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Semantic feature production norms for a large set of objects and events

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Semantic features produced by speakers of a language when given a word corresponding to a concept have provided insight into numerous behavioral phenomena concerning semantic representation in language-impaired and -unimpaired speakers. A number of theories concerning the organization of semantic memory have used features as their starting point. Here, we provide a set of feature norms collected from approximately 280 participants for a total of 456 words (169 nouns referring to objects, 71 nouns referring to events, and 216 verbs referring to events). Whereas a number of feature norms for object concepts already exist, we provide the first set of norms for event concepts. We have used these norms (for both objects and events) in research addressing questions concerning the similarities and differences between the semantic representation of objects and events and in research concerning the interface between semantics and syntax, given that events can be expressed in language as nouns or verbs. Some of this research is summarized here. These norms may be downloaded from www.psychonomic.org/archive.

Semantic features have been assumed to be the building blocks of semantic representation by a variety of theories, some of them developed within a cognitive psychology/cognitive science tradition (see Murphy, 2002, for an overview) and some within a cognitive neuroscience tradition (e.g., Martin & Chao, 2001). For example, within cognitive psychology, concept and categorization theories have made use of features (e.g., Minsky, 1975; Norman & Rumelhart, 1975; Rosch & Mervis, 1975; Smith, Shoben, & Rips, 1974), as have some network models of semantic memory (Collins & Loftus, 1975). Computational models of semantic representation also have relied upon features as the building blocks of semantic representation (e.g., Hinton & Shallice, 1991; McRae, de Sa, & Seidenberg, 1997; Plaut, 1995; Vigliocco, Vinson, Lewis, & Garrett, 2004).

Within cognitive neuroscience, feature-based representations, grounded in the fundamental distinction between sensory and functional/motoric properties of objects, have been invoked to account for category-specific deficits (Warrington & Shallice, 1984) and semantic dementia (e.g., Garrard, Lambon Ralph, Patterson, Pratt, & Hodges, 2005). Damage with respect to specific types of features (e.g., sensory vs. functional) and/or damage that involves features on the basis of their degree of correlation with one another and on the basis of their salience have been argued to account for semantic deficits in different populations (Devlin, Gonnerman, Andersen, & Seidenberg, 1998; Hinton & Shallice, 1991; Plaut, 1995; Rogers et al., 2004; Tyler, Moss, Durrant-Peatfield, & Levy, 2000). Imaging studies have provided support for the idea that perceptual and functional/motoric features are parts of conceptual representation (e.g., Martin & Chao, 2001, for objects' features; Vigliocco et al., 2006, for features of events).

In many previous models, featural representations are assumed to have certain properties on the basis of a priori considerations; however, a number of recent models have used semantic feature norms obtained from naive participants (especially the work by McRae and colleagues: Cree, McNorgan, & McRae, 2006; Cree & McRae, 2003; Cree, McRae, & McNorgan, 1999; McRae & Cree, 2002; McRae, Cree, Seidenberg, & McNorgan, 2005; McRae, Cree, Westmacott, & de Sa, 1999; McRae et al., 1997; see also Garrard, Lambon Ralph, Hodges, & Patterson, 2001; Moss, Tyler, & Devlin, 2002; Rogers et al., 2004; Rogers & McClelland, 2004; Tyler et al., 2000). In particular, McRae and colleagues' norms for 541 living and nonliving object concepts have been made available through a publication in this journal (McRae et al., 2005).

We have taken such an approach in our own work, but crucially, going beyond the domain of nouns referring to objects, and applying the same techniques to the domain of actions and events. Here, in addition to providing an additional featural database for 167 living and nonliving object concepts, we provide the first published norms for a total of 287 events: from simple actions, such as *kicking* and *throwing*, to more abstract events, such as *exchanging*, *suggesting*, and *losing*. We have used these norms to assist us in the selection of materials for imaging studies (Vigliocco et al., 2006), to generate predictions concerning semantic impairments in brain-damaged individuals

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(Vinson, Vigliocco, Cappa, & Siri, 2003), and to develop a model of semantic representation (Vigliocco et al., 2004), from which we have derived and tested predictions concerning semantic similarity effects in normal and impaired populations (Vigliocco, Vinson, Damian, & Levelt, 2002; Vigliocco et al., 2004; Vinson & Vigliocco, 2002) and predictions concerning the separability of semantic and syntactic factors (e.g., Vigliocco, Vinson, & Siri, 2005). The goal of this article is to render these feature norms available to other scientists. Before we turn to describing the norms, let us briefly review some literature that highlights the type of theoretical questions that we have addressed, using speaker-generated featural norms like the ones we collected.

Some Theoretical Issues That Have Been Addressed Using Feature Norms

Feature types and feature properties in the representation of object concepts. In order to account for selective impairment of certain categories of knowledge, particularly the often-observed selective impairment of living things in the face of spared concepts referring to artifacts, some researchers have argued that living things and nonliving things differ with regard to the importance of sensory versus functional features and that, therefore, feature type (sensory/functional) is the underlying principle of organization of semantic knowledge. In particular, whereas for living things sensory features would be more important, for artifacts, instead, functional features would be more important (e.g., Farah & McClelland, 1991; Warrington & Shallice, 1984). Selective impairment of living things would then arise as selective damage to sensory features (a claim that is further supported by the fact that, often, patients suffering a selective deficit for living things have lesions in inferior temporal areas, part of the "what" visual system). Speaker-generated features have been used to assess this claim. For example, classifications of our norms into feature types have shown that, indeed, sensory features are more common for living than for nonliving concepts. For the latter, motoric and functional properties, instead, are more prominent (Vigliocco et al., 2004; Vinson et al., 2003). Note that our classification into feature types differs from those reported by other authors in the literature (Caramazza & Shelton, 1998; Farah & McClelland, 1991; Garrard et al., 2001; McRae & Cree, 2002). First, it differs from the other reports in that we proposed a classification of feature types for action words; the other studies have limited their domain to object words. Thus, this classification leads to novel predictions concerning which concepts referring to events should be impaired or spared along with concepts from the object domain (see Vinson et al., 2003). Second, it differs from the classifications proposed in Caramazza and Shelton (1998), Farah and McClelland (1991), and Garrard et al. (2001) in that it goes beyond a broad distinction between sensory (visual, acoustic, etc.) and functional features. Finally, it differs from the classification proposed by McRae and Cree (2002) and Cree and McRae (2003) in that we limited our classification to those feature types that can plausibly be represented in the brain following the sensorimotor systems. These authors, instead, propose classifications that include higher order cognitive functions, such as *contingency*, *evaluation*, and so forth. Our classification into feature type has also been successfully used to select words for use in an imaging experiment focusing upon words referring to events: obtaining one set of items for which sensory features were more prominent than motoric features and another set of items for which motoric features were more prominent than sensory features. In this study, we found greater left primary motor activations for the motor words than for the sensory words and greater left anterior inferior temporal activations for the sensory words (Vigliocco et al., 2006).

Feature type, however, cannot be the only underlying principle of semantic organization, since it is well established that featural properties—such as whether features (regardless of type) are shared (i.e., features that are common to more than one entity; e.g., <tail> applies to both *dog* and *cat*), distinctive (i.e., features that are unique to a specific entity within a domain of knowledge; e.g., <see> is unique to *eyes* among body parts), and/or correlated (i.e., the fact that some features shared among concepts co-occur with other shared features within a given domain of knowledge; e.g., entities that have a <tail> are also likely to have <four legs>)—play an important role in semantic organization. In the object domain, Garrard et al. (2001) and McRae et al. (1997) have shown that living things tend to have more correlated features than do nonliving things. Differences in featural properties between living and nonliving things have also been argued to have explanatory power in accounting for category-related deficits both in patients suffering from herpes simplex encephalitis and in patients with degenerative conditions, such as Alzheimer's disease and semantic dementia (Devlin et al., 1998; Tyler et al., 2000). Researchers have also stressed the differential importance of certain feature properties in the online processing of words referring to animate versus inanimate entities. For example, McRae et al. (1997) showed that different featural properties were implicated in priming in visual word recognition, depending on the type of word: For living things, the degree of featural correlation between the prime and the target predicted the amount of priming, whereas for artifacts, the number of shared features was most relevant. We have confirmed, using our norms, that living things have more strongly intercorrelated features than do nonliving things and that objects have more strongly intercorrelated features than do events. Using a subset of concepts matched for concept familiarity, the average correlation coefficient between pairs of features was .146 for animals, .119 for artifacts, and .081 for events. All the conditions were significantly different from each other (see Vinson et al., 2003).

Featural representation of objects and events. To our knowledge, our norms are the first published norms for events. We have used them to begin exploring the representation of these concepts. This issue has received relatively little attention, given that most of the behavioral research whose aim has been to assess models of semantic representation has focused on concrete objects.

Objects differ from events along a number of dimensions. A first, intuitive difference between objects and actions/events is that objects can be understood in isolation, whereas events are relational in nature. One implication of this difference is that words referring to events are more abstract than words referring to objects (Bird, Lambon Ralph, Patterson, & Hodges, 2000; Breedin, Saffran, & Coslett, 1994). Differences concerning concreteness have been linked in some connectionist models to differences in richness of featural representation, with concrete words having semantically richer representations than do abstract words (Plaut, 1995). Such differences between objects and events have been confirmed in our norms: In a subset of items matched for concept familiarity, animals and artifacts had higher summed feature weights (the number of participants who reported a given feature for a given concept) than did events (121.8 for animals, 117.2 for artifacts, 97.2 for events; see Vinson et al., 2003).

Some authors have also argued that objects and events differ in featural properties. Objects have more features referring only to narrow semantic fields (e.g., <domesticated> vs. <wild> for animals), as compared with events (Graesser, Hopkinson, & Schmid, 1987; Huttenlocher & Lui, 1979). For the latter, instead, more features apply to members of diverse semantic fields (e.g., <intentionality>, <motion>). Furthermore, features tend to be more strongly correlated within semantic fields for objects (e.g., <tail> and <four legs> for mammals) than within those for events. Differences of this nature are indeed observed within our feature norms (see Vinson & Vigliocco, 2002; Vinson et al., 2003).

From concepts to words: Using the feature norms in psycholinguistic studies. Semantic similarity effects among words are well established in the psycholinguistic literature, especially with respect to words referring to objects. Given feature norms, quantitative predictions regarding semantic similarity effects can be developed by obtaining measures of semantic similarity among the words in the norms. These measures of semantic similarity may be obtained without any dimensionality reduction of the featural space (cosine between vectors; see McRae et al., 2005) or may be obtained after some dimensionality reduction technique is applied to the featural data. In our work, we have followed the latter procedure. As a measure of semantic similarity among words, we have used the average Euclidean distance between the units best responding to words' feature vectors in output layers of multiple self-organizing maps (see Vigliocco et al., 2004). The main reason for choosing this method is theoretical: We have argued that conceptual representations (the featural space for which our featural norms provides us with some insight) should be distinguished from lexicosemantic representations (meaning of words); thus, dimensionality reduction techniques serve this function in mapping from one domain to the other (for discussions, see Vigliocco & Vinson, 2007; Vigliocco et al., 2004).

The resulting measures of semantic similarity have been used to predict *graded* semantic effects (fine-grained effects that are sensitive to degree of similarity, rather than simply reflecting the difference between related and unrelated) in word production and word recognition for both words referring to objects and words referring to events. In particular, we showed that measures of semantic similarity based on our feature norms successfully predicted, first, graded semantic interference effects in object and event naming when pictures were presented in blocks of semantically related/unrelated objects/events (Vigliocco et al., 2002). In both domains, the greatest amount of interference was observed when participants named pictures in semantically related contexts (e.g., all pictures of clothing); an intermediate amount of interference was observed when the contexts were moderately similar (e.g., naming pictures in a mixed block of clothing and body parts, two semantic fields that are somewhat similar according to featural measures), as compared with naming in semantically unrelated contexts (e.g., a mixed block of clothing and vehicles). Second, the measures successfully predicted graded semantic interference effects in object and event naming when the picture–word interference paradigm was used (Vigliocco et al., 2004). Finally, they successfully predicted graded semantic priming effects, again for both object and events, in visual word recognition when a lexical decision task was used (Vigliocco et al., 2004). These measures of semantic similarity are available upon request. Importantly, this work was the first to show graded effects for the conceptual domains of both objects and events.

Having established that these measures of semantic similarity were successful in predicting semantic effects separately for objects and events, we then used them to address the issue of separability of semantic and syntactic information. Words referring to objects and words referring to events also differ in dimensions crossing the boundary between semantics and syntax. Words referring to objects are nouns; words referring to events can be nouns or verbs. The claim that nouns and verbs are separately represented in the brain has been quite influential in the neuropsychological literature (see Damasio & Tranel, 1993) and has been based primarily on the observation of a double dissociation between patients selectively impaired with nouns or verbs (e.g., Daniele, Giustolisi, Silveri, Colosimo, & Gainotti, 1994; Miceli, Silveri, Nocentini, & Caramazza, 1988). However, most previous work assessing the separability of nouns and verbs confounded the syntactic distinction between words belonging to these two classes and the semantic distinction between objects and events, using stimuli in which nouns were objects and verbs were events. Using our semantic distance measures, we showed that semantic distances between words referring to objects and words referring to events were greater than semantic distances between words referring to objects from different semantic fields or words referring to events from different semantic fields (Vinson & Vigliocco, 2002). Most crucially, focusing solely on words from our set referring to events[1] (thus minimizing the semantic confound), we investigated whether grammatical class effects come about when semantic similarity is controlled. In picture–word interference experiments, we manipulated both the semantic similarity between the target picture and the distractor word and whether the distractor was a noun or a verb (with the target always being a verb). For example, for a target picture depicting *slapping*, semantically similar distractors might be *the hit* and *to punch*; dissimilar distractors might be *the scream* and *to screech*. Crucially, noun and verb distractors were matched for semantic similarity to the target. Under such conditions, we observed no effect of the grammatical class of the distractor when speakers named the pictures as bare verbs. When speakers produced phrases, instead, we observed grammatical class effects that did not interact with the semantic effects, suggesting that effects of grammatical class (nouns vs. verbs) are syntactic in nature, rather than lexical, and that, therefore, grammatical class differences for single words that have been reported in neuropsychological studies may have arisen from semantic confounds, rather than from grammatical class per se.

The Feature Norms

Word selection. In order to capture general properties of semantic representation, we selected words from a variety of semantic fields, including objects (such as fruits and vegetables, tools, body parts, vehicles, clothing, and animals) and events (such as manner of motion, light emission, contact, exchange, communication, sounds, body motion, and sensation; see archived materials for the complete list of words and their semantic fields). Such a wide range of semantic fields was also necessary to provide as neutral a context as possible. Care was taken to avoid semantically ambiguous words, and special attention was made to include nouns depicting events, whenever possible, within the semantic fields of action. A total of 456 words were used, including 240 nouns, of which 169 depicted objects and 71 events (all nouns referring to events were homonymous or derivationally related to event verbs also in the set), and 216 verbs, all of which depicted events. In order to disambiguate syntactically ambiguous words, nouns were always presented with the article *the*, and verbs with the particle *to* (e.g., *the blink* vs. *to blink*).

Feature collection. Fourteen lists were prepared, each of which contained from 30 to 40 words from the complete set. Words were pseudorandomly assigned to lists, with the following restrictive criteria: The noun and verb forms of the same word could not appear on the same list (this was the case both for noun–verb homonyms, such as *to blink/the blink*, and for derivationally related pairs, such as *to construct/the construction*), and at least one word from each semantic field appeared in each list. Each list was presented in randomized order.

Two hundred eighty undergraduate students from the Department of Psychology at the University of Wisconsin, Madison, participated in exchange for extra credit. Twenty participants were assigned to complete each list and were instructed to define and describe each word on the list in turn by using features (see the Appendix for exact instructions). They were asked to avoid free association and to list different features separately, avoiding the use of "dictionary style" definitions, which tend to contain complex combinations of features in sentence form; two examples (one object noun and one action verb not occurring on that list) were provided as a model. The participants generally completed the task in about 45 min. Those participants who failed to comprehend the task ($n = 5$) were replaced.

Feature analysis. Data consisted of a large quantity of speaker-generated features for each word, separated by participants. Because the participants often produced conjoint features (i.e., *red fruit* for *the apple*), it was necessary to determine an operational criterion for identifying a feature. In such cases, three native English speakers (D.P.V. and two naive speakers) judged whether the intersection of multiple terms had a different meaning than the terms considered separately (here, *red* and *fruit*). Such conjoint features were separated only if the three speakers unanimously agreed that separating them preserved their meaning. Similarly, because the participants were unconstrained in their responses, they often used variations in wording or synonyms to express the same feature (e.g., "four-legged," "has four legs," "quadruped"). As was the case for separation of conjoint features, *synonymous* features were combined into a single featural representation only when the three raters unanimously agreed that they were synonymous.

A subset of the words were independently scored and entered by two native speakers of English, and disagreements were mediated by a third. For each word, this analysis resulted in a vector of features weighted according to the number of speakers who had generated that feature. The feature vectors were then combined across words, creating a word × feature matrix. At this point, idiosyncratic features (those features whose summed weight across all 456 words was less than 9) were discarded, resulting in a matrix of 456 (words) × 1,029 (features); values correspond to the weight of a given feature for a given word.

Table 1
Average Number of Features and Average Sum of Feature Weights As a Function of Semantic Field

Semantic Field	Mean No. Features	Mean Feature Weight
Object Nouns		
Animals	30.96	126.2
Fruit and vegetables	26.88	115.8
Tools	30.48	109.9
Vehicles	31.00	109.8
Body parts	32.46	116.4
Clothing	27.18	108.4
Miscellaneous artifacts	32.45	106.6
Action Words (verbs and nouns)		
Body actions	29.15	98.0
Body sense	26.17	89.7
Change of location	29.36	86.4
Change of state	25.40	76.4
Noises	28.17	93.6
Communication	28.89	88.8
Construction	27.29	95.1
Contact	27.33	91.5
Cooking	24.43	95.9
Destruction	31.88	89.4
Exchange	23.50	80.3
Heat/light emission	25.54	88.8
Motion direction	22.00	73.6
Motion manner	29.12	95.9
Tool action	34.22	104.1

This matrix appears in the archived materials. Table 1 summarizes the average number of features and summed feature weights across semantic fields referring to objects and actions. These two domains are largely differentiated according to these measures, but fine-grained differences within object and action domains are also present.

Classifying the speaker-generated features. The speaker-generated features were classified into the following five categories by two English speakers; disagreements were discussed and agreed upon. First, perceptual features, defined as "features that describe information gained through sensory input, including body state and proprioception," were identified and then subdivided into *visual* features, referring to the sense of vision (22.2% of all the features), and *other perceptual* features from other sensory modalities (19.7%). The nonperceptual features were then classified into *functional* (those features referring to the purpose of a thing, "what it is used for," or the purpose or goal of an action; 26.5%), *motoric* ("how a thing is used, or how it moves," or any feature describing such motor component of an action; 12.0%), and *other* (37.6%; the total percentage of scored features exceeds 100%, since some features met criteria for more than one feature type classification). The latter class, which contains the largest proportion of the speaker-generated features, is highly heterogeneous. Some of the features can be considered as reflecting encyclopedic knowledge (e.g., <from Africa>), whereas many of the other features reflect relationships among meanings (e.g., IS A <animal>; PART OF <face>) well represented in taxonomies developed by lexicographers (see, e.g., Miller & Fellbaum, 1991). For the purpose of the present work, we will not attempt to further classify these features, since we limit the assumption of modality-specific organization to features related to perception and action. The contrast between motoric and functional features was introduced because of the existing evidence (Buxbaum, Veramonti, & Schwartz, 2000) indicating that knowledge of how to use an object and knowledge of what the object is used for can dissociate. Figure 1 illustrates the average composition of different feature types for exemplars in some different object categories (taking weights into account), and Figure 2 reports composition of exemplars of some action fields. As can be seen from the figures, exemplars in different categories differ along the lines of their featural composition.

Conclusion

We have described the collection of a set of speaker-generated feature norms for a set of words referring to objects and to events and have described some of our research stemming from them. We provide them here in the hope that they can be of further use to various members of

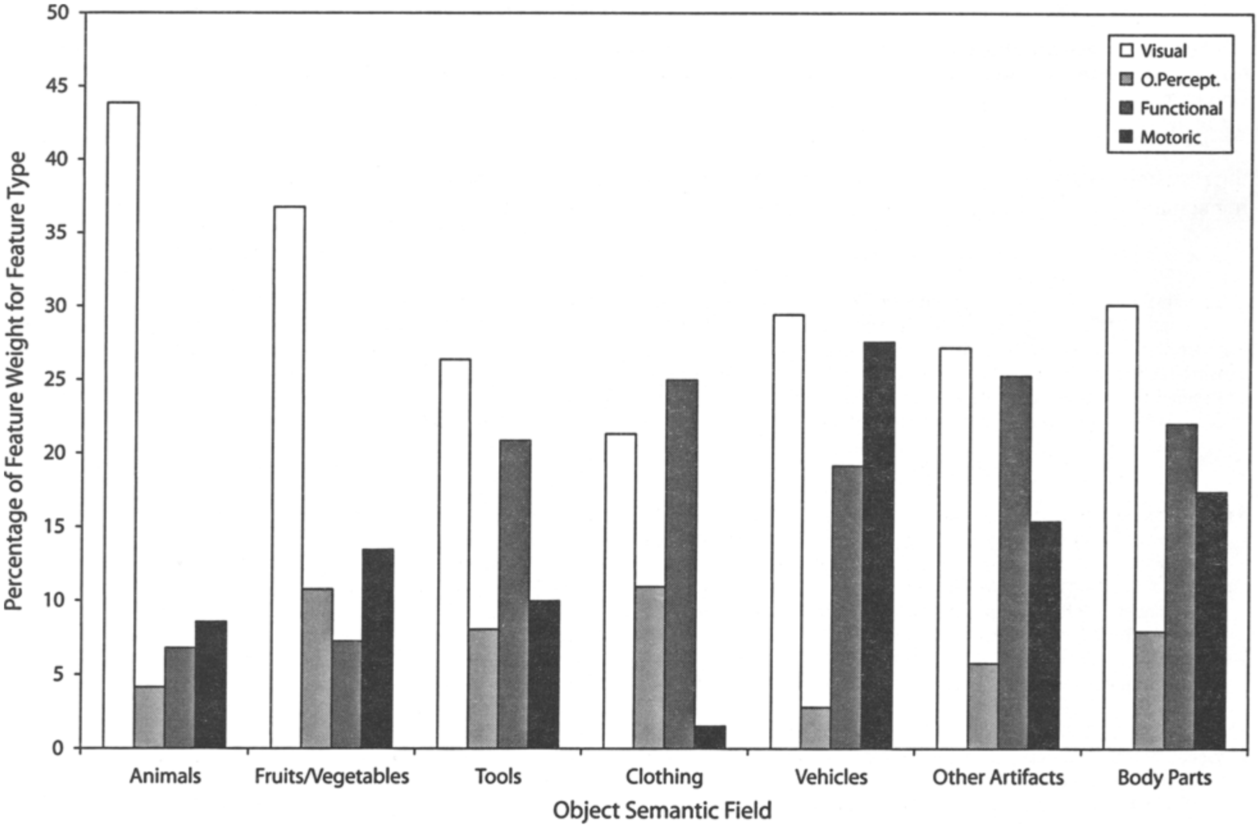

Figure 1. Percentage of feature types in exemplars from various object semantic fields, adjusted by weight. Features labeled as "other" are not displayed.

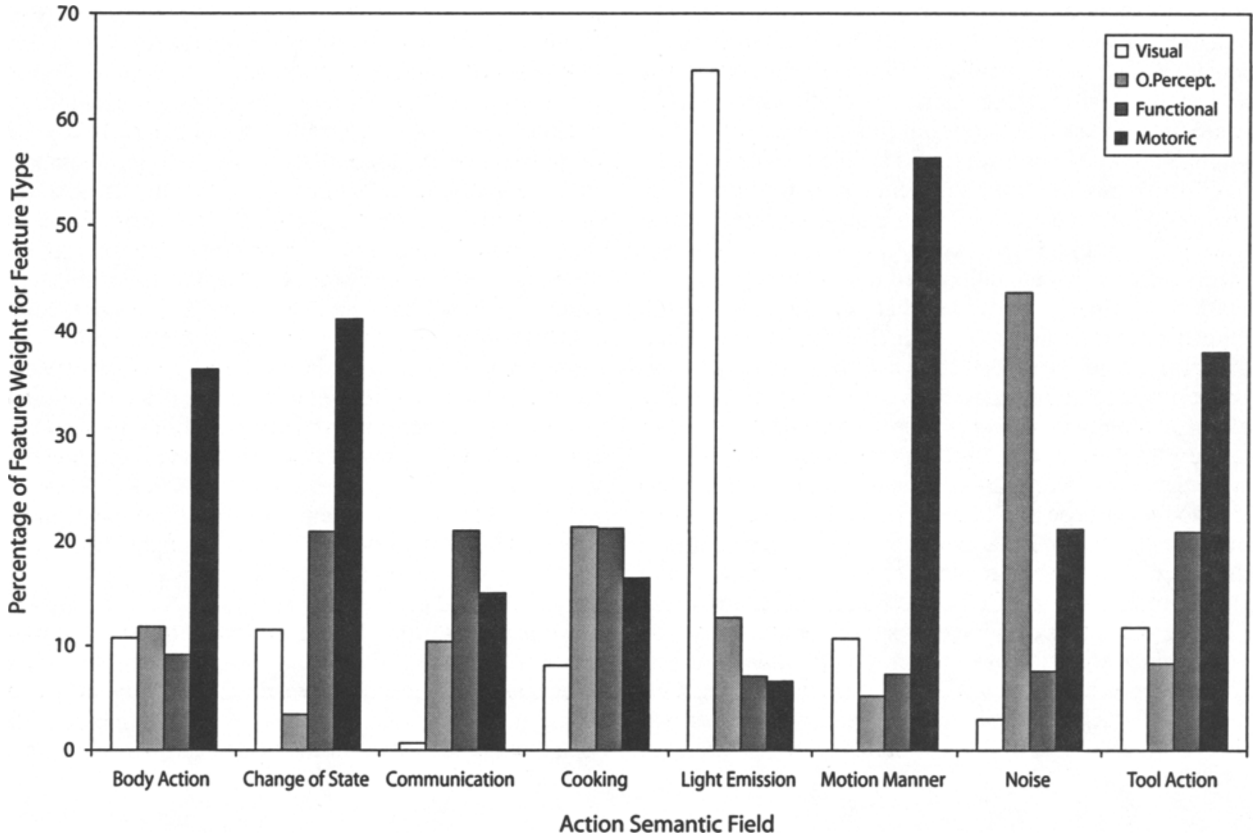

Figure 2. Percentage of feature types in exemplars from a subset of action semantic fields, adjusted by weight. Fields were selected to be indicative of the range of featural composition in the complete set of semantic fields. Features labeled as "other" are not displayed.

the research community in addressing questions concerning semantic representation across domains.

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NOTE

1. As was described in the Method section, in our set of words, we included both nouns and verbs referring to events (e.g., *the smile* and *to smile*); in order to disambiguate between the two during feature collection, words were preceded by *the* for nouns and by *to* for verbs.

ARCHIVED MATERIALS

The following materials associated with this article may be accessed through the Psychonomic Society's Norms, Stimuli, and Data Archive, www.psychonomic.org/archive.

To access these files, search the archive for this article, using the journal name (*Behavior Research Methods*), the first author's name (Vinson), and the publication year (2008).

File: Vinson-BRM-2008.zip

Description: The compressed archive file contains four files in tab-delimited text format:

1. word.categories.txt contains a list of the words for which speaker-generated features were obtained, and includes four fields:

ID#: Value from 1 to 456, indicating which column of the feature weight matrix corresponds to a given word.

word: The word for which speaker-generated features were produced. In the feature collection phase, nouns were distinguished from verbs by the use of "the" and "to," respectively.

type: Broad semantic/grammatical classification for a given word {actionN[oun], actionV[erb], object}.

semantic: Finer semantic classification for a given word (e.g., body part, tool, communication, exchange), from Vinson and Vigliocco (2002).

2. feature_list_and_types.txt contains a list of the features produced across all words in the test set (summed weight > 8 only), and includes six fields:

feature#: Value from 1 to 1,029, indicating which row of the feature weight matrix corresponds to a given feature.

feature: The label of a given feature.

visual: Feature type coding (see Vigliocco et al., 2004; Vinson et al., 2003). Binary coding: features classified as "visual" are given a value of 1; otherwise, 0.

perceptual: Binary feature type coding for perceptual features referring to modalities other than vision (note that cross-classification is still permissible for features experienced through, e.g., both visual and tactile modalities).

functional: Binary feature type coding for functional features.

motoric: Binary feature type coding for motoric features.

3. feature_weight_matrix_1_256.txt contains feature weight values for words #1–256. Values represent the number of participants who produced a given feature (rows) for a given word (columns).

4. feature_weight_matrix_257_456.txt contains feature weight values for words #257–456.

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(*Continued on next page*)

APPENDIX

Instructions Given to Participants in the Feature Generation Task

In this experiment, you will be asked to produce definitions for common English words. However, instead of writing "dictionary style" definitions, we want you to define the words using features (described below).

Each feature should contain as few words as possible. The features you list for a word, when they are combined, should define and describe that particular word as completely as possible. Think about the features of meaning that are most important for each word, and try to list features that will uniquely identify that word even among similar words.

Here are two examples of the kinds of definitions that people produce:[A1]

"a dog"	"to write"
pet	communication
animal	action
has fur	requires paper
barks	requires pen/pencil
4 legs	uses words
friendly	expression
has a tail	done by humans
mammal	uses hands
. . .	. . .

Please note that this is NOT a test of word association, so please avoid those "PURE ASSOCIATIONS" which do not serve to define or describe a word's meaning.

We will give you a definition sheet containing all the words we would like you to define. Please make sure to define all of the words in the order in which they are presented, completing each one before moving to the next.

APPENDIX NOTE

A1. Examples were taken from responses by pilot participants and always included one noun and one verb. Different examples were selected for different participants, so that the examples were never the same as any items on a given participant's list.

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