt	fib	ought	cork	sip	fight
memo	flat	come	oval	heaven	white
bureau	core	swirl	flour	blunt	soak
ox	scoop	brow	john	yield	litter
tube	acre	cholesterol	ladder	move	blame
tax	source	knock	swarm	cuddle	flash
miss	jar	chaos	pave	wolf	shag
casual	them	tickle	glimmer	positive	acid
robust	condition	lean	figure	marry	close
tap	daisy	assault	teal	drift	lot
drizzle	cheddar	slim	porcupine	are	range
section	matrix	wake	mine	tissue	strangle
pencil	grill	curtain	pet	spinach	duo
spread	add	haze	chat	lobby	crack
bikini	shake	west	mirror	spoil	fluff
tuna	sudden	obscure	thunder	dawn	plain
gecko	minute	buff	corpse	subcontract	wax
bible	slope	Cancer	scallop	aggregate	harm
stress	tide	pluck	sue	display	sludge
kitten	release	burp	surf	stole	alert
new	shack	peculiar	bill	yeah	scurry
apply	drought	main	benefit	race	idea
golf	tooth	senior	thrive	fable	metal
pain	cheek	bench	offensive	statute	dispatch
seem	serpent	hill	shut	beak	carrot
slug	scar	precise	gross	spin	film
of	cold	steam	magic	sphinx	bright
graph	number	cat	surgeon	tulip	menthol
job	pixie	target	bet	pin	triple
whim	gust	solitary	glad	one	soar

sugar	pity	document	rescue	follow	tall
treason	piano	wash	termite	ankle	help
honey	answer	adult	happen	pump	mountain
fungus	omen	sickle	plot	hornet	gamble
amaze	navel	wow	vortex	thing	yesterday
textile	paint	noise	rack	after	ledge
stop	military	italic	would	gesture	prompt
occupy	grate	hike	poppy	calm	lease
flap	associate	stir	kill	squawk	beta
pink	chop	tramp	respond	cactus	thump
control	shrine	risk	scare	palace	combat
consider	poem	boycott	cloud	graduate	hammer
banjo	adolescent	plenty	skim	warrant	narrow
dumb	doze	sector	picture	retain	fetch
wish	bear	allure	boot	divorce	rocket
hatchet	wine	stub	tease	moderate	brave
knead	pig	casserole	muse	how	disc
moron	doctor	consent	change	blind	wait
dope	start	throat	oral	sneeze	video
boil	twinkle	jog	cell	gasp	shrug
salmon	huge	dart	grief	tent	attribute
flag	clinch	gauge	truck	stab	stroke
graze	loop	double	pod	triumph	drunk
enamel	reach	plural	spouse	ride	crunch
progress	experience	stage	tempo	want	blow
stable	petition	learn	bitch	commend	retort
curfew	racket	label	worth	bond	cousin
skunk	late	swim	will	must	you
divide	cigar	each	bless	font	climax
mane	butt	concentrate	bid	balloon	vocal
hurry	avatar	mint	aroma	braid	snipe
found	protocol	limbo	straight	truffle	tack
brown	cornea	taper	tape	breeze	data
bath	spew	porcelain	try	fierce	vulva
study	month	rest	sober	vowel	lark
cleanse	beg	search	lunch	swagger	echo
narcotic	she	sting	lose	animal	merge
ape	dense	bizarre	eight	voodoo	fresh
owl	wail	fig	join	gather	minus
single	exit	patch	seed	dark	cascade
jeep	sea	lump	baffle	rig	ark
premise	church	between	smooch	stew	rope
rich	thrill	whirl	roar	paddle	snuff
hatch	pedestrian	bald	swallow	jaw	eye
sane	ram	valve	site	song	click

charisma	export	war	feel	dozen	grow
legend	school	set	blue	dash	crawl
clever	swift	utopia	shoe	dizzy	blurb
charter	arrest	trivia	tennis	lens	weed
lid	doctrine	climb	haste	issue	kick
express	capital	cringe	clog	champagne	nostril
flurry	piston	worm	duet	leotard	tree
hump	call	mush	sole	smudge	alpha
choose	slur	crypt	hoarse	teach	rear
torment	chess	stroll	marble	cast	viable
cool	alien	detail	boast	heap	stomach
meadow	picnic	leather	flinch	hum	hound
venture	crew	parody	contour	foil	bye
quaint	goodbye	kennel	sword	commence	chipmunk
buy	tusk	compromise	peasant	blink	canoe
prep	order	syrup	prop	stark	debit
cute	brandy	hazard	giant	bad	statistic
tiara	shoulder	forget	method	alternate	wasp
yoga	snort	scruff	juvenile	worry	sight
tone	cruise	shame	captive	hat	inherit
nibble	angel	swine	faint	scorch	floor
segment	clean	finance	flirt	zip	foul
sentence	wool	regret	croak	hand	pope
mumble	pie	fat	pull	cap	pearl
toll	sound	chemical	devil	valet	solo
frequent	suite	pat	moth	get	fatigue
fluid	cough	feline	exile	flush	metaphor
pup	malt	cocoa	jump	spat	cub
butcher	spam	commerce	whistle	metro	delight
plaster	menace	sloth	welcome	stump	ounce
fuel	less	thou	chant	aloof	feeble
quarry	kind	earn	slop	radical	shenanigan
script	guilt	snitch	herpes	fancy	margin
alter	piece	mason	rubber	parent	curry
rub	kitchen	excuse	fast	banquet	pervert
sore	disco	puke	sarcasm	deed	initial
choke	crate	omega	terror	nerve	compare
arsenic	lime	park	peck	tag	light
stack	either	radio	extreme	ball	deal
scarce	splint	put	brake	Eskimo	concert
stair	bleed	blaze	chef	sprite	calf
dare	basket	manufacture	sketch	mistletoe	hormone
fall	venison	clear	multiple	chart	collect
diet	fruit	pulp	tuxedo	hijack	hull
corn	rump	kiwi	sniffle	villain	file

volcano	flake	content	wobble	ornament	dig
dry	space	load	much	joint	comb
sheath	keen	fail	capsule	gruel	blister
go	far	suicide	elf	basil	deposit
foe	declare	pipe	icon	rascal	snoop
vice	shear	scratch	grasp	puddle	rhyme
nurture	drown	sink	slut	mandate	horizon
origin	bazooka	mascot	those	casino	sizzle
goof	shy	butter	effort	knack	carousel
warden	attire	ear	ballpoint	fracture	common
harpoon	vandal	high	cloth	curve	never
salon	resolve	prior	surround	line	intellect
torso	pretty	where	promote	flop	penis
deck	deer	speed	polio	knight	split
raffle	sedate	sharp	blouse	tutor	earnest
dung	karma	choir	scissor	lactose	hot
karate	stud	guitar	succulent	slow	drum
probe	glade	staple	spatula	support	squint
dial	sing	wick	flutter	scent	since
harp	slip	mesh	Catholic	there	volunteer
pierce	string	riot	stride	dread	lecture
whisk	fling	myth	vinegar	sponsor	quadruple
lynch	increase	strand	find	ward	broth
verge	greet	occasion	squad	cunning	swoop
brothel	scuba	extra	carnival	specimen	potato
gnat	crane	wart	asparagus	noble	horn
dusk	spot	statue	care	wing	assassin
pimp	squander	candle	stem	praise	scenario
smear	prison	dwindle	yet	tribe	grime
venom	skid	knee	snap	bundle	portrait
parachute	platform	hurdle	batch	thus	fan
leak	fist	rate	camp	farewell	horror
bleak	mug	zoom	hurt	your	bourbon
hassle	fly	again	cut	power	fumble
cocoon	harmonica	doll	shudder	monkey	venue
rattle	tend	sabotage	debt	hack	top
bacon	can	ruffle	clasp	April	theft
bounce	censor	shaft	vivid	cliff	coffee
look	ego	flow	laminate	fad	forbid
spanking	urine	squeal	creep	plump	spade
mince	heave	polish	rat	column	paste
post	hire	hotel	Sabbath	whole	beer
than	sulk	gun	man	squat	coop
ginger	stubble	luck	pamper	respect	height
circus	combine	sneak	flute	shine	fund

fanatic	comet	adore	queen	cervix	broom
write	cosmetic	sum	agree	rugby	career
walk	glaze	tuck	cafe	thug	rhapsody
jab	defect	glee	plunge	clutch	herd
romance	cop	acute	protagonist	first	make
gold	true	riddle	yolk	worship	back
lock	delinquent	steer	view	status	rodent
fowl	sponge	slice	van	weigh	shampoo
simmer	crave	faith	lodge	in	north
silver	way	loft	lad	bit	catapult
gut	scale	altar	pile	spectacle	wood
bamboo	jail	crayon	condom	glitter	nine
bracket	wreath	jerk	torpedo	manicure	thousand
grant	boogie	though	face	pardon	coin
limb	neck	vine	tear	scab	gargle
halo	squeeze	trap	nude	wear	yeast
visa	thyme	total	tick	fag	sinus
snore	ketchup	safe	catch	amateur	scrooge
ballet	costume	magazine	paprika	orchestra	rhino
shin	component	filter	beneath	cup	incense
mix	crowd	heal	aid	squid	squirrel
stream	plane	yacht	snip	cushion	swing
apron	elbow	incognito	astound	lantern	scalp
individual	pandemic	jean	convert	relish	gain
his	chariot	thin	kit	genre	cock
pastry	flimsy	covenant	jewel	lane	life
puff	probable	down	feast	dance	Democrat
tangle	freckle	boy	nimble	rot	train
pattern	estimate	mad	versus	coordinate	dove
toy	motor	paradise	yank	whisper	gay
east	cheer	term	quiver	sandal	hoax
saga	lag	pale	stink	pirate	station
buck	license	solar	atom	rupture	wilt
spend	spring	wiggle	mantle	bulb	diploma
moan	Negro	tit	tortoise	august	notice
badge	brief	snow	cosmos	lilac	zero
aisle	wrinkle	emblem	stomp	quack	hiss
accent	bravo	beagle	candy	ham	sham
bent	loan	shuttle	syringe	inferior	word
shingle	bastard	lip	sub	beige	rash
maggot	corset	retire	cart	birch	brittle
peg	cobalt	burn	notch	jug	stencil
surrender	glue	feud	grin	occur	country
grumble	crystal	dead	foot	pamphlet	muffle
panorama	slam	numb	suppose	horrid	comment

hearth	sun	bra	reverse	embryo	doodle
rapid	swamp	sock	agnostic	sample	chick
gap	storm	stripe	game	thesaurus	mend
sky	bison	antenna	spider	talk	some
squirt	chapel	whip	hear	heart	hitch
felon	rabies	conduct	boomerang	porch	ruby
widow	champ	chirp	stray	vague	die
retina	splurge	cease	all	sesame	witness
coffin	den	snare	period	tobacco	convince
indigo	full	marvel	steep	privilege	squash
most	apple	crank	contrast	fox	today
also	cunt	gem	spoke	lawn	strife
cake	pure	divine	toe	fee	retreat
hop	stereo	guild	herb	mannequin	soda
like	off	cobra	blush	okay	shelf
habitat	neat	gore	barley	proud	damp
uterus	accuse	jack	brink	pounce	turmoil
drape	god	peep	point	algebra	no
dorm	clip	swag	branch	gland	prince
appear	addict	lure	Mediterranean	desk	shot
spoof	juggle	dump	sense	rent	screw
lamp	abandon	envy	recess	giraffe	sorrow
nickel	boss	mammal	simple	coil	gadget
veal	carpet	proof	lamb	alarm	cure
type	via	tip	duck	tee	bribe
sure	compete	tale	female	vitamin	gluten
pound	grand	series	joke	end	hunk
whack	switch	skill	marrow	chrome	creek
rip	clam	trait	crow	rye	loathe
niece	sapphire	trust	four	bride	streak
tornado	movie	haul	bonus	decimal	scribe
frank	neon	brisk	arrive	second	survey
oak	lather	shower	tumble	latter	scrap
hiccup	do	ago	auxiliary	guru	reel
asset	Renaissance	jaguar	shrub	perk	pair
route	thaw	teens	vaccine	account	camel
mode	subject	flame	burden	liquid	village
fine	walrus	special	glow	console	slap
pucker	yawn	ramble	might	sheriff	pioneer
placenta	base	revolt	Mormon	apparel	smug
virgin	need	very	fool	while	invoice
partition	summons	latch	former	pool	cinema
mother	zap	canary	bean	thought	meat
smack	anthem	city	intent	rag	literate
tank	knob	prohibit	zinc	market	plead

warm	smuggle	up	wench	patent	scarlet
slum	wisp	jockey	keg	plate	ballerina
obey	incarnate	sprint	pistol	phoenix	empire
aim	wretch	floss	root	stench	darn
palm	tally	canteen	chisel	bread	fiesta
tint	ale	derby	page	denim	tea
revoke	yard	torture	modest	oblige	towel
toilet	rib	champion	calculus	chore	relay
varnish	utensil	rude	stutter	pork	panda
joy	yellow	converse	next	such	iron
vomit	channel	smirk	revise	prank	prey
dirt	ancient	nugget	colt	win	chime
mangle	border	monk	bay	eve	pursuit
sleek	dungeon	math	laugh	cuisine	banner
opaque	cook	tribute	peek	substitute	snooze
lateral	nylon	knuckle	lap	quill	interest
mind	cluster	barricade	slogan	him	rage
gig	triad	sauce	medal	nasal	runt
fetish	tattoo	skate	chap	wreck	merit
brush	cent	deep	farm	jam	throb
wipe	guard	stampede	hag	craft	pending
sledge	local	blanket	spice	muzzle	strive
march	loss	skeleton	whether	nucleus	read
clue	glove	count	whittle	vault	turtle
yarn	gown	pitch	rodeo	plague	fluke
span	attach	taunt	lotus	trench	binge
slay	goat	material	peak	science	ton
gallop	mark	skull	supply	vent	husband
client	as	era	asthma	fish	mime
pro	chord	contingent	house	real	lion
legion	rare	rant	caution	melt	berry
canine	net	glance	suspect	mammoth	bun
admiral	passive	dome	float	mash	moist
purse	octopus	monarch	degenerate	garage	pivot
velvet	troll	tread	sell	ridge	napkin
pear	jet	blot	gazelle	soft	squire
spirit	marsh	smash	mud	violet	shell
sequel	list	sniff	hush	vista	anger
bug	modern	shark	maroon	sob	door
appropriate	starve	ordeal	tycoon	detergent	tarnish
wound	yes	listen	rail	leech	browse
cross	contact	dear	gulf	cripple	thrift
grim	babe	league	articulate	purple	shave
mayor	gimmick	approximate	phase	civil	tow
behind	lava	mention	pot	steeple	garlic

gloat	acne	shall	esteem	skewer	spear
right	penicillin	linen	choice	roam	form
mask	beard	hoot	sparrow	veteran	stain
octave	past	twice	own	posture	protest
nest	bonnet	animate	discipline	mourn	tact
trance	immune	device	balcony	their	rough
clique	young	field	borrow	who	model
trunk	imagine	mood	nurse	martini	chauffeur
band	wink	due	chunk	tab	impulse
experiment	pansy	chicken	petal	travesty	bind
symptom	score	siege	moment	punk	cane
sand	waste	chief	cage	pasture	stalemate
powder	quiz	abstract	blimp	pickle	province
street	cream	nectar	it	silly	path
mobile	colonel	crab	pumpkin	pun	kidnap
axe	two	love	May	huddle	hoard
dwarf	query	wall	protein	confetti	cartoon
sheep	future	Hindu	flipping	free	land
tin	plan	chestnut	carton	taboo	nice
mock	guest	prejudice	few	season	bag
prosper	sincere	minimum	flick	edge	snug
apricot	fuck	gutter	rake	arson	tour
rum	shank	woof	relief	trump	oxide
scene	sandwich	restaurant	harness	hippo	beat
optimum	mortgage	token	brag	prime	taxi
beef	snag	damage	thrust	refuse	flunk
transport	stuff	cupid	offer	stumble	star
breach	taint	transfer	night	ever	snorkel
millennium	nag	purchase	elk	gym	dribble
image	tribune	rubbish	place	ballad	twin
index	convulse	date	strap	booze	fudge
pigment	witch	certain	south	census	pray
bulk	burrow	secure	lush	median	thigh
tilt	practical	bunker	spray	dream	prove
slate	bud	pace	cling	tub	virtue
continue	strain	cheat	vector	cheetah	straw
object	the	garnish	clot	bail	profit
slander	male	random	complex	thick	character
gospel	rob	frost	blubber	sociable	hall
slurp	silent	uncle	joust	hammock	state
orbit	circle	diamond	utter	coast	once
usher	poodle	play	bus	savvy	insect
plum	axis	bronze	out	tempt	hunch
long	atlas	scream	six	hedge	mill

APPENDIX B

Complete word list of all non-words used in the randomly generated stimulus set

Aberidus	Creahoof	Jeren	Nedril	Roinad	Tupacase
Acaer	Didiza	Jiofrax	Nekmit	Safome	Tupress
Aferraron	Digikiki	Johackle	Neoskizzle	Sasaroo	Uliratha
Aloidia	Digisol	Jovaphile	Nocobot	Sassee	Unelind
Animepolis	Dizoolexa	Kiraric	Noelind	Scitenoa	Vallume
Besloor	Drirathiel	Lazap	Novaly	Seiliu	Viottis
Biasdo	Ekcle	Locobot	Novanoid	Sepezz	Voov
Boaconic	Eraow	Loheckle	Oleald	Sexatoo	Voquev
Bopster	Ethosien	Looncan	Olielle	Skizze	Waratel
Boxscape	Firehorse	Looplab	Onama	Sooprno	Wavefire
Brewtine	Glaretram	Loopnova	Parede	Soostev	Wazzasoft
Bumola	Glomtom	Luwest	Peachflame	Sorson	Werradith
Bumooxa	Glowl	Minivivi	Pegmode	Surogou	Wetwest
Burder	Goocrux	Miresa	Peloozoid	Swopom	Winooze
Cazoova	Gorealm	Mizule	Pirend	Swoquix	Yboiveth
Chacaka	Goulbap	Modeflick	Ploosnar	Tomash	Yeinydd
Cheilith	Grodsaar	Moderock	Pounit	Toogit	Yimello
Chershoee	Grynn	Modgone	Pruvia	Toximble	Yoffa
Chillaid	Hendassa	Mogotrevo	Replitz	Trelod	Yokovich
Chillpal	Hioffpo	Momoweb	Resaix	Tribepop	
Chorenn	Hoppler	Morath	Rodrup	Tribop	

APPENDIX C

Complete list of countries participants identified

America (*n* = 29)	Greece (*n* = 1)	Mauritius (*n* = 3)	Spain (*n* = 2)
Australia (*n* = 49)	Guyana (*n* = 1)	Mexico (*n* = 2)	Sweden (*n* = 5)
Barbados (*n* = 2)	India (*n* = 26)	Morocco (*n* = 1)	Switzerland (*n* = 2)
British (*n* = 6)	Ireland (*n* = 19)	New Zealand (*n* = 6)	Thailand (*n* = 2)
Canada (*n* = 535)	Israel (*n* = 2)	Nigeria (*n* = 2)	Turkey (*n* = 1)
Emirate (*n* = 1)	Italy (*n* = 1)	Pakistan (*n* = 4)	United Kingdom (*n* = 116)
England (*n* = 15)	Jamaica (*n* = 1)	Qatar (*n* = 1)	United States (*n* = 697)
France (*n* = 5)	Lebanon (*n* = 1)	Scotland (*n* = 3)	Vietnam (*n* = 1)
Germany (*n* = 4)	Lithuania (*n* = 1)	Singapore (*n* = 5)	Wales (*n* = 2)
Great Britain (*n* = 10)	Malaysia (*n* = 3)	South Africa (*n* = 6)	

APPENDIX D

Demographic Questionnaire

1) How old are you?

2) Please select your country of residence.

3) Is English your first language?
   Yes/No

VITA AUCTORIS

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