

Context Variation and Definitions in Learning the Meanings of Words: An Instance-Based Learning Approach

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This article proposes an instance-based theoretical framework to account for the influence of both contexts and definitions on learning new word meanings and reports 2 studies that examine hypotheses about learning from context. One is that variation in contexts is important for allowing core meaning features of a word to emerge. The second is that definitions are effective because they can interact with contexts to communicate core meanings. Both experiments tested the effects of context variation by presenting adult learners with context sentences that either varied or repeated with each training trial. Experiment 1 varied whether definitions were also provided, whereas Experiment 2 varied context variability without definitions and examined the role of reading comprehension skill and pre-training word familiarity. Results across several different measures were that exposure to variable contexts led to better learning of abstract meanings than did equivalent exposure to a single context. In addition, definitions were more effective at conveying this knowledge than context alone. The instance-based framework accounts for the dual effects of contexts and definitions, suggesting how word learning results from abstraction across varied word encounters, both definitions and context sentences.

Discourse context is considered to be a primary source for learning the meanings of unknown words (Jenkins, Stein, & Wysocki, 1984; Nagy & Anderson, 1984; Nagy & Herman, 1987). Accounts of word learning suggest that the acquisition of meaning is incremental with each incidental experience with a word in context (Fukink, Blok, & de Glopper, 2001; Nagy, Anderson, & Herman, 1987; Nagy,

Herman, & Anderson, 1985; Jenkins et al. 1984). Nagy and Anderson (1984) argued that the majority of the approximately 3,000 words learned each year are acquired through incidental learning during independent reading, and that approximately 5% to 12% of the words learned are learned from a single exposure. These initial, early experiences with novel words in context tend to result in meaning knowledge that is “fragile” and pliable (Elshout-Mohr & van Daalen-Kapteijns, 1987; Jenkins et al., 1984; van Daalen-Kapteijns & Elshout-Mohr, 1981) and can be strengthened and supported with experiences in varied contexts (Jenkins et al., 1984; van Daalen-Kapteijns, Elshout-Mohr, & de Glopper, 2001) or fundamentally altered with misdirective contexts (Elshout-Mohr & van Daalen-Kapteijns, 1987; van Daalen-Kapteijns & Elshout-Mohr, 1981).

Given the clear importance of incidental learning through context, it is important to understand the conditions of context that support such learning. The main goal of our study is to test the context variability hypothesis: Contexts that vary promote word learning better than contexts that do not vary. A second goal is related to this hypothesis: Definitions are effective when they provide general information that is relatively free of specific contexts. Thus, variable contexts and definitions both have the potential value of allowing features of meaning to be understood without dependence on specific contexts. We tested the value of both varied context and the support of definitions in studies carried out with adult learners.

HOW WORDS ARE LEARNED INCIDENTALLY

The importance of incidental vocabulary learning from context has clearly been established by many studies (Herman, Anderson, Pearson, & Nagy, 1987; Jenkins et al., 1984; Kuhn & Stahl, 1998; Nagy et al., 1985; Schwanenflugel, Stahl, & McFalls, 1997). Some studies gauge the amount of word learning in terms of both the number of novel words acquired and the depth of understanding that occurs when reading naturally or “for comprehension.” The knowledge gained by experiencing a word in context is rarely “full” and “complete,” but rather partial (Durso & Shore, 1991; Shore & Durso, 1990). This partial knowledge may partly reflect the situational properties of a word’s meaning (Shore & Durso, 1990) as opposed to the more abstract, decontextualized knowledge of a word’s core meaning (Goerss, Beck, & McKeown, 1999) that can be provided in dictionary-style definitions. That the more decontextualized knowledge can come with increasing experience with contexts has been demonstrated in a think aloud protocol study by van Daalen-Kapteijns and colleagues (van Daalen-Kapteijns et al., 2001). They concluded that 11- and 12-year-old children derive decontextualized meanings of words as they accumulate knowledge from individual context experiences.

Several researchers distinguish between “deriving” word meaning (e.g., Beck, McKeown, & McCaslin, 1983; McKeown, 1985; Schatz & Baldwin, 1986; van Daalen-Kapteijns et al., 2001) and “incidental” learning from context (Jenkins et al., 1984; Nagy et al., 1987; Nagy et al., 1985; Schwanenflugel et al., 1997; Swanborn & de Glopper, 2002). Deriving meaning involves the explicit goal of attempting to learn the meaning of a target words from context, whereas incidental learning assumes the absence of any explicit learning goal. Separate meta-analyses of such studies indicate greater word learning gains in derivational tasks (Fukkink & de Glopper, 1998) than in incidental learning tasks (Swanborn & de Glopper, 1999). The results from these two separate analyses suggest two different word learning processes—one that reflects more conscious, effortful inferencing that may yield greater learning; one that reflects more passive, memory-based association, with learning gains of a lesser extent.

The more effortful processes have been studied by McKeown (1985), who identified a series of specific cognitive operations required to acquire a meaning from context and verify its meaning in new contexts. These processes require considerable cognitive resources to attend, search, retrieve, and evaluate information and may not even lead to the correct learning outcome. A study by Fukkink (2005) indicated that some readers can use these processes flexibly, not necessarily in sequence, to derive the unknown word’s meaning. However, readers with poor decoding and comprehension skills have trouble encoding word meanings (McKeown, 1985) even after several exposures to words in context (Jenkins et al., 1984; van Daalen-Kapteijns et al., 2001). More generally, difficulty in word learning tasks may be correlated with constraints on cognitive resources (i.e., working memory) that limit the effectiveness of attempts to derive word meanings (Daneman & Green, 1986).

We draw attention to an alternative conceptualization of how word meanings are obtained from context. Rather than a series of conscious resource-demanding processes, sentence contexts can activate related words through a passive resonance process. A resonance mechanism has proved useful in studies of text comprehension, where a nonselective memory for words in a text can be reactivated when related words are read (Myers & O’Brien, 1998). In word learning, a resonance mechanism would cause words in the reader’s knowledge base that are related to the context to be activated; and these words, along with the words in the context, would become associated with the new word. What is learned then would be a weak pattern of association that would become part of the word’s associative meaning. The resonance process, which can be supplemented by a more active processing stage of the sort proposed by McKeown (1985), accommodates the instance-based learning mechanism that we hypothesize brings about learning, as explained later.

DIRECT INSTRUCTION OF MEANING

Although incidental learning may be the dominant form of new word learning, some learning can take place through direct instruction by definitions (Fischer, 1994; Nist & Olejnik, 1995; Shore & Durso, 1990). However, training on definitions alone has not always met with success, particularly on tasks of comprehension (Beck, Perfetti, & McKeown, 1982, Freebody & Anderson, 1983; Beck, McKeown, & Omanson, 1987) and contextual use of words (McKeown et al., 1985). For example, McKeown et al. reported that, compared to training involving contexts and definitions, definitions alone yielded poorer performance on tasks of contextual use. Definitions, of course, vary in value; and, as Nist and Olejnik argued, adequate definitions make use of specific interpretations (i.e., not interpretations that lead to incorrect use of the word), specific language (i.e., not vague language that lacks explaining power), and connected semantic features (i.e., not disjointed pieces of information that lack integration) to exemplify a word's meaning. For this reason, it seems unwarranted to make a strong generalization against the value of definitions. Indeed, instruction of both definitional and contextual knowledge may be needed for "complete" understanding of a word (Curtis, 1987), and several studies have found that providing both contextual and definitional knowledge in training results in faster access to meaning (Beck et al., 1982; Beck et al., 1987) and better conceptual understanding (Fischer, 1994).

AN INSTANCE-BASED FRAMEWORK FOR LEARNING WORD MEANINGS

It is beyond the scope of our studies to address core questions about semantic representations (see Baumann, Kame'enui, & Ash, 2003). However, because the issue is learning the meaning of words, two contrasting perspectives on knowing word meanings are relevant. One is that words do not have meanings but instead are points in a very large multidimensional space that reflect a reader's experience of words with respect to the co-occurrence with other words (Burgess & Lund, 1997; Landauer, Foltz, & Laham, 1998). In this view, the meaning of a word depends on its present context in relation to the history of all word experiences (Rapaport, 2005). This idea, especially as implemented in latent semantic analysis (LSA; Landauer et al., 1998), is compatible with a resonance approach to learning new words and leads to many interesting practical outcomes in the measurement of meaning (Foltz, Kintsch, & Landauer, 1998).

The second view assumes that a word's meaning, no matter how broad its movement through various contexts, is delimited by a core set of meaning features. In this view, a word's meaning is not identical to the summation of all con-

texts (or to the summations of all the contexts' contexts). Words have a "core meaning" along with a flexibility that accommodates a wide range of specific contextual features (Drum & Konopak, 1987; Pustejovsky, 1995). Thus, full knowledge of a word includes its abstract core features and its "extendibility" to particular contexts. This traditional view might be understood as predicting that definitions, conceived as indicators of these core features, are privileged in shaping a learner's representation of a word. This contrasts with the co-occurrence point of view in which a definition is merely one of many contexts, and perhaps not a very good one.

Our theoretical approach reflects an assumption that each of these perspectives captures something correct about the nature of word meanings. However, their contrast is misleading because neither provides a realistic learning procedure. We believe that a plausible learning model will include both a context-dependent learning process and the potential for learning enhancement through definitions. From our learning perspective, what counts are specific episodes or instances of word use. Reichle and Perfetti (2003) demonstrated the usefulness of an instance-based memory model of word form learning that provides a framework for our approach to learning the meanings of new words. This framework combines the assumption of instance-based word memories with resonance processes that activate these memories when the word is encountered in a new context.

The key gain from this framework is that it provides an account of incremental learning of word meaning from discourse. In particular, this framework allows both abstract and context-specific word knowledge to increment through a single learning mechanism. Encounters with words provide specific word memories that include the contexts of these encounters. Abstraction over these instances occurs as memories of prior instances affect the processing of a new instance. Thus, abstract meanings arise from the summation of unique contexts and their effects on new encounters with the word. This framework also allows the emergence of an aspect of meaning that is often neglected in modern treatments, namely connotative meaning (Snider & Osgood, 1969). Associations between a word and the non-linguistic contexts of its occurrences are part of what gets encoded in the instance-based memory model. Finally, and perhaps most important, it provides a theoretical basis for understanding the role of definitions. Definitions are encoded as specific contexts for a word, as are sentences that contain the word. Whether a definition is just another context or a privileged context depends on the overlap of its features with those of other contextual memory traces. The definition has the potential of resonating with sentence episodes (and vice versa) so as to aid in the emergence of core meaning features.

Our instance-based framework provides for some general hypotheses about word learning. Because each instance or encounter with a word lays down a contextualized episode, what is learned about a word's meaning will depend on the learner's degraded memory over a history of context-specific word instances. This

predicts specific effects of context variability, which are explained as follows: Memory traces from prior contexts may resonate or reactivate¹ as fragments of decontextualized knowledge. More varied contexts will provide more traces for this resonance process, although each trace itself may be weaker for not having been repeated. A single context that is repeated will have stronger but fewer memory traces. Accordingly, whether multiple contexts or a single repeated context is better for learning depends on the features of the new encounter in relation to the prior contexts. For a random new context with no special overlap with a memory trace, the probability of at least one resonating memory trace will be lower than when multiple contexts have been experienced. Furthermore, the reactivation of varied contexts should support the abstraction of core features. Thus, the hypotheses are that learners can acquire definition-like knowledge from sentence contexts alone and that varied contexts allow this more than single contexts.

Although a definition is also a particular episodic trace, it can gain special support for learning to the extent that it explicitly conveys features that resonate with prior sentence episodes or with future episodes. Thus, the process of deriving abstract knowledge from contextual instances is enhanced with explicit exposure to dictionary-style definitions that provide core meaning features. Thus, we predict that presenting definitions as well as sentence contexts will lead to better learning of core meaning features than will presenting only sentence contexts. In this view of the role of definitions, sentence contexts take on a special importance in supporting the comprehension. The remnant trace information from prior contextual episodes provides resonance with new episodes, allowing support for comprehending a word in a sentence context than would ordinarily be provided by a definition. According to models of lexical semantics (Pustejovsky, 1995), this contextual knowledge is critical to formulating the constraints or *qualia* that enable the comprehension of a word in the variety of contexts that it might appear.

Skill and experience are relevant for how our model applies to individual learners, especially the conditions that lead to abstraction as opposed to context-bound understandings of words. Curtis (1987) reported that, in general, both children and adults with low-vocabulary knowledge are more likely to define words in terms of the contexts in which they occur, whereas higher skill individuals tend to make more “abstract, decontextualized” responses. Although differences in ability are significant for deriving decontextualized word meaning from context (McKeown, 1985; McKeown et al., 1985; Nagy et al., 1987), there is also substantial variation within skill level as well (van Daalen-Kapteijns et al., 2001). Similarly, the ability to derive meaning from context increases as a function of age (Fukkink et al., 2001;

¹*Reactivation* here can refer to both a repetition of a feature with the word in context and also, as in latent semantic analysis and hyperspace analogue to language (HAL), to features that emerge from second-order co-occurrences in text. Thus, the words *assiduous* and *hardworking* may never occur in the same text, however, they co-occur with words such as *diligent* and *effort*.

Nagy et al., 1987; Werner & Kaplan, 1952). These differences in age affect both the quantity of words learned from context (Nagy et al., 1987) and also the extent to which full, decontextualized meanings are acquired (Fukkink et al., 2001). These findings suggest that, in addition to the resonance mechanism, several factors including individual differences in age and ability will influence the amount of learning that may occur.

OTHER FACTORS INFLUENCING WORD LEARNING

Beyond this basic episodic learning process, the ability to learn word meanings from context can be mediated by three classes of factors: (a) word factors (e.g., part of speech, concreteness), (b) contextual factors (e.g., cue type, repetition, cue difficulty), and (c) individual differences in learners (e.g., reading ability, working memory, prior knowledge).

Word Factors

Individual words vary widely in their semantic (e.g., concreteness) and syntactic (e.g., part of speech) properties, and some of these factors are likely to affect learning. Indeed, concreteness (Gentner, 1982; Schwanenflugel, 1991) and part of speech (Choi & Gopnik, 1995) affect word learning during language acquisition. These factors may continue to be relevant for learning from written contexts, and related factors also may be relevant—for example, conceptual “complexity” (Nagy et al., 1987) and number of meaning components (Daneman & Green, 1986). In this study, we sampled words equally from three parts of speech: nouns, verbs, and adjectives to test part-of-speech effects. We selected rare English words (frequency range 0–2 based on Kucera & Francis, 1967, written word frequencies) to be equated for concreteness and imageability.

Text Factors

Features of the context in which a word occurs are important. Daneman and Green (1986) found that the constraint provided by the context was the primary predictor of vocabulary growth, particularly for producing trained words. More generally, contexts range from being supportive (to varying degrees) to being misleading (Beck et al., 1983). In this study, the critical text factor was context variability, and we assessed the supportiveness of context by using a cloze task procedure, which, similar to that of Daneman and Green, asked a separate set of participants to produce words for the context sentences with the target word removed. Because our target words are too rare to be produced in this cloze procedure, the cloze responses were evaluated by independent scorers for their relatedness to the target

word and used in subsequent analyses as the predictors of context support from the context sentences.

Individual Differences

Reading ability has been shown to be a contributing factor in learning from context (Cain, Oakhill, & Lemmon, 2004; Curtis, 1987; Jenkins et al., 1984; McKeown, 1985). McKeown found that high-skill readers outperformed their low-skill counterparts at nearly every task designed to assess the stages of acquisition detailed earlier. The hypothesis that skill differences reflect working memory differences was tested by Daneman and Green (1986), who found that receptive and productive working memory span predicted incidental learning from context. Individual differences in vocabulary depth and breadth also are highly correlated with reading skill (Ouellette, 2006), and these differences coupled with reading comprehension difficulty indicate impaired performance in learning from context (Cain et al., 2004). Learning from definitions is also related to comprehension skill (Perfetti, Wlotko, & Hart, 2005).

OVERVIEW OF STUDIES

The two studies reported later examined the role of context variability and definitions in learning word meanings. Our theoretical framework leads to the hypothesis that multiple contexts—contexts with convergent variability—lead to better abstraction of core features than do unvaried contexts. Further, it assumes that definitions can provide useful information for word meaning by directly providing core features. Our three primary hypotheses are that (a) context variability results in better learning of abstract knowledge of word meaning as measured by meaning generation; (b) when definitions are provided to support contextual learning, they provide abstract knowledge directly leading to better word learning; and (c) contextualized knowledge results from episodes of contextual experience and is not influenced by direct abstract meanings conveyed in definitions.

Both experiments consisted of a pretest phase, a training phase, and a testing phase in which participants were exposed to 72 rare English words divided into selected conditions according to our primary hypotheses. Because abstract and contextualized knowledge are not conveyed in a single measure, learning was assessed using multiple dependent measures. To probe the acquisition of abstract meaning following training, participants were asked to generate a meaning for the trained words to which the responses were evaluated for components of the abstract word knowledge. Generation tasks have been consistently used in the literature to assess meaning knowledge (Durso & Shore, 1991; Fischer, 1994; Shore & Durso, 1990) because responses can be evaluated independently for target features

of meaning and biases in responses (e.g., see Fischer, 1994). Contextualized knowledge was assessed in a correct usage task in which participants were asked to complete a sentence with the appropriate word in a forced-choice procedure. Previous studies have shown that dependent measures in which sentence contexts are evaluated are sensitive to weaker, partial knowledge of word meaning (Beck et al., 1983; Jenkins et al., 1984; Durso & Shore, 1991; Shore & Durso, 1990), particularly when compared to unknown words (Durso & Shore, 1991; Shore & Durso, 1990). Previously cited findings of McKeown et al. (1985) showed poorer performance on such contextual tasks from experience with definitions alone compared with contextual learning. However, due to the lower sensitivity of these tasks, studies have shown that only a few experiences in context are required before ceiling effects occur (Jenkins et al., 1984). Thus, context-based assessment tasks have proven to be sensitive to features of word meaning that are gleaned from context, but that these measures are limited to less experienced items. Knowledge of orthographic form was also assessed to evaluate the impact of the training conditions on the learning of form. We assessed participants' prior knowledge of words in a pretest probing familiarity with the target words and their meanings.

EXPERIMENT 1

In our first experiment, we compared context variability (4 different sentences vs. 4 same sentences) and the presence or absence of a definition in a 2×2 within-subjects design.

During the pretest phase, we exposed participants to the 72 rare words and asked them to rate the level of familiarity with each word and their confidence of its meaning (i.e., how well they knew its meaning). We then trained participants on the meaning of each word with learning events, each consisting of a single sentence or, for one half of the items, a sentence and a definition of the word. After the initial training, we assessed learning of form and meaning knowledge through a series of tests: First, an Orthographic Choice task with similar-form foils tested what the participants learned about the spellings of the words; then, we had subject-generated descriptions of word meanings ("definitions") to assess the learning of abstract, decontextualized knowledge; finally, to assess basic context-cued knowledge of word meanings, we had a multiple-choice Sentence Completion task in which participants chose one of four words (the target and foils all from the training set) to complete a sentence.

According to our instance-based learning framework, word knowledge accrues with each experience with the word in context. This initial knowledge is inherently contextual because each experience constitutes a memory that includes the word and parts of its context. The more experiences with a word across a variety of contexts, the more decontextualized the memory for the meaning becomes. Thus,

several different contexts will enable more abstract learning than an equal number of experiences with a single context. According to the framework, definitions will also support learning of abstract information because they provide core features in a single learning event.

Finally, although our main interest is in the learning of meanings, we examine whether orthographic learning occurs as part of learning meanings. An association between form and meaning learning might be expected on the basis of prior research linking word recognition ability and vocabulary knowledge (Nation & Snowling, 2004; Ouellette, 2006). Such a link is also part of computational models of word reading (Harm & Seidenberg, 1999; Reichle & Perfetti, 2003). Moreover, the Lexical Quality Hypothesis (Perfetti & Hart, 2001) suggests that the high levels of individual word knowledge are characterized by strong links between components of form and meaning. Thus, we hypothesize that semantic information will resonate with form information over the course of the word learning events. Greater learning of meaning, therefore, should be associated with greater learning of orthographic form, as contexts and definitions provide occasions for form-meaning associations. Specifically, if multiple contexts and definitions increase meaning learning, they should also increase form learning.

Method

Participants

Twenty-four undergraduate students taking an introduction to psychology course at the University of Pittsburgh participated after being recruited through the participant pool for course credit. All participants were native speakers of English with no known learning disabilities.

Design and Procedure

The study used 72 rare English words selected with frequencies of fewer than three per million (Kucera & Francis, 1967). The words were evenly divided among word classes: 24 nouns, 24 adjectives, and 24 verbs. In a 2 (definition vs. no definition) \times 2 (1 repeated vs. 4 varied contexts) within-subjects design, words were randomly assigned to conditions such that 6 words from each part of speech were assigned to one of the four cells. Participants were given a familiarity task as a pretest of experience with these words. The pretest was followed by the training task in which the words were randomly assigned to one of the four conditions. Following training, form and meaning were assessed in three separate tasks: an orthographic-decision choice task, a Meaning Generation task, and a Forced-Choice Sentence Completion task. All tasks were conducted on a PC using E-Prime experimental software (Psychology Software Tools, Inc.).

Pretest Familiarity Task

Prior to training, participants rated the experimental words for familiarity. Participants were randomly presented each of the 72 rare words and asked to respond on a scale ranging from 1 to 7 to two separate questions: first, how familiar they were with the word (1 = *unfamiliar, never seen it before*; 7 = *very familiar, definitely seen before*); second, how well they knew its meaning (1 = *definitely do not know its meaning*; 7 = *definitely know its meaning*). Once ratings were obtained for each word, the training task began.

Training Task

During the training task, participants saw each target word presented with a context sentence or sentences and, for one half of the items, a definition depending on the condition assigned for a word. See Appendix A for the set of words and example context sentences. For each word, four context sentences were developed so as to avoid overlap in the sentence schema (e.g., the semantic domain and the words filling the sentence arguments). For example, if the first sentence generated for the word *assiduous* contained a schema about lawyers and law, we avoided using this schema for the other sentences generated for this word. To further assure the uniqueness of our contexts, we applied the LSA (Foltz et al., 1998) Word \times Word matrices to compare the 4-Context sentences and the 1-Context sentence to be used in the Sentence Completion task. All words from the sentences except the target word entered the comparison. Sentences were modified until all contexts in the set were rated below 0.25 cosine value. Average cosine values for context sentences within the set were 0.18, with a standard deviation of 0.17 (LSA returns negative cosine values). So as not create any advantage for the four-different context (4-Context) condition relative to the repeated context condition, the context sentence with the highest cosine value for the test sentence was assigned to the repeated context condition. Thus, any differences in LSA determined meaning similarity between training sentence and test sentence would work against the hypothesized effect of context variability.

Dictionary definitions were taken from dictionary.com and tended to rely on the American Heritage Dictionary (2000). See Appendix B for a full set of words and definitions. A 2×2 within-subjects design was utilized in which the target words were randomly assigned evenly among the four conditions. In each of the conditions, the participants encountered the target word four times. In the varied (4-Contexts) condition, the word appeared in a novel sentence each time. In the repeated (1-Context) condition, the target word was presented in the same context sentence, repeated four times. In the definition condition, the same definition appeared on the screen in each trial for a target word along with the context sentences. Learning trials for each were presented randomly in four blocks. In each trial, the word was presented alone at the top of the screen for 500 msec and

remained on the screen until the trial was terminated. On trials that included a definition, this appeared after 500 msec above the context sentence. Both remained on the screen for 12 sec or until the participant hit the space bar. The participant could press the space bar at any time to move on to the next trial.

The participants were instructed that they were to attempt to learn the following words from the information provided and that they would be assessed on these words following the training period.

Post-Training Assessments

The assessment tasks were administered in the following order.

Orthographic Choice task. Immediately following completion of the training task, participants were given an Orthographic Choice task to test word form knowledge. Four foils were created for each of the 72 words. The foils maintained the onsets and consonant sounds of each word and were matched for length and number of syllables. Each word was then presented with its four foils. Participants were asked to choose from among the five options which word was correctly spelled by making a button press.

Meaning Generation task. Participants were then assessed on their knowledge of the word's meanings. Each word was individually presented on the screen for a maximum of 15 sec. Participants were asked to provide a brief definition or one-word synonym out loud, and responses were transcribed by the experimenter.

Forced-Choice Sentence Completion task. For the final task, a fifth sentence was created for each of the 72 words and evaluated in the LSA procedure described earlier. Participants were presented with the context sentence with the target word blanked out. Below the sentence, five choices appeared: the target word and four foils that had been chosen from among the other trained words from the same part of speech. Participants selected the word that best fit in the context by making a keyboard response (1–5) that corresponded with the correct answer.

Results

Two participants were eliminated due to poor performance (more than 2 standard deviations below the group mean) on at least two of the dependent measures used in the assessments; 2×2 repeated-measures analysis of variance (ANOVA) for context variability—varied (4-Contexts) versus single repeated (1-Context)—and definition (present vs. absent) were carried out for each of the main measures.

TABLE 1
Experiment 1: Means and Standard Deviations for All Assessment Tasks

Task	Definition				No Definition			
	4-Contexts		1-Context		4-Contexts		1-Context	
	M	SD	M	SD	M	SD	M	SD
Orthographic								
Choice								
Accuracy	0.86	0.149	0.87	0.122	0.86	0.153	0.82	0.151
Response time (milliseconds)	6,475	2,194	6,394	2,106	6,671	2,616	6,556	2,283
Meaning								
Generation								
Accuracy	0.66	0.221	0.65	0.223	0.51	0.244	0.37	0.181
Sentence								
Completion								
Accuracy	0.78	0.162	0.77	0.186	0.76	0.187	0.76	0.219
Response time (milliseconds)	9,492	2,336	9,464	3,150	9,557	2,897	10,032	2,558

Orthographic Choice Task

There were no main effects or interactions for definition or context conditions. However, planned comparisons revealed more accurate performance for 4-Contexts versus 1-Context without definitions ($t = 2.63, p < .016$) in a pairwise two-tailed t test. Both the 2×2 repeated-measures ANOVA and planned comparisons found no main effects or interactions for reaction time. The means and standard deviations of this task are reported in Table 1.

Meaning Generation Task

Definitions produced by participants in the Meaning Generation task were blind scored by Eve Landen. Reliability was assessed with two other trained scorers on 10% of the data, resulting in an interrater reliability of 0.91. Definitions were scored on a binary scale (1 = *correct*, 0 = *incorrect*) referenced to the definitions that were used in the training phase of the study.

Definitions were more accurate following 4-Contexts (mean proportion correct = 0.59) than repeated 1-Context ($M = 0.52$), $F(21, 1) = 4.90, p < .05$. Definitions were also more accurate for words whose definitions were presented ($M = 0.66$) than for words presented without definitions ($M = 0.36$), $F(21, 1) = 70.55, p < .001$. However, the context and definition conditions interacted, $F(21, 1) = 6.18, p < .05$. Planned comparison showed an advantage for 4-Context (0.51) versus 1-Context (0.38) when no definitions were presented, $t(21, 1) = 3.262, p$

< .004; but little or no advantage when definitions (0.66 vs. .65) were presented. However, the benefit of definitions was general across the two context conditions (see table 1). For the 4-Context condition, the means were 0.66 definitions and 0.52 for no definitions: $t(21) = 4.74, p < .001$. Because an advantage of presenting definitions can arise from having definition words to recall during the generation task (Fischer, 1994), we analyzed the content of responses in the Meaning Generation task for their verbatim use of words from the presented definitions.

To carry out this analysis, we scored participant-generated definitions as follows: 1, if the response contained terms presented in the definition during training; and 0, if not. The results of this analysis revealed that when definitions were presented, either with a single context or varied 4-Contexts, participants produced terms in the definition verbatim in the Meaning Generation task approximately in 56% of correct cases (41% overall) in both conditions. These results suggest that in the Meaning Generation task, participants were not merely recalling verbatim the surface form of the definitional knowledge presented during training.

Forced-Choice Sentence Completion Task

No main effects were found for either accuracy or response time measures in the Sentence Completion task. However, a weak but significant interaction in response time was observed: $F(21, 1) = 4.30, p < .05$. Planned comparisons revealed a marginally significant response time difference, $t(20, 1) = 1.91, p = .07$ (2-tailed test), between 4-Context and 1-Context conditions when no definition was presented. Participants responded more slowly to items in the repeated context condition ($M = 10,032$ msec) compared to the varied context condition ($M = 9,557$ msec). The means and standard deviations for the Sentence Completion task are reported in Table 1.

Semantic Constraint Analysis

The semantic constraint of each of the training sentences was measured by a separate cloze study. Each sentence was presented to a separate group of participants ($N = 26$) with the trained word replaced by a blank. The participants' task was to provide a word that would best fit the sentence context. Given that our training words were of very low frequency, we did not expect our participants to provide the trained word in the cloze task. To evaluate the fit between the words provided in the cloze task and the rare target words, we used WordNet 2.1 to generate responses that are semantically related to the trained word. We assigned each cloze response one of three scores (e.g., 1, 0.5, & 0)—1 for a first-order synonym (e.g., *recant* for *abjure*) was given a score of 1; 0.5 for a second-order synonym (e.g., *back down* for *abjure*); 0 for a word unrelated semantically to the intended trained word. These scores were averaged for each sentence, resulting in a semantic

constraint score for each sentence that ranges between 0 and 1, where 1 is the maximal constraint of the word's meaning.

To measure the effectiveness of the semantic constraint of context sentences, we performed an item-based analysis for the sentences in the 1-Context (no definition condition) for 72 target words. Because only one of the four training sentences for each word was presented in this condition, we computed the average meaning generation accuracy for each sentence from at least five observations across participants. We computed a linear regression relating the constraint scores for these sentences with the meaning generation accuracy for their target word. The result was a significant positive relation between semantic constraint and Meaning Generation for the target word, $r(71) = 0.31, p < .01$. Thus, when a word was presented in only a single context, the degree of contextual constraint of that context predicted the accuracy of meaning generation.

Part-of-Speech Analysis

Part of speech had no effect on either meaning generation or sentence completion accuracy. However, in sentence completion, participants were slower to respond to trials with nouns than verbs ($t = -3.66, p < .001$) and adjectives ($t = -3.32, p < .001$).

Summary

Variability of context affected accuracy in the Meaning Generation task and interacted with the presence of definitions. The interaction effects suggest that in the absence of definitions, experiencing words in a variety of contexts leads to better learning of abstract meaning compared with a single repeated context. Context variability also affected decision times (with marginal reliability), but not accuracy, in the Sentence Completion task. A main effect of providing definitions was found in the Meaning Generation, but not the Orthographic Choice or Sentence Completion tasks. These results suggest that the additional support of a definition enables the learner to encode a more decontextualized meaning of the word beyond what the contexts can provide. The fact that definitions aided learning from both varied contexts and constant contexts suggests the general value that definitions have to convey this abstract meaning information. The contextual constraint analysis showed that learning the decontextualized meaning of a word was influenced by how well the context supported the meaning represented by the target word. In addition to these meaning results, form learning, as measured by orthographic choice performance, was higher with varied contexts than repeated contexts when no definitions were presented.

EXPERIMENT 2

The results of the first experiment support the context variation hypothesis. Varied context resulted in greater ability to derive decontextualized knowledge as exhibited in the Meaning Generation task, especially when definitions were not present. Because definitions appear to have an impact on the effectiveness of context variation, we carried out a second experiment to observe the effects of contexts without definitions. Also, by eliminating definitions, the second experiment had more trials to test context constraint effects and other word variables. Finally, we designed Experiment 2 to test comprehension skill effects in learning. In studies of children, comprehension ability has been shown to be highly correlated with existing vocabulary knowledge (Stanovich & West, 1979; Ouellette, 2006) and with the ability to acquire new vocabulary knowledge (McKeown, 1985). More relevant, adults from the population used in our studies show comprehension effects in learning new words taught through definitions (Perfetti, Wlotki, et al., 2005). In fact, Perfetti et al. (2005) found evidence that skilled comprehenders showed stronger episodic memories for the words experienced in training.

We made a methodological change to increase demands on processing speed because of the absence of an effect of context variability on accuracy in the Sentence Completion task of Experiment 1. (The tendency for faster response times for varied contexts did suggest an effect.) In Experiment 2, we forced responses by 9 sec—less than the mean response time of 10 sec observed in Experiment 1. This, we reasoned, would increase the sensitivity of accuracy measures to any context effects, picking up the converging effect of multiple episodic traces derived from varied context instances. A final methodological change is the addition of a no-context condition—a word appears in isolation—that serves as both a form and meaning control, allowing a clearer conclusion on whether learning words in context affects learning orthographic form as well as meaning. For meaning, this condition allows a comparison with accuracy in the Sentence Completion task that could produce “learning” even in the absence of relevant meaning contexts, consistent with the conclusion that people can perform above chance on context-based assessments of partial knowledge on words they claim to have no knowledge (Durso & Shore, 1991; Shore & Durso, 1990).

Method

Participants

Twenty new students from the same undergraduate population as Experiment 1 participated. None had participated in Experiment 1.

Design and Procedure

The procedure followed that of Experiment 1, except for the addition of the pre-training comprehension assessment by the Nelson–Denny test (Nelson & Denny, 1973) and the elimination of definitions during training. In place of the definition condition, a no-context, form-based control (the word in isolation) was added to the set of repeated and varied context conditions. Thus, the overall design was a single factor three-way design: one context repeated four times, four varied contexts, and form only (no context). As in the first experiment, for each participant words were randomly assigned to each cell such that equal numbers (8) from each part of speech were represented.

Pretest Assessments

Experiment 2 employed the same assessments of familiarity and meaning knowledge using the seven-point rating system as in Experiment 1.

Comprehension

All participants completed a pen-and-paper version of the Nelson–Denny Comprehension Test (Version E) before performing the remaining computer-based tasks described in Experiment 1. This is a timed task resulting in two measures: accuracy—percentage of correct items attempted and overall number of items attempted. Participants were given 15 min to complete the test, which was timed on a stopwatch with the experimenter in the room.

Training Task

We again used a within-subjects design. Participants experienced one third of the target words presented in each of the following conditions: 4-Context, 1-Context, and no context (form only). In each condition, participants encountered the target word four times. In the 4-Context condition, the word appeared with a novel sentence each time. In the 1-Context condition, the target word was presented with the same context, repeated four times. In the no-context, form-only condition, the word appeared in isolation four times. For each participant, words were randomly assigned to conditions.

The participants were told that they would be seeing the words in context sentences and that they should do their best to learn the meanings of the words from the context as they would be assessed later on in the experiment. A fixation cross was presented for 500 msec preceding each word. The word and its context sentence (if any) were then presented for a maximum of 9,500 msec. The participant could press the space bar at any time to move on to the next word.

Post-Training Assessment

The same assessment materials were used as in Experiment 1. In the Sentence Completion task, the test sentence and four words to select for completion were presented as in Experiment 1. Unlike Experiment 1, participants were forced to respond to items within 9 sec, after which they received a message stating, “No Response Detected,” and moved on to the next trial. Participants were provided with two practice trials on unrelated sentences to make them aware of the timing parameters. Non-responses were less than 0.5% of responses, not different from the rate in Experiment 1.

Results

For each of our main measures, we carried out a single factor three-way repeated measures ANOVA to assess the effects of our three context conditions.

Orthographic Choice Task

Accuracy on the Orthographic Choice task was affected by context: $F(59, 2) = 3.47, p < .05$. Planned comparisons revealed no differences between 4-Contexts (mean proportion correct = 0.79) and 1-Context ($M = 0.81$), thus failing to replicate the 4-Context advantage found in Experiment 1. However, both 4-Contexts ($t = 2.86, p < .01$) and 1-Context ($t = 4.06, p < .001$) conditions performed better than the no-context (form-only) condition (mean proportion correct = 0.70). These same tests conducted for reaction time revealed no main effects or interactions.

Meaning Generation Task

Meaning generation was more accurate for the 4-Contexts (mean proportion correct = 0.43) than 1-Context condition ($M = 0.29$), and was least accurate for the no-context, form-only condition ($M = 0.04$). These overall differences were reliable, $F(59, 2) = 33.59, p < .001$; and a planned comparison confirmed the reliability of the difference between 4-Contexts and 1-Context conditions, $t(19, 1) = 7.27, p < .001$.

Forced-Choice Sentence Completion Task

There was a reliable main effect of context on sentence completion accuracy: $F(59, 2) = 12.77, p < .001$. As shown in Table 2, performance was more accurate for words with four different contexts (mean proportion correct = 0.71) than one repeated context ($M = 0.67$), but this difference was not reliable ($t = 1.27, p = .11$). Both the 4-Context ($t = 10.62, p < .001$) and the 1-Context ($t = 7.44, p < .001$) resulted in more accurate performance than the no-context, form-only condition ($M = 0.48$). Decision times were affected by context, $F(59, 2) = 6.23, p < .005$; with

TABLE 2
Experiment 2: Means and Standard Deviations for All Assessment Tasks

Task	Context Condition					
	4-Contexts		1-Context		No Context	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Orthographic						
Choice						
Accuracy	0.79	0.146	0.81	0.137	0.70	0.146
Response time (milliseconds)	4,419	798	4,414	903	4,851	465
Meaning						
Generation						
Accuracy	0.43	0.186	0.29	0.174	0.04	0.050
Sentence						
Completion						
Accuracy	0.71	0.177	0.67	0.165	0.48	0.117
Response time (milliseconds)	6,348	506	6,885	656	7,018	982

faster correct decisions for the 4-Contexts ($M = 6,348$ msec) compared with the 1-Context condition ($M = 6,885$ msec), $t(19, 1) = 4.11, p < .001$; and the no-context condition ($M = 7,018$ msec), $t(19, 1) = 3.95, p < .001$, which did not differ. The means and standard deviations are shown in Table 2.

Familiarity

Pre-training familiarity and degree of word knowledge were assessed via a 7-point scale ranging from 1 (*no familiarity/knowledge*) to 7 (*complete familiarity/knowledge*). Participant \times Item regression analyses (72 Item \times 20 Participant resulting in 1,440 observations) revealed significant but small correlations of familiarity with orthographic choice accuracy ($r = 0.15$), response time ($r = -0.13$), and sentence completion accuracy ($r = 0.08$). Ratings of degree of word knowledge were significantly related to orthographic choice accuracy ($r = 0.12$) and response time ($r = -0.10$), as well as sentence completion accuracy ($r = 0.11$), and more weakly for response time ($r = 0.06$) and meaning generation accuracy ($r = 0.08$). (See Table 3 for all correlations.) As a check of the effect of prior knowledge on our dependent measures of meaning, we ran the correlations for words in the no-context conditions alone. Participants responded accurately in the no-context condition on roughly 4% of trials in the Meaning Generation and 48% in the Sentence Completion tasks. Ratings of familiarity and item knowledge were significantly correlated with accuracy in the Meaning Generation task ($r = 0.32$ and 0.40 , respectively; $p < .001$ for both) and the Sentence Completion task ($r = 0.20$ and

TABLE 3
 Experiment 2: Correlation Matrix of Familiarity/Knowledge
 Ratings and Assessments

	<i>Familiarity</i>	<i>Knowledge</i>	<i>Orthographic Choice Accuracy</i>	<i>Orthographic Choice Response Time</i>	<i>Sentence Completion Accuracy</i>	<i>Sentence Completion Response Time</i>	<i>Meaning Generation Accuracy</i>
Familiarity	1						
Knowledge	0.83**	1					
Orthographic Choice Accuracy	0.15**	0.12**	1				
Orthographic Choice Response Time	-0.13**	-0.10**	-0.08*	1			
Sentence Completion Accuracy	0.08*	0.11**	0.11**	-0.01	1		
Sentence Completion Response Time	-0.02	-0.06*	-0.01	0.04	-0.31**	1	
Meaning Generation Accuracy	0.03	0.08*	0.13**	-0.01	0.30**	-0.27**	1

* $p < 0.05$; ** $p < 0.005$.

0.21, respectively; $p < .001$ for both). However, these factors were not significantly related to accuracy in either task for either context condition, and only weakly related to response time in the Sentence Completion task ($r = 0.07$ and 0.08 for familiarity and item knowledge, respectively; $p < .05$). To further assure that the effects of context were not influenced by prior familiarity and knowledge, we carried out regression analyses separately on accuracy in the Meaning Generation and Sentence Completion tasks, with condition (varied and repeated context), item familiarity, and item knowledge as predictors. Context remained a primary predictor of accuracy in meaning generation (adjusted beta of 0.145 , $t[958] = 4.53$, $p < .001$), with familiarity and item knowledge not significant. In addition, after accounting for the variance of familiarity and item knowledge, the effect of context condition was a significant predictor of sentence completion accuracy (adjusted beta of 0.08 , $t[958] = 2.51$, $p < .05$)—again, this is a Participant \times Item-based analysis as opposed to the repeated-measures test in which participants are a random factor. We performed a similar regression with response time (for correct trials only) and found that the effect of context was preserved (adjusted beta of 518 , $t[549] = 3.47$, $p < .001$), as familiarity and item knowledge were not significant predictors of this measure.

Part-of-Speech Analysis

We tested the effects of part of speech as we did in Experiment 1 with a series of three-way repeated measures ANOVA and planned comparisons; however, no differences were found among grammatical classes.

Comprehension Ability

The Nelson–Denny comprehension test is a timed test; thus, results in variable performance are based on how participants respond to time pressure. Assessments on the Nelson–Denny are divided into two scores: percentage correct, based on the number of items attempted; and percentage attempted, based on total number of items in the test. We compared performance on these two measures, which roughly translate into accuracy and speed metrics. Strong correlations were found with accurate performance (percentage correct) on the Nelson–Denny and overall accuracy on the Meaning Generation ($r = 0.607$, $p < .005$) and Sentence Completion ($r = 0.544$, $p < .05$) tasks. However, speed on the Nelson–Denny test (percentage attempted) did not significantly account for performance on these tasks (see Correlation Matrix in Table 4).

Semantic Constraint Analysis

The Experiment 1 ratings of semantic constraint of each of the training sentences were applied to the data from Experiment 2. A linear regression relating the

TABLE 4
 Experiment 2: Correlation Matrix of Nelson–Denny Comprehension Test Accuracy and Speed Measures With Accuracy on Meaning Generation and Sentence Completion Tasks

	<i>Nelson-Denny % Correct</i>	<i>Nelson-Denny % Attempted</i>	<i>Meaning Generation Accuracy</i>	<i>Sentence Completion Accuracy</i>
Nelson-Denny % correct	1			
Nelson-Denny % attempted	-0.001	1		
Meaning Generation Accuracy	0.607**	0.058	1	
Sentence Completion Accuracy	0.544*	0.284	0.812**	1

* $p < .05$. ** $p < .005$.

constraint scores for these particular sentence items to performance on the Meaning Generation task produced a significant, positive relation, $r(71) = 0.32, p < .005$, suggesting that contextual constraint played a role in learning the decontextualized meaning of a word.

Form and Meaning

To more directly test the influences of meaning contexts on learning orthographic form, we computed a Participant \times Item stepwise regression, using participants' pretest ratings of familiarity, item knowledge, and meaning generation accuracy as the predictor variables for performance on the Orthographic Choice task. In Table 3, accuracy and response time measures on the Orthographic Choice task were significantly correlated with familiarity ($r = 0.15$ and $0.13, p < .01$ for accuracy and response time, respectively) and item knowledge ($r = 0.13$ and $0.10, p < 0.01$ for accuracy and response time, respectively). In the stepwise regression for accuracy, familiarity accounted for the largest proportion of variance ($r = 0.14, \beta = 0.02, t = 5.17, p < .001$) followed by definition generation accuracy ($r = 0.12, \beta = 0.12, t = 4.67, p < .001$). Item knowledge did not uniquely account for any variance after familiarity was entered. The stepwise regression for response time found only familiarity accounting for any significant proportion of the variance ($r = -0.06, \beta = 65, t[1,437] = 2.24, p < .05$). (Response times here include all responses instead of just accurate responses.)

Summary

Experiment 2 produced more pronounced effects of varied contexts compared with repeated contexts on accuracy of meaning generation and speed of sentence completion decisions. The results of the Meaning Generation task replicated the finding of Experiment 1 of greater accuracy in meaning generation for varied

than repeated contexts (mean difference = 0.14) when no definition was provided. These findings again suggest that acquiring abstract knowledge of word meaning from discourse alone is determined by the extent to which the contextual experience of a word is varied. Findings of semantic constraint from this experiment replicated those of the first experiment, suggesting that acquisition of meaning determined by the constraint of the context as well as its variability.

We also replicated the differential indicators provided by response times and accuracies on the Sentence Completion task. Accuracy, despite the reduction in time allowed to respond, was not affected; but, response times were faster for words studied in varied compared to repeated contexts. The accuracy data are consistent with previous studies showing little or no differences when the words are “known” or “familiar” (Shore & Durso, 1990). However, the response time data reveal that our task was sensitive to the differential word knowledge obtained from varied compared with constant context conditions.

Although prior familiarity with words and their meanings had a significant impact on accuracy in both tasks, these effects were limited to words presented in isolation with no meaning context provided. This result shows that our tasks were sensitive to both the prior knowledge of words and to learning that occurred in our contexts. In fact, when familiarity and prior knowledge were accounted for our regression, an effect of context variability was found for accuracy in the Sentence Completion task. Both meaning generation and sentence completion were related to comprehension ability, suggesting that skill plays a role in learning meaning from context.

There were two points of departure from the results of Experiment 1. First, orthographic choice was not sensitive to context conditions. Second, no part-of-speech effects were observed. It is possible that both of these effects are more likely to emerge when the learners experience definitions as part of the training.

GENERAL DISCUSSION

According to our instance-based resonance framework of incremental word learning, based on the Reichle and Perfetti (2003) model, we hypothesized that encountering a word in context establishes a memory trace that encodes the word and its context. This trace is the experiential memory of associated meaning knowledge, which may consist of resonant memories of the word experience as well as conscious “inferred” meanings. Experiencing a word in multiple, varied contexts, according to this framework, results in a more decontextualized knowledge of the word’s meaning. We further hypothesized that this decontextualized knowledge can be supported by dictionary-style definitions provided in addition to contexts.

The two experiments produced results consistent with these hypotheses. Experiment 1 manipulated context variability and the presence of word definitions or-

thogonally within subjects. Context effects were found for measures of meaning generation and (marginally) for speed of response to sentence completions. When definitions were provided, the impact of varied contextual experience was reduced. With some methodological changes, including the elimination of definitions and time pressure on responding, Experiment 2 found more robust effects of context variation, with effects in meaning generation and speed of sentence completions. This second study added the result that individual differences in comprehension ability and prior word familiarity were correlated with learning word meanings from text.

Although we did not directly compare definitions alone to context, the effect of definitions in reducing the context variability effect suggests that definitions play a role in supporting the contextual experience. The value of definitions in meaning generation was constant across the context conditions. Learners were consistently around 66% accurate when definitions occurred in training, regardless of context variability. Although generating a definition is obviously affected by having read a definition, learners used the terms in the presented definition only about one half of the time. This suggests, consistent with our instance-based framework, that definitions are not retrieved intact, but rather interact with memories for sentence contexts.

We suggest that the value of sentence contexts and definitions are complementary in the following sense: Sentences provide referentially specified predication for a new word, whereas definitions add pointers to meaning boundaries. Consider the word *stolid* in a particular sentence: “He knew she was angry and let her have her say, maintaining a stolid silence that gave nothing of what he was thinking.” The definition for this word adds the general pointer to meaning boundaries: “having or revealing little emotion or sensibility; impassive” (American Heritage Dictionary, 4th ed., 2000). The context sentence shows *stolid* as a specific descriptor that modifies a human state, a man’s silence, and links this state to giving “nothing of what he was thinking.” Whereas the definition provides the most general sense of the word, this particular context sentence associates *stolid* with a particular human state—one that occurs in response to another human state of an antagonist (in this case, the woman’s anger). This rich set of information from context provides an extension of the word’s meaning replete with associates such as silence and thinking.

Although our results show the value of definitions, the scope of their effect appears to have been limited. In the Sentence Completion task, providing definitions did not improve performance beyond the effects of contexts alone. Similar null results have been reported from other studies (Fischer, 1994; McKeown et al., 1985; Shore & Durso, 1990). For example, Fischer provided learners with contexts only, definitions only, or both, and found no differences in accuracy of using the word in a sentence. However, simple generalizations do not seem warranted. Durso and Shore (1991) found that in their simple context discrimination task, there was no effect of definition training, but that discriminations requiring finer grain semantic knowledge were affected by the definitional training.

In this respect, it may be important that in our Sentence Completion task, participants were choosing among alternatives—all of which had occurred in the training. Thus, all choices could activate recent training-based encounters, and the participant merely had to choose the one that fit the test context. Most important is that the choices did not necessarily require fine meaning discrimination. If, as the Durso and Shore (1991) study suggested, definitions may be useful mainly for fine-grain discriminations, our particular choice task would have worked against a benefit for definitions.

We note that in sentence completion, accuracy and response times were not equivalent in showing the effects of context. Response times for sentence completion in both Experiments 1 and 2 suggest faster meaning decisions following variable contexts compared with a single repeated context, although accuracy was nearly identical in the two conditions. This effect was larger in Experiment 2, where participants responded as slowly to words presented with a single context as to those presented with no context at all. This result suggests that for completing a sentence that is of the same type as the sentences experienced in training, a single context may be sufficient to perform accurately; however, context variability provides stronger cues that enable faster retrieval of this information or comparison of the information with the test sentence.

Several findings in the literature suggest that minimal experience with words in context is sufficient for high-level performance on these tasks. Jenkins et al. (1984) found that performance on a sentence decision task peaked after the lowest number of exposures (2) and did not improve with increasing experiences. Similarly, Schwanenflugel et al. (1997) tested the effects of incidental learning from context by fourth-grade students. Despite finding positive effects of incidental learning on all words, they found no differences in gains made on partially known words, which had been encountered before, compared with unknown words. A small number of experiences with a word in context may be sufficient to support its use and possibly understanding in other contextual situations. More experiences with a word in a variety of contexts lead to more retrieval cues, which may enable faster access to word knowledge (Beck et al., 1982). However, on the instance-based model, there is no minimum or optimal number of contexts because the value of stored instances and their subsequent reactivation depends critically on the features they share with each other and with a currently encountered context.

These experiments add to the research showing that the degree of constraint provided by contexts predicts word learning. We could test only the effect of constraint when there was a single repeated context, and here the degree of semantic constraint for individual contexts played a substantial role in learning word meanings. These findings replicate those of Daneman and Green (1986), who found that contextual constraint, as measured by a similar cloze procedure, was a significant predictor of learning the meaning of words; although this relation was attenuated when the effects of working memory span were controlled.

Comprehension skill and familiarity with words proved to be relevant for learning words from sentence contexts. Familiarity assessed prior to training predicted form learning, as assessed by the Orthographic Choice task, but a much weaker relation with meaning knowledge, as assessed by accuracy on the Sentence Completion task. Thus, the familiarity ratings reflect some knowledge of words, a sense of familiarity based at least on form, which supports acquiring the spelling of the words as they are exposed. The very modest relation between familiarity and performance on sentence completion suggests that partial knowledge of the word form helps support learning of meaning to some extent. Findings of partial knowledge of words with which participants have some familiarity have been detailed in a series of experiments by Shore and colleagues (Durso & Shore, 1991; Shore & Durso, 1990; Shore & Kempe, 1999). In our study, ratings of participants' confidence in their knowledge of the words were found to be significantly related to measures of form and contextual use—most likely due to the high covariance between the familiarity and knowledge ratings. However, in our results this measure of prior knowledge is also weakly correlated with performance on the Meaning Generation task. This suggests that word form knowledge can provide support for learning of meanings that goes beyond recognition.

Learning word meanings depends also on individual skill, and our second experiment found both meaning generation and sentence completion to be related to reading comprehension skill. A relation between vocabulary knowledge and comprehension has been cited in other studies (Freebody & Anderson, 1983; Oullette, 2006; Stanovich & West, 1979; Sternberg & Powell, 1983). Although the causal direction of this relation has been unclear (Anderson & Freebody, 1983; Freebody & Anderson, 1983; Perfetti, Landi, & Oakhill, 2005), a recent time-lag study suggests that, among children, vocabulary and comprehension may develop reciprocally (Wagner, 2005).

Comprehension skill can lead to better word learning by the engagement of comprehension processes that operate on words in context. Students with greater comprehension ability may make critical inferences or engage other skills that help learn words from context (Jenkins et al, 1984; McKeown, 1985). For example, high-skill comprehenders are able to maintain text representations better in memory, which pays off in the availability of prior text sentences in memory at the time a new context sentence is being read (for a review, see Perfetti, Wlotko, et al., 2005). In fact, individual differences in working memory span are consistent with the conclusion that learning new words in context is related to working memory span (Daneman & Green, 1986). A role for memory does not entail that memory supports an active inference process, however. As we observed in the introduction, connecting the new context to the prior context can be accomplished by a more passive resonance memory.

A study by Perfetti, Wlotko, et al., (2005) suggested that the word learning–comprehension skill relation partly reflects individual differences in the ability to learn

new words. When students learned rare words that, on an individual basis, they had failed to classify as words prior to training, skilled comprehenders learned more new words from definition-like training than did less-skilled comprehenders. More interesting, event-related potentials recorded after word learning indicated that skilled comprehenders showed stronger episodic memories for words they had learned during training compared with less-skilled comprehenders. Thus, this result directly connects with our instance-based framework, suggesting that individuals vary in their encoding of word events, even those in definition episodes, and this affects the later reactivation of word-context memories.

The instance-based framework can be viewed as further specifying the incremental nature of word learning (Deighton, 1959; Fukkink, 2005; Nagy et al., 1985). A single context is sufficient to provide some degree of word learning, especially if the context is sufficiently constraining. However, context variability—not a single context sentence but multiple sentences that vary—supports the ability to express decontextualized meanings of a new word and also allows more rapid decisions about the fit of a word to a new context. This advantage of varied contexts is aptly described by a model that assumes each encounter with a word produces a context-encoded episodic memory trace to which new encounters add new traces. Abstraction over instances occurs with time, as the context portion of the memory fades (still allowing resonance-like retrieval when retrieval cues are present) and the meaning features shared over contexts become more prominent.

ACKNOWLEDGMENTS

The research reported in this article was supported by Grant R305G020006 from the U.S. Department of Education Institute of Educational Sciences (IES) to the University of Pittsburgh. The IES asks authors to note that any opinions are their own and not those of the Department of Education.

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APPENDIX A

<i>Words</i>	<i>Part of Speech</i>	<i>Dictionary Definition</i>
abjure	V	To renounce under oath; forswear
abrogate	V	To abolish, do away with, or annul, especially by authority
abscond	V	To leave quickly and secretly and hide oneself, often to avoid arrest or prosecution.
abstruse	ADJ	Difficult to understand; recondite
ameliorate	V	To make or become better; improve
apotheosis	N	An exalted or glorified example
apposite	ADJ	Strikingly appropriate and relevant
asperity	N	Harshness of manner; ill temper or irritability
assiduous	ADJ	Constant in application or attention
bawdy	ADJ	Humorously coarse; risqué; vulgar; lewd
bemuse	V	To cause to be bewildered; confuse
bifurcate	V	To divide into two parts or branches
canard	N	An unfounded or false, deliberately misleading story
captious	ADJ	Marked by a disposition to find and point out trivial faults
churlish	ADJ	Having a bad disposition; surly
comity	N	An atmosphere of social harmony
commodious	ADJ	Spacious; roomy
contemn	V	To view with contempt; despise
contrition	N	Sincere remorse for wrongdoing; repentance
corrigibility	N	Capable of being corrected, reformed, or improved
degust	V	To taste with relish; savor
descry	V	To catch sight of (something difficult to discern).
diffident	ADJ	Lacking or marked by a lack of self-confidence; shy and timid
disport	V	To amuse (oneself) in a light, frolicsome manner
doughty	ADJ	Marked by stouthearted courage; brave
encomium	N	A formal expression of praise; a tribute
enervate	V	To weaken or destroy the strength or vitality of
evanesence	N	To dissipate or disappear like vapor
exculpate	V	To clear of guilt or blame
exigency	N	A pressing or urgent situation
expatiate	V	To speak or write at length
extirpate	V	To pull up by the roots; to get rid of completely
fastidious	ADJ	Possessing or displaying careful, meticulous attention to detail.
fribble	V	To waste time; trifle
gainsay	V	To oppose, especially by contradiction.
gauche	ADJ	Lacking social polish; tactless

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hubris	N	Overbearing pride or presumption; arrogance
ignominy	N	Great personal dishonor or humiliation
incise	V	To cut into, as with a sharp instrument
indemnity	N	Security against damage, loss, or injury
insipid	ADJ	Lacking qualities that excite, stimulate, or interest; dull.
lacuna	N	An empty space or a missing part; a gap
levity	N	Lightness of manner or speech, especially when inappropriate; frivolity
marplot	N	An officious meddler whose interference compromises the success of an undertaking
maunder	V	To talk incoherently or aimlessly
mendacious	ADJ	False; untrue
mephitic	ADJ	poisonous or foul-smelling
mordant	ADJ	Bitingly sarcastic; Incisive and trenchant
obviate	V	To anticipate and dispose of effectively; render unnecessary
otiose	ADJ	Lazy; indolent
petulant	ADJ	Unreasonably irritable or ill-tempered; peevish
probity	N	Complete and confirmed integrity; uprightness
propitious	ADJ	Presenting favorable circumstances; auspicious
rapparee	N	A bandit or robber
reprove	V	To voice or convey disapproval of; rebuke
revile	V	To assail with abusive language; vituperate
riposte	N	A retaliatory action, maneuver, or retort
sagacity	N	The quality of being discerning, sound in judgment, and farsighted; wisdom
salubrious	ADJ	Conducive or favorable to health or well-being
solecism	N	A violation of etiquette
spate	N	A sudden flood, rush, or outpouring
stentorian	ADJ	Extremely loud
stolid	ADJ	Having or revealing little emotion or sensibility; impassive
subterfuge	N	A deceptive stratagem or device
temerity	N	Foolhardy disregard of danger; recklessness
turgid	ADJ	Excessively ornate or complex in style or language
vacillate	V	To sway from one side to the other; oscillate
venial	ADJ	Easily excused or forgiven
vicissitude	N	The quality of being changeable; mutability
vitiate	V	To reduce the value or impair the quality of
wheedle	V	To persuade or attempt to persuade by flattery or guile; cajole
wizened	ADJ	dried up; withered

APPENDIX B

<i>Words</i>	<i>Example Context 1</i>	<i>Example Context 2</i>
Abjure	Galileo was forced by the Inquisition to abjure, on his knees, his heretical views that the Earth moves around the Sun.	Mel didn't abjure his beliefs immediately, but agreed to reconsider in order to please his parents.
Abrogate	The government abrogated the treaty it had with the Indian tribes.	Because there were so many problems with the trade treaty between Brazil and the United States, the treaty was abrogated and a new one was negotiated.
Abscond	The defendant was released on bail provided he would not abscond to avoid trial.	Slaves were often chained for fear they would abscond.
Abstruse	Nuclear physics is an abstruse subject for most people.	Bill has had a lot of difficulty understanding his math professor's abstruse lectures on mathematical theories.
Ameliorate	The new programs are aimed to ameliorate the condition of the poor, including better healthcare and education.	The aid from the U.N. served to ameliorate the suffering of the refugees.
Apotheosis	Ray Kroc, who started the McDonald's franchise from one restaurant, is held up as an apotheosis of the American entrepreneurial success.	Their fearless leader is the apotheosis of wisdom and courage.
Apposite	The figures and illustrations were very apposite for the subject and were just what her paper needed.	The newspaper pointed out the most apposite examples of the problem with the city policy.
Asperity	The bitter young man answered with asperity.	Marsha was upset by the asperity in her daughter's retort.
Assiduous	The police chief was assiduous in directing the search as he worked persistently day and night until the children were found and brought home.	Annie's elderly mother could not get by without her daughter's assiduous help.
Bawdy	The boss annoyed the women in the office because his comments and stories were bawdy and generally not appropriate or professional.	The drunks sang bawdy songs which dismayed the sleeping villagers.
Bemuse	The crowd was thoroughly bemused because the speaker constantly contradicted himself and it was impossible to understand his point.	The tourists were bemused by the winding roads and misleading signs.

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Bifurcate	The company recently announced plans to bifurcate their research and development department and house the new groups in separate buildings.	As an embryo grows, the cells bifurcate to form new cells.
Canard	Surely no one would believe such a ridiculous canard published in that disreputable magazine.	The paper apologized for the report it published on the singer which turned out to be a canard.
Captious	I think his adviser's criticisms are quite useful and have never found them to be captious.	The colonel was the most captious and the hardest to please by far.
Churlish	It was churlish of Tom to complain about his Christmas gifts when most of his friends got nothing at all.	It would have been churlish to refuse the Armstrongs' invitation even though I don't like them much.
Comity	There are many group activities that promote comity among the students in contrast with debates and arguing.	The bitter accusations between the players and the owners were destructive and resulted in the mediator demanding comity between the two sides before resuming negotiations.
Commodious	Diane was surprised by her friend's commodious Manhattan apartment, she had expected it to be very cramped.	The converted warehouse became a commodious home where the pianist could easily install his grand piano.
Contemn	It was a horrible punishment to have to spend her life with those she contemned.	It is not unusual to contemn the person who injures us.
Contrition	George's contrition was apparent when he spoke tearfully of his use of bribery and blackmail.	I'm sympathetic because he's demonstrated contrition in confessing what he's done.
Corrigibility	It is not yet safe to enter the building, but the architect has assured us of the structural problem's corrigibility.	Suzanne is a counselor and believes in the corrigibility of all delinquents.
Degust	The king loved his new chef's cooking and degusted every crumb, commenting on its deliciousness.	The food was okay, but not worth degusting the way Evan did.
Descry	As dusk faded away and night set in, the children in the yard were hard to descry as they chased after lightning bugs.	Through the trees she could descry a little smoke wafting from the chimney.
Diffident	Because of his lack of success, Tim has always seemed diffident about public speaking.	I was diffident to give details about my condition because I found it embarrassing.
Disport	They may disport themselves at their pleasure in the meadow nearby.	Let's get some work done before we go to the park to disport.

(continued)

APPENDIX B

<i>Words</i>	<i>Example Context 1</i>	<i>Example Context 2</i>
Doughty	Mark James is always a doughty campaigner that is not afraid to campaign anywhere, even in his opponent's backyard.	The doughty soldiers came to the rescue of their wounded comrade who was under fire.
Encomium	The president gave an unstinted encomium fit for the national hero when they laid him to rest.	The fans showed their appreciation for the retiring player at the pre-game ceremony after the coach paid him a tribute with an eloquent encomium.
Enervate	Depression enervated his spirit and his will to enjoy his friends and family.	His alcoholism had a tendency to enervate his body and he was frequently ill.
Evanescence	Joy and sorrow are characterized by evanescence, coming and going over time.	The evanescence of Sam's passions became apparent when they gave way to jealousy.
Exculpate	The jury exculpated the man of any wrongdoing.	She only wanted to exculpate the innocent, and not to punish the guilty.
Exigency	Ambulances were brought to the scene in case of an exigency.	In a moment of exigency, Sarah was forced to beg for aid from her parents.
Expatiate	Pressed to expatiate on his position, George was unable to give sufficient evidence for his claims.	Simply mentioning politics will lead Erica to expatiate on it for hours.
Extirpate	It will be difficult to extirpate crime without the help of the entire community.	Eating at the delicious Japanese restaurant will extirpate any doubts about Asian cuisine.
Fastidious	We should be more fastidious about our measures to keep air pollution low.	The men were fastidious to a fault in keeping the ship clean.
Fribble	Barry's mom demanded that he not fribble his time and begin working on his homework.	Wanda tends to fribble her energy on useless endeavors.
Gainsay	No one can gainsay the fact that tuition is increasing dramatically.	I hate to gainsay my uncle because he will argue energetically until he wins whether he's right or wrong.
Gauche	Growing up on a farm, Tammy's behavior was considered gauche by people in the city.	Yelling to her would have been gauche among such refined company, so I kept my mouth shut.
Hubris	Immediate success and fame can result in an inflated ego and lead to hubris.	After winning the championship, he's become so full of hubris that almost no one can stand him.
Ignominy	She was unable to avoid the ignominy of having the child out of wedlock.	Though Adam had done nothing wrong, he nevertheless shared his wife's ignominy for what she had done.

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Incise	A special design was incised on the ancient coins.	His prize was a silver medal which was incised with the club's logo.
Indemnity	After the hurricane, Sher was upset to find that she had no indemnity and would receive no aid.	It would be wise to have some indemnity in case something should happen to you.
Inspid	Spike Lee portrayed a character that was totally inspid and nerd like, which was exactly what he was shooting for.	Larry thought about leaving his job because it seemed like a jejune position that the director assigned lots of busywork to.
Lacuna	The lacuna in her argument merits serious consideration and could ultimately be quite devastating.	The lacuna in the text made it difficult to decipher.
Levity	His unprincipled levity is in stark contrast to the sternness of his father.	The levity of the jokes was meant to hide her sadness.
Marplot	Eve was considered the marplot of Eden for taking the forbidden apple.	The plan never got off the ground because of a vicious marplot who took all the funding.
Maunder	My mother can mander endlessly without my having the slightest clue what she's talking about.	Dr. Rossi may be brilliant, but he seems quite silly when he begins to mander about who-knows-what.
Mendacious	The campaign was so transparently mendacious that very few people took it seriously.	He was accused of perjury for his mendacious and evasive testimony about his dealings with the mafia.
Mephitic	There are some mephitic odors coming from the businesses on Fifth street in Oakland.	The smoke was not so bad as the smell of the mephitic elements spewing out in the eruption.
Mordant	Her mordant evaluation of the company's performance made everyone painfully aware of its many failings.	Her son's disappearance has caused Sylvia mordant pain.
Obviate	Sadly, there was no way to obviate the forces which would eventually destroy the country.	The results were clear enough to obviate the need for further analysis.
Otiose	I didn't like the play because the actors seemed otiose and just looked bored the whole time.	The otiose doctor seemed uninterested in performing the rigorous set of tests to make the proper diagnosis.
Petulant	The waitress realized she would never be able to please her petulant customers who kept sending their food back.	The petulant child threw himself to the floor screaming when he was told he couldn't have any candy.
Probity	The company demonstrated their probity and accountability by making records of their dealings publicly available.	She strongly believed in the probity of the firm and never questioned their judgment.
Propitious	I am worried because the Chinese almanacs have foretold that this will not be a propitious day by any account.	Ripe apples are symbols of hope and are considered propitious to the dreamer.

(continued)

APPENDIX B

<i>Words</i>	<i>Example Context 1</i>	<i>Example Context 2</i>
Rapparee	The police caught the rapparee as he tried to escape after holding up the bank.	After pleading guilty to the accusation of car theft, the young rapparee was put in a detention center.
Reprove	Many managers were reprovved for failing to give their subordinates the necessary guidance.	Max took the opportunity to reprove the waiter for the poor service.
Reville	Jack didn't publicly revile his opponents because he was afraid of their response to his criticisms.	The officials who revile the cultural practices in their speeches often simply misunderstand them.
Riposte	The mayor felt it was necessary to give a riposte to the reporter's comments because he felt an immediate response was necessary and warranted.	Sadly, Jake had no riposte to Janet's scathing criticism.
Sagacity	His experience as a guide meant that he had great sagacity and was able to make tough decisions.	It will require great sagacity to choose the appropriate course of action among so many competing ideas.
Salubrious	The family moved out West because of health problems, thinking the climate might be more salubrious.	Taking vitamins and getting exercise are keys to a salubrious lifestyle.
Solecism	Children who are not taught manners when they are young often commit solecisms and act improperly in formal situations.	It would be a diplomatic solecism to not give refuge to the asylum seekers who are being persecuted for their religious beliefs.
Spate	Jacob was surprised by the spate of people who came flooding into his store when the sale was announced.	The author received a spate of fan mail after she published her latest, highly acclaimed book.
Stentorian	She has a stentorian voice because she is used to speaking to her mother who is hard of hearing.	No one expected such a small girl to have such a stentorian voice.
Stolid	He knew she was angry and let her have her say, maintaining a stolid silence that gave nothing of what he was thinking.	Most of his relatives are utterly stolid and never laugh.
Subterfuge	The gift is cleverly employed subterfuge to hide the extent of the betrayal.	My day off was well-deserved and I do not regret my use of subterfuge to get it.
Temerity	Jenny knew that Governor Johnson had the temerity to act too quickly even when his advisors cautioned him to be careful.	The officer scolded the teenagers for their temerity, giving them a speeding ticket and cautioning them to drive with care.

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Turgid	Book reviewers find most romance novels turgid because they use language that is flowery and melodramatic to the point of being overblown.	While he could be more concise and to the point, the speaker's lectures are never turgid.
Vacillate	The candidate appeared less forceful because he so frequently vacillated on key issues.	The emperor was not sure if he should attack, defend or vacillate between the two.
Venial	It was considered a venial crime, and he escaped with little more than a slap on the wrist.	Compared to his previous offenses, the mistake was so venial that the principal decided to simply give the student a warning.
Vicissitude	The work was subject to the vicissitude of the weather, which slowed progress considerably.	The recent political shift is simply part of the vicissitude of these affairs.
Vitiate	Jeff was a talented cartoonist, one of the few who was able to use humor to accentuate, not vitiate, his points.	It is conceivable that an error could be so serious as to vitiate the entire body of work.
Wheedle	Many wives can wheedle their husbands into things they don't want to do.	If you carefully wheedle them, they will think they are getting their way even while working for you.
Wizened	The wizened plant was revived after the heavy rains.	I was looking forward to a fresh salad from the garden, but the wizened lettuce leaves were a disappointment.
