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BRIEF REPORTS

Making Sense of Word Senses: The Comprehension of Polysemy Depends on Sense Overlap

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Studies of polysemy are few in number and are contradictory. Some have found differences between polysemy and homonymy (L. Frazier & K. Rayner, 1990), and others have found similarities (D. K. Klein & G. Murphy, 2001). The authors investigated this issue using the methods of D. K. Klein and G. Murphy (2001), in whose study participants judged whether ambiguous words embedded in word pairs (e.g., *tasty chicken*) made sense as a function of a cooperating, conflicting, or neutral context. The ambiguous words were independently rated as having low, moderate, or highly overlapping senses to approximate a continuum from homonymy to metonymic polysemy. The effects of meaning dominance were examined. Words with highly overlapping meanings (e.g., metonymy) showed reduced effects of context and dominance compared with words with moderately or low overlapping meanings (e.g., metaphorical polysemy and homonymy). These results suggest that the comprehension of ambiguous words is mediated by the semantic overlap of alternative senses/meanings.

Keywords: lexical ambiguity, homonymy, polysemy, semantic processing, context effects

Successful comprehension occurs even when listeners must infer a speaker's intended meaning from words that convey many possible meanings. Lexical ambiguity is linguistically subdivided into two main categories: homonymy and polysemy (Cruse, 2000). Homonymous words have semantically unrelated and mutually incompatible meanings (Lyons, 1995). Thus, *punch* may refer to a kind of fruit drink or may mean "to hit something/someone with a closed fist." Some have described such homonymous word meanings as essentially distinct words that accidentally have the same phonology (e.g., Murphy, 2002). Polysemous words, on the other hand, have semantically related or overlapping senses (Cruse, 2000; Jackendoff, 2002; Pustejovsky, 1995). Thus, *lamb* may refer to the animal and to the meat of that animal, and the two senses bear considerable semantic similarity to each other. Polysemy is far more frequent in language than is homonymy, as almost any word can become polysemous and have its core meaning extended (Copestake & Briscoe, 1995; Jackendoff, 2002; Murphy, 2002; Pustejovsky, 1995). Understanding how the human language system represents and processes these different forms of lexical ambiguity is a central problem of psycholinguistics.

Relatively few studies have examined how people comprehend polysemy, whereas decades of psycholinguistic research has examined how people comprehend homonymy (e.g., Duffy, Morris, & Rayner, 1988; Fodor, 1983; McClelland, 1987; Rayner, Pacht, & Duffy, 1994; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982; Simpson, 1981). Two factors play key roles in lexical ambiguity resolution: meaning dominance and context. Dominant meanings are understood more readily than are subordinate meanings in a wide range of tasks (Onifer & Swinney, 1981; Simpson, 1981; Simpson & Krueger, 1991; Tabossi, Colombo, & Job, 1987). Dominance effects, moreover, can be modulated by contextual constraint. According to the reordered access model (Duffy et al., 1988), a subordinate context may increase activation of subordinate meanings; increased activation brings the sense of the word closer to that of a dominant meaning and facilitates comprehension (see also Neill, Hilliard, & Cooper, 1988; Pacht & Rayner, 1993; Rayner, Binder, & Duffy, 1999; Rayner & Duffy, 1986; Rayner & Frazier, 1989; Rayner et al., 1994).

Further, a strong assumption of almost all models of ambiguity resolution is that these processes occur as soon as homonyms are encountered (e.g., Frazier & Rayner, 1990), although the immediacy provision may be relaxed for homonymous verbs (e.g., Pickering & Frisson, 2001). This assumption is supported by a number of studies (e.g., Duffy et al., 1988; Pacht & Rayner, 1993; Rayner et al., 1994, 1999; Rayner & Duffy, 1986; Rayner & Frazier, 1989), most notably eye-tracking studies of unbalanced homonyms (i.e., those with clear dominant and subordinate meanings) and

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balanced homonyms (i.e., those with equally frequent alternative meanings). These studies demonstrate immediate slowing of reading times for balanced homonyms in neutral context and for unbalanced homonyms in subordinate contexts relative to control words.

It is an open question whether polysemy is associated with similar comprehension effects. Several studies suggest that homonymous and polysemous words are represented and processed differently (Frazier & Rayner, 1990; Klepousniotou, 2002, 2007; Klepousniotou & Baum, 2007; Pickering & Frisson, 2001; Pylkkänen, Llinás, & Murphy, 2006; Williams, 1992). For example, Frazier and Rayner (1990) recorded eye movements of participants as they read sentences containing polysemous or homonymous words. When a disambiguating subordinate context preceded target words, reading times were significantly longer for homonymous words and were only marginally longer for polysemous words relative to control words. In the post-target region, however, reading times were slower only for homonymous words. Thus, only homonyms showed a subordinate-bias effect. Moreover, in a following disambiguating context, reading times were longer for homonymous words than for polysemous words; this suggests that an immediate semantic commitment was made to the former word type but not the latter. In addition, reading times on the following disambiguating regions themselves were slower when they were subordinate biased and when they followed homonymous but not polysemous words.

Frazier and Rayner (1990) argued in favor of a partial commitment hypothesis. According to the hypothesis, because the meanings of homonymous words are mutually exclusive and are represented separately, the reader is compelled to select the appropriate one before proceeding to maximize resource constraints on comprehension. Unlike the different senses of homonymous words, those of polysemous words are not mutually exclusive and may share a core representation. By core representation, we mean specifically a memory structure encompassing all semantic features that are common across multiple senses of a polysemous word (e.g., for the word *rabbit*, a core representation might include [+animate, +farm animal, +edible, +meat]). Because the alternative senses of polysemous words overlap semantically, readers are more able to keep all possible meanings activated without taxing resource constraints. Thus, within Frazier and Rayner's framework, a semantic commitment to a particular sense of a polysemous word may be delayed. (See Pickering & Frisson, 2001, for a similar conclusion for polysemous vs. homonymous verbs and Williams, 1992, for further evidence that polysemous words have one central meaning from which all related senses are derived.)

Klein and Murphy (2001; see also Klein & Murphy, 2002) found no evidence that polysemous words were processed differently from homonymous words in a series of experiments that embedded polysemous words in contextually biased word pairs (e.g., *daily paper* vs. *shredded paper*). For each word pair, the second word was polysemous and the first word was biased toward one possible meaning. For example, *wrapping paper* and *shredded paper* referred to actual paper sheets, whereas *daily paper* and *liberal paper* referred to a newspaper. By using a neutral baseline that consisted of a blank line (______ *paper*) in one of their experiments, Klein and Murphy compared the amount of priming observed for consistent pairs (e.g., *wrapping paper* and *shredded paper*) and inconsistent pairs (e.g., *wrapping paper* and *daily paper*) to determine whether the priming of polysemous word meanings arose from facilitation or inhibition. The results for both homonymous and polysemous words showed that contextual consistency facilitated comprehension and that contextual inconsistency inhibited comprehension; thus, they supported the separate representation view for both homonymous and polysemous words.

Given that these findings are inconsistent with previous work (e.g., Frazier & Rayner, 1990; Frisson & Pickering, 1999; Pickering & Frisson, 2001; Williams, 1992), it is important to consider what factors may differentiate these studies. One possible factor is the choice of task (e.g., eye movement recordings of reading in Frazier & Rayner vs. sensicality judgments in Klein & Murphy, 2001). Another factor is the type of polysemous words studied. In Klein and Murphy, meaning relatedness or dominance ratings were not reported and the type of semantic overlap between the senses was not established. It is thus possible that the majority of the polysemous words used had fairly distinct senses (as acknowledged in that study's Discussion; see Klein & Murphy, 2001, p. 278).

In this study, we investigated the comprehension of polysemous words that differed in meaning overlap as a function of context and meaning dominance. We used the methods of Klein and Murphy (2001) because this study failed to distinguish between polysemous and homonymous words. Our working hypothesis was that the amount of semantic overlap between the individual meanings or senses of ambiguous words would determine how they were activated and processed. We tested this hypothesis by presenting ambiguous words in cooperating, neutral, or conflicting contexts. We predicted that ambiguous words with highly overlapping senses would differ both from ambiguous words with low overlapping senses and from ambiguous words with moderately overlapping senses in terms of the observed pattern of context and meaning dominance effects.

Method

Participants

Participants were 60 students (30 in the dominant target condition and 30 in the subordinate target condition) at McGill University; they were compensated at a rate of $10/hour. Participants were native speakers of English and had normal or corrected-to-normal vision. The mean age was 24 years (SD = 3.5, range = 19–35 years) for those in the dominant target condition and 22 years (SD = 3.1, range = 19–35 years) for those in the subordinate target condition.

Materials

We selected 72 ambiguous words for use as experimental stimuli (see Appendix A for details). On the basis of semantic overlap ratings, these 72 ambiguous words were subdivided into three groups of 24 items each: low overlap (e.g., *panel*), moderate overlap (e.g., *beam*), and high overlap (e.g., *lamb*). The three groups were matched on meaning dominance, frequency of occurrence (Kucera & Francis, 1967), length in letters, and transitional probability (see Appendices A, B, and C for more details). In previous studies (e.g., Frazier & Rayner, 1990; Klepousniotou, 2002; Klepousniotou & Baum, 2007; Rodd, Gaskell, & Marslen-

Wilson, 2002), ambiguous words categorized as high overlap tended to be metonymically polysemous (e.g., *lamb,* referring to the animal or to the meat of that animal); ambiguous words categorized as low overlap tended to be homonymous (e.g., *panel,* referring to a divider or to a group of experts); and ambiguous words categorized as moderate overlap tended to be metaphorically polysemous (e.g., *beam,* referring to a piece of wood or to a ray of light). For each ambiguous word, two meanings/senses were selected and two word pairs were constructed for each meaning/sense, so that four word pairs were created for each of the 72 ambiguous words (see Appendix B).

Dominance was manipulated as a between-subjects factor. For the dominant target group, participants saw only dominant senses/meanings of the ambiguous words as targets. Thus, both dominant prime pairs (*marinated lamb*) and subordinate prime pairs (*baby lamb*), as well as neutral prime pairs (***** *lamb*), were always followed by dominant target pairs (*tender lamb*). Hence, cooperating contexts were always formed by a dominant prime pair followed by a corresponding dominant target pair, and conflicting contexts were formed by a subordinate prime pair followed by a dominant target pair.

For the subordinate target group, participants saw only subordinate senses or meanings of the ambiguous words as targets. Thus, dominant prime pairs (*marinated lamb*) and subordinate prime pairs (*baby lamb*), as well as neutral prime pairs (***** *lamb*), were always followed by subordinate target pairs (*friendly lamb*). Hence, cooperating contexts were always formed by a subordinate prime phrase followed by a corresponding subordinate target phrase, whereas conflicting contexts were formed by a dominant prime followed by a subordinate target phrase.

Neutral primes (***** *lamb*) were included to provide a baseline with which to compare cooperating prime–target pairs and conflicting prime–target pairs. However, given our findings in the pre-experiment (i.e., neutral modifiers resulted in longer reaction times than did both cooperating and conflicting modifiers; see Appendix A), we view the data for this condition with caution. To be consistent with Klein and Murphy's (2001) methodology, we retained the neutral condition, although our conclusions regarding the effect of context for the different word types rely heavily on a direct comparison of conflicting and cooperating contexts.

To properly counterbalance all 72 ambiguous words and modifiers and to ensure that all participants viewed the experimental stimuli in each condition an equal number of times, we created six counterbalanced lists for each dominance group (dominant or subordinate). We also created a total of 168 fillers that had the same structure as the experimental stimuli, namely, two phrases sharing a word. Of the fillers, 48 were sensible phrases (*hair comb*) followed by a nonsense phrase (*card comb*), 48 had the reverse pattern (*trapped bruise* followed by *painful bruise*), and 48 had two nonsensical phrases (*spicy binder* followed by *charismatic binder*). The remaining 24 consisted of a neutral phrase (***** *shoe*) followed by a nonsensical phrase (*busy shoe*). As a result of these fillers, the sensibility of the first phrase did not predict the sensibility of the second phrase across the experiment.

Procedure

Participants were explicitly told that they would see pairs of words that had one word in common and that they should judge whether each word pair made sense as quickly as possible without making errors. They were instructed to respond that neutral pairs (e.g., ***** *shoe*) made sense. Each word pair appeared on the screen by itself until participants responded. Participants received feedback after every trial on whether their response was correct or incorrect; feedback to correct responses appeared for 1 s, and feedback to incorrect responses appeared for 2 s. The intertrial interval was 250 ms. Thirty practice trials preceded the main part of the experiment to ensure that participants fully understood the instructions. The experiment was completed in approximately 35 min.

Results

Separate repeated-measures analyses of variance (ANOVAs) were conducted for the dominant and subordinate conditions. We subjected data to a 3 (word type: high overlap, moderate overlap, low overlap) × 3 (context: cooperating, neutral, conflicting) ANOVA, with word type and context as within-subject factors. Trials for which responses were below 200 ms or above 1,750 ms were omitted; for both the dominant and subordinate pairs, these trials constituted less than 1% of the total trials presented. Furthermore, trials for which responses to the prime pair were incorrect were omitted; they constituted 5.7% of the dominant pairs and 5.1% of the subordinate pairs. In this section of the article, significant main and interaction effects are followed by Newman–Keuls post hoc subject and item analyses, and differences associated with a $p < .05$ are considered significant. Table 1 presents the results for correct reaction time and accuracy.

Correct Reaction Time

For the dominant target pairs, there were significant main effects of word type, $F_1(2, 58) = 9.47$, $MSE = 59{,}991$, $p < .001$; $F_2(2, 69) = 3.12$, $MSE = 47{,}561$, $p < .05$, and context, $F_1(2, 58) = 27.22$, $MSE = 118{,}145$, $p < .0001$; $F_2(2, 138) = 19.11$, $MSE = 95{,}150$, $p < .0001$, and a significant interaction of Word Type × Context, $F_1(4, 116) = 3.5$, $MSE = 19{,}865$, $p < .01$; $F_2(4, 138) = 2.7$, $MSE = 13{,}530$, $p < .05$. Post hoc analyses of the significant Word Type × Context interaction revealed that low- and moderate-overlap words were significantly faster when presented with cooperating contexts (low, 768 ms; moderate, 804 ms) in comparison with neutral contexts (low, 844 ms; moderate, 878 ms) and conflicting contexts (low, 844 ms; moderate, 885 ms), which did not differ from each other. Most important, high-overlap words presented in cooperating (788 ms) and conflicting (783 ms) contexts did not differ from each other and were significantly faster in comparison with those presented in the neutral contexts (848 ms).

For the subordinate pairs, the ANOVA revealed significant main effects of word type (for participants only), $F_1(2, 58) = 6.1$, $MSE = 33{,}915$, $p < .01$; $F_2(2, 69) = 2.4$, $MSE = 46{,}260$, $p = .10$, and context, $F_1(2, 58) = 29.6$, $MSE = 217{,}794$, $p < .0001$; $F_2(2, 138) = 39.9$, $MSE = 187{,}623$, $p < .0001$, and the Word Type × Context interaction was not significant, $F_1(4, 116) = 2.0$, $MSE = 9{,}629$, $p = .11$; $F_2(4, 138) = 1.2$, $MSE = 6{,}216$, $p = .30$. Post hoc analyses did not reveal any statistically significant differences as a function of word type, although high-overlap (846 ms) words were faster numerically than were both moderate- (873 ms) and low-overlap (884 ms) words. Post hoc analyses of the main effect of

Table 1
Mean Accuracy and Correct Reaction Time (and Standard Deviation) for All Word Types and Context Types for the Main Experiment

Variable	Context type: Cooperating	Neutral	Conflicting	Difference: Neutral–cooperating	Neutral–conflicting	Cooperating–conflicting
Dominant target pairs						
Accuracy						
High-overlap	98 (4)	95 (7)	96 (7)	−3	−1	2
Moderate-overlap	99 (4)	95 (8)	93 (11)	−4	2	6^{**}
Low-overlap	99 (3)	98 (6)	94 (10)	−1	4	5
Correct reaction time						
High-overlap	788 (103)	848 (133)	783 (103)	60^{**}	65^{**}	5
Moderate-overlap	804 (99)	878 (134)	885 (121)	74^{***}	−7	-81^{***}
Low-overlap	768 (91)	844 (122)	844 (137)	76^{***}	0	-76^{***}
Subordinate target pairs						
Accuracy						
High-overlap	97 (6)	92 (10)	91 (10)	−5	1	6^{*}
Moderate-overlap	96 (7)	91 (11)	85 (9)	−5	6	11^{***}
Low-overlap	97 (6)	88 (12)	79 (15)	-9^{***}	9^{***}	18^{***}
Correct reaction time						
High-overlap	812 (106)	866 (128)	861 (105)	54^{**}	5	-49^{**}
Moderate-overlap	810 (88)	916 (131)	893 (108)	106^{***}	23	-83^{***}
Low-overlap	815 (105)	937 (145)	899 (121)	122^{***}	38	-84^{***}

* $p < .10$. ** $p < .05$. *** $p < .01$.

context revealed that participants were significantly faster for cooperating (812 ms) contexts, in comparison with both neutral (906 ms) and conflicting (884 ms) contexts, which did not differ from each other (see Table 1).

We conducted sub-ANOVAs to test the effect of dominance for each word type as a function of context; only the cooperating and conflicting conditions were included, given concerns about the neutral condition. For high-overlap words, there was a significant interaction between context and dominance, $F_1(1, 58) = 6.18$, $MSE = 21{,}759$, $p = .05$; $F_2(1, 46) = 7.92$, $MSE = 22{,}912$, $p = .01$. The interaction indicated that dominant targets of high-overlap words were equally fast in the cooperating (788 ms) and conflicting (783 ms) conditions but that subordinate targets of high-overlap words were significantly slower for the conflicting condition (861 ms) than for the cooperating condition (812 ms). The interaction between context and dominance was not significant for moderate- and low-overlap words: moderate overlap, $F_1(1, 58) = 0.009$, $MSE = 36$, $p = .92$; $F_2(1, 46) = 0.1$, $MSE = 609$, $p = .74$; low overlap, $F_1(1, 58) = 0.103$, $MSE = 495$, $p = .74$; $F_2(1, 46) = 0.47$, $MSE = 2{,}932$, $p = .49$. This result suggests that cooperating and conflicting contexts have a comparable effect for dominant and subordinate target pairs for moderate- and low-overlap words (i.e., consistent targets were always faster than were inconsistent targets).

Relative to the neutral condition, cooperating contexts for all ambiguous words facilitated comprehension, whereas conflicting contexts produced no inhibition, given that the conflicting condition was statistically similar to the neutral condition. (The conflicting condition tended to be numerically different from the neutral condition in a direction that indicated poorer comprehension for the conflicting condition.) The absence of inhibition is peculiar, given the findings of Klein and Murphy (2001). This result leads us to question whether the neutral condition in the present experiment was a valid reflection of neutrality. One difference is that Klein and Murphy used a neutral condition consisting of a blank line, whereas our neutral condition consisted of a string of asterisks. The asterisks may have been more visually complex and distracting, consistent with the pre-experiment, in which participants were substantially slower at responding to the neutral primes than to the primes consisting of words.

It is also possible that the absence of interference for conflicting contexts is a real effect. Some studies that compared the homonymous and polysemous words to neutral control target words also failed to produce clear inhibition effects for inconsistent contexts (e.g., Klepousniotou, 2002). Similar findings were obtained in studies that compared homonymous words with neutral control target words (e.g., Seidenberg et al., 1982; Swaab, Brown, & Hagoort, 2003; Tabossi et al., 1987). Thus, further work is needed to clarify the degree to which ambiguous words are facilitated or inhibited with respect to an appropriate baseline.

In summary, the findings for correct reaction times were that dominant targets of high-overlap words showed no difference across cooperating and conflicting contexts, whereas dominant targets for the other two word types showed slower reaction times for the conflicting context than for the cooperating context. In contrast, correct reaction times for subordinate targets of high-overlap words were comparable with those of the other word types as a function of cooperating and conflicting contexts (i.e., cooperating contexts led to faster processing).

Accuracy

We conducted a repeated-measures ANOVA on the accuracy data for the dominant pairs that revealed a significant main effect of context, $F_1(2, 58) = 8.0$, $MSE = 437$, $p < .001$; $F_2(2, 138) = 6.34$, $MSE = 361$ $p < .01$; no other effects were significant, which indicates that there were no significant differences among the three types of ambiguous words. Post hoc analyses of the main effect of context did not reveal any significant differences, although cooperating contexts were more accurate numerically (98.6%) than were both neutral (96%) and conflicting (94.3%) contexts for all three types of words (see Table 1).

In contrast with that for dominant pairs, the accuracy ANOVA for subordinate pairs revealed significant main effects of word type (for participants only), $F_1(2, 58) = 6.85$, $MSE = 684$, $p < .01$; $F_2(2, 69) = 1.24$, $MSE = 490$, $p = .29$, and context, $F_1(2, 58) = 32.18$, $MSE = 3{,}099$, $p < .0001$; $F_2(2, 138) = 17.64$, $MSE = 2{,}199$, $p < .0001$, that were qualified by a significant interaction of Word Type × Context (for participants), $F_1(4, 116) = 2.75$, $MSE = 266$, $p < .05$; $F_2(4, 138) = 1.52$, $MSE = 189$, $p = .2$. Post hoc analyses of the significant Word Type × Context interaction revealed that participants were significantly more accurate for low-overlap words when these were presented with cooperating contexts (97%) in comparison with neutral contexts (88%) and conflicting contexts (79%), which were statistically different from each other. For moderate-overlap words, participants were significantly more accurate when these were presented with cooperating contexts (96%) in comparison with conflicting contexts (85%) but not neutral contexts (91%). Finally, there were no significant differences in accuracy for high-overlap words, whether participants were presented with cooperating (97%), conflicting (91%), or neutral (92%) contexts.

As a further test of the effects of dominance, sub-ANOVAs were computed with dominance as a between-subjects factor for pairwise combinations of each word type, as a function of context. These analyses revealed different effects of dominance for high- compared with low-overlap words but not moderate-overlap words: high compared with low overlap, $F_1(1, 58) = 4.09$, $MSE = 416$, $p < .05$; $F_2(1, 92) = 1.7$, $MSE = 348$, $p = .20$; high compared with moderate overlap, $F_1(1, 58) = 0.68$, $MSE = 51$, $p = .41$; $F_2(1, 92) = 0.34$, $MSE = 50$, $p = .56$. Specifically, high-overlap words were equally accurate in the dominant (97%) and subordinate (94%) conditions, while low-overlap words were significantly more accurate in the dominant (96.5%) than the subordinate (88%) condition. The sub-ANOVA including low- and moderate-overlap words did not produce a significant Word Type × Dominance interaction, $F_1(1, 58) = 2.55$, $MSE = 175$, $p = .12$; $F_2(1, 92) = 0.63$, $MSE = 134$, $p = .43$. This result suggests that there were no differences between these two types of ambiguous words.

In summary, the primary finding for accuracy, was found for the subordinate target condition. Here, high-overlap words differed from moderate- and low-overlap words in two ways. First, the high-overlap words showed attenuated negative effects of a conflicting context relative to a cooperating context, and, second, they showed attenuated negative effects of a subordinate relative to a dominant word pair.

Discussion

Our objective was to determine whether the amount of semantic overlap between the alternative multiple meanings or senses of ambiguous words affects how these words are processed during comprehension and, by inference, represented in memory. Taken together, the results suggest that high-overlap words are processed differently from moderate- and low-overlap words, which differed minimally. In particular, when the prime pair biased the subordinate meaning and the target pair biased the dominant meaning, there was little processing cost for high-overlap target pairs. In contrast, when the prime pair biased the dominant meaning and the target pair biased the subordinate meaning, high-overlap words were comparable with the other word types in showing a cost (although the cost was numerically smaller for the high-overlap words than for the other word types). These effects generally appeared for both accuracy and correct reaction time, although they were most clearly seen in the correct reaction times analyses.

Thus, our findings suggest that high-overlap polysemous words differ from moderate- and low-overlap ambiguous words in comprehension; nevertheless, there are several potential ways in which they may differ in representation. One possibility is that the alternative meanings of high-overlap words are contained in one unitary lexical representation, in a similar manner to the alternative meanings of unambiguous words that have more or less salient semantic features (e.g., a *piano* can be both a musical instrument and a heavy object; Barsalou, 1982). For example, a unitary representation for the polysemous word *rabbit* might include all possible semantic features associated with any possible sense of the word, even those that might be semantically contradictory (e.g., [+animate, +farm animal, +edible, +meat, +furry, +hop, +big ears, +stew, +delicacy]). In contrast, the alternative meanings of moderate- and low-overlap words constitute independent lexical representations. A second possibility is that high-overlap polysemous words have a core meaning representation, which generally maps on to their dominant meanings. For example, a core representation (with a tendency to map more closely on to the dominant meaning) for the polysemous word *rabbit* might include only those semantic features that are common and compatible across all possible senses of the word (e.g., [+animate, +farm animal, +edible, +meat, +furry, +hop, +big ears]). When people encounter high-overlap words in any context, be it neutral, dominant, or subordinate, they activate this core meaning representation (see also Williams, 1992). In this view, a subordinate meaning would only be activated, or generated via a semantic rule (e.g., Copestake & Briscoe, 1995; Jackendoff, 2002; Murphy, 2002; Pustejovsky, 1995), in a subordinate context. This possibility is consistent with the asymmetry in cost reduction that we obtained for high-overlap words as a function of dominance, although it is unclear from our data whether subordinate meanings are stored, generated via a rule, or both.

A final possibility is that the alternative senses of high-overlap words are independently represented, as are moderate- and low-overlap words, but that conflicting conditions are easier to resolve because the alternative meanings are highly related. For example, the polysemous word *rabbit* would have two separate representations, such as [+animate, +farm animal, +furry, +hop, +big ears] and [+edible, +meat, +stew, +delicacy]. Thus, the reduction in processing cost for high-overlap words would be viewed as a late occurring integration or revision effect rather than as an immediately occurring activation or meaning selection effect. Although this possibility may have some viability, we do not believe that the data support this view exclusively. On the one hand, if word type differences in ease of integration were the whole story, one would not expect the dominance asymmetry for high-overlap words, given that the same two meanings compete at integration for both dominant and subordinate target pairs. On the other hand, the hint in the data that the cost in the conflicting condition is smaller for subordinate targets of high-overlap words leads us to believe that there must also be some benefit of integrating highly overlapping meanings. Further work is necessary to adjudicate between these options.

Thus, our results differ from those obtained by Klein and Murphy (2001) using the same task for high-overlap words (i.e., polysemous words) but are similar to their results for moderate- and low-overlap (i.e., homonymous) words. Klein and Murphy argued that polysemy is processed similarly to homonymy, on the basis of results that showed that polysemous words presented in conflicting contexts were responded to more slowly than were those presented in cooperating contexts. However, the stimuli used by Klein and Murphy consisted of polysemous words with moderately or loosely overlapping senses, as the authors themselves acknowledged (Klein & Murphy, 2001, p. 278). Inspection of stimuli used in Klein and Murphy (graciously provided by D. K. Klein) revealed that at least half of the items were metaphorically polysemous or homonymous. For example, the list of polysemous words in Klein and Murphy (2001, p. 280) includes words like *book*, *atmosphere,* and *nail*. However, on the basis of rating norms that were obtained from an independent set of participants, *book* was empirically classified as high overlap and *atmosphere* was classified as moderate overlap in our study. *Nail* was not included in our study, but standardized norms for ambiguous words classify it as homonymous (Gilhooly & Logie, 1980; Twilley, Dixon, Taylor, & Clark, 1994). Thus, the failure to obtain differences between polysemous and homonymous words in Klein and Murphy may have arisen because of a mixture of word types in the stimulus set.

Our results for high-overlap words are consistent with those of previous studies that found processing differences between polysemous and homonymous words (e.g., Frazier & Rayner, 1990; Frisson & Pickering, 1999; Pickering & Frisson, 2001). It is of note that Frazier and Rayner examined two sets of homonymous words in relation to polysemy: those whose alternative meanings relied on an animacy contrast (e.g., *pitcher*) and those whose alternative meanings relied on an abstract/concrete contrast (e.g., *ring*). The two sets were included to control for the fact that virtually all polysemous words tested consisted of an abstract/concrete contrast. Frazier and Rayner found that the processing differences between polysemous words and the two types of homonymous words were comparable. This finding ruled out concreteness as an explanatory factor.

In the present study, high-overlap words as a group tended to be more concrete than did the other word types. Concreteness ratings from the MRC database (Coltheart, 1981) revealed a mean concreteness of 530 ($SD = 72$) for high-overlap words, 453 ($SD = 104$) for moderate-overlap words, and 471 ($SD = 102$) for low-overlap words. To ensure that word type effects would remain the same after analyses had accounted for variability associated with concreteness, we conducted a post hoc regression analysis on the item data using the reaction time difference between cooperating and conflicting conditions for dominant targets as the dependent variable. The independent variables were the categorical coding of word type and the continuous item mean for concreteness. The regression model was significant, adjusted $R^2 = .10$, $F(3, 61) = 3.48$, $p < .05$, and the effects test showed a main effect of word type, $F(3, 61) = 3.40$, $p < .05$, but no effect of concreteness, $F(3, 61) = 0.76$, $p = .39$. Thus, we found that the observed cooperating/conflicting context difference for high-overlap words still holds when concreteness is taken into account. On this point, our findings are similar to the conclusions of Frazier and Rayner (1990).

According to theoretical linguistics, lexical ambiguity is a continuum from homonymy to metonymic polysemy, and metaphorical polysemy falls in the middle (Apresjan, 1974). This view is similar to those expressed in studies of graded conceptual representations of unambiguous words (e.g., Damian, Vigliocco, & Levelt, 2001; Kroll & Stewart, 1994; McRae & Boisvert, 1998; Vigliocco, Vinson, Lewis, & Garrett, 2004). In the present study, we used empirical ratings of meaning overlap to categorize ambiguous words into high-, moderate-, and low-overlapping conditions, and we likely confounded linguistic type with group membership. Thus, the low-overlap condition contained mostly homonymous words, the moderate-overlap condition contained a mixture of homonymous words and metaphorically and metonymically polysemous words, and the high-overlap condition contained mostly metonymically polysemous words.

This general assignment of our conditions to linguistic conceptions of polysemy enables us to integrate our findings with prior work that focused on specific linguistic classes of polysemy. For example, Klepousniotou (2002) found faster processing times for metonymically polysemous compared with homonymous or metaphorically polysemous words in a cross-modal sentence priming task (see also Klepousniotou and Baum, 2007). These results corroborate both Frazier and Rayner's (1990) and Frisson and Pickering's (1999) findings suggesting the relative ease of processing for metonymically polysemous words compared with other kinds of ambiguous words.

What remains an open question is the extent to which representational and processing differences exist between metaphorically polysemous words (i.e., ambiguous words with moderately overlapping meanings) and homonymous words (i.e., ambiguous words with low overlapping meanings). It is possible that the present task was unable to discriminate between comprehension differences for these word types, although previous studies have done so successfully using different tasks (e.g., Klepousniotou, 2002; Klepousniotou & Baum, 2007). This concern is especially salient, given a recent magnetoencephalographic (MEG) study of polysemy (Pylkkänen et al., 2006). Using the stimuli of Klein and Murphy, 2001), Pylkkänen et al. showed no behavioral differences between polysemy and homonymy in the presence of neural signature differences for these word types. Thus, advances in characterizing the representation and processing of ambiguous words will benefit from many different tasks and methodological approaches.

To conclude, we demonstrated that polysemous words are processed differently from homonymous words to the extent that their senses are highly overlapping semantically. Using a task that previously failed to discriminate between polysemy and homonymy (Klein & Murphy, 2001), we found that high-overlap polysemous words were less negatively affected by conflicting semantic contexts and by meaning dominance than were moderate- and low-overlap ambiguous words. The specific pattern of effects points to the notion that high-overlap polysemous words (i.e., metonymous words) have a unified lexical representation with a core meaning that is always activated, irrespective of context. In contrast, for moderate- and low-overlap ambiguous words (in which the low-overlap words are identical to homonymous words), the specific pattern of effects points to distinct meaning representations. Further work should determine whether more subtle differences in representation and process exist for moderate- and low-overlap ambiguous words and whether the conclusions we generated in this study using nouns extend to ambiguity found for other grammatical classes.

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Appendix A

Pre-Experiment

Method

Participants. Twenty-four McGill students participated for course credit or compensation of $10/hour. All were native speakers of English and had normal or corrected-to-normal vision.

Materials. Initially, we selected 122 ambiguous words using Durkin and Manning (1989) and the *BBI Dictionary of English Word Combinations* (Benson, Benson, & Ilson, 1997). After two senses were selected for each word, two word pairs were constructed for each sense, so that four word pairs were created for each of the 122 ambiguous words. The word pairs were constructed to minimize the likelihood of semantic overlap between the modifiers used for each sense.

These word pairs were rated by 22 independent participants using two scales, and mean ratings were calculated by the experimenters. For both scales, the two modifiers for one meaning of an ambiguous word were presented on one side of the page (*baby lamb, friendly lamb*), and the two modifiers for the other meaning were on the other side of the page (*marinated lamb, tender lamb*).

For the first scale (range = 1–5), participants rated the degree of relatedness between the two senses of the ambiguous words; 1 indicated the weakest degree of relatedness and 5 indicated the strongest degree of relatedness. For the second scale (range = 1–5), participants rated the dominance of the two senses; 1 indicated that the meaning of the pairs on the left side of the page was maximally dominant, 5 indicated that the meaning of the pairs on the right side of the page was maximally dominant, and 3 indicated that the meanings on the left and right were equally dominant. The raw dominance scores were then recoded into a scale that ranged from 0 (*equally dominant*) to 3 (*clear dominant/subordinate*).

We chose 72 ambiguous words for the main experiment (see Appendix B) and subdivided them into three groups of 24 items each: low overlap (e.g., *panel*), moderate overlap (e.g., *beam*), and high overlap (e.g., *lamb*). The three types of words differed statistically in their semantic relatedness, $F(2, 69) = 509.64$, $MSE = 39.88$, $p < .01$; low-overlap words exhibited less semantic relatedness than did both moderate- and high-overlap words, which differed significantly from each other (Newman–Keuls, $p < .05$; see Appendix C).

There were no statistical differences among the three types of words in mean dominance scores, $F(2, 69) = 1.28$, $MSE = 0.11$, $p = .28$; frequency of occurrence (Kucera & Francis, 1967), $F(2, 69) = 1.34$, $MSE = 17{,}774$, $p = .27$; or length in letters, $F(2, 69) = 0.701$, $MSE = 0.93$, $p = .50$. The modifiers used with low-, moderate-, and high-overlap words were matched for mean frequency (Kucera & Francis, 1967), $F(2, 285) = 0.47$, $MSE = 7{,}788$, $p = .62$, and mean length in letters, $F(2, 285) = 2.65$, $MSE = 14.29$, $p = .08$. The word pairs were matched for transitional probability, which was computed from the 100-million-word British National Corpus (Burnage & Dunlop, 1992; for a discussion, see Frisson, Rayner, & Pickering, 2005; McDonald & Shillcock, 2003). There were no differences among word types for the dominant word pairs, $F(2, 141) = 0.15$, $MSE = 398$, $p = .85$, or for the subordinate word pairs, $F(2, 141) = 1.21$, $MSE = 6{,}684$, $p = .3$.

Procedure. Following Klein and Murphy (2001), we conducted a lexical decision task to ensure that context effects observed in the main experiment could not be attributed to lexical priming of the modifiers. The stimuli of interest were modifiers taken from consistent pairs (e.g., *baby* and *friendly*) versus modifiers taken from inconsistent pairs (e.g., *tender* and *baby*). A neutral prime (*****), similar to the one used in the main experiment, was included. Primes appeared for 500 ms, targets remained on the screen until a response was made, and the intertrial interval was 250 ms. Fillers consisted of 24 neutral trials (*****) followed by nonwords and 48 real words followed by nonwords. Pronounceable nonwords were constructed by changing one or two letters of real words that were matched for length. All stimuli were counterbalanced across a series of lists identical to those used in the main experiment, except that the ambiguous word stimuli were not presented.

Participants viewed the materials on PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993) using a Macintosh computer connected to a CMU button box (New Micros). They were instructed to use the index finger of their dominant hand to make responses. Participants were told that a string of letters would appear on the screen one at a time, in pairs. Their task was to decide quickly and accurately whether the second string was an English word. Feedback occurred after every trial; feedback to correct responses appeared for 1 s, and feedback to incorrect responses appeared for 2 s. Thirty practice trials preceded the main experiment, and the entire experiment lasted approximately 20 min.

Results and Discussion

Accuracy and correct reaction time data (see Table A1) were analyzed with a 3 (modifier type: modifiers used with high-, moderate-, and low-overlap words) × 3 (context: cooperating, neutral, conflicting) repeated-measures analysis of variance (ANOVA). Detection of outliers and post hoc analyses were similar to those in the main experiment.

No effects were significant for the accuracy data. In contrast, the reaction time ANOVA revealed a significant main effect of context, $F_1(2, 46) = 12.137$, $MSE = 41{,}599$, $p < .01$; $F_2(2, 138) = 11.16$, $MSE = 46{,}714$, $p < .01$. Post hoc analyses revealed that participants responded faster when modifier words were presented (cooperating context pairs = 689 ms; conflicting context pairs = 693 ms) than when asterisks and a target word were presented (732 ms). Thus, words may have served as better warning stimuli for other words, but there were no significant modifier priming effects.

(*Appendixes continue*)

Table A1
Mean Accuracy and Correct Reaction Time (and Standard Deviation) for All Word Types and Context Types for the Pre-experiment

Variable	Context type: Cooperating	Neutral	Conflicting	Difference: Neutral–cooperating	Neutral-conflicting	Cooperating–conflicting
Acccuracy						
High-overlap	98 (5)	98 (4)	97 (6)	0	1	1
Moderate-overlap	98 (5)	95 (7)	97 (5)	−3	−2	1
Low-overlap	97 (6)	97 (5)	96 (6)	0	1	1
Reaction times						
High-overlap	685 (93)	734 (110)	679 (101)	49	55*	6
Moderate-overlap	697 (126)	737 (154)	701 (107)	40	36	−4
Low-overlap	686 (98)	726 (120)	698 (130)	40	28	−12

* $p < .10$.

Appendix B

Experimental Stimuli

Ambiguous word	Dominant meaning/sense: Modifier 1	Modifier 2	Subordinate meaning/sense: Modifier 1	Modifier 2	Ratings: R-mean	Adj D-mean
Low-overlap words						
admission	movie	concert	guilty	false	1.14	1.00
appeal	sex	universal	legal	pending	1.36	0.68
arms	muscular	hairy	to	lethal	1.23	0.82
block	toy	wooden	mental	writer's	1.68	0.18
board	ironing	wooden	executive	school	1.05	0.23
body	skinny	injured	administrative	political	1.59	1.00
charm	devilish	natural	gold	good-luck	1.77	0.14
cold	icy	freezing	chest	common	1.77	0.32
column	gossip	sports	concrete	support	1.50	0.55
company	investment	pharmaceutical	pleasant	holiday	1.77	0.36
course	introductory	pass–fail	plotted	collision	1.32	0.77
dart	metal	game	suddenly	quickly	1.86	0.50
date	dinner	blind	expiration	historical	1.86	0.23
degrees	centigrade	fifty	associate	college	1.14	0.09
foundation	charitable	educational	shaky	concrete	1.45	0.18
function	properly	safely	social	official	1.55	0.36
issue	sensitive	political	back	special	1.68	0.50
key	duplicate	master	delete	backspace	1.55	0.05
movement	rhythmic	graceful	feminist	civil-rights	1.91	0.18
panel	control	instrument	advisory	consumer	1.77	0.27
passage	secret	narrow	literary	biblical	1.18	0.23
patient	infinitely	frustratingly	cancer	private	1.09	0.05
tape	scotch	double-sided	interview	video	2.05	0.05
tracks	indoor	racing	moose	snowshoe	1.91	0.14
Moderate-overlap words						
act	desperate	humane	disappearing	comedic	2.86	0.27
atmosphere	tense	informal	upper	polluted	3.00	0.09
barrier	police	concrete	language	religious	3.09	0.14
beam	laser	shining	wood	balance	2.64	0.18
blood	coagulated	thin	blue	royal	3.27	0.91
business	profitable	imports	dirty	funny	3.14	1.00
case	best	hypothetical	divorce	criminal	3.18	0.09
cause	worthy	political	immediate	primary	3.09	0.23
clasp	broken	necklace	tightly	firmly	2.91	0.09
cone	waffle	sugar	orange	traffic	2.59	0.59
country	foreign	democratic	moose	rugged	2.73	1.05
cover	pot	jar	cozy	satin	3.18	0.09
film	action	censored	35 mm	color	2.86	0.59
ground	firm	frozen	camp	picnic	3.27	0.64
guide	assembly	TV	talkative	friendly	2.82	0.05

Appendix B (continued)

	Dominant meaning/sense		Subordinate meaning/sense		Ratings	
Ambiguous word	Modifier 1	Modifier 2	Modifier 1	Modifier 2	R-mean	Adj D-mean
intelligence	natural	limited	classified	military	2.73	1.05
market	flea	fish	housing	stock	3.00	0.32
orange	juicy	ripe	bright	reddish	3.09	0.27
position	embarrassing	prominent	fetal	lotus	3.05	0.18
power	economic	foreign	hydroelectric	steam	2.77	0.18
scene	touching	well-acted	nature	panoramic	2.91	0.05
space	open	large	planetary	outer	3.27	0.32
term	winter	school	short	long	2.86	0.23
title	essay	poem	academic	professional	2.91	0.50
High-overlap words						
article	history	well-written	submitted	popular	4.45	0.14
book	best-selling	advertised	heavy	leather-bound	4.73	0.18
breakfast	pancake	nutritious	family	lonely	4.45	0.73
chicken	juicy	roasted	clucking	young	4.14	0.86
class	inquisitive	misbehaved	boring	stimulating	4.05	0.36
cloud	puffy	storm	mysterious	suspicious	3.77	0.95
concern	cause	express	national	public	4.05	0.50
contribution	charitable	voluntary	scholarly	outstanding	3.86	0.36
design	floral	geometric	product	architectural	4.05	0.18
dinner	turkey	light	formal	anniversary	4.32	0.27
dollar	one	silver	rising	weak	4.27	0.68
dream	recurring	bad	childhood	career	3.77	0.23
dress	wrinkled	long	business	evening	3.82	0.50
examination	multiple-choice	entrance	thorough	careful	3.91	0.27
guard	watch	security	coast	national	4.27	0.45
home	summer	childhood	funeral	nursing	3.73	0.77
lamb	marinated	tender	baby	friendly	4.00	0.45
lunch	hot	sandwich	afternoon	women's	4.27	0.68
magazine	women's	sports	glossy	old	4.55	0.64
medicine	cough	prescription	orthopedic	veterinary	3.59	0.82
message	phone	computer	urgent	clear	4.18	0.18
newspaper	national	daily	faded	shredded	4.50	0.82
novel	best-selling	popular	thick	paperback	4.59	0.59
oil	canola	cooking	crude	engine	3.64	0.18

Note. R-mean = semantic relatedness between two senses/meanings (1 = *low*, 5 = *high*); Adj D-mean = adjusted dominance (0 = *balanced meanings*, 3 = *clear dominant and subordinate meaning*).

Appendix C

Means (and Standard Deviations) of Stimuli Characteristics for Ambiguous Words and the Modifiers Used With Them

					Transitional probability	
Stimuli	Semantic overlap	Meaning dominance	Frequency	Length	Dominant sense	Subordinate sense
Ambiguous words						
High-overlap	4.12 (0.32), range = 3.59–4.73	0.49 (0.26)	88 (108)	6.38 (2.24)	24.6, range = 0–459	29.6, range = 0–380
Moderate-overlap	2.97 (0.2), range = 2.59–3.27	0.38 (0.33)	147 (120)	5.75 (2.07)	21.1, range = 0–210	36.2, range = 0–661
Low-overlap	1.55 (0.3), range = 1.05–2.05	0.37 (0.29)	126 (113)	5.79 (1.79)	18.9, range = 0–97	15.5, range = 0–110
Modifiers						
High-overlap			103 (38)	7.3 (0.4)		
Moderate-overlap			92 (41)	6.6 (0.3)		
Low-overlap			81 (80)	7.3 (0.5)		

Note. Semantic overlap was rated on a scale from 1 to 5. Meaning dominance was rated on a scale from 1 to 3. Length was measured in number of letters.

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