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Disambiguating the Ambiguity Advantage Effect in Word Recognition: An Advantage for Polysemous but not Homonymous Words

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ABSTRACT

Previous lexical decision studies reported a processing advantage for words with multiple meanings (i.e., the “ambiguity advantage” effect). The present study further specifies the source of this advantage by showing that it is based on the extent of meaning relatedness of ambiguous words. Four types of ambiguous words, balanced homonymous (e.g., “panel”), unbalanced homonymous (e.g., “port”), metaphorically polysemous (e.g., “lip”), and metonymically polysemous (e.g., “rabbit”), were used in auditory and visual simple lexical decision experiments. It was found that ambiguous words with multiple related senses (i.e., polysemous words) are processed faster than frequency-matched unambiguous control words, whereas ambiguous words with multiple unrelated meanings (i.e., homonymous words) do not show such an advantage. In addition, a distinction within polysemy (into metaphor and metonymy) is demonstrated experimentally. These results call for a re-evaluation of models of word recognition, so that the advantage found for polysemous, but not homonymous, words can be accommodated.

Key words: lexical ambiguity; homonymy; polysemy; metaphor; metonymy; word recognition

1. THE AMBIGUITY ADVANTAGE EFFECT

Lexical ambiguity, where a single string of letters or phonemes can lead to more than one interpretation, is very common in natural language. Usually, we select one of these different interpretations based on the context in which the ambiguous word occurs. Ambiguous words can also be recognized in isolation. Upon presentation of an ambiguous word in isolation, we are normally able to identify an appropriate meaning and we are often unaware of alternative meanings.

Most research that has compared the processing of ambiguous and unambiguous words in isolation has proposed that ambiguous words have a separate entry for each of their meanings (e.g., Forster & Bednall, 1976; Jastrzembski, 1981; Millis & Button, 1989; Piercey & Joordens, 2000; Rubenstein, Garfield, & Millikan, 1970). These studies reported faster reaction times for ambiguous words than for unambiguous words in visual lexical decision tasks, known as the "ambiguity advantage" effect. This result, which seems to be counter-intuitive, as one might expect ambiguous words that have competing meanings to take longer to process, was explained by hypothesizing that ambiguous words have more entries in the internal lexicon than unambiguous words do (Jastrzembski, 1981; Rubenstein et al., 1970). Furthermore, it was hypothesized that these multiple entries do not actually inhibit each other in the process of word recognition but rather work together to inhibit any other competing lexical items. Thus, the fact that ambiguous words have multiple entries would make it possible that one of their entries would be selected sooner than the entry of an unambiguous word and, therefore, they would be recognized faster than unambiguous words.

Regarding the representation of ambiguous words, based primarily on homonymy, studies on lexical ambiguity processing have proposed that ambiguous words have a single phonological/orthographic representation linked to multiple semantic and syntactic representations (e.g., Seidenberg et al., 1982). Further support for the hypothesis that ambiguous/homonymous words have multiple semantic/syntactic entries in the mental lexicon has come from priming studies that showed that the facilitation effects observed for repeated words do not occur with ambiguous words when different meanings are primed on separate trials (e.g., "runner-race" followed later by "ethnic-race") (Masson & Freedman, 1990). This result, which is in contrast to the strong repetition priming effects that are usually seen in lexical decision tasks, suggests that separate entries of the ambiguous word are processed on the two trials (Kellas, Ferraro, & Simpson, 1988).

Parallel distributed processing (PDP) models, which have become the dominant descriptions of the word recognition process (e.g., Hinton & Shallice, 1991; Joordens & Besner, 1994; Kawamoto, Farrar, & Kello, 1994), have tried to explain the so-called ambiguity advantage effect by assuming that there is both feedforward and feedback activation between orthography/phonology and semantics. Hino and Lupker (1996) theorized that because ambiguous words (referring to homonymous words) have multiple semantic representations, corresponding to their multiple meanings, they create more semantic activation. This semantic activation, in turn, could provide stronger feedback to the orthographic units which would lead to higher activation levels for ambiguous words than unambiguous words.

Joordens and his colleagues (Besner & Joordens, 1995; Joordens & Besner, 1994; Piercey & Joordens, 2000) actually suggested that the ambiguity advantage effect in word recognition arises from a "blend" state in the semantic units which represents multiple learned meanings. Ambiguous words are assumed to reach a threshold level of semantic activation earlier than unambiguous words; thus, a processing advantage is expected in lexical decision tasks. Nevertheless, although Joordens and his colleagues managed to simulate an ambiguity advantage due to "blend" states, this did not generalise to larger networks. Furthermore, their simulations had a very high number of errors (74% errors), failing, thus, to replicate the so-called ambiguity advantage effect reported in lexical decision tasks.

Another model, along similar lines, was offered by Borowsky and Masson (1996), who attempted to simulate the results of behavioural experiments using a version of the distributed memory model described by Masson (1995), with a very restricted set of words, namely two ambiguous and two unambiguous words. They were able to simulate an advantage for ambiguous words for lexical decision tasks, due to faster settling of the meaning units into attractor basins for these words, arguing that it arises because of a "proximity advantage". In other words, when the orthography of a word is presented to the network, the initial state of the semantic units is randomly determined. The network, then, must move from this state to a valid finishing state corresponding to the meaning of the word. The researchers argued that for ambiguous words, there are multiple valid finishing states and, on average, the initial state of the network will be closer to one of these states than for an unambiguous word, where there is only one valid finishing state. However, one limitation of these models is that the settling performance of the networks is poor. As mentioned above, Joordens and Besner (1994) report an error rate of 74%, while Borowsky and Masson (1996) resolve this issue by not considering these blend states, which are a mixture of the ambiguous word's different meanings, as errors.

An alternative explanation in terms of activation models was offered by Kawamoto, Farrar and Kello (1994), who suggested that the ambiguity advantage effect would arise mostly in tasks that emphasize orthographic processing, while in tasks that emphasize semantic processing, such an advantage should be lost. Kawamoto and his colleagues (Kawamoto et al., 1994) actually suggested that the activation of units representing the orthography of a word (and possibly the phonology) is used to mark the word recognition time and not the units representing the semantics of a word. The researchers focused on the orthographic level and created a model (in particular, a recurrent connectionist model) in which the weights of the connections between orthographic units (and not semantic units, as in the models described above) were enacted differently for ambiguous and unambiguous words. In particular, for ambiguous words, for which the mapping between orthography and meaning units is inconsistent, the learning algorithm makes the connection weights between orthographic units, which are the same across the different learning trials, particularly strong. On the other hand, for unambiguous words, for which the mapping between orthography and meaning units is consistent, the learning algorithm leads to more moderate connection weights both within and between the different units. Comparing ambiguous balanced words and unambiguous words, Kawamoto et al. (1994) argued that the ambiguity effect would depend on the nature of the task. If performance depended on orthography, such as a lexical decision task, then there would be a processing advantage for ambiguous words. However, if performance depended on semantics, such as a semantic categorization task, then there would be a processing disadvantage for ambiguous words.

Overall, then, it seems that although there have been several attempts to simulate the evasive so-called ambiguity advantage effect observed in behavioural studies of word recognition, there have been difficulties. One possible explanation for these difficulties may be the fact that most of the studies that reported this ambiguity advantage effect did not distinguish among the different types of lexical ambiguity, treating, thus, lexical ambiguity as an all-or-nothing phenomenon.

Nevertheless, lexical ambiguity is not a uniform phenomenon. In theoretical linguistics, a distinction is made between two types of lexical ambiguity, namely homonymy and polysemy. In homonymy, a word form carries two (or more) distinct and unrelated meanings, such as “bank 1” which means “financial institution” and “bank 2” which means “river side”. On the other hand, in polysemy, a single lexical item has several different but related senses, such as “rabbit” which refers to “the animal” and to “the meat of that animal” (Cruse, 1986; Lyons, 1977).

A number of studies, focusing on the semantics of ambiguous words, provide evidence for differences in processing between homonymy and polysemy. For example, in a study analyzing eye movements, Frazier and Rayner (1990) explicitly compared the reading of ambiguous words with multiple meanings (i.e., homonymous words) with the reading of ambiguous words with multiple senses (i.e., polysemous words) in context. When disambiguating information preceded the target word, Frazier and Rayner (1990) found that fixation times for the target word and the post-target region were longer for all sentences with ambiguous words. However, when the disambiguating information followed the target word, reading times for the disambiguating region were longer for homonymous target words than unambiguous words, probably due to the cost of reanalysis when the assignment of meaning - possibly due to frequency - proved to be incompatible with the subsequent context. No such differences were found for polysemous words, suggesting that there was no reanalysis effect. Based on their results, Frazier and Rayner (1990) suggested that, in the case of polysemy, since the multiple senses are not incompatible with one another, immediate selection of one sense may not be necessary for processing to proceed. Thus, there is processing facilitation for polysemous words only. In the case of homonymy, on the other hand, the meanings of the word are mutually exclusive. Therefore, one meaning must be selected before further processing, and this is a time-consuming process. The findings of Frazier and Rayner (1990) again point toward facilitation effects only for polysemous words (i.e., when an ambiguous word has multiple related senses), indicating a polysemy processing advantage effect, rather than an “ambiguity advantage” effect.

Further evidence for the facilitatory effects due to the interrelatedness of multiple senses on the processing of polysemous words comes from a study by Williams (1992). In a lexical decision priming task, as well as in a relatedness judgement task, Williams (1992) examined whether the processing patterns observed for homonymous words also hold for polysemous words. He visually presented polysemous adjectives (e.g., "dirty" meaning "soiled" and "obscene") incorporated in sentence primes followed by targets which were related either to the central or the secondary sense of the adjective. Williams (1992) found that the polysemous adjectives facilitated targets related to the contextually inappropriate sense at all ISIs (0 ms, 500 ms, 850 ms), although this effect was stronger for the basic sense of the adjectives. He obtained similar results in the relatedness judgement task. Williams (1992) compared his findings to the findings of previous studies with homonymous words (e.g., Seidenberg et al., 1982; Swinney, 1979) and concluded that the various senses of polysemous words are interrelated in a way that is not the case for the meanings of homonymous words for which there may be initial activation of multiple meanings, but the activation of contextually irrelevant meanings is short-lived.

There are also studies that (either intentionally or unintentionally) made a distinction between homonymy and polysemy, and used the two types of ambiguous words in isolation. For example, Jastrzembski, using visual tasks, (1981) indicated that words with multiple meanings associated with a single derivation (i.e., all the meanings have the same etymology) were accessed faster than words with an equal number of meanings that were associated with multiple derivations (i.e., the meanings are associated with different etymologies). Therefore, Jastrzembski (1981) is actually pointing towards a linguistic polysemy (i.e., words with multiple related senses) effect.

Similarly, a study by Azuma and Van Orden (1997) that sought to verify the psychological "ambiguity advantage" effect, in fact found some evidence for a linguistic polysemy effect. In particular, using visual lexical decision tasks, Azuma and Van Orden (1997) designed two experiments to further investigate and verify the "ambiguity advantage" effect. In both experiments, for the real word condition, they used ambiguous words and they manipulated the degree of the relatedness between the meanings of the ambiguous words (high or low) and the number of meanings of these words (many or few). For the non-word condition, in the first experiment they used legal non-words, while in the second experiment they used pseudohomophones. Azuma and Van Orden (1997) found that there were no significant effects when legal nonwords were included in the experimental paradigm. However, when pseudohomophones were used, Azuma and Van Orden (1997) found that ambiguous words with few unrelated meanings had the slowest response times, while there were no differences among all the other words. Based on these findings, the researchers concluded that their results do not actually support a psychological "ambiguity advantage" effect, since ambiguous words with few unrelated meanings were processed slower than any other type of ambiguous words, possibly pointing toward a linguistic polysemy effect.

More recently, Rodd, Gaskell and Marslen-Wilson (2002) used a visual and an auditory simple lexical decision task to compare reaction times to ambiguous and unambiguous words with many or few senses. However, clarification is required concerning what the investigators call unambiguous words. They based their classification of ambiguous and unambiguous words on a dictionary. So, if a word had multiple separate entries in the dictionary, it was taken to be an ambiguous word; on the other hand, if a word had only one entry in the dictionary, then it was classified as an unambiguous word, even though it had multiple senses. Thus, it seems that Rodd et al. (2002), in fact, made a rudimentary distinction between homonymous and polysemous words. For their visual task, Rodd et al. (2002) found that words with many senses (both ambiguous and unambiguous) were processed faster and with fewer errors than words with few senses, but there were no processing differences between ambiguous and unambiguous words (recently replicated by Beretta et al., 2005). In the auditory task, both number of meanings (many or few) and ambiguity (ambiguous or unambiguous) significantly influenced response times. In particular, words with many senses (both ambiguous and unambiguous) were processed faster and with fewer errors than words with few senses (both ambiguous and unambiguous); further, ambiguous words (both with many and few senses) were slower than unambiguous words (both with many and few senses). Rodd et al. (2002) concluded that there is a processing advantage for words with many senses (regardless of whether they are ambiguous or unambiguous), while there was a trend for a disadvantage for ambiguous words (regardless of whether they have many or few senses).

Based on these findings, Rodd and her colleagues (Rodd, Gaskell, & Marslen-Wilson, 2004) proposed a model to account for the processing differences between words with multiple unrelated meanings and words with multiple related senses. They suggested that words with few senses form deep, narrow attractor basins that are represented in different parts of semantic space, while words with many senses form shallow, broad basins which are represented within the same region of semantic space. The ambiguity disadvantage emerges because homonymous words have separate meanings that correspond to separate attractor basins in different regions of semantic space. The orthographic input of these words is ambiguous, and in the early stages of the network's settling, a blend of their meanings will be activated. Gradually, the network moves away from the blend state and settles in one of the different meanings. This process of moving away from a blend state makes homonymous words harder to recognise. In contrast, the different possible semantic representations of words with multiple senses do not correspond to separate regions in semantic space; the distributed semantic representations of the different senses of these words are highly overlapping, and thus correspond to neighbouring points in semantic space, resulting in faster activation of semantic features, and producing a processing advantage. Using this description, the researchers were able to simulate partially the results of their behavioural study, namely an advantage for words with many senses. However, the simulation also led to a significant disadvantage for words with many meanings which, nevertheless, was not statistically significant in the behavioural study. Rodd et al. (2004) caution that their simulations predict that the sense benefit should be restricted to tasks in which the activation of any semantic information is sufficient to support performance. However, in tasks that require a particular sense of a word to be retrieved, it is possible that the different word senses will compete with each other and produce a sense disadvantage (e.g., Klein & Murphy, 2001).

Thus, the majority of these studies seem to provide experimental support to the theoretically motivated differentiation of lexical ambiguity into homonymy and polysemy (but cf. Klein & Murphy, 2001; 2002 who found similar processing patterns for homonymous and polysemous words). Nevertheless, a further distinction of polysemy based on theoretical linguistics is possible. In particular, polysemy is further divided into two types which are basically motivated by two distinct figures of speech, namely metaphor and metonymy (Apresjan, 1974). In metaphor, a relation of analogy holds between the senses of the word and the basic sense is literal, whereas the secondary sense is figurative. For example, the ambiguous word “lip” has the literal basic sense “organ of the body” and the figurative secondary sense “edge of a vessel”. In metonymy, a relation of contiguity or connectedness holds between the senses of the word. It is claimed that metonymically motivated polysemy respects the usual notion of polysemy, which is the ability of a word to have several distinct but related meanings (Apresjan, 1974). In metonymic polysemy, both the basic and the secondary senses are literal. For example, the ambiguous word “rabbit” has the literal basic sense referring to “the animal”, and the literal secondary sense of “the meat of that animal”. Drawing on the observation that homonymy and polysemy are relative concepts, it seems that some types of metaphorically motivated polysemy are closer to homonymy. On the other hand, metonymically motivated polysemy is a step further away from homonymy (Apresjan, 1974).

Thus, polysemy is distinguished into regular (observed mostly in metonymic polysemy) and irregular (observed in metaphorical polysemy). A formal definition of regular polysemy holds that "Polysemy of a word A with the meanings a_i and a_j is called regular if, in the given language, there exists at least one other word B with the meanings b_i and b_j, which are semantically distinguished from each other in exactly the same way as a_i and a_j and if a_i and b_i, a_j and b_j are nonsynonymous" (Apresjan, 1974). For example, nouns with the meaning "container" also have the meaning "content", like "bottle" in the sentences "John broke the bottle" and "John drank the whole bottle". On the other hand, polysemy is irregular if the distinction of the meaning between "a_i and a_j" is not attested in any other word of the language - for example, the word "star" in the sentences "Our Sun is a star" and "Madonna is a star". This is also attested in sets of words, like body parts that can be used to refer to objects. The relations are not predictable; so, the metaphorical sense of "mouth", for example, cannot be predicted on the basis of the knowledge that the metaphorical sense of "hand" refers to "a part of a clock or watch". Regularity, thus, seems to be a feature of metonymical transfers, whereas irregular polysemy is more typical of metaphorical transfers (Apresjan, 1974).

However, the distinction between homonymy and polysemy is not clear-cut; rather it seems to be a matter of a continuum from "pure" homonymy to "pure" polysemy (which is best exemplified by regular metonymic transfers). Consistent with the observation that homonymy and polysemy are relative concepts, metaphorical polysemy (i.e., metaphor) seems to be somewhere in the middle between "pure" homonymy and "pure" polysemy.

There is only a single study to date (Klepousniotou 2002) that exploited the distinction within polysemy and directly compared homonymous and polysemous (both metaphorical and metonymic) words in context, investigating their processing and representation patterns. The three types of ambiguous words (homonymous words, polysemous words with metaphorical extensions and polysemous words with metonymic extensions) were used in a cross-modal lexical decision task. Klepousniotou (2002) presented sentences auditorily that biased either the dominant or the subordinate meaning of homonymous and polysemous words. Immediately following the sentence primes (at 0 ms ISI), a target was visually presented for lexical decision. Targets were either homonymous or polysemous words, unrelated control words or non-words. Differences were found among the three types of ambiguous words. In particular, polysemous words with metonymic extensions demonstrated stronger facilitation effects and were processed significantly faster than homonymous words, while polysemous words with metaphorical extensions fell somewhere between metonymy and homonymy and did not differ statistically from either. Based on these results, Klepousniotou (2002) suggested that the processing differences could indicate representational differences, depending on the type of ambiguity that the words exhibit. Homonymous words showed longer reaction times, possibly because their multiple unrelated meanings were competing, thus slowing the activation process. Homonymous words, then, could be seen as having several distinct mental representations in the mental lexicon. Polysemous words, on the other hand, and in particular metonymies, were processed significantly faster presumably because there was no meaning competition. This finding could indicate that, for metonymous words, there is only a single mental representation specified for the basic sense of the word, assigning it a general semantic value. In this investigation, then, the processing advantage was confined to ambiguous words with multiple related senses (i.e., metonymically polysemous words).

These findings provide preliminary evidence that homonymy and polysemy rely on distinct underlying processing mechanisms that probably reflect differences in their representation. Homonymy seems to rely on the process of sense selection whereby the different meanings of the word are activated by being chosen from a pre-existing, exhaustive list of senses. Polysemy, on the other hand, seems to rely on the activation of a basic sense from which the extended senses are created possibly by means of lexical rules (i.e., sense creation). Given these findings that reveal processing differences among homonymy, metaphorical polysemy and metonymic polysemy in sentential contexts, it is important to investigate their processing in isolation in order to explore further the effects of multiple unrelated meanings versus those of multiple related senses in the processing of ambiguous words.

2. THE PRESENT STUDY

The present study, thus, aims to identify further and clarify the source of the processing advantage found in previous lexical decision studies for words with multiple meanings (i.e., the "ambiguity advantage" effect). Based on the hypothesis that "sense-relatedness" drives the processing advantage in word recognition, the present study, using two simple lexical decision experiments (an auditory and a visual, similar to Rodd et al., 2002), addressed the following question: If "sense-relatedness" produces the processing advantage, is this advantage found for both types of polysemy (i.e., both metaphor and metonymy)?

Based on the hypothesis that "sense-relatedness" produces the processing advantage observed for ambiguous words, it was predicted that, in general, ambiguous words with multiple related senses (i.e., polysemous words) would be processed faster than unambiguous control words matched for frequency. Nevertheless, it was expected that differences might emerge between metonymy and metaphor. In particular, metonymous words were expected to show a more robust processing advantage relative to unambiguous control words than metaphorical words. Although metaphorical senses are still quite related in meaning, they tend to be more lexicalized and “irregular” than metonymic senses. As a result, they may be less sensitive to processing facilitation effects. Finally, ambiguous words with multiple unrelated meanings (i.e., homonymous words) were not expected to exhibit any processing advantage relative to unambiguous control words.

3. EXPERIMENT 1

To investigate the effects of having multiple unrelated meanings (i.e., homonymous words) versus the effects of having multiple related senses (i.e., polysemous words) on word processing, a simple auditory lexical decision task was designed.

3.1 Participants. Twenty native speakers of English with an average age of 25 years (range 20-35) and an average of 17 years of education (range 15-25) participated in the study. All participants were free of speech-language and hearing disorders and had normal or corrected to normal (20/20) vision.

3.2. Materials. Target words representing four distinct types of lexical ambiguity as well as one set of unambiguous control words were constructed in the following way. Eighteen of each of the four types of ambiguous words as well as a set of unambiguous frequency-matched control words were selected as targets (see Appendix A): 1) unbalanced homonymous words (e.g., “coach”) (i.e., one meaning is more frequent (i.e., dominant) than the other meaning (i.e., subordinate)); 2) balanced homonymous words (e.g., “panel”) (i.e., both meanings are equally frequent); 3) metaphorical words (e.g., “mouth”); 4) metonymous words (e.g., “rabbit”); and 5) unambiguous frequency-matched control words (e.g., “chalk”).

Both unbalanced and balanced homonymous words were used in the present experiments to investigate whether the differences reported in the literature when these words appear in context (Duffy, Morris & Rayner, 1988; Rayner & Duffy, 1986; Rayner & Frazier, 1989) also hold when they are used in isolation. Unbalanced and balanced homonymous words were chosen from standardized lists of ambiguous words (e.g., Gilhooly & Logie, 1980; Nelson, McEvoy, Walling, & Wheeler, 1980; Twilley, Dixon, Taylor, & Clark, 1994; Yates, 1978). For the unbalanced homonymous words, the frequency of occurrence of the dominant meaning was never less than 63%, and the frequency of occurrence of the subordinate meaning was never greater than 32%. Overall, the dominant meaning had a mean frequency of occurrence of 77% (range: 63% - 93%) and the subordinate meaning had a mean frequency of 15% (range: 2% - 32%). The average frequency of occurrence of the unbalanced homonymous words was 34 (Francis & Kucera, 1982), their average letter length was 4.4 letters, their average acoustic duration was 527 ms, and their average uniqueness point was 5.4.

For the balanced homonymous words, the frequency of occurrence of the dominant meaning was never less than 41%, and the frequency of occurrence of the subordinate meaning was never greater than 48%. Overall, the dominant meaning had a mean frequency of occurrence of 51% (range: 41% - 59%) and the subordinate meaning had a mean frequency of 41% (range: 35% - 48%). The average frequency of occurrence of the balanced homonymous words was 30 (Francis & Kucera, 1982), their average letter length was 4.5 letters, their average acoustic duration was 516 ms, and their average uniqueness point was 5.4.

As there are no standardized lists of metonymous and metaphorical words, these were chosen to exhibit specific relations between their two senses as documented in the theoretical linguistics literature (e.g., Apresjan, 1974; Nunberg, 1979; Pustejovsky, 1995). In order to investigate the effects of a broader range of words with metonymous and metaphorical meaning extensions, as well as to control for repetition effects and semantic facilitation effects from one experimental stimulus to another, multiple types of metonymous and metaphorical words were included. In particular, metonymous words exhibited the following types of metonymic relations:

6 words with the count/mass relation, in which the noun that refers to the individual item can also be used to refer to the substance/mass of the word (e.g., “lemon”); 6 words with the container/containee relation, in which the noun that refers to the container can also be used to refer to the content (e.g., “bottle”); and 6 words with the figure/ground reversals relation, in which the noun that refers to the “physical object used to frame an aperture” can also be used to refer to the “aperture” (e.g., “cage”). The mean frequency of occurrence for the metonymous words was 28 (Francis & Kucera, 1982), their average letter length was 4.4 letters, their average acoustic duration was 502 ms, and their average uniqueness point was 5.3.

Similarly, metaphorical words exhibited three types of metaphorical relations, namely 6 body part/object words, in which the noun that refers to a body part can also be used metaphorically to refer to an analogous part of a physical object (e.g., “mouth”), 6 animal/human characteristic words, in which the noun that refers to an animal can also be used metaphorically to refer to a human characteristic (e.g., “fox”), and 6 object/human characteristic words, in which the noun that refers to a physical object can also be used metaphorically to refer to a human characteristic (e.g., “star”). The average frequency of occurrence of the metaphorical words was 29 (Francis & Kucera, 1982), their average letter length was 4.5 letters, their average acoustic duration was 531 ms, and their average uniqueness point was 5.4.

All experimental ambiguous words (unbalanced-homonymy, balanced-homonymy, metaphorical-polysemy, metonymic-polysemy) were matched for a number of criteria so that there were no significant differences among them for frequency [$F(3, 68) = 0.118$, $p > 1$], familiarity [$F(3, 68) = 0.293$, $p > 1$], concreteness (of the lemma) [$F(3, 68) = 0.536$, $p >1$], acoustic duration [$F(3, 68) = 0.644$, $p > 1$], length in number of letters [$F(3, 68) = 0.063$, $p > 1$], orthographic neighbourhood [$F(3, 68) = 0.180$, $p > 1$] and recognition uniqueness point [$F(3, 68) = 0.039$, $p > 1$].

A set of 18 unambiguous control words (mean frequency 30; average letter length 4.7; average acoustic duration 506 ms; uniqueness point 5.7) matched to the ambiguous words for the above mentioned criteria (e.g., frequency, familiarity, concreteness, letter length, etc.) was also used. The classification of these words as unambiguous was further verified by consulting a large word association database (Nelson, McEvoy, & Schreiber, 1998) in which they were also classified as unambiguous. It should be noted here that although it may be difficult to find words that are genuinely unambiguous, the set of words used in the present experiments was not found to evoke more than one interpretation/meaning, as shown from the responses of participants in the database. In addition, ambiguous words predominantly and most clearly exhibited one type of lexical ambiguity and they were accordingly classified as such, serving as instances/examples of their broader ambiguity group (i.e., unbalanced homonymy, balanced homonymy, metaphorically motivated polysemy and metonymically motivated polysemy).

A set of 45 filler words was also included in the experiment, in order to dilute the experimental sets of stimuli, for a total of 135 real word targets (see Appendix A). Furthermore, 135 legal non-words were also included in the experiment. Non-word targets were constructed by changing one or two letters of real words and they all respected English phonotactics (see Appendix A). All stimuli were recorded by a female native speaker of English, digitized at a rate of 20k samples/second and low pass filtered at 9 kHz using the Brown Lab Interactive Speech System (BLISS) software (Mertus, 2000).

3.3. Procedure. All participants were tested in a single session that lasted approximately 15 minutes. Stimuli were presented in random order. Participants were tested individually, seated in a comfortable position. For the auditory simple lexical decision task, they were wearing headphones and the volume was adjusted to their preference. Each trial began with the auditory presentation of a target (either real word or non-word) through the headphones, and participants were told to make lexical decisions about the target. They were instructed to respond as accurately and as quickly as possible on a response box located in front of them by pressing the YES key if they thought the target was a real word in English, and the NO key if they thought it was a non-word. The position (left or right) of the YES/NO response buttons was counterbalanced across participants. Reaction times (in ms) and accuracy rate were recorded by the computer.

Reaction times were recorded from the onset of the target until the participant responded. If the participant did not respond within 1500 ms, the trial was recorded as a non-response. Following the participant's response (or non-response), the next trial was presented after a delay of 100 ms. A practice session of 6 trials preceded the presentation of the actual experiment. If the participants did not understand the task, the practice session was repeated and oral examples were given until it was clear what the task required.

3.4 Results

Only correct responses to word targets were analyzed. Prior to statistical analysis, errors (comprising 3.66% of the data) and outliers (±2 standard deviations from each subject's mean per condition; comprising 4.14% of the data) were removed. The mean reaction times, as well as the standard errors, for each condition are provided in Figure 1. Furthermore, Table 1 provides all the information about the mean reaction times in ms (and standard deviations) and the percentage of error rates per condition for each of the experimental word types (i.e., homonymy-balanced, homonymy-unbalanced, polysemy-metaphor, polysemy-metonymy, unambiguous control) for both the auditory and visual experiments.

Insert Table 1 approximately here

Insert Figure 1 approximately here

The data were subjected to 1-way repeated measures analyses of variance (ANOVA) for subjects (F1) and a between effects ANOVA for items (F2), with Word type as a factor having 5 levels (i.e., balanced-homonymy, unbalanced-homonymy, metaphor, metonymy, and unambiguous-control-word), for both accuracy and reaction times (RT).

In the analysis of error rates, the main effect of Word type was significant (only for subjects) [$F1(4, 76) = 6.002$, $MSE = 2.785$, $p < 0.001$; $F2(4, 85) = 1.836$, $p > 1$]. Post-hoc tests (Newman-Keuls, $p<0.05$) revealed that there were significantly more errors in balanced and unbalanced homonymous words relative to metaphorical and metonymic polysemous words, while no differences were found with control words.

In the analysis of the reaction time data, the main effect for Word type was significant [$F1(4, 76) = 15.112$, $MSE = 43962$, $p < 0.0001$; $F2(4, 85) = 8.57$, $MSE = 54828$, $p < 0.0001$]. To explore further the significant main effect of Word type observed in the reaction time ANOVA, post-hoc comparisons with the Newman-Keuls test ($p<0.05$) were carried out. These comparisons revealed that reaction times were significantly faster for metaphorical and metonymous ambiguous words than unambiguous control words. On the other hand, there were no significant differences between balanced and unbalanced homonymous words and unambiguous control words (see Figure 1). In addition, both types of polysemous words (i.e., metaphors and metonymies) were also processed significantly faster than both types of homonymous words (i.e., balanced and unbalanced homonymous words). Finally, although there were no significant differences between balanced and unbalanced homonymous words, metonymically polysemous words were processed faster than metaphorically polysemous words, pointing to a division within polysemy as well.

3.5 Discussion

Thus, consistent with our hypothesis that "sense-relatedness" produces the processing advantage that is observed in lexical decision studies with ambiguous words, only polysemous words (both metaphors and metonymies) showed faster reaction times than unambiguous control words. In addition, the theoretical distinction within polysemy was experimentally supported since differences in processing were also observed between metaphor and metonymy. On the other hand, homonymous words, both balanced and unbalanced, did not show any facilitation effects. In other words, there was no indication of the advantage that had been previously reported; on the contrary, there was a slight disadvantage for homonymous words compared to unambiguous control words, which did not reach significance.

4. EXPERIMENT 2

Experiment 2 used the same materials as Experiment 1, but in the visual modality.

4.1 *Participants*. A different group of twenty native speakers of English with an average age of 25 years (range 21-34) and an average of 17 years of education (range 15-23) participated in the study. All participants were free of speech-language and hearing disorders and had normal or corrected to normal (20/20) vision.

4.2 *Materials*. Same as in Experiment 1.

4.3 *Procedure*. All participants were tested in a single session that lasted approximately 15 minutes. Stimuli were presented in random order. Participants were tested individually, seated in a comfortable position. For the visual simple lexical decision task, each trial began with the visual presentation of a series of signs (######) on the computer screen for 500 ms to alert the participants to fixate on the computer screen. After a delay of 200 ms, a target (either real word or non-word) was presented on the screen for 500 ms, and participants were told to make lexical decisions about the target. They were instructed to respond as accurately and as quickly as possible on a response box located in front of them by pressing the YES key if they thought the target was a real word in English, and the NO key if they thought it was a non-word. The position (left or right) of the YES/NO response buttons was counterbalanced across participants. Reaction times (in ms) and accuracy rate were recorded by the computer.

Reaction times were recorded from the onset of the target until the participant responded. If the participant did not respond within 1500 ms, the trial was recorded as a non-response. Following the participant's response (or non-response), the next trial was presented after a delay of 100 ms. A practice session of 6 trials preceded the presentation of the actual experiment. If the participants did not understand the task, the practice session was repeated and oral examples were given until it was clear what the task required.

4.4 Results

Only correct responses to word targets were analyzed. Prior to statistical analysis, errors (comprising 3.16% of the data) and outliers (±2 standard deviations from each subject's mean per condition; comprising 4.34% of the data) were removed. The mean reaction times, as well as standard errors, for each condition are provided in Table 1 and Figure 2.

Insert Figure 2 approximately here

The data were subjected to 1-way repeated measures analyses of variance (ANOVA) for subjects (F1) and a between effects ANOVA for items (F2), with Word type as a factor having 5 levels (i.e., balanced-homonymy, unbalanced-homonymy, metaphor, metonymy, and unambiguous-control-word) for both accuracy and reaction times (RT).

As in the auditory experiment, in the analysis of error rates, the main effect of Word type was significant (only for subjects) [$F1(4, 76) = 2.849$, $MSE = 2.849$, $p < 0.05$; $F2(4, 85) = 1.282$, $p > 1$]. However, post-hoc tests (Newman-Keuls, $p<0.05$) did not reveal any differences of interest.

For the reaction time data analysis, the main effect for Word type was significant (for subjects) [$F1(4,76) = 2.849$, $MSE = 1993$, $p < 0.05$; $F2(4, 85) = 1.282$, $p > 1$]. To explore further the significant main effect of Word type, post-hoc comparisons with the Newman-Keuls test ($p<0.05$) were carried out. These comparisons revealed that reaction times were significantly faster only for metonymous ambiguous words relative to unambiguous control words. In addition, metonymous words were also processed significantly faster than unbalanced homonymous words. On the other hand, there were no significant differences between ambiguous words and unambiguous control words in the metaphor, balanced-homonymy and unbalanced-homonymy conditions (see Figure 2).

4.5 Discussion

Consistent with our hypothesis that "sense-relatedness" produces the processing advantage that is observed in lexical decision studies with ambiguous words, again only polysemous words showed faster reaction times than unambiguous control words. In this experiment, the division within polysemy is observed again; namely, the processing advantage which is observed in metonymous words is lost in metaphors (although the data pattern is in the expected direction). It should be noted that the reaction times in this experiment were much faster than those in the auditory experiment and the effects were generally much smaller (see Table 1). It is conceivable that the speeded lexical decisions in the visual word recognition actually masked the processing advantage that was observed in the auditory study for metaphors. In this respect, our findings are parallel and comparable to those of Rodd et al. (2002) who also found similar differences between their visual and auditory tasks. Thus, it is possible that participants were processing the visual forms very fast without, in fact, allowing time to proceed to deeper semantic processing, masking, therefore, the facilitatory effects for metaphor. As in Experiment 1, both types of homonymous words (i.e., both balanced and unbalanced) did not show any facilitation effects, demonstrating no indication of the so-called ambiguity processing advantage.

5. GENERAL DISCUSSION

The present set of studies addressed the issue of whether homonymous ambiguous words (i.e., ambiguous words with multiple unrelated meanings) are processed differently from polysemous ambiguous words (i.e., ambiguous words with multiple related senses) in an attempt to clarify further the so-called "ambiguity advantage" effect in word recognition. Overall, the results supported our hypothesis of a "sense-relatedness advantage" effect, as opposed to an "ambiguity advantage" effect, in that a processing advantage was found for ambiguous words with multiple related senses (i.e., polysemous words), but not for ambiguous words with multiple unrelated meanings (i.e., homonymous words).

The present results suggest that contrary to the common view in the literature (e.g., Borowsky & Masson, 1996; Jastrzembski, 1981; Kellas et al., 1988; Rubenstein et al., 1970), there is no processing advantage for ambiguous words with multiple unrelated meanings (i.e., homonymous words). Rather, the advantage seems to stem from ambiguous words that have multiple related senses (i.e., polysemous words). In particular, the auditory study revealed that ambiguous words with both metaphorically and metonymically related senses showed faster processing times relative to unambiguous frequency control words. In contrast, both balanced and unbalanced homonymous words did not show any processing differences from unambiguous control words. In that respect, our findings are consistent with recent findings that reported a processing advantage for words with multiple related senses (e.g., Beretta et al., 2005; Rodd et al., 2002). Importantly, though, our findings extend such previous research by demonstrating a division within polysemy as well, into metaphor and metonymy.

Experiment 1 (i.e., the auditory study) demonstrated that both types of polysemous words (i.e., metonymous and metaphorical words) were processed faster than control words; nevertheless, a distinction within polysemy was also evident. In particular, metonymically polysemous words were processed significantly faster than metaphorically polysemous words. Thus, the distinction between metaphor and metonymy emerges even when a processing advantage relative to control words is observed for both types of polysemous words. These differential processing patterns within polysemy were also evident in Experiment 2 (i.e., the visual study). Metonymous words (considered to be closer to “pure” polysemy; e.g., Apresjan, 1974), which have senses that are very closely related, were indeed processed significantly faster than unambiguous control words. Metaphorical words, however, did not show such a processing advantage. Experiment 2, thus, provides additional evidence for a distinction within polysemy (into metaphor and metonymy) by indicating that the processing advantage for metaphors is less robust than the processing advantage observed for metonymous words.

This finding is consistent with observations in the theoretical linguistics literature (e.g., Apresjan, 1974; Nunberg, 1979) that metaphorical polysemy is quite unsystematic and unconstrained in nature. There are cases where the senses are sufficiently related, but there are also cases where the relatedness in meaning is not so obvious. However, given that in the present set of experiments, the same stimuli were used for both the auditory and the visual experiments, it seems that the modality in which the metaphorically ambiguous words were presented differentially affected the recognition process. In this respect, our findings are parallel to those of Rodd et al. (2002) who also found differences across the visual and auditory modalities. In particular, in our study, when the words were presented in the auditory modality, metaphors showed facilitation in processing relative to control words (although they were still significantly slower that metonymous words). However, when the words were presented in the visual modality, this processing advantage was lost for metaphors. It is conceivable that the fact that visual word processing is a learned activity (i.e., people have to go through schooling in order to learn how to read) as opposed to the more natural auditory task (i.e., all people regardless of their education understand spoken language) differentially affects word processing for metaphors by eliminating the processing advantage that is observed in the auditory task. Metaphors are probably the most vulnerable set of ambiguous words to any differences that may arise due to modality because of the fact that they don't seem to have a fixed status in the lexical ambiguity continuum. Rather, although metaphor is grouped under polysemy, it seems to lie somewhere between "pure" homonymy and "pure" polysemy (e.g., Apresjan, 1974; Nunberg, 1979). Thus, it is possible that metaphors are more prone to any processing differences that may arise from the presentation of words in different modalities. In that respect, the present findings are consistent with those of an earlier study (Klepousniotou, 2002) which used a cross-modal priming task and showed that metonymous words had significantly greater priming effects and were processed significantly faster than homonymous words, while metaphors lay somewhere in the middle and were not statistically different from either homonymous or metonymous words. In addition, it is also conceivable that the observed differences between the auditory and visual experiments could be due to the increased speed of the lexical decisions in the visual experiment, relative to those in the auditory experiment, which could actually mask the processing advantage that was observed in the auditory study for metaphors, as described earlier.

The results of the present study have important implications for models of lexical processing, as well as for the nature of the mental representation of ambiguous words. They seem to be mostly consistent with models that allow for differential representation of homonymy and polysemy in the mental lexicon (e.g., Pustejovsky, 1995). As originally suggested in Klepousniotou (2002), for polysemous words, only a basic sense, which has general specifications about the meaning of the word, may be assumed to be stored in the lexicon. Polysemous words thus have a single, semantically rich representation in the mental lexicon. The extended senses, which are closely related to the basic sense, are generated (presumably on-line) from the basic sense possibly by means of lexical rules (e.g., Copestake & Briscoe, 1995; but cf. Pustejovsky, 1995). These rules are assumed to be stored in the lexicon and they can operate on a basic sense of a lexical item, which is also stored in the lexicon, in order to derive an extended sense of that item. This process is known as sense extension (Copestake & Briscoe, 1995). Although sense extension accompanies many morphological and syntactic changes in the lexicon, there are also processes of conversion that do not affect the major category status of the lexical item involved, and are, therefore, more controversial in nature. Sense extension rules seem to be productive and susceptible to processes such as blocking by synonymous items that already exist in the lexicon (Copestake & Briscoe, 1995). So, for example, although there is a lexical rule that derives "meat" from "animal", it does not work for the lexical item "cow", presumably because it is blocked by the existence of "beef" in the lexicon. Sense extension rules can apply to both metonymic and metaphorical transfers as well as account for novel uses in language.

Having a single representation in the mental lexicon, thus, polysemous words (and in particular metonymous words which are assumed to represent "pure" polysemy) avoid any issues of ambiguity resolution that might compromise the activation process. Since only one meaning is stored, there is no competition among meanings for activation, as might happen in the case of homonymous words. As a result, the activation process is not compromised by extra processing that is caused by the necessity of selecting a single meaning of the ambiguous words when more than one has been activated. Furthermore, given that they are assumed to have a single, semantically rich representation in the mental lexicon, this could also facilitate processing rates relative to unambiguous words. Thus, polysemous words are expected to be processed differently from homonymous words, revealing a processing advantage effect relative to unambiguous words.

On the other hand, as Klepousniotou (2002) discussed, homonymous words have been assumed to have several distinct mental representations, one for each of their multiple and unrelated meanings (e.g., Jastrzembski, 1981; Joordens & Besner, 1994; Klepousniotou, 2002; Rubenstein et al., 1970). Homonymous words are assumed to have a single phonological/orthographic representation in the mental lexicon which is associated with multiple semantic representations. Thus, they have their different meanings represented separately in the lexicon, and are, therefore, understood by selecting their intended meaning from a (presumably exhaustive) list of potential meanings. Thus, homonymy requires the process of sense selection.

In homonymy, the ambiguity is already established and the different meanings (i.e., the semantic representations) of the word pre-exist and are stored separately in the mental lexicon from where they are selected when required. Thus, when a homonymous word is encountered, its multiple unrelated meanings are competing for activation, slowing down the word recognition process. The results of the present set of studies suggest that the fact that homonymous words have separate representations eliminates the processing advantage that is observed for ambiguous words with multiple related senses (i.e., polysemous words and, in particular, metonymous words). Thus, homonymous words are not processed faster than unambiguous control words.

The present findings, thus, corroborate with other recent studies (e.g., Beretta et al., 2004; Rodd et al., 2002) on how lexical ambiguity affects the recognition of words presented in isolation. Unlike previous studies on lexical ambiguity processing (e.g., Borowsky & Masson, 1996; Kellas et al., 1988), which did not distinguish between the different types of ambiguous words (i.e., homonymy, metaphor, and metonymy) and were interpreted as showing a processing advantage for ambiguous words relative to unambiguous words, these more recent studies (Beretta et al., 2004; Rodd et al., 2002), like the present study, draw a distinction between ambiguous words with multiple unrelated meanings (i.e., homonymy) and ambiguous words with multiple related senses (i.e., polysemy).

Previous models of lexical access (e.g., Borowsky & Masson, 1996; Jastrzembski, 1981; Joordens & Besner, 1994) have tried to accommodate the behavioural findings of the so-called "ambiguity advantage" effect. As already discussed in the Introduction, though, data simulations using most of these models have failed to produce effectively the "ambiguity advantage" effect, namely faster processing for ambiguous than unambiguous words (e.g., Besner & Joordens, 1995; Joordens & Besner, 1994; Kawamoto et al., 1994; Piercey & Joordens, 2000; but cf. Rodd et al., 2004). Yet, this finding is not surprising given that previous behavioural data were mostly based on sets of ambiguous words which tended to conflate homonymous and polysemous words. Given the results of the present study, as well as those of Beretta et al. (2004) and Rodd et al. (2002), that clearly distinguish between the two types of lexical ambiguity (homonymy and polysemy), the existing models of word recognition need to be re-considered, so that the advantage found for multiple related senses (i.e., polysemous words), but not for multiple unrelated meanings (i.e., homonymous words), can be better accommodated.

One way previous models attempted to explain the so-called "ambiguity advantage" effect was to resort to multiple representations of ambiguous words in the mental lexicon, and the postulation that ambiguous words benefit from having more than one competitor in the race for recognition. In addition, these models would postulate that there is no competition between the meanings of ambiguous words, but rather cooperation in inhibiting any other competing lexical items (e.g., Jastrzembski, 1981; Kellas et al., 1988). An alternative explanation was proposed by models that used distributed lexical representations so that the same orthographic pattern would be associated with two (or more) different semantic patterns corresponding to the multiple meanings of ambiguous words (e.g., Borowsky & Masson, 1996; Joordens & Besner, 1994). These models would then postulate that the multiple semantic representations would not interfere with each other and, thus, there would be no competition effects.

Interestingly, by removing the postulation that having multiple entries or semantic representations facilitates processing, these models may be able to account for the lack of a processing advantage for multiple unrelated meanings. In general, distributed models of word recognition assume that words are represented as patterns of activation across a set of nodes. These nodes are subdivided into groups that represent the various layers of information (e.g., orthography, phonology, semantics) of any given word (e.g., Gaskell & Marslen-Wilson, 1997; Joordens & Besner, 1994; Kawamoto et al., 1994; Pexman & Lupker, 1999). Furthermore, a feedforward/feedback type of activation is typically assumed between orthography/phonology and semantics. These models can account for the lack of a processing advantage for multiple unrelated meanings (i.e., homonymous words) by assuming competition among the semantic representations of the different unrelated meanings within the semantic component or layer.

In particular, in accordance with the original assumptions of interactive activation models (e.g., McClelland, 1987; McClelland & Rumelhart, 1981; Rumelhart and McClelland, 1981; Rumelhart & McClelland, 1982), one could assume that a similar mechanism to the feedforward/feedback mechanism operates within a processing level (i.e., within the semantic level) as well. This intra-level mechanism (which is considered to be an inhibition only mechanism) affects the recognition process by impeding the activation of neighbouring features that exist within the same level, when they are inconsistent with each other. In the case of homonymy, where the multiple meanings of an ambiguous word are unrelated (i.e., inconsistent with each other), there is no successful rapid activation of a single meaning within the semantic level; instead the inhibition mechanism in this case would result in competition, or perhaps in lack of cooperation, among the semantic units that represent the multiple meanings of the ambiguous word which, in turn, would result in compromised, or at least comparable, processing times for homonymous words relative to unambiguous words.

On the other hand, the same intra-level inhibition mechanism (or rather the inactivity of it) could account for the processing advantage that has been found for ambiguous words with multiple related senses (i.e., the “sense-relatedness advantage” effect). In particular, since the senses of polysemous words (and in particular metonymous words) are closely related, one could assume that they have a considerable number of core semantic units/features in common. These common semantic features constitute the core representation of a polysemous word; in addition, in the semantic representation of a polysemous word, more peripheral features (represented in the same space) are also found, corresponding to a particular sense. Thus, polysemous words are assumed to have richer semantic representations than unambiguous words. Activation of one sense of a polysemous word would entail the activation of the common core features as well as the activation of peripheral features that pertain to that sense. Since the senses of polysemous words are interrelated (i.e., they have semantic features that suggest each other's existence), there would be no competition among their semantic features, but rather synergy (i.e., the intra-level inhibition mechanism would be inactive, in contrast to what would happen with homonymous words). As a result, activation of one sense would also prompt the activation of the other sense through spreading activation to the remaining peripheral features. The spread of activation to the whole set of semantic units/features, thus, would strengthen the activation patterns of any given sense, providing overall stronger activation to the polysemous word in question. Therefore, spreading activation would result in a processing facilitation effect in the recognition of ambiguous words with multiple related senses (i.e., polysemous words) relative to unambiguous words.

Rodd and her colleagues (2004) in fact, as already discussed in the Introduction, offered a model that operated on similar principles and were able to partially simulate their previous behavioural findings, which are largely consistent with the findings of the present study. In particular, their model produced a processing advantage for words with multiple related senses (i.e., polysemous words) and a disadvantage for words with multiple unrelated meanings (i.e., homonymous words). However, the behavioural findings of Rodd et al. (2002), as well as our present findings, do not show a processing disadvantage for homonymous words; there is a trend, but neither study actually found a statistically significant disadvantage in processing these words. Nevertheless, the model offered by Rodd et al. (2004) could produce two opposing effects of ambiguity because unrelated meanings were represented in different parts of semantic space and competed with each other for activation, while multiple senses were represented within a single region of semantic space and combined to form a single large attractor basin. However, it should be noted that, as the authors caution (Rodd et al., 2004, p. 101), the processing advantage of their model for words with multiple related senses would only be seen in tasks for which processing does not depend on the activation of any specific semantic information, such as lexical decision in isolation. In contrast, when one particular sense has to be retrieved, the model predicts a sense disadvantage stemming from competition between senses until a representation is stable, similar to what happens for words with multiple unrelated meanings. This implication of the model, though, may not be in complete agreement with existing behavioural findings that showed that the processing advantage for ambiguous words with multiple related senses holds in context situations as well that presumably require the activation of a specific sense only (e.g., Frazier & Rayner, 1990; Klepousniotou, 2002; but cf. Klein & Murphy, 2001).

Nevertheless, the findings of the present study that have shown a distinction within polysemy, into metaphor and metonymy, necessitate further changes to models of word recognition so that these new behavioural data can be accommodated. For example, a model such as the one proposed by Rodd and her colleagues (2004) could accommodate the distinction within polysemy by manipulating the type of attractor basins for metaphorical and metonymous words. In particular, for metaphorical words, although still representing their multiple senses within a single region of semantic space, the model could assume smaller and deeper attractor basins than the ones for metonymous words, which represent the prototypical words with multiple related senses. This manipulation would presumably lead to longer processing times for metaphorical words relative to metonymous words, while still preserving their advantage with respect to homonymous words which have their unrelated meanings represented in different parts of semantic space.

The same effect, namely the distinction between metaphor and metonymy, could be accommodated in the type of model that we proposed and described above. In particular, metaphorical words, the senses of which are less closely related than those of metonymous words, could be assumed to have less core semantic units/features in common than metonymous words, which would then lead to decreased cooperation/synergy of the multiple senses in the activation of the word. Thus, spreading of activation to the peripheral features that pertain to each sense would be harder for metaphorical than metonymous words. As a result, processing of metaphorical words would be slower than processing of metonymous words, but still faster than homonymous words for which there is no cooperation at all between their multiple unrelated meanings.

In conclusion, the data reported here investigated the effects of different types of lexical ambiguity on the recognition of words in isolation. Multiple unrelated meanings (i.e., homonymous words) were not found to produce any processing advantage in word recognition, in sharp contrast to multiple related senses (and in particular metonymous words) which were found to produce such a processing advantage relative to unambiguous frequency-matched control words. Furthermore, an important division within polysemy was demonstrated for the first time. In particular, it was shown that, even in the presence of a processing advantage, metaphorically polysemous words take longer to process than metonymically polysemous words, providing experimental support to the theoretical linguistic division of polysemy into metaphorically motivated and metonymically motivated polysemy. Overall, the current studies extend previous research by showing that not only is there a distinction between homonymy and polysemy, but also a distinction within polysemy itself. Our findings provide further evidence that the so-called "ambiguity advantage" effect has to be re-defined to reflect the fact that it is close “sense-relatedness” that produces facilitation in word recognition, and suggest differential representations depending on the nature of lexical ambiguity the specific word exhibits.

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Table 1. Mean reaction times in ms (and standard deviations) and percent error rates for each type of experimental word (i.e., homonymy-balanced, homonymy-unbalanced, polysemy-metaphor, polysemy-metonymy, unambiguous control) for the auditory and visual experiments.

		Word type				
		Homonymy		Polysemy		Unambiguous
Experiment		Balanced	Unbalanced	Metaphor	Metonymy	Control
Auditory	Reaction times Mean (SD)	1005 (132)	1024 (124)	944 (129)	908 (125)	985 (107)
	Difference from Control Word	+20	+39	-41	-77	-
	Error rates (%)	6.11%	5.27%	2.22%	1.11%	3.61%
Visual	Reaction times Mean (SD)	557 (73)	564 (90)	554 (79)	541 (70)	566 (76)
	Difference from Control Word	-9	-2	-12	-25	-
	Error rates (%)	1.38%	4.16%	3.88%	1.94%	4.44%

Figure 1. Auditory task: Mean reaction times in ms (and standard errors) for each type of ambiguous words and unambiguous control words.

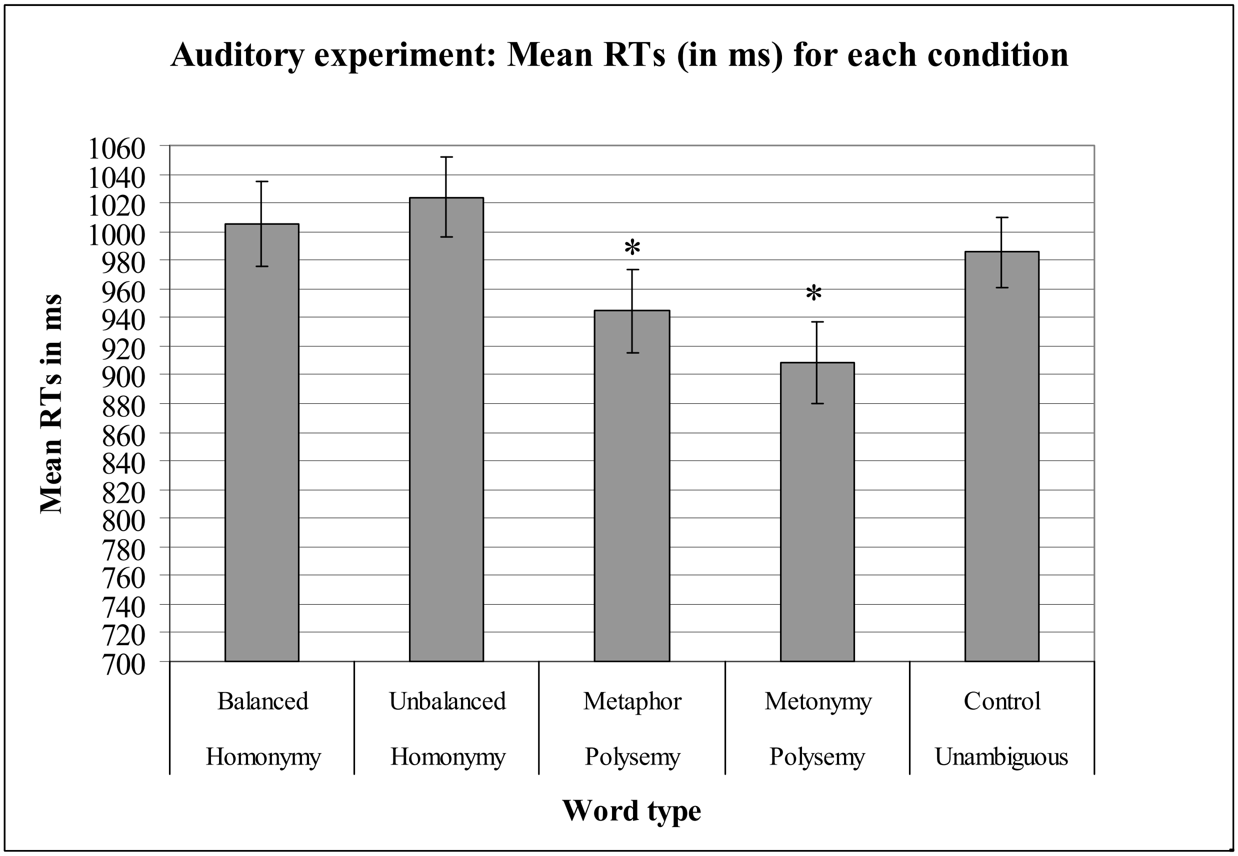
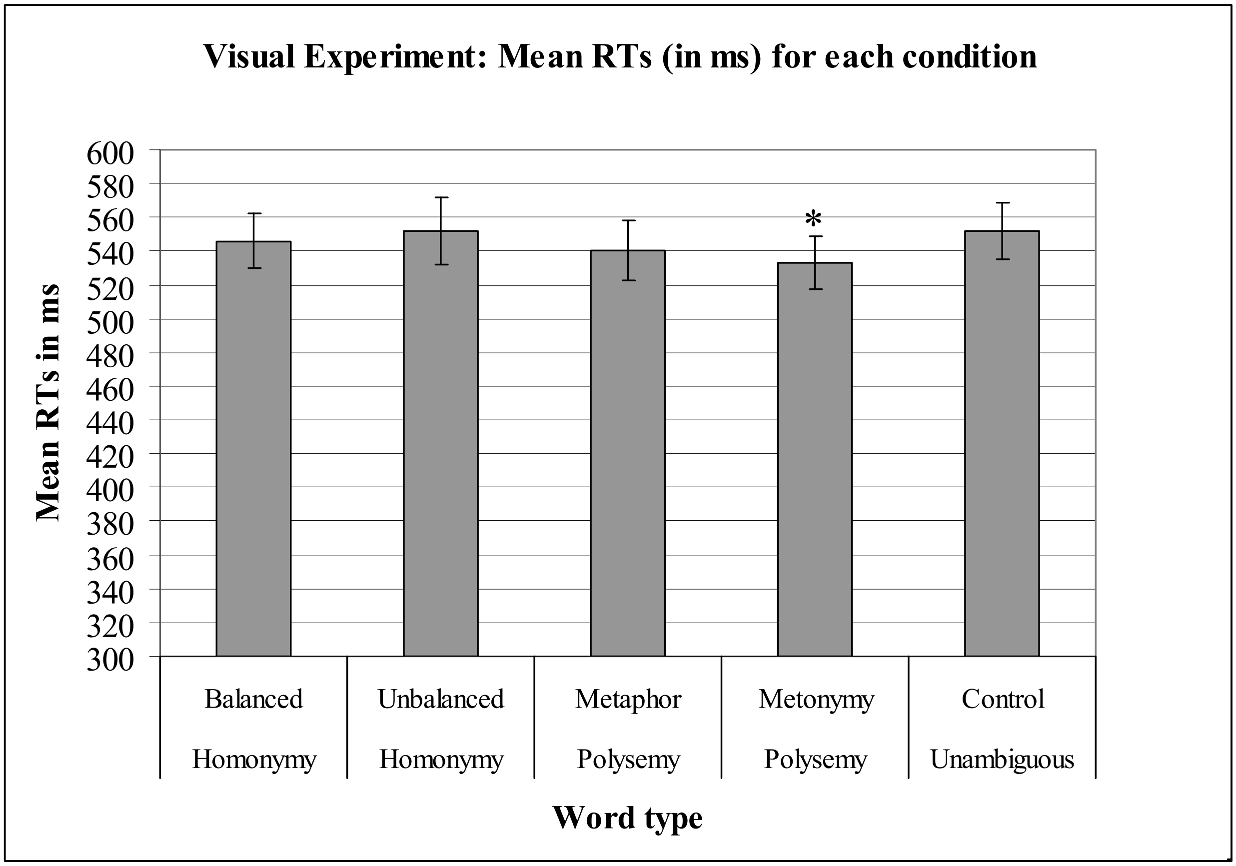


Figure 2. Visual task: Mean reaction times in ms (and standard errors) for each type of ambiguous words and unambiguous control words.



Appendix A

List of stimuli used in Experiments 1 and 2.

Balanced Homonymy	Unbalanced Homonymy	Metaphor	Metonymy	Unambiguous Control
mass	march	mouth	glass	seven
china	race	arm	bottle	clay
cell	file	neck	fig	region
mold	scale	shoulder	cup	notion
match	count	tongue	bag	guest
panel	yard	cow	theater	myth
bowl	drill	star	pipe	noon
pitcher	coach	sheep	lemon	planet
cape	port	lip	onion	tent
pupil	foil	fox	oak	monk
bat	fan	nucleus	pine	lagoon
tap	toll	doll	tub	razor
seal	bolt	pig	bin	cigar
bass	mint	worm	cage	dusk
hail	sage	gem	alley	ink
spade	racket	spice	maple	chalk
cricket	mole	pillar	arena	thorn
tick	perch	parrot	chimney	gust

Filler words	Non-words	Non-words	Non-words
length	lesp	kub	vab
justice	togic	vind	calern
health	ebergy	gricken	fike
speed	folbune	prock	darpim
career	digorce	pober	trage
birth	glame	gair	napion
belief	linerty	nalt	pagorn
motion	snate	rigab	mirg
symbol	shabe	gith	pelton
breath	sagary	hing	wame
depth	hoger	grev	plark
humour	clikate	plazet	reafon
trend	cedlor	zate	tuge
fun	lige	neg	stument
wisdom	galben	reeg	prasen
pride	zold	flaz	prile

proof	gort	nilp	ribal
error	troz	gress	drave
fate	gatch	torg	blaffic
shade	bap	saf	subar
scope	rall	dosk	wurp
ritual	dafe	grost	baple
rhythm	pake	vil	proot
wealth	veck	plem	pladow
shame	zote	woot	zipe
realm	douth	sul	plice
fame	nofe	zild	loat
flame	shourber	sern	lape
horror	wogom	pid	dilt
flavor	zear	jave	plet
custom	gis	wirn	norb
mist	brum	lork	shay
debt	licot	blim	fint
vapor	soog	krog	drick
grief	neach	dolp	plave
token	arkond	gope	sholk
pulse	blail	zibe	tanel
sorrow	glick	spag	skling
rumor	viode	tist	kunch
oath	chidel	murse	sile
glamour	modey	spall	nacket
greed	spirach	glub	foach
mirth	ceber	stape	zal
caveat	dralk	glork	crant
nuance	goice	stom	tunt