



## Original Articles

# It's all in the delivery: Effects of context valence, arousal, and concreteness on visual word processing



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## ABSTRACT

Prior research has examined how distributional properties of contexts (number of unique contexts or their informativeness) influence the effort of word recognition. These properties do not directly interrogate the semantic properties of contexts. We evaluated the influence of average concreteness, valence (positivity) and arousal of the contexts in which a word occurs on response times in the lexical decision task, age of acquisition of the word, and word recognition memory performance. Using large corpora and norming mega-studies we quantified semantics of contexts for thousands of words and demonstrated that contextual factors were predictive of lexical representation and processing above and beyond the influence shown by concreteness, valence and arousal of the word itself. Our findings indicate that lexical representations are influenced not only by how diverse the word's contexts are, but also by the embodied experiences they elicit.

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## 1. Introduction

Words are not acquired, comprehended, or produced in isolation. Language researchers have long since recognized that context – whether defined as an immediate linguistic environment of an individual word occurrence or as systematic statistical patterns of co-occurrence of a word with other linguistic units – plays a fundamental role in all aspects of word representation and processing (Firth, 1957; Wittgenstein, 1922). Unsurprisingly, context is given a place in all major models of word recognition. Thus, several computational models of word recognition identify context either as an independent module (Harm & Seidenberg, 1999; Seidenberg & McClelland, 1989) or an integral part of the semantic module (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001, for a related interpretation see also Perfetti & Hart, 2002). Others incorporate contexts of words into their quantification of a word's orthographic or semantic representations (Baayen, Milin, Đurđević, Hendrix, & Marelli, 2011; Norris, 2006). Yet others rely on patterns of co-occurrences between words as a primary source of information about lexical meaning (Landauer & Dumais, 1997; Lund & Burgess, 1996; Shaoul & Westbury, 2010). For a review of models of word recognition, see Norris (2013).

The importance of contexts for theorizing about the mental lexicon and word recognition raises a question of what properties of lexical contexts are of relevance for storing words in long-term memory and retrieving them, and how the reader's mind associates these contextual properties with individual words. Particularly interesting in this regard are the “long-term” contextual influences that arise from global statistics of co-occurrence between words.<sup>1</sup> What is it about those preferred neighbors that we store in our memory in association with the word, and make contact with when the word is used? Our review of the literature suggests that the focus so far has been on *distributional* characteristics of contexts. For instance, McDonald and Shillcock (2001) defined an information-theoretic measure of contextual distinctiveness that quantifies the distance between contexts of a specific word and contexts based on all words in the corpus, and Adelman, Brown, and Quesada (2006) proposed the measure of contextual diversity, i.e. the number of unique contexts a word occurs in. The measures indicate that words occurring in a smaller number of contexts and in more distinctive contexts than others are slower to recognize in the lexical decision task. Jones, Johns, and Recchia (2012) found that repetitions of a word facilitate processing more when repetitions include changes in semantic context. Moreover, Buchanan,

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<sup>1</sup> This paper leaves aside the discussion of a well-studied impact of context that is supplied by the discourse around individual word occurrences, including contextual constraint (e.g. Ehrlich & Rayner, 1981; Fischler & Bloom, 1979) and semantic priming (for review see Neely, 1991).

Westbury, and Burgess (2001) demonstrated that a number of semantic associates that a word elicits in a free-association task comes with shorter lexical decision and naming latencies as well. A further family of measures stems from models of distributional semantics, which quantify semantic distance between words as a function of their propensity to occur in similar contexts, and represent distances between words in a multidimensional space (Landauer & Dumais, 1997; Lund & Burgess, 1996; Shaoul & Westbury, 2010). Words with lower semantic neighbourhood density (i.e. fewer close words in semantic space) are recognized more quickly in lexical decision (Buchanan et al., 2001; Mirman & Magnuson, 2008). Hoffman, Ralph, and Rogers (2013) and Hoffman and Woollams (2015) also found that words with greater average semantic distance between their contexts elicit longer RTs in lexical decision but slower responses in a semantic relatedness task.

We argue that important insights into the role of context can be gained if its semantics is interrogated directly, over and above mathematic characterization of how many contexts there are or how similar they are. Specifically, for a target word we propose to quantify semantics of a word's context by estimating aggregated semantic properties of words that co-occur with that target word in a large corpus. For this inquiry, we chose affective (valence and arousal) and sensorimotor (concreteness) aspects of lexical connotative meaning to examine whether these properties of contexts inform the meaning of the word and affect its recognition.

There are two reasons to select these out of the many semantic properties that words engender for our study of contextual semantics. First, corpus linguistics found distributional evidence that, despite being affectively neutral, some words (such as *cause*, *utterly*) have strong tendencies to co-occur with words that are negative, while their also neutral synonyms (*produce*, *totally*) do not. This phenomenon is known as semantic prosody (Louw, 1993; Partington, 2004; Sinclair, 1991; Stubbs, 1995) and, at least for some words, has been demonstrated to affect the speed of word recognition. Ellis, Frey, and Jalkanen (2009) reported shorter lexical decision response times in congruent phrases where positive/negative contexts followed words with the positive/negative semantic prosody (e.g., *attain goals or maturity*) rather than incongruent phrases (*attain problems or damage*). Generalizability of these results over the entire lexicon is, however, under discussion (Ellis et al., 2009; Hunston, 2007; Whitsitt, 2005). One of our goals is then to test whether semantic prosody, i.e. emotional and sensorimotor connotations of the contexts in which a word appears, contribute to recognition of that word over and above the influence of the word's own connotative meaning.

The second reason arises from the well established "concreteness effect", i.e., the tendency of words with tangible, physical referents to be learned earlier, recognized faster and recalled with less effort than words with abstract referents (Paivio, 1991; Schwanenflugel, 1991). Most proposed explanations regard verbal context as a primary vehicle of difference between concrete and abstract words. Thus, Paivio (1990) proposed that some words are represented in both a verbal and imagistic systems, whereas others are only represented verbally. Schwanenflugel, Harnishfeger, and Stowe (1988) proposed that abstract words are more difficult to recognize because they rely more heavily on context to be interpreted: for a merge of these proposals see cf. Holcomb, Kounios, Anderson, and West (1999) and West and Holcomb (2000). Hoffman et al. (2013) proposed *semantic diversity*, a measure which quantifies the extent of variability of a words' meaning based on the distance between the contexts of a word in a semantic space. Words with greater contextual variability in meaning were found to be more abstract. Kousta, Vigliocco, Vinson, Andrews, and Del Campo (2011) make a further step in claiming that sensorimotor, affective and linguistic information is implicated in representations of both concrete and

abstract words, with concrete words relying more on tangible sensorimotor experience with their real-life referents and abstract words on the affective aspect of experience.

Studies of the effects of word valence, arousal, and concreteness on word recognition almost exclusively use explicit judgments gleaned from participants. From the literature on semantic prosody (cited above), there is reason to suspect that explicit judgments of word properties may not take into account regularities in word contexts. A word that is considered to have some quality (high concreteness, low valence, etc.) does not necessarily occur in contexts that share that quality. We present the first attempt to quantify the affective and sensorimotor qualities of contexts, and establish whether it forms a systematic relation with the qualities of the words these contexts embed. Our goal is to provide empirical evidence for the relationship between word semantics and that of context, and inform models of visual word recognition by specifying what aspects of the semantics of contexts are relevant.

To do so, we explain how we extract and quantify the valence, arousal, and concreteness of contexts from a corpus. We then assess and report correlations between connotations of a word and of its contexts. Finally, we use available lexical decision and recognition memory megastudies to determine if the semantics of context exerts an effect on word recognition, and if this effect is maintained after word-level semantics is controlled for. Given the important role allocated to context in the acquisition of abstract, concrete and emotion-laden words (see Kousta et al., 2011), we also consider the effect of context semantics on the age of acquisition ratings for thousands of words. Critically, we selected tasks that present words in isolation, such that globally defined contexts of those words are not primed or suppressed by local context.

## 2. Methods

### 2.1. Valence, arousal, and concreteness of contexts

As our corpus of contexts, we used the 7 billion token USENET corpus (Shaoul & Westbury, 2013), which consists of email newsgroup postings. Characters were converted to lowercase, punctuation except for intra-word hyphens and apostrophes were removed, and a whitespace tokenizer was applied. Function words were removed from the corpus. A word's context was defined as the 5 content words that immediately preceded it, and the 5 content words that immediately followed it in the text. The target word itself was not considered part of its context.

Our goal was to determine if the valence, arousal and concreteness of a word's contexts influence word processing above and beyond the effect of those same affective and sensorimotor properties of the word alone. Our estimates of contextual semantics were based on results of two recent mega-studies. Warriner, Kuperman, and Brysbaert (2013) collected norms of valence and arousal for 13,915 English lemmas (or citation forms of the word). Words were rated on a scale of 1–9 (sad to happy for valence, calm to excited for arousal) by about 20 raters each. We have enhanced the set of affective norms by assigning the value of valence and arousal given to the lemma (i.e. sing) to all its inflected wordforms (sang, sung, singing): This increased the dataset to 28,724 data points. Brysbaert, Warriner, and Kuperman (2014) collected norms of concreteness for 40,000 English words (both citation and inflected wordforms). Words were rated on a scale of 1 (abstract) to 5 (concrete) by about 30 raters each. In both studies, words were presented in isolation, without any information about word sense, word's part of speech, or supporting context: the average of ratings was taken as the value of the word's semantic norm.

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