English Semantic Word-Pair Norms and a Searchable Web Portal for Experimental Stimuli Creation

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Abstract

As researchers explore the complexity of memory and language hierarchies, there is a need to expand normed stimulus databases. Therefore, we present 1,808 words paired with their features and concept-concept information that were collected using previously established norming methods (McRae, Cree, Seidenberg, & McNorgan, 2005), which supplements existing stimuli and complements the Semantic Priming Project (Hutchison et al., 2010). The dataset includes many words (nouns, verbs, adjectives, etc.), which exceeds the previous collections of nouns and verbs (Vinson & Vigliocco, 2008). The relation between other semantic norms, as well as a short review of word pair norms is provided. Stimuli are provided in conjunction with a searchable web portal that allows researchers to create a set of experimental stimuli without prior programming knowledge. When used in tandem with previous norming efforts, precise stimuli sets can be created for future research endeavors.

*Keywords:* database, stimuli, semantics, words, norms

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Psychologists, linguists, and researchers in modern languages require both traditional knowledge about what words mean and how those words are used when paired in context. For instance, we know that rocks can roll, but when rock and roll are paired together, mossy stones no longer come to mind. Up-to-date online access of word meanings will empower linguistic research, especially given language's ability to mold and change with culture. Several collections of word meanings and usages already exist online (Fellbaum, 1998; Nelson, McEvoy, & Schreiber, 2004), but several impediments occur when trying to use these stimuli. First, a researcher may want to use existing databases to obtain psycholinguistic measures, but will likely find very little overlap between the concepts present in all of these databases. Second, this information is spread across different journal and researcher websites, which makes material combination a tedious task. A solution to these limiting factors is to expand norms and to create an online portal for the storage and creation of stimuli sets.

Concept information can be delineated into two categories when discussing word norm databases: 1) single-word variables, such as imaginability, concreteness, or number of phonemes and 2) word-pair variables, wherein two words are linked together, and variables denote when those concepts are combined. Both category types can be important when planning an experiment using word stimuli as an area of interest, and many databases contain a mix of variables. For example, the Nelson et al. (2004) free association norms contain both single-word information (concreteness, cue-set size, word frequency) and word-pair information (forward strength, backward strength). For the word-pair variables, these values are only useful when exploring the cue and target together (i.e. first word-second word, concept-feature, concept-concept) because changing word combinations result in different variable values. In this study, we have collected semantic feature production norms, which are, in essence, word-pair information. Each of the concepts was combined with their listed features, and a frequency of the concept-feature pair was calculated. Further, we used these lists of concept and feature frequency to calculate the cosine value between concepts, which created another word-pair variable. Both of these variables should be considered word-pair norms because both words are necessary to understanding the numeric variable (i.e. frequency, cosine). Therefore, we use the term *word-pair relations* to describe any variable where concepts are paired with either their features or other concepts and supplementing previous work on these norms was a major goal of this data collection.

When examining or using word-pairs as experimental stimuli, one inherent problem is that some words have stronger connections in memory than other words. Those connections can aide our ability to read or name words quickly via meaning (Meyer & Schvaneveldt, 1971) or even influence our visual perception for words we did not think were shown to us (Davenport & Potter, 2005). The differences in word pair relations can be a disadvantage to researchers trying to explore other cognitive topics, such as memory or perception, because such differences can distort experimental findings if such factors are not controlled. For example, semantic priming research investigates the facilitation in processing speed for a target word when participants are presented with a prior related cue word as compared to an unrelated cue. Priming differences are attributed to the meaning-based overlap between related concepts, such that activation from the cue word readies the processor for the related target word. When the target word is viewed, recognition is accelerated because the same feature nodes are already activated (Collins & Loftus, 1975; Stolz & Besner, 1999; Plaut, 1995). Meta-analytic studies of semantic priming have shown that context-based connections in memory (association) were present in stimuli for studies on meaning-based priming, thus drawing attention to the opportunity to study these factors separately (Lucas, 2000; Hutchison, 2003). Consequently, researchers such as Ferrand and New (2004) have shown separate lexical decision priming for both semantic-only (DOLPHIN-WHALE) and associative-only (SPIDER-WEB) connections.

The simplest solution to this dilemma is to use the available databases of word information to create stimuli for experiments. A current literature search for semantic word norms illustrates the dearth of recent meaning-based information in the psycholinguistic literature (specifically, those norms accessible for download). At present, McRae, Cree, Seidenberg, and McNorgan (2005) and Vinson and Vigliocco (2008) feature production norms are available, along with the Maki et al. semantic dictionary distance norms (all word-pair norms). Toglia (2009) recently published an update to the original Toglia and Battig (1978) single-word norms describing the continued use and need for extended research in psycholinguistics. McRae et al. detail the common practice of self-norming words for use in research labs with small groups of participants. Rosch and Mervis (1975) and Ashcraft’s (1978) seminal explorations of category information were both founded in the individualized creation of normed information. Furthermore, Vinson and Vigliocco used their norm collection to investigate topics in semantic aphasias (Vinson, Vigliocco, Cappa, & Siri, 2003; Vinson & Vigliocco, 2002), build representation models (Vigliocco, Vinson, Lewis, & Garret, 2004), and understand semantic-syntactic differences (Vigliocco, Vinson, & Siri, 2005; Vigliocco, Vinson, Damian, & Levelt, 2002) before finally publishing their collected set in 2008. The literature search does indicate a positive trend for non-English database collections, as norms in German (Kremer & Baroni, 2011), Portuguese (Stein & de Azevedo Gomes, 2009) and Italian (Reverberi, Capitani, & Laiacona, 2004) can be found in recent publications.

The databases of semantic feature production norms are of particular interest to this research venture. They are assembled by asking participants to list many properties for a target word (McRae et al., 2005; Vinson & Vigliocco, 2008). For example, when asked what makes a ZEBRA, participants usually write features such as STRIPES, HORSE, and TAIL. Participants are instructed to list all types of features, ranging from is-a/has-a descriptors to uses, locations, and behaviors. While many idiosyncratic features can and do appear with this data collection style, the combined answers of many participants can be a reliable description of high probability features. In fact, these feature lists allow for the fuzzy logic of category representation reviewed by Medin (1989). Obviously, semantic feature overlap will not be useful in explaining every meaning-based phenomenon; however, these data do appear to be particularly useful in modeling attempts (Cree, McRae, & McNorgan, 1999; Vigliocco et al., 2004; Moss, Tyler, & Devlin, 2002; Rogers & McClelland, 2004) and studies on the probabilistic nature of language (McRae, de Sa, & Seidenberg, 1997; Pexman, Holyk, & Monfils, 2003; Cree & McRae, 2003).

The drawback to stimuli selection becomes apparent when researchers wish to control or manipulate several variables at once. For instance, Maki and Buchanan (2008) combined word pairs from popular semantic, associative, and thematic databases. Their word pair list across just three types of variables was only 629 concept-concept pairs. If a researcher then wished to control for pair strength (i.e. only highly related word pairs) or single word variables (i.e. word length, concreteness), the stimuli list would be limited even further. The Maki, McKinley, and Thompson (2004) semantic distance norms might be a solution for some research endeavors. Combining the online dictionary WordNET (Fellbaum, 1998) with a measure of semantic similarity, JCN (Jiang & Conrath, 1997) measures semantic distance by combining information on concept specificity and hierarchical distance between concepts. Therefore, this measurement describes how much two words have in common in their dictionary definitions. For example, COMPUTER and CALCULATOR have high relation values because they have almost identical dictionary definitions. Alternatively, there are several databases that are based on large text collections, that appear to measure thematic relations (Maki & Buchanan, 2008), which is a combination of semantic and associative measures. Latent Semantic Analysis (LSA, Landauer & Dumais, 1997), BEAGLE (Jones, Kintsch, Mewhort, 2006), and HAL (Burgess & Lund, 1997) all measure a mixture of frequency and global co-occurrence where related words frequently appear either together or in the same context.

Given the limited availability of semantic concept-feature and concept-concept information, the present collection seeks to fill two goals. The first goal is to alleviate the limiting factor of low correspondence between existing databases, so that researchers will have more options for stimuli collection. The semantic feature production norms are the smallest set of norms currently available, at less than 1000 normed individual concepts; while associative norms, dictionary norms, and text based norms all have tens of thousands of words. Compilation of this information would allow researchers to have more flexibility in generating stimuli for experiments and allow for studies on the specific lexical variables. The second goal is to promote the use of these databases to improve experimental control in fields using words as experimental stimuli. These databases are available online separately, which limits public access and awareness. Consequently, a centralized location for database information would be desirable. The web portal created in tandem with this paper will allow researchers to create word lists with specific criteria in mind for their studies (http://www.wordnorms.com). Our online interface is modeled after projects such as the English Lexicon Project (http://elexicon.wustl.edu/; Balota et al., 2007) and Semantic Priming Project (http://spp.montana.edu/; Hutchison et al., 2010) which both support stimuli creation and model testing, focusing on reaction times for words presented in pronunciation and lexical decision experiments.

**Method**

**Participants**. Participant data were collected in three different University settings: The University of Mississippi, Missouri State University, and Montana State University. University students participated for partial course credit. Amazon’s Mechanical Turk was used to collect final word data (Buhrmester, Kwang, & Gosling, 2011). Mechanical Turk provides a very large, diverse, subject pool where short surveys can be implemented for very small amounts of money. Participant answers can be screened for errors, and any surveys that are incomplete or incorrectly answered can be rejected. Subjects were paid five cents for each short survey. Table 1 includes the number of participants for each site, as well as the number of concepts and average number of participants per concept. Common survey rejections included copying definitions from online dictionary sites or answering by placing the concept in a sentence. These answers were discarded from both the University data and the paid data set.

**Materials.** First, other databases of lexical information were combined to examine word overlap between associative (Nelson et al., 2004), semantic (Maki et al., 2004; McRae et al., 2005; Vinson & Vigliocco, 2008), and word frequency norms (Kucera & Francis, 1967). Concepts present in the feature production norms were excluded, and a unique list of words was created, mainly from the free association norms. Some words in the feature production norms were repeated to ascertain convergent validity. This list of words not previously normed, along with some duplicates, was randomized. These norms contain several variations of concepts (i.e. swim, swims, swimming), and the first version that appeared after the word list was randomized was used for most words. However, as another measure of convergent validity, we included morphological variations of several concepts (i.e. state/states, begin/beginning) to examine feature overlap. After several experimental sessions, information about the Semantic Priming Project (Hutchison et al., 2010) became available and with their provided stimuli, concepts not already normed were targeted for the completion of our investigation. For the Semantic Priming Project, cue-target pairs were selected from the Nelson et al. free association norms wherein no concept was repeated in either the cue or target position but allowed to appear as cue and target each once. Target words were both one cue word’s most common response (first associate) and a different cue word’s associate (second or greater associate). The cue words from their list (1,661 concepts) were compared to the first author’s completed norming work, the previous feature production norms, and the unique words were the final stimuli selected. Therefore, our dataset provides a distinctive view into concepts not previous explored, such as pronouns, adverbs, and prepositions, while also adding to the collection of nouns and verbs.

Words were labeled by part of speech using both the English Lexicon Project and the free association norms. Words not present in these databases or with conflicting entries were labeled using Google’s “define” feature search, and two experimenters reviewed these labels. The most prominent usage of the word was considered its main part of speech for this analysis, but multiple senses were allowed when participants completed the experiment. The dataset (*N* = 1,808) contains 61.3% nouns, 19.8% adjectives, 15.5% verbs, 2.2% adverbs, 0.6% pronouns, 0.5% prepositions, and 0.1% interjections. Because of the small percentage of words for adverbs, pronouns, prepositions and interjects, these types were combined for further analyses. Table 2 shows the average number of features by subject and data collection location. Table 3 indicates the word parts of speech by the parts of speech for features produced in the experiment.

**Procedure.** Given the different standards for experimental credit across universities, participants responded to different numbers of words in a session. Some participants responded to 60 words during a session lasting approximately an hour (the University of Mississippi, Montana State University), while others completed 30 words within approximately a half hour (Missouri State University). Mechanical Turk survey responses are best when surveys are short; therefore each session included only five words, and average survey response times were five to seven minutes. Word lists implemented on Mechanical Turk were restricted to contain 60 unique participants on each short survey, but participants could take several surveys.

In order to maintain consistency from previous work, the instructions from McRae et al.’s Appendix B (pg. 556) were given to participants with only slight modifications. For instance, the number of lines for participants to write in their answers was deleted. Second, since many verbs and other word forms were used, the lines containing information about noun use were eliminated (please see discussion for potential limitations of this modification). Participants were told to fill in properties of words, such as their physical (how it looks, sounds, feels), functional (how it is used) and categorical (what it belongs to) properties. Examples of three concepts were given (duck, cucumber, stove) for further instruction. To complete the survey, participants were given a web-link to complete the experiment online. Their responses were recorded and then collated across concepts.

**Data Processing.** Each word’s features were spell-checked and scanned for typos. Feature production lists were evaluated with a frequency-count program that created a list of features mentioned and their overall frequency. For example, the cue word FALSE elicited some target features such as ANSWER (13), INCORRECT (25), and WRONG (30). This analysis is a slight departure from previous work, as each concept feature was considered individually. Paired combinations are still present in the feature lists, but as separate items, such as FOUR and LEGS for animals. From here, the investigator and research assistants examined each file for several factors. Filler words, such as prepositions (into, at, by) and articles (a, an, the) were eliminated unless relevant (e.g. concept listed is alphabet). Plural words and verb tenses were combined into one frequency, so that walk-walked-walks are all listed as the same definition for that individual word concept. Then, features were examined across the entire dataset. Again, morphologically similar features were combined into one common feature across concepts, where concepts like KIND and KINDNESS would be considered the same feature. However, some features were kept separate, such as ACT and ACTOR for the following reasons. First, features were not combined when the term marked differences in the noun/verb tense and the gender or type of person. For instance, ACTOR denotes both that the feature is a person and the gender (male) of that person (versus ACTRESS or the noun form ACT). Second, similar features were combined when the cue subset was nearly the same (80% of the terms). Features like WILL and WILLING were not combined because their cue sets only overlapped 38%, which implied that these terms were not meant as the same concept.

Each final feature term is given a word type, as described above. Previously, both McRae et al. and Vinson and Vigliocco analyzed features by categorizing them as animals, body parts, tools, and clothing. However, the types of words included in this database did not make that analysis feasible (i.e. pronouns would not elicit feature items that would fit into those categories). Therefore, feature production was analyzed as main parts of speech (see Table 3). Given the number and varied nature of our stimuli, idiosyncratic features were examined for each individual concept. Features listed at less than two percent were eliminated, which amounted to approximately two to five mentions per concept.

Cosine values were calculated for each combination of word pairings. These values were calculated by summing the multiplication of matching feature frequencies divided by the products of the vector length of each word. Equation 1 shows how to calculate cosine, which is similar to a dot-product correlation. *Ai* and *Bi* indicate the overlapping feature’s frequency between the first cue (*A*) and the second cue (*B*). The subscript *i* denotes the current feature. When *Ai* and *Bi* match, their frequencies are multiplied together and summed across all matching features (Σ). This product-summation is then divided by the feature frequency squared for both *A*and *B,* which is summed across all features from *i* to *n* (the last feature in each set). The square root (√) of the summation is taken for both the cue sets, and these are multiplied together.

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| --- | --- |
|  | (1) |

The McRae et al. and Vinson and Vigliocco norms were added to the current feature norms for comparison. This procedure resulted in more than a half-million non-zero combinations of word pairs for future use. The program written to create cosine values from feature lists allowed for like-features across feature production files to be considered comparable (i.e. investigate and investigation are different forms of the same word). The feature lists were analyzed for average frequencies by word type, and the cosine values were used for comparison against previous research in this field. Both are available for download or search at our website (<http://wordnorms.com>).

**Results**

***Data Statistics*.** Overall, participants listed 58.2% nouns, 19.3% adjectives, 19.9% verbs, 1.7% adverbs, 0.6% prepositions, 0.2% pronouns, 0.1% other word types. The feature file includes 26,047 features for cue words, with 4,553 unique words. Features had an overall average frequency of approximately 14 mentions (*M* =14.88, *SD* = 19.54).Table 3 shows the different types of features, percentages by concept, and average number of features listed for each type of concept. Most of the features produced by participants were nouns, but more verbs and adjectives were listed as features when the cue word provided was also a verb or adjective. A corresponding shift in features is seen when other parts of speech are presented as cue words. Interestingly, a 4X4 (word type by data collection site) between subjects ANOVA revealed differences in the average number of features listed by subjects for parts of speech, *F*(3, 1792) = 15.86, *p*<.001, partial *η*2 = 0.03, and for the data collection site, *F*(3, 1792) = 12.48, *p*<.001, partial *η* 2 = 0.02, but not their interaction, *F*<1, *p*=.54. Nouns showed a higher average number of features listed by subject over verbs (*p*<.001), adjectives (*p*<.001), and other parts of speech (*p*=0.03) using a Tukey post hoc test. Mechanical Turk participants also listed more features than all three University collection sites (all *ps*<.001), which is not surprising since Mechanical Turk participants were paid for their surveys. All means and standard deviations can be found in Table 2.

Cosine values show a wide range of variability from zero overlap between words to nearly complete overlap between words. The cosine excel files include all non-zero cosine values for our stimuli. Words were examined for reliability to comparing similar concepts, as there was some overlap in word forms. For example, begin and beginning yielded a cosine overlap of 0.95, while a low overlap was found between state and states (0.31). Examining the multiple senses of state (a place) versus states (says aloud) might explain the lower feature overlap between that pair. The average overlap for these like pairs (*N* = 121) was *M* = 0.54, *SD* = 0.27. Given that the instructions allowed participants to list features for any number of word meanings, this overlap value indicates a good degree of internal consistency.

***Convergent Validity*.** Our feature production list was compared to the datasets from McRae et al. and Vinson and Vigliocco for overlapping concepts to show convergent validity. Both previous feature production norms were downloaded from the archives of *Behavior Research Methods*. Then, concepts were selected that were in at least two of the databases. Concept-feature lists were compared, and concepts with multiple word features (i.e. four-legs in McRae et al.) were separated to match our current data processing. Cosine values were then calculated between all three datasets for matching concept-feature pairs, as described above. As noted previously, the McRae et al. and Vinson and Vigliocco norms had a strong relation, even though they were collected in different countries (Maki & Buchanan, 2008; *M*cosine = 0.63, *SD* = 0.16, *N* = 114). The overall relationship between the combined datasets and these norms mirrored this finding with an equally robust average (*M*cosine = 0.61, *SD* = 0.18, *N* = 128). When examined individually, the McRae et al. (*M*cosine = 0.59, *SD* = 0.16, *N* = 60) and Vinson and Vigliocco (*M*cosine = 0.61, *SD* = 0.22, *N* = 68) norms showed nearly the same overlapping relationship.

Concept-concept combinations were combined with JCN and LSA values from the Maki et al. semantic distance database (LSA originally from Landauer & Dumais, 1997). 10,714 of the pairs contained information on all three variables. Given this large sample size, *p*-values for correlations are significant at *p*<.001, but the direction and magnitude of correlations are of more interest. Since JCN is backwards coded as a zero value showing high semantic relation (low distance between dictionary definitions), it should be negatively correlated with both LSA and cosine values, where scores closer to one are stronger relations. The correlation between cosine values and JCN values was small-to-medium in the expected negative direction *r* = -0.22. This value is higher than the correlation between JCN values and LSA, *r* = -0.15, which is expected given that LSA has been shown to measure thematic relations (Maki & Buchanan, 2008). The correlation between LSA and cosine values was a medium positive relationship, *r* = 0.30, indicating that feature production may have a stronger connection to themes than dictionary distance.

***Divergent Validity****.* Lastly, we examined the connection between the cue-feature list and the cue-target probabilities from the free association database. Participants were instructed to think about word meaning; however, separation between meaning and use are not always clear, which might cause participants to list associates instead of features. Table 4 indicates the percentage of cue-feature combinations that were present as cue-target combinations in the free association norms. Nearly all of our concepts were selected based on the Nelson et al. (2004) norms, but only approximately 32% of these lists contained the same cue-target/feature combination. The forward strength values for these common pairs were averaged and can be found in Table 4. While these values showed quite a range of forward strengths (0.01-0.94) overall, the average forward strength was only *M* = 0.09 (*SD* = 0.13). An example of the very large forward strength values are combinations such as BROTHER-SISTER and ON-OFF. Additionally, these statistics were broken down by part of speech to examine how participants might list associates instead of features for more abstract terms, such as adjectives and prepositions. Surprisingly, the most common overlaps are found with nouns and verbs (32% of cue-target/feature listings) with less overlap for adjectives (29%) and other parts of speech (26%). The range and average forward strength across all word types showed approximately the same values.

***The Web Portal (http://www.wordnorms.com).*** The website built for this project includes many features for experimenters who wish to generate word-pair stimuli for research into areas such as priming, associative learning, and psycholinguistics. Word information is available for download, including the individual feature lists created in this project. The search function allows researchers to pick variables of interest, define their lower and upper bounds, or enter a preset list of words to search. All terms are described in Table 5, and a complete variable list is available online with minimum, maximum, mean and standard deviation values for variables.

*Semantic.* As described above, the original feature production norms were used to create this larger database of cosine semantic overlap values. The feature lists for the 1,808 words are available, as well the cosine relation between the new words with the McRae et al. and Vinson and Vigliocco norms. Their feature production lists can be downloaded through the journal publication website. In cases where word pair combinations overlapped, the average cosine strength is given. LSA values from the Maki et al. norms are also included, as a step between semantic dictionary type measures and free association measures.

*Association.* Free association values contained in both the Nelson et al. (2004) and Maki et al. (2004) norms have been matched to corresponding semantic pairs. This information is especially important given the nature of the associative boost (Moss, Ostrin, Tyler, & Marslen-Wilson, 1995), indicating that both association and semantics should be considered when creating paired stimuli.

*Frequency.* Although Brysbaert and New (2009) have recently argued against the Kucera and Francis (1967) norms, they are still quite popular and are therefore included as reference. Other frequency information, such as HAL and the new English SUBTLEX values from Brysbaert and New’s research are included as well.

*Word Information*. Lastly, basic word information is available, such as part of speech, length, neighborhoods, syllables, and morphemes. Part of speech (nouns, verbs, etc.) was obtained from the English Lexicon Project (Balota et al., 2007), free association norms (Nelson et al., 2004), and using Google search’s define feature for words not listed in these databases. Multiple parts of speech are listed for each cue on the website. The order of the part of speech listing indicates the most common to least common usages. For example, NN|VB for the concept snore indicates that snore is typically used as a noun, then a verb. Word length simply denotes the number of letters for the cue and target words.

Phonological and orthographic neighbor set sizes are also included. Phonological neighborhoods include the set of words that can be created by changing one phoneme from the cue word (GATE -> HATE, Yates, Locker, & Simpson, 2004). Conversely, orthographic neighborhood of a cue is the group of words that can be created by replacing one letter with another in the same placeholder (i.e. SET -> SIT), and these neighborhood set sizes and their interaction have been shown to affect the speed of processing (Coltheart, Davelaar, Jonasson, & Besner, 1977; Adelman & Brown, 2007). These values were obtained from WordMine2 (Durda & Buchanan, 2006), as well as crosschecked with the English Lexicon values. The number of phonemes, morphemes, and syllables for concepts are provided as the final set of lexical information for cue and target words. Snore, for example, has four phonemes, one syllable, and one morpheme.

**Discussion**

The word information presented here adds to the wealth of word norming projects available. A large set of semantic feature production norms has been collected, and semantic feature overlap between words was calculated for use in future research. A strong relationship between this data collection and previous work was found, which indicates that these norms are reliable and valid. A searchable web database is linked for use in research design. Interested researchers are encouraged to contact the author about addition of their information (norms, links, corrections) to the website.

Several limitations of feature production norms should be noted, especially when considering their use. First, our data processing procedure created feature lists as single word items. We believe that this change over some paired concepts did not change the usability of these norms, as correlations between our database and existing databases were as high as between the existing databases themselves. However, this adjustment in feature processing may have some interesting implications for understanding semantic structure. For instance, is the concept of “four legs” stored in memory as one entry or separated into two entries with a link between them? Three-legged dogs are still considered dogs, which forces us to consider if the “legs” feature of the concept is necessarily tied to four or is separated with a fuzzy boundary for these instances (Rosch & Mervis, 1975).

The negative implication of this separation may be an inability to finely distinguish between cues. For instance, if one cue has four legs and another has four eyes, these cues will appear to overlap because the four features will be treated the same across cue words. However, separating linked features may provide advantages to a person when trying to categorize seemingly unrelated objects (Medin, 1989). In other words, dog would be more similar to other four-legged objects because the concept is linked to a four feature.

Second, multiple word senses can be found for many of the normed stimuli, which will invariably create smaller sub-lists of features depending on participant interpretation. While these various sense lists are likely a realistic construal of linguistic knowledge, the mix of features can lower feature overlap for word-pairs that intuitively appear to match. The feature production lists are provided to alleviate the potential problem (i.e. cosine values may be calculated for feature sub-lists), and future research could investigate if sense frequency changes production rate of certain items. Also, participant creation of norms may exclude many non-linguistic featural representations, such as spatial or relational (i.e. bigger than) features. Likewise, while the features listed for a concept could match, their internal representations may vary. For example, rabbits and kangaroos both hop, but one would argue that the difference in their hops is not present in these types of concept features. Finally, overlap values are prone to capturing the relationship of salient features of concepts, possibly because salient features have special status in our conceptual understanding (Cree & McRae, 2003).

Lastly, our database is the first to examine feature production for abstract terms, adjectives, and other word types not typically normed. We examined the relationship of our cue-feature lists to the free association cue-target data, with approximately 32% overlap between lists. If participants were unable to list features for verbs and adjectives, we would expect this overlap to be higher for such cues, which it was not. Further, we would expect to find many low-frequency cues with no general agreement on the features for a concept (i.e. cues listed by all participants). Yet, most participants listed accomplish, success, and goal for the verb achieve along with other similar infrequent features, such as finish, win, and work. The adjective exact only showed large frequency features, such as precise, accurate, and strict indicating that most participants agreed on the featural definition of the concept. Finally, we would expect reduced correlations to other databases or lower internal overlap of pairs if participants were unable to list features for abstract terms, which did not occur.

While this project focused on word-pair relations, there are many other types of stimuli that are available to investigators. Although out of date, Proctor and Vu (1999) created a list of many published norms, which ranged from semantic similarity to imaginability to norms in other languages. When the Psychonomic Society hosted an archive of stimuli, Vaughan (2004) published an updated list of normed sets. Both of these works indicate the need for researchers to combine various sources when designing stimuli sets for their individualized purposes. Furthermore, concept values found in these norms are an opening for other intriguing research inquiries in psycholinguistics, feature distributional statistics, and neural networks.

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Table 1

*Data Collection Site Statistics: Words, Participants, and Average Response N.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | University of Mississippi | Missouri State University | Montana State University | Mechanical Turk |
| Total Participants | 749 | 1420 | 127 | 571 |
| Concepts | 658 | 720 | 120 | 310 |
| Average *N* per Concept | 67.8 | 71.4 | 63.5 | 60 |

*Note*. Average participants per concept are dependent on the number of words per experimental session. Mechanical Turk total participants are the number of unique participants across all 5-word sessions.

Table 2

*Average Number of Features Listed by Participants and Data Collection Location*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | University of Mississippi | Missouri State University | Montana State University | Mechanical Turk | Total |
| Noun | 10.06 (6.56) | 10.78 (5.70) | 10.59 (4.87) | 14.36 (10.26) | 11.12 (7.00) |
| Adjective | 8.01 (4.69) | 8.25 (3.76) | 10.90 (6.10) | 10.78 (6.73) | 8.67 (4.88) |
| Verb | 6.69 (4.54) | 8.18 (5.28) | 8.17 (3.01) | 9.86 (6.35) | 7.91 (5.16) |
| Other | 7.13 (4.94) | 7.86 (3.14) | 10.83 (6.40) | 13.55 (14.20) | 8.83 (7.48) |
| Total | 8.93 (6.01) | 10.12 (4.74) | 9.78 (5.45) | 13.01 (9.57) | 10.03 (6.54) |

*Note*. Standard deviations are in parentheses.

Table 3

*Concept and Feature Parts of Speech, Percentages, and Average Frequency Response*

|  |  |  |  |
| --- | --- | --- | --- |
| Cue Type | Feature Type | Percent Features | Average Frequency |
| Noun | Noun | 65.90 | 17.10 (23.28) |
|  | Verb | 16.80 | 16.56 (20.03) |
|  | Adjective | 15.80 | 14.75 (16.80) |
|  | Other | 1.40 | 11.65 (9.79) |
| Verb | Noun | 48.70 | 13.20 (19.17) |
|  | Verb | 32.60 | 12.80 (17.53) |
|  | Adjective | 15.10 | 11.67 (12.22) |
|  | Other | 3.70 | 12.16 (10.93) |
| Adjective | Noun | 44.20 | 12.07 (14.78) |
|  | Verb | 16.90 | 11.24 (11.81) |
|  | Adjective | 36.10 | 11.41 (11.22) |
|  | Other | 2.90 | 12.89 (16.36) |
| Other | Noun | 44.80 | 11.95 (13.85) |
|  | Verb | 17.40 | 10.18 (13.70) |
|  | Adjective | 19.40 | 12.42 (12.70) |
|  | Other | 18.30 | 12.88 (17.53) |

*Note*. Average frequency is the average number of times that a participant listed a feature for that type of cue (i.e. the feature was a noun and the cue was a noun). Standard deviations are listed in parentheses.

Table 4

*Percent Overlap between Cue-Feature Lists and Cue-Target Lists from Free Association Norms*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Percent Overlap | *M* FSG | *SD* FSG | Minimum | Maximum |
| Complete Database | 31.68 | 0.09 | 0.13 | 0.01 | 0.94 |
| Nouns | 32.61 | 0.09 | 0.12 | 0.01 | 0.89 |
| Verbs | 32.08 | 0.09 | 0.13 | 0.01 | 0.94 |
| Adjectives | 29.44 | 0.10 | 0.14 | 0.01 | 0.94 |
| Other | 25.68 | 0.14 | 0.20 | 0.01 | 0.90 |

*Note*. FSG = forward strength.

Table 5

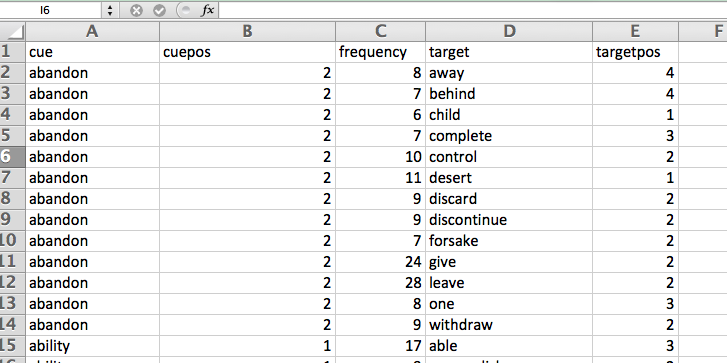
*Search Variables Available at Wordnorms.com*

|  |  |  |
| --- | --- | --- |
| Variable Type | Variable | Definition |
| Semantic | Cosine | Feature overlap between word pairs |
|  | JCN | Semantic dictionary distance taken from WordNet |
|  | LSA | Thematic relations examined by frequency of co-occurrence in text |
| Associative | FSG | Forward strength, the probability of a cue eliciting a target word |
|  | BSG | Backward strength, the probability of a target eliciting a cue word |
|  | QSS/TSS | Cue and Target set size, the number of associates for either the cue or target |
|  | QCON/TCON | Cue and target concreteness values, ranging from 1-7 |
| Frequency | KF | Frequency per Million, Kucera & Francis, 1967 |
|  | HAL | Frequency per Million, HAL norms, Burgess & Lund, 1997 |
|  | LogHAL | Log of HAL frequency |
|  | Subtlex | Frequency per Million, Brysbaert & New, 2009 |
|  | LogSub | Log of SUBLTEX |
| Word Information | Length | Number of letters |
|  | POS | Part of Speech, noun, verb, pronoun, etc. |
|  | OrthoN | Orthographic neighborhood size |
|  | PhonoN | Phonological neighborhood size |
|  | Phonemes | Number of phonemes |
|  | Syllables | Number of syllables |
|  | Morphemes | Number of morphemes |

*Note.* Descriptive statistics for non-null values in the database are found online in the variables list include minimum and maximum values, averages and standard deviations.

Appendix A. *Database Files– Feature Lists.*

Feature\_lists.xlsx – contains features listed for each cue word, excluding features eliminated due to low frequency.



The file contains the following information:

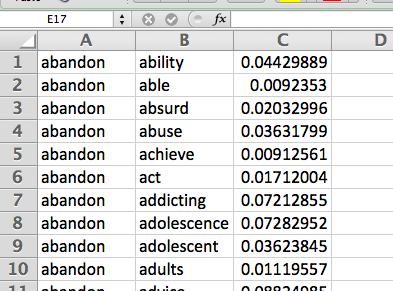
1. Cue word
2. Cue part of speech
   1. 1 = Noun, 2 = Verb, 3 = Adjective, 4 = Other
3. Frequency of feature – the number of times participants listed the feature word.
4. Feature word
5. Feature part of speech
   1. 1 = Noun, 2 = Verb, 3 = Adjective, 4 = Other

The feature lists can be viewed online at:

<http://wordnorms.missouristate.edu/database/feature_lists.xlsx>

Appendix B. *Database Files attached – Cosine Values.*

Cosine A-J.xlsx and Cosine K-Z.xlsx – This file contains all non-zero cosine values for every cue-to-cue combination. These values are calculated as described in the methods section.



The columns are as follows:

1. Cue word
2. Target word
3. Cosine value

These cosine values can be viewed online at:

<http://wordnorms.missouristate.edu/database/cosine_A_J.xlsx>

<http://wordnorms.missouristate.edu/database/cosine_K_Z.xlsx>

Appendix C. *Database Files attached – Complete Database.*

Dataset.zip – This file contains six separate space delimited text files of all available values on the webportal. Each file is 100,000 lines except for the final text file. These files can be imported into excel for sorted and searching. Please note the files are quite large and may open very slowly. The dataset can also be searched online for easier use.

Information contain in these files include:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Information  Type | Variable | Label | Minimum | Maximum | *M* | *SD* |
|  | Cue Word | The first word in a word pairing. For semantic variables, the order of pairings is not important. For the association variables, this value represents the first word given to participants in a free association task. |  |  |  |  |
|  | Target word | The second word in a word pairing. For associative variables, this word represents the first word that "came to mind when shown the cue word" |  |  |  |  |
| Semantic | Cosine | The feature overlap between two words. This value ranges from 0 to 1, where 0 values indicate no overlap between words and 1 values indicate complete overlap between words. | 0.00 | 1.00 | 0.13 | 0.12 |
| Semantic | JCN | The dictionary distance between words. Using WordNet, Maki et al. (2004) have calculated the relationship between word pairs. This variable ranges from 0 to 32 and is reverse coded so that 0 values have a very high semantic relationship. | 0.00 | 28.03 | 10.97 | 6.19 |
| Semantic | LSA | Latent Semantic Analysis shows both the semantic and thematic relationship between word pairs. Low values are close to 0 and high values are close to 1. | 0.00 | 1.00 | 0.25 | 0.17 |
| Associative | FSG | Forward strength is the probability of the target word association when shown the cue word (ranges from 0 to 1). | 0.00 | 0.94 | 0.07 | 0.11 |
| Associative | BSG | Backward strength is the probability of the cue word association when shown the target word (ranges from 0 to 1). | 0.00 | 20.00 | 0.06 | 0.57 |
| Associative | QSS | Cue set size – the number of associates a cue word is connected to (neighbors). | 1.00 | 34.00 | 14.66 | 5.04 |
| Associative | TSS | Target set size – the number of associates a target word is related to. | 1.00 | 34.00 | 14.61 | 5.01 |
| Associative | QCON | Cue concreteness – ranges from low (1) to high (7). | 1.49 | 7.00 | 4.95 | 1.33 |
| Associative | TCON | Target concreteness – ranges from low (1) to high (7). | 1.00 | 7.00 | 4.94 | 3.41 |
| Frequency | KF1 | Cue word frequency – Kucera and Francis (1967) norms. | 0.00 | 21341.00 | 105.14 | 505.04 |
| Frequency | KF2 | Target word frequency – Kucera and Francis norms. | 0.00 | 1625073.00 | 114.33 | 2552.49 |
| Frequency | HAL1 | Cue word frequency - Burgess and Lund (1997) | 0.00 | 8015301.00 | 47464.93 | 231060.18 |
| Frequency | HAL2 | Target word frequency – Burgess and Lund norms | 0.00 | 8015301.00 | 51479.61 | 256346.73 |
| Frequency | LogHAL1 | Log of cue word frequency from HAL | 0.00 | 15.90 | 8.93 | 1.98 |
| Frequency | LOGHAL2 | Log of target word frequency from HAL | 0.00 | 5247.45 | 8.96 | 7.96 |
| Frequency | Subtlex1 | Cue word frequency - Brysbaert and New (2009) | 0.02 | 18896.31 | 133.79 | 681.69 |
| Frequency | Subtlex2 | Target word frequency – Brysbaert and New norms | 0.02 | 41857.12 | 165.83 | 1263.21 |
| Frequency | LogSub1 | Log of Subtlex cue word frequency | 0.30 | 5.98 | 2.90 | 0.86 |
| Frequency | LogSub2 | Log of Subtlex target word frequency | 0.30 | 9.00 | 2.92 | 0.87 |
| Lexical | Length1 | Cue number of letters | 2.00 | 16.00 | 5.75 | 1.99 |
| Lexical | Length2 | Target number of letters | 2.00 | 16.00 | 5.75 | 2.00 |
| Lexical | POS1 | Part of speech (noun, verb, etc.) for cue word |  |  |  |  |
| Lexical | POS2 | Part of speech for target word |  |  |  |  |
| Lexical | Ortho1 | Orthographic neighborhood size (number of neighbors that look similar) for the cue word | 0.00 | 34.00 | 5.57 | 6.54 |
| Lexical | Ortho2 | Orthographic neighborhood size for the target word | 0.00 | 50.00 | 5.50 | 6.41 |
| Lexical | Phono1 | Phonographic neighborhood size (number of words that sound the same) for the cue word | 0.00 | 59.00 | 12.80 | 14.47 |
| Lexical | Phono2 | Phonographic neighborhood size for the target word | 0.00 | 59.00 | 12.71 | 14.25 |
| Lexical | Phonemes1 | Number of phonemes for the cue word | 1.00 | 12.00 | 4.63 | 1.70 |
| Lexical | Phonemes2 | Number of phonemes for the target word | 1.00 | 12.00 | 4.62 | 1.69 |
| Lexical | Syllables1 | Number of syllables for the cue word | 1.00 | 5.00 | 1.70 | 0.80 |
| Lexical | Syllables2 | Number of syllables for the target word | 1.00 | 5.00 | 1.68 | 0.79 |
| Lexical | Morphemes1 | Number of morphemes for the cue word | 1.00 | 5.00 | 1.30 | 0.54 |
| Lexical | Morphemes2 | Number of morphemes for the target word | 1.00 | 5.00 | 1.30 | 0.53 |

*Note*. Variables are in order of the database. Some words appear twice (i.e. with a 2 or \_information) due to multiple entries in previous semantic databases. The denotations are indicators of different tenses or word meanings. These values are explained in the original database (Vinson & Vigliocco, 2008, McRae et al., 2005). This table is also provided online.

The entire dataset may be downloaded at:

<http://wordnorms.missouristate.edu/database/dataset.zip>

This variable list may be downloaded at:

<http://wordnorms.missouristate.edu/database/variables.docx>