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PERCEPTUAL PROCESSING IN SIMILE COMPREHENSION

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ABSTRACT

Psycholinguists have generally assumed that language comprehension is mediated by the use of abstract, propositional symbols. Alternative theories, however, posit a role for analog, imagistic representations in cognitive processing, and indeed, many researchers have obtained evidence consistent with the presence of mental imagery in linguistic tasks. One domain of particular interest with respect to imagery has been figurative language, but research in this area has not been able to demonstrate conclusively whether mental imagery is functionally useful for comprehension.

Thus, the aim of this dissertation was to investigate more directly the role of mental imagery during the comprehension of figures of speech. The general strategy was to employ similes that differ in the degree to which perceptual knowledge is <u>required</u> for comprehension. Specifically, "perceptual" similes like *A rope is like a snake* were expected to provide the strongest evidence for the use of perceptual information during comprehension, given that they may best be understood through a perceptual matching process. These similes were contrasted with so-called "mixed" similes like *A lighthouse is like a candle*, which have meanings that include both perceptual and conceptual components. These mixed similes were used to explore whether perceptual processing would be affected by the availability of other routes for comprehension. Importantly, both types of sentences were presented in the context of experimental tasks that were intended to tap more directly into people's ongoing comprehension processes.

In Experiments 1 and 2, perceptual and mixed similes were presented to participants accompanied by pictures that were either consistent or inconsistent with the perceptual aspects of the similes' meanings. In Experiment 1, a perceptual priming procedure showed that comprehension of the perceptual similes received the greatest facilitation from prior presentation of a consistent picture, but no differences were found in the degree to which the two picture types primed comprehension of the mixed similes. Experiment 2 used a sentence-picture verification task to demonstrate that people are also faster to verify a consistent picture after hearing a perceptual simile. Additionally, this facilitation was present at ISIs of both 0ms and 750ms. For the mixed similes, some weak evidence for the activation of perceptual information was apparent early, but this effect disappeared after the delay. Experiment 3 ruled out the possibility that the results of Experiment 2 were due to the consistent pictures being overwhelmingly more typical or easily recognizable depictions of the target concepts. Finally, Experiment 4 used a visual interference technique to establish that the comprehension of perceptual similes is indeed accomplished through visual processing. For mixed similes, and for two additional groups of relatively abstract similes, no evidence consistent with visual processing was observed. This study was important because it provided direct evidence for the presence of visual representations during comprehension.

Together, these experiments demonstrate that perceptual information can indeed play a role in figurative language comprehension, and that such information is apparently instantiated through visual mental images. These results motivate an account of "perceptual processing" that draws upon previous work in visual working memory and which has implications for language processing more generally. At the very least, this research shows that abstract representations cannot mediate all aspects of figurative language comprehension. For many types of expressions and in many situations, perceptual representations clearly have an important role to play.

CHAPTER 1
INTRODUCTION AND OVERVIEW

Introduction

It has become commonplace to observe that figurative language is a ubiquitous part of everyday language. Indeed, in recent years psycholinguistic research on figurative language has seemed almost as ubiquitous, as metaphors and related expressions have become the focus of numerous studies (see edited volumes by Cacciari & Tabossi, 1993, Mio & Katz, 1996, and Ortony, 1993). Figurative language has received such attention in part because it poses several interesting problems for researchers interested in how people understand language. Consider a sentence like *Thought is a snake sliding and coiling on warming stones*. Obviously, this statement cannot be literally true: a thought is certainly not a snake unwinding itself in the sun. The fact that we can still make sense of this sentence, however, illustrates a fundamental puzzle such expressions pose for theories of language processing. On the surface, sentences like this seem anomalous: Juliet is not really the sun, nor is my job really a jail. In spite of this fact, metaphorical expressions are generally understood just as easily as literal sentences, especially in an appropriate context (Gildea & Glucksberg, 1983; Glucksberg, Gildea, & Bookin, 1982; Ortony, Schallert, Reynolds, & Antos, 1978; Shinjo & Myers, 1987).

Yet there remains the introspective sense that metaphors and similar expressions are somehow processed differently from other forms of language (Gibbs & Gerrig, 1989). Given this apparent contradiction between intuition and evidence, it is natural to speculate about the commonalities and differences that might underlie literal and figurative language processing. Some philosophers and psychologists have argued that literal language is fundamentally different from other, figurative uses of language (e.g., Dascal, 1987), while others have denied the necessity of making a distinction between the literal and the metaphorical altogether (Gibbs, 1989; 1994). Within cognitive psychology, researchers have begun to focus upon the general capacities that might mediate both types of language (e.g., analogical mapping, Gentner & Wolff, 1997; conceptual metaphor, Gibbs, 1994; categorization, Glucksberg & Keysar, 1990). As a result, theories of language processing more generally are beginning to recognize the need to explain how people comprehend figures of speech (e.g., Kintsch, 1998; Wisniewski, 1997).

While a substantial portion of these debates has centered around the particular processes that play a role in figurative language comprehension, relatively little attention has been devoted to the type of knowledge representation that makes metaphorical interpretation possible in the first place. Most models of metaphor, when they have been explicit about this issue at all (e.g., Gentner & Wolff, 1997; Ortony, 1979; Verbrugge & McCarrell, 1977), have been content to adapt already-existing models of conceptual or linguistic representation. Specifically, these models usually assume some type of abstract propositional representation. This is not surprising, given that networks of amodal propositions have been considered by many psychologists to be the primary mode of cognitive representation.

Recently, however, such amodal models of cognition have been called into question (e.g., Lakoff, 1987). Instead, a number of researchers have proposed that the human conceptual system must necessarily be rooted in modality-specific knowledge structures (Barsalou, in press; Glenberg, 1997). The possibility of such perceptual representations will be considered in some detail, but for now, the primary implication of this view is that, if perceptual representations do mediate our cognitive activities, then this presumably holds true for language comprehension as well, including figurative language. In other words, metaphor comprehension might be accomplished via representational structures other than networks of abstract propositions.

This dissertation, then, will examine whether or not metaphors and similes can be understood at least in part via modality-specific representations. Such representations may often (but not always) be experienced as conscious mental images (Barsalou, in press; Paivio & Walsh, 1993). These perceptual representations, derived from sensory experience, could aid metaphor comprehension by directly instantiating information about the visual (or other sensory modality) appearance of entities, and about the relations between them. As Ortony (1975) has pointed out, metaphors package aspects of experience into particularly compact chunks, which may often require imagery to specify their underlying meanings in full detail. Indeed, he states that metaphors may derive much of their power from their "proximity to perceptual experience" (Ortony, 1975, p. 50).

The importance of mental imagery to cognitive processing has been a matter of some debate. Indeed, much of the early research on this issue has been subject to multiple reinterpretations (for reviews, see Finke, 1989, and Tye, 1991). This has not, however, discouraged numerous researchers from considering whether imagery might be related to linguistic processing. And in particular, a number of these investigations have focused on the specific relationship between imagery and figurative language. Because figures of speech do often seem to be particularly vivid, image-inducing modes of expression, they are a natural domain in which to explore the connections between language and imagery (Honeck & Hoffman, 1980). It has been suggested, for instance, that imagery might aid metaphor processing by facilitating the discovery of relevant similarities (Helstrup, 1995; Johnson & Malgady, 1980; Miller, 1993), by allowing efficient storage and retrieval of information (Paivio & Begg, 1981; Paivio & Walsh, 1993), or by providing increased flexibility in metaphoric processing (Ortony, 1975; Paivio & Begg, 1981). I shall argue, however, that much of the empirical research on this issue is problematic when it comes to addressing a more fundamental issue: Do imagistic representations have a functional role in the comprehension of metaphor? This dissertation is intended to provide a more definite answer to this question.

Overview of the dissertation

To provide an adequate framework for this undertaking, I will first review previous research relating to imagistic processing, language, and metaphor. Chapter 2 will consider various types of evidence relating to a possible relationship between imagery and language, and in particular I will highlight an approach that has had a great deal of influence in this area: Paivio's (1986) dual-coding model. Other research investigating the connections between imagery and language will be discussed as well. Then, I will describe two recent proposals concerning perceptual processing and cognition (Barsalou, in press; Glenberg, 1997), both of which support the claim that perceptual representations might have an important role in language processing. Chapter 3 will present a selective review of the literature concerning imagery and figurative language comprehension. The general conclusion will be that the methodologies and materials used in much of this work have been inadequate for exploring the role for imagery in the online comprehension of figurative language. I will then propose that a productive starting point for approaching this problem involves the use of figures of speech that are most likely to require the use of mental images for successful comprehension. These so-called "perceptual" metaphors and similes will be described in detail. Such perception-based expressions will enable me to establish a more definitive role for imagery in at least one type of figurative language. With this evidence in hand, it should then be possible to consider the role of perceptual processing in language more broadly.

To accomplish these goals, four experiments were carried out. Experiment 1 uses a perceptual priming paradigm to demonstrate that comprehension of similes can be aided by the prior presentation of a relevant pictorial stimulus. In particular, such perceptual facilitation will be primarily apparent for the group of similes that have meanings rooted in perceptual resemblances between concepts. Experiment 2 uses a sentence-picture verification paradigm to establish a similar finding. In this study, the positive verification of pictures will be facilitated by prior simile comprehension, suggesting that comprehension processes activated perceptual information that was then available for making the verification decision. Again, this facilitation will be strongest in the context of the perceptual similes, although there will be some indication that such facilitation may occur for other similes having concrete components as well. Experiment 3 rules out the possibility that some of the pictures may have been more readily recognizable. Finally, Experiment 4 uses an interference paradigm to investigate whether the processing involved in simile comprehension has a specifically visual component. The results of this study will confirm that visual processing does indeed play a role in the comprehension of perceptual similes. For other similes, which have primarily relational interpretations, equivalent evidence for visual processing will be lacking.

In general, by employing experimental tasks that more directly tap into online comprehension processes, and by using a range of figurative expressions, some of which are especially likely to involve imagistic processing, this dissertation will shed light on when and how imagery can mediate the comprehension of metaphors and similes. In doing so, it will demonstrate that perceptual representations must be taken into account if one hopes to provide a complete model of how people understand figurative language. Finally, given that metaphorical and literal language may very well be two sides of the same coin, this evidence will suggest that models of language comprehension more generally must consider the possibility of perceptual processing as well.

CHAPTER 2
IMAGERY AND LANGUAGE

The dual-coding view

Much of the research investigating the relationship between imagery and language processing has been motivated by Paivio's (1986) dual-coding theory of cognitive representation. This model states that both verbal and imagistic codes are utilized in representing and processing linguistic information. That is, concepts are thought to be encoded not only via verbal associations, but through analog imagistic representations as well. For example, our knowledge about a concept like "apple" consists not only of verbal associates like "fruit" and "tree" that are related to apples in our semantic network, but we also have access to mental images of an apple's shape, color, texture, and the like. The mental images that are activated in response to verbal input are thought to make language processing more efficient by providing an alternate route through which comprehension can take place, as well as a means by which information can be stored in a holistic fashion. These verbal and visual systems are considered to be independent but interconnected, such that information from one system can activate information in the other. In addition, the imagery system is assumed to construct "synchronously organized, integrated informational structures, analogous to the continuous, structural layout of the perceptual world" (Paivio & Walsh, 1993, p. 320). Importantly, the probability that an image will be invoked in response to a particular concept depends on the degree to which that notion is concrete -- abstract words and phrases are thought to be handled primarily by verbal processes.

A substantial amount of data has been marshaled in support of the claims of dual-coding (for reviews, see Paivio, 1986; 1991), although much of it has focused on the processing of individual words. In general, it has been shown that words can elicit mental images as well as verbal associates, and that visual scenes can be encoded either imagistically or through verbal descriptions. Both pictures and concrete words lend themselves to superior recall compared to abstract words, and instructions to use imagery generally enhance performance, especially on tasks involving concrete materials. Measures of individual differences in visual or imagery abilities have also revealed that people with strong visual skills perform relatively well on various experimental tasks that lend themselves to imaginal processes. Neuropsychological studies (e.g., Kounios & Holcomb, 1994) have also shown that concrete and abstract materials produce different distributions of neural activation, consistent with Paivio's claims. The dual-coding view, then, is certainly compatible with the idea that imagistic representations have a functional role to play in figurative language comprehension, particularly for sentences that have concrete elements.

Imagery and sentence comprehension

In addition to the findings mentioned above, other studies investigating sentence comprehension have also obtained results consistent with the tenets of dual-coding. For example, sentences high in concrete content are generally understood more rapidly than their abstract counterparts (Holmes & Langford, 1976; Jorgensen & Kintsch, 1973; Klee & Eysenck, 1973). As Paivio (1986) points out, this processing advantage for concrete sentences supports dual-coding because the presumed imagistic codes available for concrete material should provide alternate routes for comprehension. Furthermore, Belmore, Yates, Bellack, Jones, and Rosenquist (1982) measured verification latencies for inferences of concrete and abstract sentences, and demonstrated that this advantage for concrete materials extends to inferential processing as well. Such results have generally been interpreted as indicating that concrete words and sentences more directly activate information relevant to their interpretation. Abstract sentences, on the other hand, may require elaborative context in order for equally rapid comprehension to occur (Schwanenflugel & Shoben, 1983).

Despite Paivio's (1986) claims to the contrary, it is relatively difficult, however, to decisively attribute such effects to perceptual processing (Kieras, 1978). Concrete linguistic materials may have other properties, such as greater distinctiveness (Marschark, Richman, Yuille, & Hunt, 1987), that could also explain why they lend themselves to faster comprehension. Thus, it is necessary to consider research that explores more directly the role of imagery in sentence comprehension. One line of research addressing this issue was carried out by Glass and his colleagues. In an initial set of studies, Glass, Eddy, and Schwanenflugel (1980) generated sentences such as *The stars on the American flag are white*, which were intended to require access to perceptually-stored information for verification, while other sentences were low in imagery and did not involve such information. Half of the participants carried out a sentence verification task alone, while the other half was given an additional secondary task in which a visual pattern was presented both before and after each sentence. These participants were asked to indicate whether the second pattern was the same or different as the first. This secondary visual task was intended to interfere with verification of the high imagery sentences, under the assumption that the two tasks involve similar visual processes.

Unlike previous research (Holmes & Langford, 1976; Jorgensen & Kintsch, 1973) which found shorter comprehension times for concrete sentences, Glass et al. (1980) discovered that their high imagery sentences took significantly longer to verify, even in the absence of the secondary visual task. Performance on this secondary task, however, revealed that visual patterns following a high imagery sentence took significantly longer to identify than those following low imagery sentences, and were also more likely to be misidentified. Glass et al. (1980) interpreted this result as evidence for selective interference between the imageable sentences and the visual processing necessary to perform the pattern identification task.

Eddy and Glass (1981) attempted to demonstrate a similar selective interference effect, but utilized a different sort of concurrent visual processing. They used a subset of the sentences from Glass et al. (1980) in both a sentence verification task and a meaningfulness judgment task, presenting these sentences either visually on a computer screen or auditorily via headphones. The rationale was that the modality of presentation, either visual or auditory, should selectively interfere with analogous components of sentence processing, either imagistic or verbal, and should do so differently for the high and low imagery sentences. In the verification task, participants judged the truth or falsity of the sentences, while the comprehension task required participants to judge their meaningfulness. The results revealed an interaction between presentation modality and sentence type in both the verification and comprehension tasks. High imagery sentences took longer to verify and to comprehend under visual presentation, while there was no difference between reaction times to high and low imagery sentences when presented auditorily. Eddy and Glass conclude that imagery must be playing a role in sentence comprehension, especially for sentences high in imagery. This selective interference upon the verification and comprehension of visually-presented high imagery sentences was taken as evidence in favor of Paivio's (1986) dual coding hypothesis.

A major problem with interpreting the results of Eddy and Glass (1981), however, is that their comprehension task confounded meaningfulness with truth value: the meaningful sentences were all true, while the distractor sentences were all false variations of the target sentences (e.g., *A baseball team has nine players* was transformed into *A baseball team has nine flavors*). As a result, these materials could have prompted participants to carry out an implicit verification task, which would explain the analogous results for the verification and meaningfulness judgment tasks. Therefore, it was crucial to investigate whether selective effects due to imagery could be demonstrated in a task that more clearly involved straightforward comprehension. To this end, another set of studies was carried out by Glass, Millen, Beck, and Eddy (1985), who generated sentences that were indeterminate in truth value but still varied in imagery value. Thus, a sentence rated high in visual imagery was *His shirt looked like a giant checkerboard* while a low imagery sentence was *She was at the top of her class*. These sentences were presented either visually or auditorily in a meaningfulness judgment task, as in Eddy and Glass (1981). In this study, there were no effects of either sentence imagery or presentation modality upon reaction times, across several experiments. Glass et al. (1985) conclude that imagery must only play a role in sentence verification when truth value must be assessed against the real world, and that visual processing is not a necessary component of comprehension.

Glass et al. (1985) suggested, however, that visuospatial components of semantic representations could still play a role in linguistic processing, but may do so to varying degrees of automaticity. Thus, sentences high in concrete content, such as *An apple is red*, may prompt relatively rapid automatic access of visuospatial information, while other sentences, like *The Statue of Liberty holds her torch in her right hand*, may involve more effortful and time-consuming access to similar information. As a result, these concrete/effortful sentences would take longer to verify than concrete/automatic sentences, given the extra processing time necessary to generate the appropriate information. This can account for why Glass, et al. (1980), unlike previous studies (Holmes & Langford, 1976; Jorgensen & Kintsch, 1973), found longer verification times for their concrete sentences.

Glass et al.'s (1985) continuum of visuospatial automaticity, although primarily aimed at explaining sentence verification rather than comprehension, nonetheless takes into account the important fact that not all high imagery sentences may be processed similarly. When experimental participants are asked to process sentences in isolation, they bring to bear whatever information seems relevant, all else being equal. In particular, imagistic information for familiar, concrete entities may become activated independent of a particular context (Schwanenflugel, 1991). For a sentence verification task, such information is likely to be especially important when perceptual knowledge is necessary in order to give an accurate response.

The question remains, however, whether the same can be said about sentence comprehension more generally . A high imagery sentence like *Huge black clouds gathered on the horizon* could have been judged as meaningful without necessarily accessing any kind of mental image. Indeed, participants may have chosen to process the sentences for meaning at the expense of elaborative imagery. As suggested by Walter and Fox (1981), semantic and perceptual elaboration may be involved in a trade-off affected by task demands and processing goals (cf. Kieras, 1978). In general, perceptual processing may be less crucial for sentences and in contexts in which access to modality-specific information is relatively optional.

Theories of perceptual representations

Thus, the empirical evidence concerning imagistic processing in language comprehension appears somewhat equivocal and subject to particular constraints. However, there are significant theoretical reasons to believe that perceptual processing could indeed have a pervasive influence on how people understand language, and indeed, how they understand the world at large. Until recently, however, most cognitive theories have assumed, to varying degrees of explicitness, that mental operations are generally accomplished through the manipulation of abstract symbols (e.g., Fodor, 1975). Furthermore, such theories have often explicitly denied the possibility that analog, perception-based representations play a role in higher-order processing (Pylyshyn, 1973). Instead, a standard assumption within cognitive psychology has been that sensory information must first be transduced into amodal form prior to further processing. As a result, these abstract symbols have an arbitrary relationship to their original perceptual states (Barsalou, in press).

Recently, however, a handful of researchers have begun to reevaluate whether such abstract symbols are necessary. These theorists propose instead that analog, perceptual representations are central to cognitive processing. In general, these perception-based accounts of cognition offer an intriguing set of arguments in favor of a role for perceptual representations in both conceptual processing and language comprehension. Two related proposals that will be discussed here are the Indexical Hypothesis of Glenberg (1997; Glenberg, et al., 1998) and the perceptual symbols approach outlined by Barsalou (Barsalou, in press; Barsalou & Prinz, 1997).

Both Glenberg (1997; Glenberg, et al. 1998) and Barsalou (in press) begin with the observation that theories of meaning which rely upon abstract symbols (such as propositions) confront the problem of *symbol grounding*, which was described by Harnad (1990) as the difficulty of assigning meaning to arbitrary symbols without a priori knowledge of how these elements are mapped to the world. Without such knowledge, one is only able to interpret symbols in reference to other arbitrary symbols, resulting in an endless regress. As both Glenberg (1997) and Barsalou (in press) argue, without such grounding, the determination of meaning is impossible. To complicate this further, unlike categories based on arbitrary symbols, which must be Aristotelian, human semantic categories are often fuzzy (Glenberg, 1997). In addition, a multitude of mappings are possible between a given abstract symbol system and the world (Putnam, discussed in Lakoff, 1987). For these reasons, Glenberg and Barsalou suggest that amodal symbol systems are inadequate to properly describe human cognition. Instead, they propose that knowledge is directly grounded in perception. As they argue, perceptual representations are able to fully account for our sophisticated cognitive abilities without being compromised by the kinds of problems faced by abstract symbol systems described above.

Since Barsalou's proposal is the more general, it will be described briefly first. In his account (Barsalou, in press; Barsalou & Prinz, 1997), human cognition is based in "perceptual symbols," which are direct encodings of the neural activation that occurs during perception of some event or scene. Such perceptual symbols are unconscious and schematic, taking advantage of selective attention to store extracted elements of experience in memory. Furthermore, multiple encodings of similar entities can become organized around a common frame, which results in the implementation of a "simulator" that can subsequently simulate aspects not only of sensory experience, but also of proprioception and introspection as well. It is these simulators that form the basic conceptual system, which in turn can accomplish higher-order functions like the representation of types, categorization, and inferential processing. While the details of Barsalou's extended proposal go beyond the present context, the important point is that these sophisticated cognitive functions emerge out of a symbolic system that is directly rooted in perception. Thus, the human conceptual system shares a great deal (if not all) of its representational apparatus with perception, an assumption which leads Barsalou to predict that "perceptual systems should become engaged when people perform conceptual processing" (Goldstone & Barsalou, 1998, p. 236). Indeed, Barsalou (e.g., Solomon & Barsalou, 1999) has obtained evidence for spontaneous perceptual processing in tasks that are traditionally thought to involve the use of abstract semantic features, such as property verification.

Barsalou's theory of perceptual symbols is primarily an account of the human conceptual system rather than linguistic processing per se. He does suggest, however, that "[l]anguage comprehension can be viewed as the construction of a perceptual simulation to represent the meaning of an utterance or text" (in press, Sec. 4.1.6). Such simulations are thought to be constructed in response to the "processing instructions" contained within texts dealing with specific individuals and the relations between them. To anticipate the present research, this approach is in accord with the claim that perceptual processing could be involved in the understanding of metaphors and similes. Upon encountering a simile like *A rope is like a snake*, a comprehender might initiate a simulation of both a rope and a snake and then undertake transformations of one or both of these entities to arrive at a suitable representation of the meaning of the sentence as a whole. It should be noted, however, that Barsalou does not insist that a given simulation be limited to the "literal" content of a sentence -- perceptual symbols and simulations can be quite flexible. This means that a word like *jail* should be able to invoke perceptual simulations not only of literal jails, complete with cells and guards, but should also simultaneously induce a simulation of a schematic "confining situation" in order to understand a sentence like *My job is a jail.*

Finally, it is important to note two differences that distinguish Barsalou's framework from Paivio's (1986) dual coding view. First, Barsalou assumes that perceptual representations underlie all types of language, not just the most concrete elements. This constrasts with Paivio's claim that abstract concepts can only be understood verbally. Secondly, Barsalou believes that perceptual simulations are usually unconscious and take place without our awareness. Paivio often seems to suggest, however, that mental imagery is necessarily conscious. For Barsalou, the mental images that we sometimes experience in response to particular stimuli are only the conscious reflection of underlying perceptual simulations, not all of which will necessarily induce conscious imagery.

Glenberg (1997; Glenberg, et al., 1998) has developed an account of human cognition and memory that is in many ways similar to and complements Barsalou's perceptual symbols approach. Glenberg argues that the nature of our conceptual systems is determined to a large extent by the manner in which our bodies interact with the environment. This "embodied" approach (sharing considerable overlap with Lakoff, 1987) entails that the meaning of a particular situation for an organism is the set of actions available to that organism in that situation, which is in turn dependent upon the affordances of the situation, the individual's experiences, and the individual's goals for action (Glenberg, et al., 1998). All of these determinants for action can be "meshed," or integrated in a way that respects bodily constraints. For example, sitting cannot be integrated with jumping, which prevents these concepts from successfully meshing. This meshed set of actions is the individual's understanding of a given situation.

Glenberg's proposals concerning the embodied nature of concepts and the centrality of "mesh" have a number of consequences for human cognition -- including, among other things, language comprehension. In his formulation, language comprehension is "the successive transformation of conceptualizations that are patterns of possible action" (Glenberg, 1997, p. 12). That is, conceptualizations of the situation described by a text are derived via mesh and transformed as needed as successive textual elements are encountered. In particular, Glenberg, et al. (1998) propose the Indexical Hypothesis, which states that as linguistic words and phrases are encountered, they are first indexed to actual objects or to analogical perceptual symbols, which can be exactly those described by Barsalou (in press). Then, these objects or symbols are used to derive affordances for action, which are then meshed according to the syntax of the sentence. Thus, a stool has particular affordances such that a sentence like *John stood on the stool* is understood so that John is on the stool rather than under the stool. Importantly, Glenberg states that "[a] sentence is meaningful to the extent that the reader can then mesh the objects and activities as directed by the sentence" (Glenberg, et al., p. 7). In this respect, the indexical hypothesis is a type of mental model theory (Johnson-Laird, 1983), because it involves representations of a situation rather than representing the language itself. Crucially, these representations are rooted in bodily experience and perception. This entails, in a manner similar to Barsalou's perceptual symbols approach, that language comprehension and related cognitive processes are always perception-based.

Glenberg, et al. (1998) describe several experiments providing evidence in favor of the indexical hypothesis. In one study, people were much more likely to interpret as meaningful sentences in which concepts could be meshed in novel ways in accordance with their affordances. For example, participants found a sentence like *As a substitute for her pillow, she filled up an old sweater with leaves* much more meaningful than *As a substitute for her pillow, she filled up an old sweater with water*, even though on a purely associative account (Landauer & Dumais, 1997) "water" was just as related to "pillow" as "leaves."

Glenberg's indexical hypothesis, therefore, supplements Barsalou's perceptual symbols account of representation by offering an account of how perceptual symbols might play a role in language comprehension. Namely, people find a particular sentence meaningful to the extent that they are able to "mesh" the affordances of the perceptual symbols generated in response to the sentence. Again, to foreshadow the current research, consider how this process might be applied to *A rope is like a snake*, compared to a nonsense simile like *A cathedral is like a skateboard.* In the former sentence, the perceptual representations of a rope and snake can be meshed directly on the basis of their perceptual similarity (cf. Goldstone & Barsalou, 1998). This successful mesh is what allows people to judge the former sentence as meaningful. Such mesh, however, may not be possible for the cathedral and a skateboard in the second sentence -- just as "pillow" and "water" were not able to be similarly integrated by the participants in Glenberg, et al.'s (1998) study. Note that the concept of "mesh" should work equally well for less-perceptual similes such as *A lighthouse is like a candle* or *A mind is like a sponge*. As long as the affordances found in the representations of "candle" and "sponge" can be meshed with "lighthouse" and "mind" respectively, then interpretation should be successful.

In summary, then, the available research and theory relating to imagistic processing and language would seem to suggest that imagery (or perceptual representations) should indeed play a substantial role in how particular sentences are understood. In particular, the proposals outlined by Barsalou and Glenberg implicate perceptual processing in nearly all aspects of cognition and language use. Given, however, the success of abstract symbols in accounting for a wide variety of cognitive phenomena, the burden is on these perceptual approaches to generate empirical predictions that can not be easily explained by amodal processing accounts (e.g., Solomon & Barsalou, 1999). In the domain of language comprehension, however, much of the previous work on imagery has not been able to clearly rule out such amodal explanations. As suggested by Glass, et al. (1985), sentences may vary in the degree to which they automatically induce perceptual processing. For this reason, what may be needed in order to conclusively demonstrate the involvement of imagery in language comprehension are linguistic materials that require accessing perceptual information in order to be understood. Once such an initial demonstration is achieved, then further investigation with other types of language can proceed. In the next chapter, I will argue that certain kinds of figurative expressions will be an appropriate place to begin.

CHAPTER 3
IMAGERY AND FIGURATIVE LANGUAGE

The research presented in the previous chapter offers a mixed portrait of the potential relationship between imagery and language. In some contexts, particularly with concrete materials that demanded perceptual processing, evidence consistent with the use of imagery was observed. In another contexts that did not induce similar demands, evidence for the use of perceptual information was limited (e.g., Glass, et al., 1985). What, then, about the relationship between imagery and figurative language? As suggested by Riechmann and Coste (1980), "the disparate semantic domains of metaphor may *require* imagery for comprehension to occur, whereas a semantically consistent, literal sentence may be comprehended without using imagery" (p. 195, emphasis in original). As I shall argue, figurative language should be an especially useful domain for consideration of these issues. Indeed, as Experiments 1 and 2 will explore, some figurative expressions may be understood by directly utilizing perceptual information, analogous to the manner in which we judge whether the Statue of Liberty holds her torch in her right hand. Thus, for a sentence like *A cotton ball is like a cloud*, the question to be addressed is whether perceptual representations play a role online in how people instantiate knowledge about the topic (*cotton ball*) and vehicle (*cloud*) domains, which in turn allows them to derive the metaphorical meaning, or grounds (e.g., soft and fluffy).

Dual-coding and metaphor

What evidence exists concerning the relationship between imagistic processing and metaphor comprehension? From the standpoint of dual-code theory, Paivio and Walsh

(1993) suggest five ways in which visual and verbal representations might aid metaphor processing: 1) dual codes can enhance the probability of finding a common metaphorical ground by allowing information from both verbal and imagistic sources to contribute to the final product; 2) images could make for efficient information storage by being organized into large integrated chunks (cf. Ortony, 1975); 3) imagery may ensure processing flexibility and freedom from sequential constraints; 4) the topic and vehicle can serve as retrieval cues for relevant information; 5) verbal processes can keep search and retrieval on track by constraining what is considered relevant.

Although each of these suggestions are motivated by the tenets of dual-coding, supporting evidence from research on metaphor is limited. One idea that has been investigated is whether metaphorical vehicles can serve as "conceptual pegs" for understanding. Paivio (1986) suggested that the vehicle may be particularly important in metaphor processing given that it supplies the properties that are attributed to the topic. In particular, it was hypothesized that a given vehicle may be an especially potent conceptual peg to the extent that it is high in imagery. To test this claim, Paivio and Clark (1986) presented participants with metaphors that varied in topic and vehicle imagery. Additionally, in order to investigate which component would have a greater influence upon subsequent processing, each metaphor was preceded by either its topic or its vehicle alone, as a prime. Participants were asked to indicate when they had understood the metaphor, after which they wrote a brief paraphrase for the sentence. Reaction times overall were quite slow, ranging between 10 and 16 seconds on average, which suggests that participants were waiting until they had a fully thought-out paraphrase in mind before giving their response. Despite this fact, the results did show some differences. Metaphors with high imagery vehicles exhibited generally faster comprehension times and led to more successful interpretations, consistent with the conceptual peg hypothesis. Contrary to this hypothesis, however, presenting the vehicle prior to comprehension produced significantly slower reading times for the metaphors overall. Paivio and Clark (1986) suggest that their vehicle primes, unconstrained by further context, may have led to the consideration of irrelevant properties, interfering with subsequent processing of the metaphor. This possibility is consistent with the findings of McGlone and Manfredi (1997), who showed that presenting metaphor-irrelevant properties of vehicles does indeed interfere with subsequent comprehension. In general, however, the importance of high-imagery vehicles for comprehension was supported by this work.

The conceptual base hypothesis

In opposition to the dual-coding position, other researchers have questioned the basic assumption that figurative language processing must necessarily involve some kind of mental imagery. In particular, Honeck and his colleagues (Honeck, 1973; Honeck, Riechmann, & Hoffman, 1975; Honeck & Temple, 1994) have proposed the *conceptual base hypothesis*, which states that figures of speech are understood via abstract representations that are independent of either linguistic or imagistic codes. According to this view, understanding a given expression involves accessing or constructing an appropriate abstract conceptualization of its meaning (cf. Potter, Valian, & Faulconer, 1977). Imagery is considered to be epiphenomenonal, related to the surface instantiation of a given expression, with no useful role in arriving at its meaning.

The results of several studies have been taken as support for the conceptual base hypothesis. Honeck (1973) found that recall of proverbial expressions such as *Great weights hang from small wires* was best when cued by paraphrases of their meanings, even though these paraphrases were generally more abstract than the proverbs themselves. This recall advantage for paraphrases was present for proverbs that had been rated both high and low in imagery, although high imagery proverbs were generally recalled better. Honeck, Riechmann, and Hoffman (1975) used a similar recall task and found that good (as opposed to poor or mediocre) interpretations and brief story prompts illustrating the proverbial meaning were most useful as recall cues. All of these effective cues were related to the conceptual content of the proverbs. Again, however, high-imagery proverbs produced better recall. Similarly, Verbrugge & McCarrell (1977), using metaphors, found that paraphrases of metaphorical grounds were more effective as recall cues than either the topic or vehicle nouns alone. Both Honeck (1973; Honeck, et al., 1975) and Verbrugge and McCarrell (1977) conclude that figurative understanding must be mediated by an abstract semantic level of representation, which can be accessed most directly with the appropriate conceptual paraphrase. These data do not necessarily rule out a role for imagistic processing, however. For example, it is possible that the scenarios used in Honeck, et al. (1975) were themselves understood imagistically, improving recall for the target proverbs. Also, it should be noted that high-imagery proverbs were in general more likely to be recalled than expressions low in imagery. This finding is consistent with other work showing superior recall for concrete verbal materials (Paivio, 1986; although see Marschark and Hunt (1989) for an alternative view).

In interpreting their results, Honeck et al. (1975) suggest that high-imagery proverbs may lend themselves more easily to the construction of the requisite conceptual base, which is then stored in memory for later retrieval. Although this speculation is consistent with the claim that proverb recall is mediated by an abstracted conceptual base, imagery could still play a role in initial comprehension. Riechmann and Coste (1980) attempted to investigate this possibility more directly by presenting participants with proverbs and instructing them to either form a mental image of each proverb or to comprehend its meaning as accurately as possible. The participants were then given interpretations of the proverbs, which had been previously rated as being either low or high in imagery, and were asked to indicate if a proverb with that meaning had been presented previously. The crucial result was that participants in the comprehension group performed better on this task than those in the imagery group. Riechmann and Coste argue that instructions to comprehend induced participants to encode a representation of the meaning of each proverb that was general enough to be accessed later by the interpretations, in agreement with the notion of a conceptual base. They also interpret the relatively poor performance by participants who had generated images for the proverbs as indicating that imagery may have interfered with successful comprehension. They conclude that imagery is a "tangential" phenomenon, useful only at a shallow level of processing. Forming a mental image of a proverb, however, is not necessarily the same thing as forming a mental image of the *meaning* of the proverb. Participants instructed to use imagery may have chosen to focus on the surface elements of the expressions, which could have indeed produced interference in the meaning recognition task. And as a result, less attention may have been given to the actual meaning of each proverb under these conditions. The two sets of instructions, therefore, do not appear to have given participants equal incentive to encode the meanings of the proverbs.

So are there any useful conclusions that can be drawn from these studies testing the conceptual base hypothesis? Abstracted interpretations, scenarios describing the meaning of a proverb, and general instructions to comprehend all resulted in better performance in the recall and recognition of common proverbs. And given related work in memory for sentence gist (e.g., Bransford, Barclay, & Franks, 1972), it is likely that people do encode some kind of representation of the meaning of these expressions. The claim, however, that imagery plays no role in processing seems overly strong, however. The consistent advantage in recall for proverbs rated high in imagery suggests that even if some kind of conceptual base is indeed encoded, it might still be at least partially influenced by the presence of imageable information.

Additionally, proverbs may be somewhat unique due to the fact that their literal elements are often an oblique instantiation of the proverbial sense of the expression, which is itself something held to be more generally true. For example, *Great weights hang from* *small wires* can be depicted literally by the image of a large boulder hanging from a thin strand, but this image is probably not sufficient in itself to communicate the meaning that momentous events or ideas are often dependent upon small details (although see Honeck and Kibler, 1985). This point may be even more likely to hold true as expressions become more opaque. As Marschark and Hunt (1985) point out, "generating an image . . . of the act of sewing will no more facilitate understanding of *A stitch in time saves nine* than an image of equine molars will for *Don't look a gift horse in the mouth*" (p. 414). Thus, one might question the validity of generalizing findings concerning the effects of imagery upon proverbs onto considerations of figurative language in general and to the online understanding of metaphors and similes in particular. Cacciari and Glucksberg (1995) make a similar argument with respect to idiom processing and the role of imagery in interpretation.

Further evidence for imagery in metaphor

The conceptual base hypothesis aside, Honeck and his colleagues have not been the only psychologists to investigate the relationship between figures of speech and imagery. For example, Harris, Lahey, and Marsalek (1980) conducted a study in which they presented novel metaphors (*The ivy cuddled up to the window*), dead metaphors (*The ivy crept up to the window*), or literal sentences (*The ivy grew up to the window*) to participants who were given either neutral instructions or directions to use imagery in interpreting these expressions. The participants were then given a recognition task in which they had to choose which sentence (from a set of the three possible versions) they had seen before, and were also asked to indicate whether or not they had used an image during initial comprehension. The results revealed no effect for instruction type -- although given the previous criticism of Riechmann and Coste's (1980) instructional manipulation, it should be noted that both the imagery and comprehension groups in Harris, et al. were indeed told to interpret the expressions. Furthermore, participants reported using images more frequently to encode the metaphorical than the nonmetaphorical sentences. Although these metalinguistic judgments lend support for the claim that imagery was used in understanding these metaphors, this assertion is weakened by the fact that the participants were required to distinguish a memory of creating an image during comprehension from an inference that an image might have been created (End, 1986). Moreover, independent ratings of the 'imageability' of each sentence indicated that the novel metaphors were in fact less conducive to imagery, which appears to contradict the self-report measure. As Harris, et al. (1980) point out, people may come to such tasks with preconceived notions about the difficulty and abstractness of many metaphors, which could affect their responses. As a result, these data are unrevealing about what happens in normal comprehension (cf. Nisbett & Wilson, 1977).

Other researchers have adopted an alternative approach, which involves asking participants to rate metaphors along a variety of dimensions as a means of simultaneously exploring factors that might influence metaphor processing. Marschark, Katz, and Paivio (1983), using metaphors generated by psycholinguists, and Katz, Paivio, and Marschark (1985), using poetic metaphors taken from literary works, employed such a multidimensional rating and correlation procedure. They asked separate groups of participants to rate hundreds of metaphors along a variety of dimensions such as "Ease of interpretation," "Metaphor goodness," or "Degree of metaphoricity." Most relevant for the present purposes were ratings of "Overall imageability," "Subject (topic) imagery," and "Predicate (vehicle) imagery." After obtaining the ratings on each of these dimensions, the authors computed the correlations among the various factors and also ran multiple regressions to identify the more important factors for metaphor processing. The findings of these two studies were highly similar, especially regarding the influence of imagery. Sentences rated high in metaphoricity and comprehensibility tended to have vehicles that were easy to image, supporting Paivio's (1986) claims about the significance of vehicles in metaphor understanding. In addition, overall imagery was positively correlated with metaphor goodness. Fainsilber and Kogan (1984) investigated the latter relationship more closely and found that, although imagery may be positively related to the aptness of a particular metaphoric comparison, another measure of goodness, metaphoric novelty, was inversely correlated with imagery. Images, then, can constrain the way in which people attribute novelty to metaphoric expressions. In general, as both Marschark, et al. (1983) and Katz, et al. (1985) point out, the results of these rating tasks suggest at the very least that Riechmann and Coste's (1980) characterization of imagery as a "tangential" phenomenon cannot be entirely correct. Imagery appears to be highly correlated with other factors that influence metaphoric processing.

Relatively few studies, however, have investigated whether imagery is directly implicated in the comprehension of metaphor. One example of such work was Paivio and Clark (1986), discussed earlier. Another set of studies was carried out by Helstrup (1988), who was interested in studying the kinds of strategies that people can bring to bear upon metaphor processing. Administering several metaphor comprehension and production tasks, he told participants to either use visual imagery or verbal strategies in carrying out these tasks, or gave them neutral instructions. Performance for participants under imagery instructions was superior on both the metaphor comprehension and production tasks. Furthermore, participants' scores on a test of visual ability correlated positively with their performance on these tasks. Performance under neutral instructions fell between the verbal and visual conditions, which suggested that while imagery may be facilitative for metaphor processing, verbal strategies may actually be inhibitory. Helstrup then tested whether such facilitation from imagery would generalize to metaphor learning and retention. He gave participants one of the two sets of instructions and presented them with a list of metaphors to study, administering a memory test afterwards. No differences in recall were found between the two strategy groups, similar to Harris, et al. (1980). Helstrup (1988) concludes that metaphors must possess both abstract and concrete properties that are not incompatible, given that alternative strategies were equally efficient at recall. In subsequent work, Helstrup (1995) suggested that imagery may actually be most useful in metaphor comprehension when the discovery of similarities between the topic and vehicle is necessary.

End (1984; 1986) was also interested in testing the possibility of imagistic processing in metaphor comprehension. She had found previously that presenting a metaphor with a particular ground will facilitate comprehension of metaphors with similar meanings. Some examples of metaphors sharing a common ground were: *Some roads are snakes*; *Some rivers are ribbons*; *Some subways are worms*. Given that a particular metaphor can speed comprehension of expressions with similar grounds, End (1986) used a modified interference paradigm to test whether this facilitation is due to the activation of linguistic or imaginal information. She inserted an unrelated sentence, either literal or metaphorical and of low or high imageability, between pairs of related metaphors that were embedded in a longer list of sentences, which participants were told simply to read individually. The expectation was that this unrelated sentence should interfere with the ongoing activation of the shared metaphorical grounds if similar processing (i.e., imagery) is required for both the unrelated sentence and the metaphorical target.

End (1986) found that when pairs of related metaphors were separated by just one unrelated sentence the priming effect disappeared. This result led her to conclude that the interference from the intervening sentence overpowered the activated representation of the ground. Importantly, the imageability of the unrelated sentence had little effect -- both low and high imagery filler sentences produced similar results, as did both literal and metaphorical sentences. Unfortunately, End did not independently vary the imageability of the target metaphors as well. Although her metaphor triads and pairs did vary in the imagistic nature of their shared grounds, she does not present any data indicating whether there were any differences in the pattern of interference upon metaphors with more abstract versus more imagistic grounds. Also worrisome is the rather indeterminate nature of her task: participants were told simply to press the response button when they had read and understood each sentence. Thus, there was little assurance that the participants were indeed engaged in the task. The fact that her priming effect seems to be rather tenuous suggests that this could have been an issue.

Finally, Gibbs and Bogdonovich (1999) reported several studies investigating the nature of people's interpretations for highly imagistic poetic metaphors. These studies were rooted in the observations of Lakoff and Turner (1989), who noted that poetic metaphors often involve mappings between detailed, concrete mental images. Such "image metaphors," which are highly similar to the perceptual metaphors discussed in the next section, include sentences like *Her waist is an hourglass*, in which a mental image of a hourglass is mapped onto another image of a woman's waist. Lakoff and Turner proposed that mental images are structured in a manner analogous to other domains, having part-whole relations (such as that between a roof and a house), attribute structures (such as color, light intensity, and curvature) and event structures ("continuous" versus "discrete"), and that it is possible for images to be mapped onto one another by virtue of their common structure. However, Lakoff and Turner contrasted such limited "one-shot" image metaphors with more robust conceptual mappings, claiming that imagery-based metaphors are not involved in daily reasoning (cf. Gentner & Clement, 1988).

Even so, Gibbs and Bogdonovich (1999) noted that these image mappings are quite frequent in poetic metaphor, and were interested in whether people interpreted such metaphors via mental images, as opposed to using more abstract knowledge structures. An initial study collected people's interpretations for a set of rich image metaphors. The most frequent interpretations involved mappings of physical attributes from the vehicle onto the topic, and also mappings of common perceptual features shared by the topic and vehicle.

In general, perceptual attributes were clearly important for interpretation of these image metaphors, at least using this explicit self-report measure. Subsequently, Gibbs and Bogdonovich asked a new set of participants to describe their mental images for the individual topic and vehicle concepts of the metaphors, or to describe the 'main characteristics' of these concepts. While 58% of the mental images given by these participants were found in the interpretations from the first study, this was true of only 21% of the general characteristics. This difference in the proportion of imagistic versus conceptual elements was taken as evidence for the "power of mental imagery in people's interpretation of certain kinds of poetic metaphor" (p. 43).

Summary of existing research

In evaluating the above data concerning the relationship between imagery and figurative language, it seems useful to adopt a distinction made by Gibbs (1994) between the *products* and *processes* of figurative language comprehension. Much of the research reviewed in this chapter has concerned itself primarily with the products of comprehension rather than the underlying processes. This holds true especially for the sentence ratings and recall measures. Ratings of imagery value can only reflect the results of interpretation, and cannot by themselves reveal whether any differences in imagery value necessarily have direct implications for processing. Also, correlations between various rating scales only indicate which components of metaphor understanding may be interrelated at a global level (such as imageability and goodness, as in Fainsilber and Kogan, 1984). Recall data are similarly problematic, in that they can only indirectly provide information about the processes that contribute to successful comprehension. This is not to say that products are unimportant, because they undoubtedly contribute to our awareness of figurative language as somehow "special" (Gibbs & Gerrig, 1989), but for the purposes of making claims about factors contributing to on-line comprehension, more direct measures are required.

Unfortunately, clear demonstrations, using appropriate techniques, of the involvement of imagery in the comprehension of metaphors and similes are lacking. Paivio and Clark (1986) did find that metaphors with high imagery vehicles were understood more quickly, but the results of their interpretation time measure can not be directly explained via imagistic mediation, because the imagistic content in their verbal materials does not necessarily implicate imagistic processing. Helstrup's (1988) demonstration that instructions to use imagery improved performance on metaphor comprehension tasks also provides little insight into on-line processes, primarily because it is not clear how participants were implementing this strategy. Similarly, the results obtained by Gibbs and Bogdonovich (1999), while very suggestive of an important role for imagery in metaphor interpretation, have little to say about the manner in which these interpretations were generated. The only direct attempt to address the question of online imagistic processing was carried out by End (1986). But, as previously pointed out, problems with her design and procedure limit the usefulness of her results, especially considering they were mainly null effects.

Indeed, it may be more useful to consider the research investigating imagery and language discussed in Chapter 2. The fact that high imagery sentences are generally understood more quickly suggests that imagery can indeed have an impact upon sentence comprehension, but again this does not necessarily imply the online use of imagery. Glass and his colleagues, however, were able to demonstrate interference from concurrent visual processing for sentences high in imagery, particularly when successful performance on the task required access to perceptual information (Eddy & Glass, 1981; Glass, et al., 1985). This is the clearest evidence that visual processing can play a role in the comprehension of high imagery sentences. The third study presented here will employ an analogous interference paradigm to demonstrate a similar effect.

But are there limits to the use of such imagistic processing? As pointed out previously, when perceptual information can be bypassed during understanding, as in concrete sentences like *Huge clouds gathered on the horizon*, comprehension of the sentence via imagery appears less likely, as shown by Glass, et al. (1995). Applying this insight to figurative language suggests that it may be worthwhile to consider how figurative sentences might differ in the extent to which they require imagistic processing for understanding. Given that the knowledge representations of individual words seem to include both perceptual and conceptual semantic components (Schreuder & Flores D'Arcais, 1989), it may be likely that metaphors and similes can selectively draw upon one or the other of these types of semantic information. Thus, a metaphor like *A rope is a snake* appears to involve knowledge about the external appearance of snakes (what Denis (1982) calls "figurative features"), while a metaphor such as *A lawyer is a snake* draws instead upon a very different set of abstract, conceptual features. Assuming that metaphors and similes differ in how perceptual or conceptual they are, one can then inquire whether imagery is the means by which the perceptual components related to a particular type of sentence are activated.

Perceptual metaphor

The fact that certain figurative expressions seem to be clearly rooted in perceptual resemblance has been noted by a number of researchers. In addition to Lakoff and Turner's (1989) description of "image metaphors," other investigators have variously referred to similar expressions as "similarity metaphors" (Billow, 1975), "sensory metaphors" (Winner, 1988), "visual metaphors" (Dent & Rosenberg, 1990; Kogan, Conner, Gross, & Fava, 1980), and "pictorial metaphors" (Forceville, 1994; Kennedy, 1982). Fainsilber and Kogan (1984) found that metaphors rated high in imageability generally involve what they called "perceptual-configural similarities," whereas low-imageability metaphors are generally more conceptual, with little perceptual similarity between the topic and vehicle. *A rope is a snake* is a clear example of a metaphorical sentence that can be interpreted almost entirely at the level of perceptual shape resemblance. Gentner (1988; Gentner & Clement, 1988) called such sentences "attributional metaphors," or "mere-appearance matches," because they depend on similarities between surface attributes. Other metaphors, however, seem to involve more abstract, functional relationships, such as *A mind is a sponge*. Gentner and Clement called these expressions "relational metaphors." Still other metaphors, however, can involve both perceptual and relational content. For example, the sentence *A roof is a hat* can be understood not only via the physical resemblance between roofs and certain pointed hats and their similar configuration with respect to buildings and heads, but also by how roofs and hats both serve as covering and protection from the elements. Gentner and Clement (1988) referred to such metaphors as "double metaphors," because they involve both surface similarities and additional structural or relational commonalities.

It is an open question, though, whether these so-called perceptual metaphors and similes play any significant role in the language of adults. It has been observed that resemblances in the surface appearance and shapes of physical objects are particularly important in the metaphorical language of young children (Winner, 1988). This early importance of sensory information may be due to the fact that children are more likely to perceive the kinds of similarities upon which sensory metaphors are based, whereas relational metaphors very often require additional knowledge about the world, resulting in their later emergence (Keil, 1986; Voisniadou, 1987). Metaphorical grounds based in abstract relations may therefore emerge with development, seemingly at the expense of metaphors based on perceptual resemblances (Gentner, 1988). Silberstein, Gardner, Phelps and Winner (1982), using a metaphor completion task, demonstrated a reliable decrease in the preference for perceptual metaphoric grounds for children from 6 to 10 years of age, accompanied by a simultaneous increase in the preference for metaphors based in conceptual/abstract relations. Gentner and Clement (1988) argued that adults should prefer relational or structural similarities when generating interpretations for metaphorical sentences, given the richness of the potential mapping of relational information from the vehicle domain to the topic domain. Mapping of surface attributes, they claim, does not provide as rich a base from which to interpret a metaphor, and are likely to be abandoned in favor of relational mappings.

People are clearly able to generate interpretations for attributional metaphors (as demonstrated by Gibbs and Bogdonovich, 1999), although such sentences may still be generally considered less apt (Gentner & Clement, 1988). Carbonell (1982) suggests that adults might begin with the default assumption that metaphorical mappings are relational, but will map physical attributes if all that is known about a given vehicle are its physical properties, as in *John is a giraffe*, because higher-order information may not be available. This notion, though, of a trade-off between perceptual and relational interpretations of metaphorical expressions has been questioned by Reyna (1996). Data from a gist recognition study showed that adults were quite willing, at almost the same rate as young children (40% vs. 47% of the time), to accept perceptual interpretations of previously-presented metaphors. This tendency was especially strong for sentences in which the appearance of the objects mattered for the metaphorical meaning. Reyna suggests that perceptual and abstract features may not necessarily operate in opposition to one another during metaphor interpretation. Instead, perceptual information may serve as a 'bridge' towards discovery of certain metaphorical meanings, just as functional features do for metaphors such as *A sermon is a sleeping pill* (cf. Gibb & Wales, 1990b). Wisniewski and Love (1998) report similar conclusions with regard to the importance of attribute interpretations for novel noun-noun combinations.

The mere fact that people can interpret metaphors and similes on a perceptual level does not necessarily mean, of course, that imagery is the means by which such understanding is accomplished. The question of how perceptual metaphors are understood has been generally neglected in most psycholinguistic work on figurative language (Gibbs and Bogdonovich (1999) being a recent exception), which has chosen instead to focus mainly upon metaphorical expressions involving conceptual or abstract mappings. This is somewhat suprising given that imagistic metaphors seem be particularly important in domains ranging from literature (Goatly, 1997; Steen, 1994; Wijsen, 1980), certain modes of discourse (Tannen, 1989), and contexts involving physical description (Winner, 1988).

In particular, these perceptual metaphors and similes may be a class of expression that "requires" imagistic processing for successful interpretation. As such, they should be particularly useful for investigating whether or not perceptual representations play a role in metaphor processing, for the various reasons outlined previously. As Gibbs and Bogdonovich (1999) suggested in the conclusion to their research, "people indeed *must* create concrete imagistic mappings to understand novel image metaphors" (p. 43, emphasis in original). The research presented in this dissertation tested this claim by contrasting perceptual similes with sentences that had either both conceptual and perceptual components or conceptual interpretations alone. Given that imagistic information may be the primary basis of interpreting perceptual similes, measures that are sensitive to on-line perceptual processing were expected to reveal discernible effects in how such expressions are understood. For other kinds of similes, which can be understood conceptually and without access to perceptual details, imagistic processing may be less important. Given Barsalou (in press) and Glenberg's (1997) arguments concerning the ubiquity of perceptual processing, however, this was left as an empirical question. In general, any evidence in favor of the use of perceptual representations in figurative language understanding will suggest that amodal accounts are inadequate to account for all aspects of language processing.

CHAPTER 4

EXPERIMENT 1: PERCEPTUAL PRIMING

The central aim of this study was to provide an initial demonstration of the use of perceptual information in simile comprehension. Similes were used instead of metaphors because, as explicit statements of comparison, similes were thought to be more likely to invoke the consideration of perceptual similarities. This possibility has been suggested on occasion (e.g., Verbrugge & McCarrell, 1977), but solid evidence concerning this claim is relatively sparse. In one study, Gibb and Wales (1990a), using a form-preference task, found that a simile was the preferred form for expressions having concrete vehicles. Similarly, Aisenman (1999) found that attributive comparisons (e.g., *The sun is (like) an orange*) were preferred as similes, while relational comparisons (e.g., *An eyelid is (like) a curtain*) were considered more natural in the metaphoric form. Although these results say little about processing, they nevertheless suggest that similes may be particularly useful for investigating the use of perceptual knowledge in comprehension.

Pictorial priming

Consider the following simile: *A rope is like a snake*. If asked to generate a mental image for this sentence, most people would probably imagine something similar to Figure 1a: a wriggly rope curving back and forth along the ground. This particular image emphasizes the particular physical similarities between ropes and snakes that are relevant to interpretation of the simile. Note that this image of rope does not look like a hangman's noose or a jump rope suspended in mid-swing, although these could be equally valid examples of the concept "rope." Rather, the particular picture that comes to mind for this

Figure 1a. A rope that looks like a snake.

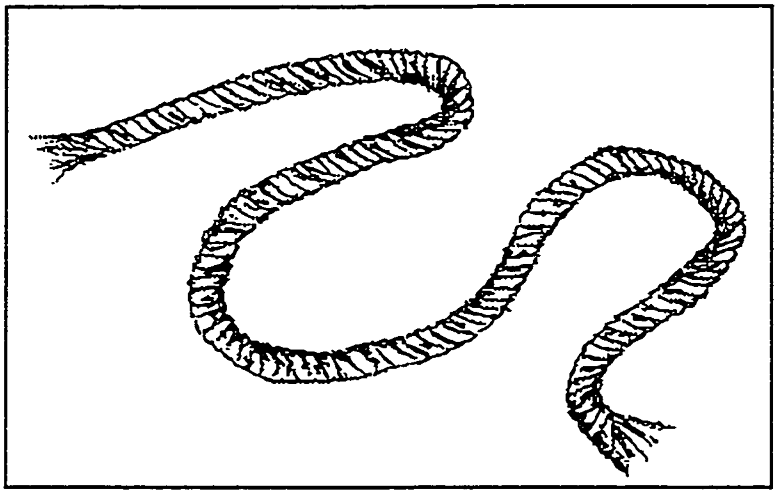


Figure 1b. A snake that looks like a rope.

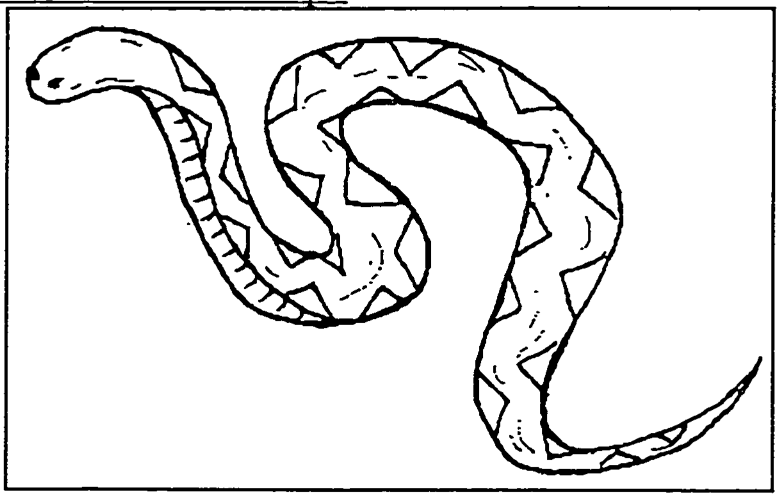
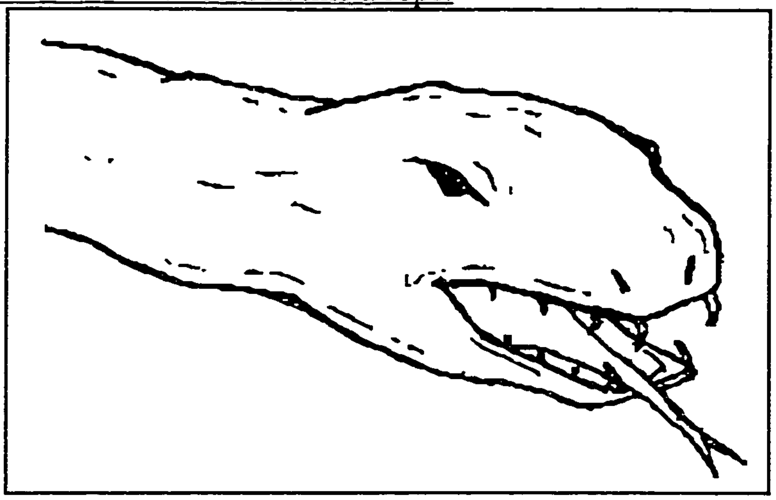


Figure 1c. A snake that does not look like a rope.



simile is constrained by the physical features shared between ropes and snakes -- namely, their long cylindrical shape and wriggly, sinuous aspect.

Now consider the snake depicted in Figure 1b. As should be apparent, this snake shares certain critical features with the rope in Figure 1a: both are long and sinuous and wriggly. If one had limited knowledge of snakes, this picture might be very helpful in constructing an appropriate interpretation of the simile as a whole. Contrast this picture, though, with Figure 1c, which is another depiction of a snake that focuses primarily upon its head and fangs. Rather than highlighting the snake's overall long and sinuous shape, this picture emphasizes a different aspect of "snakeness." This picture, then, would be much less helpful for deriving an interpretation of *A rope is like a snake*. Although it represents a snake, it fails to depict the critical aspects of snakes relevant for understanding this simile.

Thus, comprehension of this simile appears to involve accessing particular knowledge about the appearance of ropes and snakes. Experiment 1 attempted to test this observation by employing a perceptual priming paradigm. The reasoning was as follows: If there is an imagistic component to understanding, then activating relevant perceptual information prior to comprehension should facilitate processing, particularly for perceptually-based expressions. Specifically, participants viewed simple line drawings prior to judging the meaningfulness of similes that varied in their degree of perceptual content. For example, prior to understanding *A rope is like a snake*, some participants saw the picture of a snake in Figure 1b, which was intended to activate perceptual information most relevant to how snakes could be like ropes. To the extent that such information is utilized in understanding this simile, comprehension was expected to be faster compared to a baseline condition using an unrelated picture. In contrast, another condition presented a depiction of the same target object in a way that was intended to conflict with the meaning of the target simile. For the snake example, this inconsistent picture is shown in Figure 1c. Although this picture still depicts a snake, it emphasizes its evil, dangerous aspect rather than the overall shape.

If interpretation of the target simile relies upon perceptual knowledge, then a consistent picture should serve as a better prime. The inconsistent pictures, however, should produce little or no such perceptual priming, because they do not contain information directly relevant to the meanings of their corresponding similes. It is still possible that presenting a picture of a snake would be enough to speed up metaphor comprehension, due to lexical priming. Since Figures 1b and 1c are both depictions of a snake (and should activate the same lexical information), any *additional* facilitation due to the consistent picture would most clearly be attributable to the presence of perceptual information unique to this picture. Intons-Peterson (1993) reported a similar "imaginal priming" effect, in which appropriate pictures facilitated detection of subsequently-constructed images.

Alternatively, the inconsistent pictures might actually interfere with successful comprehension of the target similes, because they could activate information about the vehicle concepts that is not relevant to their metaphorical meaning (e.g., snakes are dangerous and can bite; see Billow, 1975 for a demonstration of this with children). With these inconsistent primes, any imagery (or other information) required for successful interpretation may take longer to generate and access. This outcome would be consistent with other work that has shown that activating properties of a metaphorical vehicle that are irrelevant to the grounds can produce interference (McGlone & Manfredi, 1997). Similarly, in her imaginal priming study, Intons-Peterson (1993) found that inappropriate picture primes interfered with image detection when presented prior to generation of a target image. When presented after the image had already been generated, however, they aided performance in the detection task. These conflicting results, then, do not permit a clear prediction concerning the effect of the inconsistent picture primes.

Nevertheless, facilitation in comprehension was expected to be generally greater following the consistent pictures. This may only hold true, though, insofar as the meaning of a given simile is based upon some sort of perceptual resemblance. Thus, in addition to manipulating the nature of the picture primes, the similes themselves varied as well. Some similes were considered "perceptual" in that their figurative grounds were based primarily upon common perceptual similarities between the topic and vehicle concepts, such as *A rope is like a snake*. Comprehension of these sentences, then, may involve "seeing" this perceptual resemblance, and should be facilitated by picture primes consistent with this relationship, as just outlined. The grounds of a second group of similes, however, were not limited to perceptually-based qualities, but instead involved a mix of perceptual and conceptual relationships, like *A lighthouse is like a candle*. Although there is the opportunity for perceptual information to play a role in the comprehension of these similes as well, it is possible that the conceptual information will be given precedence, given the claims of Gentner and Clement (1988) regarding the importance of relational processing. If this is the case, then the picture primes should be relatively irrelevant for understanding these similes.

Method

Materials.

Sentence norming. Item selection began with the generation of an initial set of similes that included both perceptual/attributional and conceptual/relational sentences. Prenorming of this initial group of sentences eliminated similes that were difficult to understand or troublesome to depict as required by the experimental paradigm. This procedure resulted in a final set of 18 similes. There was also an additional set of 24 anomalous sentences, which had the same surface form as the experimental similes and contained similar concrete nouns in both the 'topic' and 'vehicle' positions.

Two rating tasks were used to assess this final set of sentences. In the first rating task, 15 undergraduate volunteers from the University of Chicago received booklets containing all the metaphorical and anomalous sentences, ordered randomly, and were asked to rate their comprehensibility. The instructions defined comprehensibility as how easily and clearly one could understand each sentence, and the rating scale ranged from 1 ("completely incomprehensible") to 7 ("completely comprehensible"). Each sentence was rated by all 15 participants.

Another group of 15 participants rated the meaningful similes for their degree of perceptual and conceptual content. For these perceptual/conceptual ratings, each simile was accompanied by two separate 5-point scales: one scale for how "perceptual" each sentence was (0 = "not perceptual at all", 4 = "strongly perceptual"), and the other for how "conceptual" (0 = "not conceptual at all", 4 = "strongly conceptual"). For each simile, the participants indicated the extent to which they thought that its meaning was based upon both 1) perceptual resemblances and 2) conceptual relationships. The instructions defined perceptual resemblance as how much the meaning of each sentence relied upon shared perceptual attributes, especially sensory information. A conceptual relationship, on the other hand, was described as "the degree to which the meaning of the sentence is based upon some kind of functional or abstract relationship." Examples of sentences that could be rated high and low on both scales were given, and particular stress was placed upon the fact that the scales should be treated independently and that any particular sentence could be high on only one or both or neither of the scales. In cases where the sentence was completely incomprehensible, they were told to mark both scales as '0'.

Mean perceptual and conceptual ratings for each simile were calculated, removing those few cases where the sentence was not understood at all (8 responses out of a possible 270). Given that all of the sentences contained concrete topics and vehicles, it was not suprising that the overall level of perceptual content was rated as being relatively high (mean = 2.9, ranging from 2.0 to 3.7). The variability in the conceptual ratings was greater, ranging from 0.1 to 3.3 (mean = 1.6). Since the goal was to group the similes according to how 'purely' perceptual they were, the distribution of conceptual rating scores was considered most informative about the relative proportion of perceptual to conceptual content. Thus, the sentences were ranked according to their rated degree of conceptual content and divided by a median split into two groups of nine sentences each. The similes relatively low in conceptual content (but high in perceptual content) were called "perceptual similes." Similes high in both conceptual and perceptual content were called "mixed similes" and were analogous to Gentner and Clement's (1988) double metaphors.

Table 1 shows the mean ratings for each group of similes on the conceptual and perceptual rating scales, which were submitted to a 2 x 2 ANOVA with sentence type (mixed vs. perceptual) and rating scale (conceptual vs. perceptual) as factors. Both main effects and the interaction were significant (p<.001, although note that the 'sentence type' factor was created by item grouping). Means comparisons revealed no difference between the conceptual and perceptual ratings for the mixed similes (F<1 for both item and participant analyses). This difference was significant for the perceptual similes (p<.001). Additionally, the mixed and perceptual similes did not differ in their rated level of comprehensibility: on the seven-point scale, their mean ratings were 5.8 and 5.7, respectively. Furthermore, both were rated as significantly more comprehensible than the 24 anomalous sentences (mean = 1.5).

Table 1. Mean ratings of conceptual and perceptual content for the mixed and perceptual similes (range = 0 to 4).

	Rating scale	
Simile type	'Conceptual'	'Perceptual'
Mixed	2.5	2.6
Perceptual	0.6	3.2

Thus, these ratings helped identify a group of perceptual similes in which the relevant perceptual information was relatively free of accompanying conceptual interpretations. This is what is meant by a "purely" perceptual simile. For the mixed similes, their perceptual aspects are balanced by an equally strong conceptual component. Since the perceptual sentences are most widely separated on this perceptual/conceptual dimension, they should be much more likely to show an effect of the perceptual information than the mixed similes. For the mixed similes, both types of information can potentially be brought to bear upon understanding. Theories that give precedence to relational information in the interpretation of metaphor (Carbonell, 1982; Gentner, 1988) should predict that the perceptual information made available by the picture primes should have no impact upon processing of these similes. In order to provide as much opportunity as possible for the perceptual information to influence processing, however, these mixed similes were primed with the same kind of perceptually consistent and inconsistent pictures as the purely perceptual sentences.

Picture norming. For each simile, two pictures of the metaphorical vehicle were created. These picture pairs depicted the vehicle in two different forms, intended to be consistent or inconsistent with the figurative meaning of the expression. For the perceptual similes, the consistent picture was generally a direct representation of the shape or other configural information necessary for successful interpretation of the expression (as seen in Figure 1b), while the inconsistent picture depicted the same object in a different manner (as in Figure 1c). For the mixed similes, the consistent pictures were also intended to represent the perceptual aspect of each sentence. For example, the consistent picture for *A roof is like a hat* showed a pointed hat that was intended to resemble the slope of a pitched roof much more than the somewhat slouchy, brimmed hat used as the inconsistent picture. The experimenter's intuitions were used initially to judge how each vehicle concept should be represented pictorially. All of the anomalous sentences had pictures drawn of their 'vehicles' as well. A final batch of pictures were created to provide a pool of unrelated pictures for both the experimental and nonsense metaphors, with enough left over for the filler sentences and practice items. When appropriate, many of these pictures were based upon the Snodgrass and Vanderwart (1980) pictures, although they were recreated by the experimenter to match the drawing style of the experimental pictures. Each picture was initially drawn on drawing paper in black ink and then scanned digitally via computer to create a PICT computer file for each line drawing. The drawings were all created to be roughly the same size, approximately 9cm x 12cm on the computer screen.

An important concern was that the pictures of the experimental vehicles be easily recognizable as representing the intended objects. Given the experimental paradigm, *both* the consistent and inconsistent picture primes needed to potentially activate the relevant target concept. If the picture primes were unrecognizable or misrecognized as something else, then it would be impossible to demonstrate any priming for the simile compared to the unrelated baseline condition. Thus, a prenorming study was carried out to determine whether certain pictures might be ineffective primes for the target concepts. Two sets of rating booklets were prepared for the 36 experimental pictures. Each page contained one picture accompanied by the question: "What is this?" Twenty participants were asked to write down for each picture what they thought the picture depicted. Each participant saw only one picture from each pair and an equal number of 'consistent' and 'inconsistent' pictures. The picture labels were collected and used to identify those pictures that were problematic. Pictures that were commonly misidentified as being something other than the target object were then modified or changed completely by the experimenter in an attempt to more clearly represent the critical aspects of the target object.

As a final check on the 18 picture pairs, a name verification task was used to establish that the inconsistent and consistent pictures were equally good prompts for their target concepts. The 18 picture prime pairs plus an additional 80 pictures were presented one at a time via a Macintosh Centris 660AV computer running SuperLab experiment software. Each picture was shown briefly for 750ms and followed by a visually-presented word. Twelve undergraduate volunteers from the University of Chicago were asked to indicate whether or not the word could serve as a valid label for the object depicted in the preceding picture. The word appeared centered on the screen, all lowercase, in 36pt font. Participants were told to respond 'yes' if the word could be correctly applied to the preceding picture. After each response, there was a 1500ms interval before the next picture appeared on the screen. The experimental picture primes were always followed by their correct label. Of the remaining pictures, 44 were followed by an incorrect label, while the remaining 36 pictures were labeled correctly.

Table 2 shows the mean reaction times for the name verification task for the 18 experimental picture primes, organized by sentence and picture type. In general, the consistent (579ms) and inconsistent (577ms) pictures did not differ in the time necessary to verify their correct labels. Across simile types, there is the suggestion of an interaction in the pattern of means, but notice that it is in the direction that works against the predicted effect: the mean verification time for the consistent pictures intended as primes for the perceptual similes (587ms) is actually somewhat slower than that for the inconsistent pictures (573ms). Analyses of variance upon the correct responses, conducted with both participants and items as random effects, revealed no effects of either sentence or picture

Table 2. Mean correct name verification time (in ms) for the consistent and inconsistent picture primes, organized by associated simile type.

	Picture type	
Simile type	Consistent	Inconsistent
Mixed	571	581
Perceptual	587	573
Mean	579	577

type (All Fs<1). Thus, any facilitation for the perceptual similes can not simply be explainable by the fact that the consistent pictures for these sentences are better pictures of the target objects.

Finally, the mean name verification time was calculated for each of the additional 36 pictures that had also been presented with their correct label. These means were used to append an unrelated picture to each of the 18 consistent-inconsistent picture pairs, to serve as the unrelated baseline. The additional pictures were ranked according to their mean RT on the verification task, as were the mean RTs for each of the 18 picture pairs. The unrelated picture with the fastest mean verification time was then matched with the picture prime pair with the fastest mean time, and then the next-fastest pictures were matched, until all 18 picture triads were filled out. For a complete list of the experimental similes with their associated picture triads, see Appendix A1. Twenty-four of the remaining pictures were randomly paired with the anomalous sentences to serve as unrelated pictures for those items. The leftover pictures were used for the practice and filler items. For the list of nonsense sentences used in Experiment 1 and a description of their associated pictures, see Appendix A2.

Thus, of the 18 experimental similes, nine were primarily 'perceptual' and nine were considered 'mixed'. Each sentence had three pictures associated with it: one depicting the metaphorical vehicle in a manner consistent with the metaphorical meaning, one inconsistent with the simile's meaning, and one completely unrelated to the sentence altogether. There were 24 nonsense sentences as well, each of which had a related and an unrelated picture associated with it. In addition, to equate the number of positive and negative responses in the experimental design, there were six filler similes which were meaningful sentences paired with unrelated pictures. These filler items balanced out the number of unrelated and related pictures associated with meaningful sentences.

The pictures used in the study were the same as those used in the norming studies: PICT computer files made from scanned line drawings, centered in the middle of the computer screen and all approximately the same size, 9cm x 12cm. All of the sentences were recorded as digital sound files using 16-bit sound at a frequency of 22kHz. The sentences were recorded by a male speaker using natural intonation.

Three counterbalanced lists of picture-sentence pairs were constructed. Although each list had the same 48 sentences, what varied between lists were the pictures associated with each sentence. For the experimental similes, each list had six consistent picture primes, six inconsistent picture primes, and six unrelated pictures, split evenly between mixed and perceptual sentence types. Each sentence in a given list was thus paired with one picture of each type such that each picture appeared only once across the three lists. For the 24 anomalous sentences, each list had 12 related and 12 unrelated pictures. Because there were only two picture types, these filler items could not be completely counterbalanced across the three versions. Across all participants, however, each of the pictures associated with nonsense similes, related or unrelated, was seen by an equal number of participants. Finally, the six filler similes and their associated unrelated pictures were included in all three lists.

Thus, each list had 18 experimental similes (nine mixed and nine perceptual), 24 nonsense sentences, and six filler similes. Paired with these sentences, in various combinations, were 24 related and 24 unrelated pictures. Each participant saw, in a unique random order, an equal number of related and unrelated pictures and judged an equal number of meaningful and nonsense sentences.

Design. This study used a 2 (sentence type: mixed vs. perceptual) x 3 (picture type: consistent vs. inconsistent vs. unrelated) factorial design. Both sentence type and picture type were completely within participants.

Participants. Participants were 42 University of Chicago students recruited via electronic mail and flyers posted around campus. All were native speakers of English, and were paid for their participation. None had participated in any previous studies on metaphor.

Procedure. The experiment was controlled by a Macintosh Centris 660AV computer running SuperLab experimental software. Participants sat in a sound attenuating cubicle, and each trial began with a fixation cross in the center of the monitor, which appeared for 500 ms and was then replaced with a picture prime. This picture disappeared after 750 ms and was immediately followed by the target sentence, presented auditorily via headphones. Participants responded using the 'f' and 'j' keys on the computer keyboard, which were mapped such that "Yes" was always assigned to the dominant hand. Participants could respond to each sentence as soon as they wished. After responding, the fixation cross reappeared, signaling the presentation of the next picture. This procedure was repeated for all 48 picture-sentence pairs.

Memory task. To motivate participants to attend to the pictures, they were told that a memory task involving both the pictures and sentences would follow the sentence judgment task. This additional task had the added benefit of providing an secondary (albeit offline) measure of the impact of the priming information. After completing the simile judgment task, the participants were then presented with the same pictures they had just seen and were asked to write down the sentence that had been associated with each picture in the first half of the study. These picture cues were again either consistent or inconsistent with the figurative sense of the target simile, or were unrelated altogether. Of interest were the relative rates of recall for sentences cued by the consistent versus the inconsistent pictures. To the extent that a picture will be a more successful cue if it captures some aspect of the meaning of the target sentence, then one might predict that recall cued by the consistent pictures would be superior compared to the inconsistent pictures. After all, the consistent picture of a snake was intended to look more like a rope, unlike the inconsistent picture, and so could conceivably be more likely to prompt retrieval of the entire sentence. But given that the inconsistent picture is also a depiction of the vehicle concept, it is possible that prompting the vehicle name with a picture (regardless of its relationship to the meaning of the sentence as a whole) will provide enough information for successful recall as well, especially given the rather small pool of sentences. If this is the case, any differences in the rates of recall cued by the consistent and inconsistent pictures will be obscured.

For this second part of the experiment, 20 pictures (which included the 18 pictures associated with experimental items for that participant, preceded by two pictures related to filler items) were presented individually on the computer screen. Participants controlled the presentation of each picture by pressing the space bar. For each picture, they wrote down on a response sheet the name of the object in the picture, followed by the complete sentence that had been associated with that picture in the first part of the study. Participants were asked to write down the picture name because pilot testing revealed that participants often failed to respond when they couldn't remember the sentence, which caused problems in coding which item they had been unable to recall, due to the random presentation of the pictures. By asking for the name of the picture first, it was always possible to match which response was prompted by which picture. The participants were allowed to work at their own pace for this task.

Instructions. Participants were informed that this study would have two distinct parts. First, they were told that their primary task would be to judge the meaningfulness of a series of potentially metaphorical sentences. It was pointed out that all of the sentences would have the same "A ___ is like a ____" format, but that some of the sentences would have a possible meaningful figurative interpretation whereas others would not have any clear meaning at all. They were directed to respond "Yes" if they thought the sentence was a meaningful simile, and "No" if it was nonsense. It was further explained that each sentence would be paired with a picture, which would appear briefly on the computer screen and then go away, after which they would hear the sentence play over headphones. The participants were told that they would not have to actively respond to the pictures in the first part of the study, but that they should definitely pay attention since both the pictures and sentences would be relevant to the second part of the study, which would involve an unspecified memory task. After participants indicated that they understood the procedure, they were given a brief practice block of eight items before beginning the actual study.

After completing the entire set of items, the participants then received the instructions for the second part of the study. They were told that they would see a subset of the pictures from the first half, and that their task was to write down first the name of the object in each picture and then the sentence that had been associated with that picture previously, as completely and accurately as possible. They were explicitly informed that they would have to write down only the sentences that had been intended to be meaningful in the first part of the study. They were also told to write down whatever they could, even if this was only part of a sentence, and were encouraged to use the pictures as cues to trigger their memory for each sentence. The participants were given a response sheet and allowed to complete the second part if they indicated they understood their task.

Results

Meaningfulness judgments. Reaction times greater than three standard deviations of the overall mean were trimmed, removing 1.6% of the total data. The RTs for correct responses were then averaged within each cell of the experimental design, and the resulting means are presented in Table 3. These means support the hypothesis that people can use perceptual information in understanding similes, particularly when the figurative meaning is based in perceptual resemblance. For both simile types, the slowest latencies were obtained for sentences preceded by an unrelated picture, which indicates that

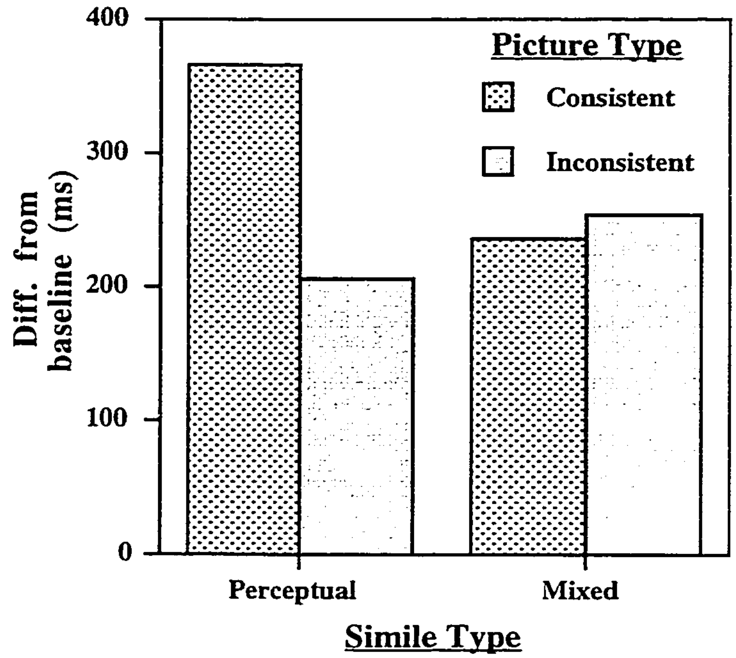
Table 3. Mean correct meaningfulness judgment latencies (in ms) in Experiment 1 as a function of simile type and picture prime condition (error rates in parentheses).

	Picture type		
Simile type	Consistent	Inconsistent	Unrelated
Mixed	2431 (.07)	2412 (.14)	2666 (.13)
Perceptual	2257 (.08)	2417 (.13)	2623 (.06)

these unrelated pictures were indeed unhelpful for comprehension. Furthermore, both the mixed and perceptual similes were facilitated to a similar extent by the inconsistent pictures: the latencies for the mixed similes were 254ms faster than the unrelated picture condition, while the perceptual similes were 206ms faster. For sentences presented with consistent picture primes, however, this pattern of similarity between simile types breaks down. Although reaction times for the mixed similes were not any faster when primed by the consistent pictures compared to the inconsistent picture condition, the consistent pictures did make a difference for the perceptual similes: the difference in priming between the inconsistent and consistent pictures for the perceptual similes was 160 ms, while this difference for the mixed similes was only -19 ms.

To confirm these observations, a more direct measure of the priming effect was derived for each sentence type. The reaction time for each picture prime type was subtracted from the time it took to make the judgment decision when preceded by an unrelated picture. In effect, this treats the unrelated picture condition as a baseline, and the resulting difference score measures the degree of facilitation produced by the consistent and inconsistent picture types compared to the unrelated picture. Figure 2 shows the pattern of facilitation produced by this calculation, which clearly indicates that the greatest priming effect was found for the perceptual similes when preceded by the consistent pictures. These data were submitted to two 2 (sentence type) x 2 (picture type) analyses of variance.

Figure 2. Mean facilitation relative to the unrelated picture baseline in Experiment 1, by simile type and picture prime type.



These and all subsequent analyses were carried out by averaging the dependent measure both across items and across participants. The analysis with participants as a random effect will be referred to as F_1. Analysis by items will be F_2. For the facilitation scores, these analyses revealed no significant main effects of either sentence type (both Fs < 1) or picture type ($F_1(1,41)=2.06$, MSe=89362, $p=.16$; $F_2(1,16)=2.45$, MSe=29167, $p=.14$). The critical interaction between sentence type and picture type, however, was significant, but in the subject analysis only ($F_1(1,41)=6.10$, MSe=71509, $p<.02$; $F_2(1,16)=1.57$, MSe=29167, $p=.23$).

Rather than relying on the omnibus F-statistic, planned comparisons were carried out directly between the consistent and inconsistent picture prime conditions for each of the two sentence types. For the mixed similes, this comparison was not significant in either analysis (both Fs < 1), which confirmed that the consistent and inconsistent picture primes were not producing differing amounts of facilitation for the mixed similes. Or, to put it another way, comprehension of the mixed similes was facilitated equally by pictures that were either consistent or inconsistent with their perceptual content. The same comparison for the perceptual similes, however, did reveal a significant difference in the amount of facilitation between the two picture types ($F_1(1,41)=8.29$, MSe=71509, $p<.01$; $F_2(1,16)=3.97$, MSe=29167, $p=.06$). Given the pattern of results, it seems clear that comprehension of the perceptual similes received additional facilitation from the consistent pictures over and above the inconsistent picture primes.

Additionally, recall Carbonell's (1982) proposal that, during metaphor understanding, accessing perceptual knowledge may only take place after initial relational processing. This rather simple stage model was not supported by the data in Experiment 1. The comprehension latencies for the perceptual similes (M = 2432ms) were not any longer than those for the mixed similes (M = 2503ms). Although comparing across different sets of sentences is problematic, there is no evidence that people were generating attributional interpretations only after searching for possible conceptual relationships.

Error rates. Across all picture prime and simile types, participants incorrectly rejected target similes as meaningless 9.9% of the time (see Table 3). Although this error rate may seem high, it should be kept in mind that participants were being asked to make speeded decisions about sentences involving comparisons between dissimilar concrete objects. Although all of these similes had been previously normed as relatively comprehensible according to self-paced ratings, the reaction time measure used here may have inflated the number of incorrect rejections, especially considering the somewhat subjective nature of metaphor comprehension. Compare this error rate to the comparatively low rate for incorrectly accepting a nonsense sentence as meaningful, which happened only 3.2% of the time. This suggests that participants were being relatively conservative in whether they were likely to accept a novel comparison as meaningful. Indeed, during debriefing several participants indicated that they had sometimes quickly rejected a particular sentence as nonsense, only to realize a moment later that it had a meaningful interpretation.

Participants were almost twice as likely to reject a meaningful simile as nonsense when it was preceded by an inconsistent picture (14% errors) than a consistent picture (8% errors), regardless of simile type. This provides converging evidence that participants were actually using the pictures to make sense of the subsequent similes. When the picture highlighted a crucial aspect of the figurative relationship, people were more likely to judge the sentence as meaningful. The raw proportions of accurate responses in each condition were recalculated using the arcsine transformation before being submitted to a 2 (sentence type) x 3 (picture type) ANOVA. The only effect that approached significance was the main effect of picture type ($F_1(2,82)=3.16$, MSe=.081, $p=.05$; $F_2(2,32)=2.51$, MSe=.059, $p=.09$). Comparisons between each of the three cell means for this effect revealed a reliable difference only between the consistent and inconsistent picture conditions ($F_1(1,41)=5.96$, MSe=.081, $p<.02$; $F_2(1,16)=4.83$, MSe=.059, $p<.05$). Thus, these analyses confirm that participants were more likely to incorrectly reject a simile as nonsense when the picture did not correspond to its figurative meaning, regardless of the type of simile. One difficulty with this conclusion, however, is that the error rate for the perceptual similes in the unrelated picture condition was only 6%, compared to 13% for the mixed similes in the same condition. Since these unrelated pictures could not have been useful in interpreting the perceptual similes, it is not clear why this condition should have produced such a relatively low rate of rejection.

Sentence recall. In the recall portion of the experiment, participants saw each of the picture primes that had been associated with meaningful similes in the first part of the experiment, and wrote down the name of the object depicted and the sentence with which it has been previously seen. Recall responses that included the correct topic noun of the

Table 4. Mean proportion of correct sentence recall in Experiment 1 as a function of simile type and picture prime condition.

	Picture type		
Simile type	Consistent	Inconsistent	Unrelated
Mixed	.78	.77	.01
Perceptual	.75	.70	.02

target sentence were coded as being correct. Thus, if the target simile were *A cotton ball is like a cloud* and the picture was of a cloud, then any response that included "cottonball," "cotton," or "cotton puff" was considered correct. Responses that did not include some variant upon "cottonball" were considered incorrect. Stricter coding criteria only reduced the overall level of correct recall and did not have a noticeable impact upon the general pattern, so this relatively straightforward coding scheme was used for analysis. See Table 4 for the recall rates by condition. Not including the unrelated picture conditions, the levels of recall for the consistent and inconsistent picture conditions for both sentence types were relatively uniform, averaging around 75% correct.

Obviously, recall was greatly impaired when the picture cue was not related to the target sentence, which should not be particularly suprising. When the picture was related to the sentence, however, the likelihood of recall was roughly equal for both sentence types. Most pertinent is the fact that the levels of recall do not appear to differ between the consistent and inconsistent picture primes for either of the two sentence types. These recall means were transformed using the arcsine transformation and were submitted to two 2 x 3 ANOVAs, one over participants and the other over items. Other than the expected effect of Picture Type (p<.0001), no other effects reached significance. Planned comparisons between the consistent and inconsistent picture prime conditions for each simile type also did not reveal any differences. Thus, people appear to have been equally likely to recall the target simile as long as the picture was related to the sentence -- the particular form of the picture did not have a discernible effect. So although the consistent and inconsistent pictures had an impact upon immediate comprehension, the fact that the type of picture does not matter for subsequent recall suggests that perceptual information may not be relevant for further encoding (cf. Kieras, 1978).

Discussion

In this experiment, participants were asked to decide whether each sentence had a meaningful figurative interpretation. This required them to assess whether there was a possible meaningful relationship between the topic and vehicle that was potentially conceptual, perceptual, or both (or absent altogether, in the case of the anomalous sentences). When a given simile was preceded by a completely unrelated picture, interpretation apparently proceeded without facilitation from the priming stimulus. When the picture was related to the target sentence, however, some degree of priming was present, even when the picture depicted the vehicle concept in a manner inconsistent with the figurative meaning. This mirrors findings reported by Intons-Peterson (1993), who found that both appropriate and inappropriate picture primes facilitated detection of a subsequent image, as long as the pictures were presented before image generation. Most simply, there was no evidence of interference from the inconsistent picture primes. Merely showing a picture of the vehicle produced facilitation: thus, activating the concept of "snake" facilitated comprehension of *A rope is like a snake*, regardless of the exact relationship between the snake in the picture and the simile. This explanation is supported by the fact that rejection of the nonsense sentences was also facilitated by the presence of a related picture. When the anomalous sentences were preceded by a related picture, the mean latency to reject them as meaningless was 2664ms, which was significantly faster than the mean latency of 2773ms following the unrelated pictures ($F_1(1,41)=17.78$, MSe=15845, $p<.001$; $F_2(1,23)=5.76$, MSe=21014, $p<.03$). Although these related pictures were not intended to represent any particular aspect of the anomalous sentences, they still sped up participants' judgments regarding their meaningfulness. Thus, exposure to a picture of some element from the target sentence prior to the judgment task was apparently enough to produce some degree of priming, regardless of whether the depicted entity was embedded in a meaningful sentence or not. It is possible that participants were generating particular expectations concerning the target sentence based upon the pictures, especially given the relatively long 750ms SOA (see Becker, 1980, for a discussion of such effects in word priming). When the sentence turned out be unrelated to the picture, processing may have been slowed down. There is no way to assess this, however, without the proper baseline.

Clear differences existed, however, in how the two simile types were affected by picture primes that were consistent with their perceptual content. The mixed similes, despite being rated as partially perceptual, were not affected any more by the consistent picture primes than the inconsistent pictures, whereas the consistent primes clearly produced additional facilitation for comprehension of the perceptual similes. This pattern of results is consistent with the explanation that participants were utilizing the particular information present in the consistent pictures primarily when comprehension of the target similes required perceptual processing. In general, these data supports the claim that people can use perceptual information as part of understanding figurative language.

It is possible, however, that the participants' responses were influenced by the fact that the pictorial stimuli were seen prior to interpretation, which may have induced a perceptual processing strategy that does not occur in 'normal' comprehension. This could have exaggerated the impact of the perceptual information, even though no instruction was given that the pictures should be used in interpreting the similes. Note, however, that the pictorial stimuli apparently did not produce any apparent facilitation for the mixed similes like *A lighthouse is like a candle*, even though such information was potentially relevant for comprehension of these sentences as well. In the general discussion, I will suggest that the extended processing time available during comprehension of these mixed similes may have obscured any effects due to activation of relevant perceptual information. Nevertheless, given the possibility that the pictorial information was strategically used to guide comprehension of the perceptual similes, it is important to demonstrate the involvement of perceptual information in a more spontaneous fashion.

CHAPTER 5

EXPERIMENTS 2 AND 3: PICTURE VERIFICATION

In order to address this potential criticism of Experiment 1, the next pair of studies used a modified sentence-picture verification procedure to allow comprehension to occur without the influence of prior perceptual input. In this manner, any effects for the consistent pictures, now serving as targets rather than primes, should be attributable to the use of perceptual information in prior comprehension. Thus, the goal of Experiment 2 was again to obtain evidence for the use of perceptual information in simile comprehension. A control study, presented here as Experiment 3, was conducted to rule out an alternative explanation for the results of Experiment 2.

Sentence-picture verification

In the standard sentence-picture verification task, people are given a statement like *The star is above the plus* and must verify whether a subsequent picture matches the situation described in the sentence (Clark & Chase, 1972). This involves comparing one's mental representation of the sentence against the pictorially-presented information. In order to do this, however, participants must strategically encode each sentence and hold it in working memory until presentation of the picture. People can adopt either a verbal strategy or an imagistic strategy when faced with this task (MacLeod, Hunt, & Mathews, 1978), although the particulars of how to determine whether a given participant is employing a linguistic or imagery-based strategy can be problematic (Roberts, Wood, & Gilmore, 1994).

It is not immediately obvious, though, whether such strategic effects are relevant for consideration of relatively automatic components of comprehension. To investigate routine language understanding, it would be better to employ tasks that do not require participants to encode sentences in a strategic fashion. This criterion has been met in other research using variations on the basic sentence-picture verification paradigm. For example, Potter, et al. (1977) explored the nature of the mental representations underlying sentence comprehension by comparing verification times between picture probes and visual word probes that followed comprehension of literal sentences. These probes, presented 800ms after each sentence, were related to the sentence content either inferentially (e.g., *The settlers cleared the woods* followed by either the word "axe" or a picture of an axe) or at an associative level (e.g., *Adam and Eve were the first humans* -- "apple").

Potter et al. (1977) found no differences in the amount of time participants took to judge the relatedness of either the picture or word probes. This result led them to conclude that sentence understanding takes place at a level of representation more abstract than either a verbal or visual code. The problem with this conclusion, however, is that it is based upon a null result. Furthermore, the fact that the probes came 800ms after each sentence may have allowed participants enough time to generate expectations concerning the upcoming probe, similar to expectation effects discussed in the priming literature (e.g., Becker, 1980). This may have reduced the probability that any relevant perceptual information would have been maintained in working memory. As Experiment 2 will explore, the activation of perceptual information may in some instances be relatively short-lived. The 800ms delay, along with the presence of a visual mask before and after each probe, could have contributed to the lack of an effect in the Potter, et al. study.

Furthermore, the fact that the probes were obliquely related to the sentences may have further reduced the likelihood of finding any differences. Because the sentences were presented in isolation, participants may have been less likely to generate the necessary inferences as part of comprehension, since a failure to do so would not have had any impact upon subsequent understanding. This would be consistent with recent accounts of discourse processing that argue that readers generally engage in the "minimal" amount of inferential work necessary for comprehension (e.g., McKoon & Ratcliff, 1992). As a result, Potter, et al.'s (1977) experiment is an inadequate test of their claims because the concepts they used as probes were unlikely to have been incorporated into the sentence representation in the first place.

Another study which did, however, find differences between inferentially-related word and picture probes was reported by Medina (1988). Medina presented participants with three types of priming sentences that contained some mention of an object category, such as "bird" or "stone." The sentences were intended in some cases to highlight the "perceptual" properties of these categories, as in *This bird is very ugly*. In other cases, the properties were more "functional" in nature, like *The stone was worth many millions*, while still other sentences were neutral with respect to particular properties. The targets themselves were either visually-presented words or pictures, and were members of the same semantic category mentioned in the previous sentence, such as "owl" or "diamond." Participants had to decide whether or not each target could match the previous sentence. Medina found that the picture targets were verified significantly faster than words when preceded by a perceptual priming sentence, while the verification times for the word and picture targets did not differ following the functional sentences. The faster picture verification times following the perceptual sentences were interpreted as indicating that these sentences activated visuospatial representations. It is important to note that Medina presented his probes immediately after each sentence, which may explain why he was able to find a differential effect of probe type, unlike Potter, et al. (1977).

Finally, Denis and Le Ny (1986) used a similar task to explore an aspect of sentence comprehension they termed "centration," which was characterized as the selective attention to particular components of semantic representations of objects. In particular, they investigated whether sentences could selectively activate features which are related to the physical properties of objects (similar to Schreuder and Flores D'Arcais' (1989) notion of perceptual semantic components). Denis and Le Ny presented a series of sentence-picture pairs to participants, asking them to verify whether or not each picture was related to the previous sentence. Pairs of sentences were constructed such that each sentence highlighted a particular perceptual aspect of the same referent. One sentence pair was:

1) *The eagle suddenly swooped down to the earth and snatched the weasel.*

2) *The eagle soared slowly and majestically into the heavens.*

For this pair of sentences, the subsequent picture depicted either the claw of an eagle or an eagle's wing, which were intended to be compatible with sentences 1) and 2), respectively. The sentence and picture pairs were fully crossed, producing two compatible pairs and two incompatible pairs. Note that since the incompatible pictures were also related to the sentence (i.e., relevant to eagles), they were expected to produce affirmative responses as well.

In general, mean verification times were faster for the compatible sentence-picture pairs than the incompatible pairs. The fact that facilitation was greatest for those pictures which directly depicted relevant perceptual information suggested that the perceptual features of the target concepts were being selectively activated by the sentences. An additional condition in which participants were instructed to use imagery produced faster verification times, but only for the incompatible sentence-picture pairs. Denis and Le Ny (1986) suggest that there may be a ceiling level of activation for the "centered" features, and that the imagery instructions affected activation solely for the noncentered features, perhaps by bringing them into clearer focus. A control experiment, which used words, rather than pictures, as targets ("claw" vs. "wing") revealed no reliable differences in verification times between compatible and incompatible sentence-word pairs. This result, in tandem with the selective facilitation effect for the picture targets, is consistent with the involvement of what Denis and Le Ny call an "integrated perceptual-semantic representation" (p. 151) during sentence comprehension.

Experiment 2

The results of Denis and Le Ny (1986) and Medina (1988) suggest that sentence comprehension can indeed involve the activation of relevant perceptual knowledge. Employing a similar methodology, Experiment 2 was designed to investigate this claim within the context of simile comprehension. The general method was as follows: participants heard a simile and then judged whether or not a subsequent picture matched the final word in the sentence. As before, this picture was either consistent or inconsistent with the figurative meaning of the simile. For example, *A rope is like a snake* was followed by either the picture of a wriggly, rope-like snake or the picture of a snake's head and fangs. The use of this task rests upon the logic that successful verification involves matching the visual picture to the activated representation of the sentence. If comprehension involves a perceptual component, the more similar a picture is to this presumed imagistic representation, the more quickly it should be verified as representing the target object. Thus, if perceptual information plays a role in comprehension, then pictures consistent with the perceptual aspects of the sentence meaning should be verified more rapidly than those inconsistent with this meaning.

There were a couple of important differences between this study and previous research, however. Unlike Experiment 1, presenting the simile first was expected to allow comprehension to proceed relatively normally, free of an implicit demand to utilize associated pictorial material. Also, unlike both the traditional sentence-picture verification paradigm (Clark & Chase, 1972; MacLeod, et al., 1978), and unlike Denis and Le Ny (1986), participants in this study were asked only to verify whether the picture depicted the final word; they were not asked to judge whether the pictures depicted the semantic content of each sentence as a whole. Not asking people to compare the picture to the meaning of the entire simile lessens any bias in favor of the consistent pictures, which were intended to be direct depictions of the similes' figurative meanings. Thus, any facilitation from the similes upon picture verification should be relatively incidental, arising from how closely the picture matches information activated as part of understanding the sentence.

In particular, the consistent pictures should be verified more quickly in the context of the perceptual similes, presumably because they are a closer match for the perceptual knowledge representations activated during comprehension. For the mixed similes, similar differences in verification times between the consistent and inconsistent pictures may be absent if comprehension can proceed without invoking perceptual relationships. If, however, perceptual information is activated in response to the mixed similes as well, then some degree of differential activation between the consistent and inconsistent pictures may be present for these sentences also.

Finally, an additional aim of Experiment 2 was to investigate the time course of the activation of perceptual information during comprehension. As noted previously, the relative timing of the target picture may have a significant impact upon whether an effect due to perceptual processing can be observed. To evaluate this possibility, the target pictures in this study appeared either immediately after presentation of each sentence or after a 750ms delay. If perceptual information does indeed play a role in comprehension, then the greatest relative facilitation for the consistent pictures should happen immediately following the perceptual similes. After a brief delay, however, this consistent picture advantage might be weakened, as the activated perceptual information may be subject to decay. For the mixed similes, in which perceptual information plays a less crucial role, the difference between picture types should be smaller, if present at all, at both intervals.

Method

Participants. The participants in this study were 28 undergraduate students at the University of Chicago, recruited via email or through flyers posted around campus. They were paid for their participation. Two participants demonstrated inordinately long response times and their data were replaced with data from two additional participants.

Materials. This study used the same mixed and perceptual similes as in Experiment 1, with the addition of one simile of each type (one perceptual, one mixed) in order to permit an even division of the experimental sentences into two sets (rather than three as in the previous study). This resulted in ten mixed and ten perceptual similes. In addition, there were 20 filler similes that were drawn from previous work. Appendix A1 lists the set of experimental similes and pictures used in Experiment 2, while a complete list of the filler similes and their associated pictures can be found in Appendix A3. All of the sentences were recorded anew as 16-bit sound files at a frequency of 22kHz. The sentences were recorded by a male speaker using natural intonation.

Matched with each experimental sentence was the same pair of consistent and inconsistent pictures used in Experiment 1. That is, although both pictures depicted the figurative vehicle of each sentence, only one picture was consistent with the simile's perceptual content. For the filler similes, each sentence was paired with an unrelated picture target, drawn from the same pool of unrelated pictures used in the first study.

There were two lists of sentence-picture pairs. Each list contained 40 similes: 20 experimental and 20 filler. Of the experimental sentences, half were paired with consistent pictures and half with inconsistent pictures, counterbalanced across the two lists. The unrelated pictures presented with the filler sentences were the same across both lists. Each participant responded to one list of similes.

Design. Both sentence type (mixed or perceptual) and picture type (consistent or inconsistent) were within-participant factors. The pictures were presented for verification at two offsets from the end of each sentence, at an ISI of either 0ms or 750ms. This was a between-participants factor. The final result was a 2 x 2 x 2 mixed experimental design.

Procedure. This experiment was conducted using the same setting and equipment as Experiment 1. Each trial began with a visual fixation point that appeared on the computer screen for 500ms. Then, a sentence was presented auditorily via headphones, and participants were told that they should carefully listen to this sentence and try to understand it as best they could. Participants were told that these sentences would all be meaningful similes having the same form: "A ___ is like a ____." Following each sentence, the target picture appeared on the computer screen either immediately following the end of the sound file or after a 750ms delay. Participants were told to respond "Yes" if this picture matched the final word in the previous sentence, or "No" if it did not match. The "Yes" response was mapped to each participant's dominant hand. A match was defined as any picture that depicted an instance of the final word. The picture disappeared from the screen after the participant's response. Following a practice block of eight items, each participant responded to 40 sentence-picture pairs, presented in a different random order for each individual.

In a pilot version of this study, participants were informed up front about a second part to the experiment that involved a memory test similar to that in Experiment 1. This procedure was originally intended to make sure that the participants paid adequate attention to the auditory sentences. The response times for the pilot study (and the participants' remarks during debriefing) suggested, however, that people were trying consciously to encode the sentences in order to do well on the subsequent memory task. Since such strategic effects would obscure any differences due to underlying comprehension processes, it was decided to make no mention of the memory task until after participants had completed the picture-verification task. The downside of this procedure was that, during debriefing, a few participants mentioned that they had paid attention primarily to the final word of each sentence, since this was most relevant to the subsequent picture judgment. This was not an unreasonable strategy given the constraints of the task, but clearly it calls into question whether participants were truly comprehending each sentence. Because this selective listening strategy would only reduce any differences between the picture types, it was decided that this procedure was an acceptable tradeoff.

So, after completing the picture verification task, the participants were presented with a surprise memory test in which they were given the pictures they had previously seen paired with the experimental similes. They were asked to recall the sentence associated with each picture by writing it down on a separate response sheet. Each participant was asked to recall 20 sentences based on these picture cues. If the sentences are originally understood through the use of perceptual information, then the consistent pictures should be more effective recall cues.

Results

Picture verification. The primary measure of interest was the time to verify whether each picture matched the final word in the previous sentence. Outliers beyond three standard deviations from the overall mean were trimmed, which removed 1.4% of the total data. Mean correct response times are presented in Table 5 for each of the experimental conditions.

Table 5. Mean correct picture verification times (in ms) in Experiment 2 for the consistent and inconsistent picture targets as a function of ISI and simile type (error rates in parentheses).

		Picture type		
ISI	Simile type	Consistent	Inconsistent	(difference)
0ms	Mixed	576 (.00)	617 (.01)	41
	Perceptual	554 (.00)	646 (.00)	92
750ms	Mixed	525 (.03)	551 (.01)	34
	Perceptual	492 (.03)	567 (.06)	75

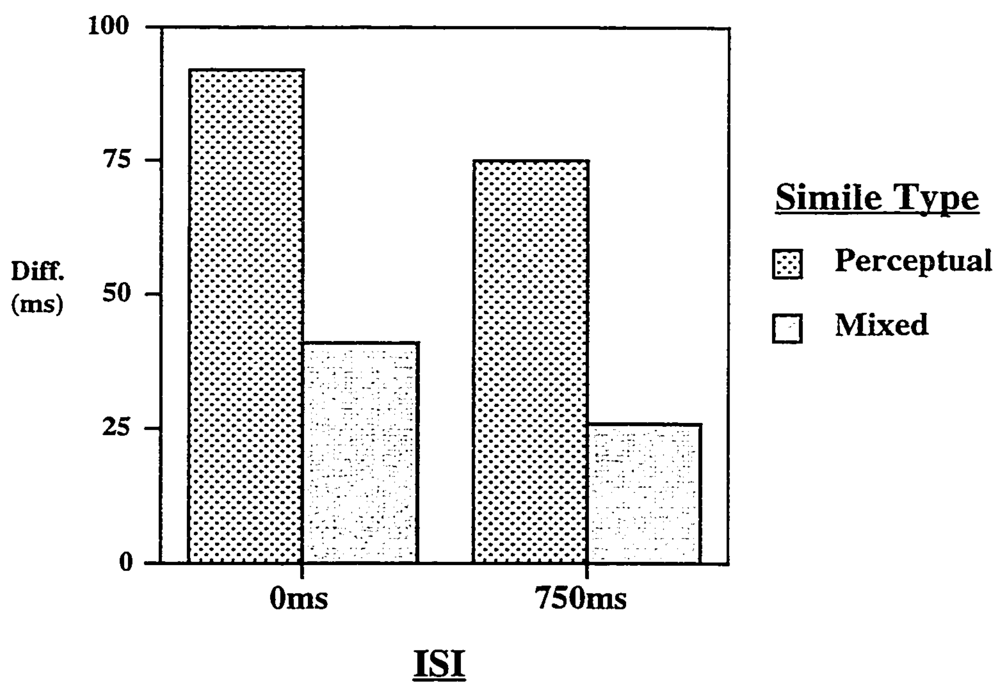
If sentence comprehension involves the activation of particular perceptual information, then a picture consistent with this information should be verified faster than a picture that depicts a different perceptual aspect of the same target concept, all else being equal. In fact, the consistent pictures were verified faster than the inconsistent pictures across the board: 537ms vs. 595ms, respectively. Initial statistical analyses were carried out on these response times via two 2 x 2 x 2 ANOVAs, with both participants and items as random effects. These analyses revealed a strong effect of picture type ($F_1(1,26)=22.9$, MSe=2213, $p<.0001$; $F_2(1,18)=10.01$, MSe=7059, $p<.006$). No other main effects or interactions were reliably significant across both analyses. The relatively faster verification times for the consistent pictures suggests that participants were indeed activating perceptual information as part of simile comprehension.

Looking at the means for the perceptual similes alone, collapsed over ISI, the difference between the verification times for the consistent and inconsistent picture targets was 523ms versus 607ms, a significant difference ($F_1(1,26)=21.2$, MSe=2760, $p<.0001$; $F_2(1,18)=10.02$, MSe=7059, $p<.006$). For the mixed similes, however, the equivalent difference (551ms vs. 583ms) failed to reach significance ($F_1(1,26)=2.12$, MSe=2760, $p=.16$; $F_2(1,18)=1.71$, MSe=7059, $p=.21$). Thus, the consistent pictures were verified reliably faster than the inconsistent pictures after the perceptual similes, but not after the mixed similes. This is again consistent with the claim that these perceptual similes were indeed inducing comprehenders to activate their perceptual knowledge of the sentence referents as part of successful comprehension.

Does the activation of this knowledge, however, follow a particular time course? Experiment 2 addressed this question by presenting the picture targets at one of two offsets following each simile: either immediately at 0ms or after a 750ms delay. Looking again at the differences between the verification times for the consistent and inconsistent pictures in Table 5, we can see that at 0ms this difference is 92ms for the perceptual similes and 41ms for the mixed similes. After 750ms, the general pattern is preserved, although both differences themselves are reduced: 75ms for the perceptual similes and only 26ms for the mixed similes. Figure 3 depicts this difference in verification times between the consistent and inconsistent pictures at each ISI for both simile types.

For the perceptual similes, planned contrasts between the consistent and inconsistent picture conditions revealed significant differences at 0ms ($F_1(1,26)=20.7$, MSe=2760, $p<.0001$; $F_2(1,18)=12.2$, MSe=3479, $p<.003$) and also at 750ms ($F_1(1,26)=3.83$, MSe=2760, $p<.06$; $F_2(1,18)=8.34$; MSe=3479, $p<.01$). Interestingly, equivalent contrasts between picture types for the mixed similes suggested that a difference in facilitation may be present at 0ms for these sentences as well ($F_1(1,26)=3.79$, MSe=2760, $p=.06$; $F_2(1,18)=2.65$, $p=.12$). By 750ms, however, any differences between verification times for the mixed similes were absent ($F_1(1,26)<1$; $F_2(1,18)=1.01$, MSe=3479, $p=.33$).

Figure 3. Mean differences in picture verification times (in ms) between the inconsistent and consistent picture targets in Experiment 2, by ISI and simile type.



The robust advantage, present at both offsets, for the consistent picture targets following the perceptual similes reinforces the claim that people use their perceptual knowledge to understand this class of similes. The most direct interpretation of this effect is that comprehension of these similes involves activating information about the particular perceptual configurations and attributes of the sentence referents. This activated information then speeds verification of the subsequent picture as a "match," as long as it contains similar perceptual elements. It remains unclear, however, whether or not a similar process is involved in understanding of the mixed similes. At 0ms, there is weak evidence of a consistent picture advantage after these similes, which disappears by 750ms. Given that the meanings of mixed similes do indeed contain a strong perceptual component, it would not be extremely surprising if perceptual information played at least an auxiliary role in comprehension of these sentences as well. The evidence presented here is somewhat inconclusive on this point, however.

Sentence recall. After completing the picture verification task, participants were presented with the pictorial stimuli that they had just seen and were asked to write down the simile that had been previously paired with each picture. All of the pictures used as recall cues in the present experiment were explicitly related to the experimental similes. Half of the pictures presented as cues were consistent with the perceptual information relevant to the figurative meanings of the similes, while the other half were inconsistent, identical to what each person saw in the first part of the study. Of interest, then, was whether memory for the target sentences would be better when cued by these consistent pictures.

The same simple coding system was used as in Experiment 1: participants' written responses were given a "1" if they included some variant of the target sentence, and a "0" if they were either incorrect or simply left blank. The mean recall ratings are presented in Table 6. Because the original ISI, which related to the initial presentation of the sentence-picture pairs, did not interact with the other factors with respect to recall, it will not be

Table 6. Mean proportion of correct sentence recall in Experiment 2 as a function of simile type and picture type.

	Picture type	
Simile type	Consistent	Inconsistent
Mixed	.58	.46
Perceptual	.56	.46

considered further. Overall, the similes were correctly recalled 52% of the time, which is lower than the approximately 75% recall found in Experiment 1. This may be attributable to the fact that participants in the current study were not warned ahead of time that they would be given a memory task in the second half of the study. Furthermore, because participants did not have to respond explicitly to the sentences (unlike Experiment 1), they may have paid less direct attention to each sentence during presentation, reducing their ability to recall the sentences later.

Nonetheless, some differences in recall are apparent. In particular, the consistent pictures were generally better cues for recall of the target similes than the inconsistent pictures: 57% vs. 46%, respectively. An arcsine transformation was carried out on the raw proportions of correctly-recalled sentences, and planned contrasts between the consistent and inconsistent picture conditions confirmed this recall advantage for the consistent picture cues ($F_1(1,26)=2.54$, MSe=.254, $p<.004$; $F_2(1,18)=1.48$, MSe=.170, $p<.009$). Furthermore, this difference in recall rates was significant for both the perceptual similes ($F_1(1,26)=4.94$, MSe=.203, $p<.04$; $F_2(1,18)=3.70$, MSe=.170, $p<.07$) and the mixed similes ($F_1(1,26)=7.75$, MSe=.203, $p<.01$; $F_2(1,18)=5.03$, MSe=.170, $p<.04$). This is quite different from the results of Experiment 1, in which the consistent pictures and inconsistent pictures produced similar levels of sentence recall. Here, the consistent pictures in this study were clearly superior in prompting accurate recall of the sentences, for both simile types.

The sentence-picture verification task used in Experiment 2, unlike the perceptual priming task in the previous study, requires a direct comparison between each picture and sentence. As a result, associations between the similes and pictures were more likely to have been formed, particularly when the picture was a direct reflection of the perceptual content of the sentence. This would explain the recall advantage for the consistent pictures. Interestingly, the fact that this advantage was present for the mixed similes as well suggests that the relevant perceptual content, although perhaps only weakly activated during initial comprehension, can nevertheless be useful in providing a route for subsequent retrieval of the original simile. For example, upon seeing a picture of a candle, participants would have known that the target simile must have the form "_______ is like a candle." If the picture cue depicts a tall, thin candle, this could aid retrieval of "lighthouse" through perceptual associations created during comprehension. On the other hand, if the picture shows a short fat candle, this is presumably less useful as a perceptual cue -- although is still related to "lighthouse" conceptually. In general, then, unlike the recall results from Experiment 1, these data suggest that perceptual information can indeed be incorporated into longer-term representations, given an appropriate task.

Experiment 3

Before further discussion of Experiment 2, it is first necessary to address an alternative explanation for the observed results. Specifically, the consistent pictures may have been more prototypical depictions of the concepts represented by the target words, which would result in faster verification times for these pictures. This possibility is supported by findings reported by Denis (1982) and Dubois and Denis (1988), who found faster responses to "typical" pictures of referents mentioned in previously presented sentences, as compared to atypical pictures. Although it is an interesting question in its own right whether people's perceptual knowledge reflects factors like typicality, the logic of the current study rests upon the assumption that picture verification will be influenced primarily by comprehension of the prior sentence and not by any pre-existing preferences. Recall that a norming study conducted prior to Experiment 1, using a name verification task, succeeded in demonstrating that the two sets of pictures possess similar degrees of identifiability. Even so, it was decided to run a control experiment to rule out the possibility of such typicality effects in the context of a sentence comprehension task.

Thus, a separate group of participants was presented with literal sentences containing the same 'vehicle' concepts as the original target similes, embedded in neutral contexts. For example, *A rope is like a snake* was transformed into *The hikers discovered a snake*. As in the Experiment 2, participants verified whether a picture matched the final word in each sentence. Although the pictures were created to be either consistent or inconsistent with the meanings of the original similes, the question here was whether verification times for the two picture types would be relatively similar in the context of the neutral sentences -- i.e., whether both are equally valid instances of "snake." Any differences between the picture pairs in the context of these neutral sentences can be taken as a baseline, such that greater differences in verification times between picture types for the figurative sentences will be attributable to the particular manner in which the similes are understood.

Method

Participants. Twenty-eight students at the University of Chicago were recruited and paid for their participation in this study. None had participated in any prior experiments on figurative language.

Materials. Twenty literal sentences were generated for use in this control study, each containing the same final word as a corresponding original simile. These sentences were intended to invoke a context for the critical word that was neutral with regard to the relationship between the sentence and the two picture types. For example, both the "consistent" sinewy snake and the "inconsistent" fanged snake were intended to be equally plausible referents for *snake* in the sentence about the hikers. At the same time, a set of twenty filler sentences were created by incorporating the final word from the filler similes in the original study into a neutral context, in a fashion similar to the other neutral sentences. See Appendix A4 for the complete list of neutral sentences. The same set of consistent and inconsistent pictures used in the previous experiment was paired with the new literal control sentences, counterbalanced across two versions of the study. Likewise, the same unrelated pictures from the previous study were used as well, paired in both versions with the same set of literal filler sentences. Like the original similes, the literal sentences were further divided into "mixed" and "perceptual" items (on the basis of the corresponding simile) -- but this split was for analysis purposes only and does not reflect any inherent differences in the sentences themselves.

Procedure and design. The task and procedure used in this control study were identical to that outlined for Experiment 2. The sentences were recorded as digitized sound files and were presented to the participants via headphones. Their task was to listen to each sentence and then decide whether or not the subsequent picture matched the final word in the previous sentence. Again, the pictures were presented at one of two ISIs following each sentence, either 0ms or 750ms. This was a between-participants factor. The design of Experiment 3, therefore, was identical to Experiment 2: a 2 (picture type) x 2 (original simile type) x 2 (ISI) mixed design.

Results

Analyses were conducted on the correct responses only, trimmed to within 3 SDs of the overall mean, which removed 1.1% of the total data. These data, averaged by conditions, are presented in Table 7. As with the original similes, picture verification times following the literal sentences were faster for the consistent pictures than their inconsistent

Table 7. Mean correct picture verification times (in ms) for the consistent and inconsistent picture targets in Experiment 3 as a function of ISI and original simile type (error rates in parentheses).

		Picture type		
ISI	"Simile" type	Consistent	Inconsistent	(difference)
0ms	Mixed	611 (.00)	616 (.00)	5
	Perceptual	566 (.00)	603 (.03)	37
750ms	Mixed	567 (.03)	601 (.06)	34
	Perceptual	568 (.00)	610 (.07)	42

counterparts (578ms vs. 608ms, respectively). This difference suggests that the speeded verification times for the consistent pictures in the Experiment 2 may have been at least partially due to some aspect of the pictures themselves. Analyses of variance, however, showed this effect of picture type to be reliable across participants only ($F_1(1,26)=7.12$, MSe=3148, $p<.02$; $F_2(1,18)=2,88$, MSe=6926, $p=.11$).

For the pictures following the "perceptual" literal sentences, the verification times for the consistent and inconsistent picture targets, collapsed over ISI, were 567ms vs. 607ms, respectively. Again, these means were reliably different in the participant analysis only ($F_1(1,26)=6.01$, MSe=3509, $p<.03$; $F_2(1,18)=2.59$, MSe=6926, $p=.13$). For the literal sentences based upon the mixed similes, the difference between verification times for the consistent and inconsistent picture targets (590ms vs. 609ms, respectively) did not approach significance in either analysis ($F_1(1,26)=1.26$, MSe=3509, $p>.25$; $F_2(1,18)=0.63$, MSe=6926, $p>.40$).

Finally, taking ISI into account, planned contrasts were carried out between the consistent and inconsistent picture types for each combination of ISI and original simile type (see Table 7 for the means). At 0ms, the difference between picture types was not significant for either the "perceptual" or "mixed" sentences (perceptual items:

$F_1(1,26)=2.40$, MSe=3509, $p=.13$; $F_2(1,18)=2.84$, MSe=2650, $p=.11$; mixed items: both Fs<1). At the 750ms delay, the difference between picture types did approach significance following the "perceptual" literal sentences ($F_1(1,26)=3.67$, MSe=3509, $p=.07$; $F_2(1,18)=3.97$, MSe=2650, $p=.06$). For the "mixed" sentences, however, this comparison was not significant ($F_1(1,26)=1.43$, MSe=3509, $p=.24$, $F_2(1,18)=2.45$, MSe=2650, $p=.14$).

Although the pattern of results from Experiment 3 suggest that there may have been a general processing advantage for the consistent pictures, the statistics indicate that this advantage was not necessarily reliable. Because this lack of an effect would be consistent with the norming data reported in Experiment 1, it is possible to conclude that the effects found for the figurative sentences in Experiment 2 were probably not driven to an overwhelming degree by differences inherent in the pictures themselves. Although the effect for the pictures presented 750ms after the perceptual similes in particular should perhaps be qualified by the finding of a marginal difference in this control study, it should nevertheless be noted that the relative size of the equivalent effect for the figurative sentences was nearly twice as large (75ms versus 42ms here). Compared to the literal sentences, the similes clearly increased participants' sensitivity to differences in the perceptual information contained in the consistent versus inconsistent picture targets.

Discussion

The results from Experiments 2 and 3 support the claim that simile comprehension can involve the activation of relevant perceptual information. Similar to the results from Experiment 1, Experiment 2 showed that this is especially true for similes that have meanings based primarily in perceptual resemblances. In addition to the strong effect for the perceptual similes, however, there was also the suggestion that people may activate perceptual information in response to the mixed similes as well -- at least immediately upon comprehension. Given that the mixed similes contained both conceptual and perceptual components, this weak evidence of perceptual priming implies that perceptual aspects may have been playing a role in their comprehension as well. After a delay, however, this selective perceptual activation, still quite robust for the perceptual similes, was attenuated for the mixed similes. In addition, Experiment 3 supported this assessment of these results by ruling out (for the most part) the possibility that the consistent pictures may have been more easily verifiable. It is possible to wonder whether more truly "neutral" control sentences, like *The relevant word is snake*, would have more clearly established the equivalence of the two picture types.

In any case, one way to interpret these results is that perceptual information is quickly and immediately activated in response to any linguistic input that contains concrete referents like "snake" or "hat." This was demonstrated in Experiment 2, in the data collected at 0ms, when such activation is apparent for both the perceptual and mixed similes. This cannot simply be, however, general activation of the relevant concept, given that the finding is a <u>difference</u> between the consistent and inconsistent pictures, for both simile types. This difference must reflect the fact that people are engaged in arriving at an interpretation of the sentence as a whole, which in turn provides additional constraints in favor of the consistent picture.

By 750ms, this process is presumably largely accomplished. For the perceptual similes, the still-significant advantage for the consistent pictures confirms that people do indeed have this perceptual information active as a result of comprehension. The fact that this advantage (although weak to begin with) goes away for the mixed similes, however, is consistent with the proposal that perceptual information is less important for how people understand sentences of this type. Recall that Gentner and Clement (1988) showed that people, when asked explicitly about their understanding of double metaphors, prefer relational interpretations. In the present context, given that such conceptual relationships were always available for the mixed similes, relatively abstract aspects of interpretation may have won out at the expense of the perceptual components. As a result, the participants' sensitivity to the kind of perceptual information presented in the consistent picture targets decreased with the delay following these similes. It is still unclear, however, whether this perceptual information still contributed to participants' interpretations on some level. If such information was activated, then it may have been subject to decay without further processing. In the general discussion, I will offer an account of perceptual processing in terms of the functions of the visual working memory system that is consistent with this suggestion. Before doing so, it is necessary to determine whether visual processing systems are indeed active during comprehension of these similes. This will be explored in Experiment 4.

CHAPTER 6
EXPERIMENT 4: VISUAL INTERFERENCE

Taken together, the previous two studies indicate that perceptual knowledge can indeed play a role in simile comprehension. Experiment 1 showed that a picture can prime comprehension, while Experiment 2 turned this around and demonstrated that understanding a simile can facilitate verification of a subsequent picture. Importantly, this relationship holds particularly true when comprehension seems to requires the use of perceptual information, as in *A rope is like a snake.* For similes in which the use of such information is relatively optional, the influence of perceptual information is less apparent, although Experiment 2 provided some indication that such perceptual knowledge may be activated early in comprehension for other sentences having concrete components.

What remains to be explored, however, is the nature of the representations that underlie the use of perceptual information in comprehension. The previous studies showed that people do make use of their knowledge concerning the perceptual attributes of objects in understanding simple similes, but they provide only indirect evidence concerning the format in which people access this information during processing. One could, for example, explain the results of the first two studies by postulating the involvement of abstract, propositionally-encoded 'perceptual' semantic features. For example, our concept of "snake" may include features that represent its overall shape (such as LONG, NARROW, or WRIGGLY; cf., Schreuder & Flores D'Arcais, 1989) and which can be matched to similar features of ropes and perhaps even to pictures of snakes, which may also be encoded abstractly. Even for primarily perceptual similes, comprehension could still take place at the level of such abstract semantic features, or propositional descriptions, rather than through analog perceptual representations (Kieras, 1978).

An alternative possibility, however, is that sentence comprehension is mediated (at least in particular circumstances) by knowledge representations that are modality-specific (Glenberg, 1997). Such modality-specific representations have been most often discussed in terms of mental imagery. As presented earlier, the claim is that people may activate imagistic representations routinely during language comprehension, particularly for words and sentences that are highly concrete (Paivio, 1986). If one agrees with Kosslyn (1994) concerning the nature of our mental imagery abilities, then this would entail that language comprehension involves (at least some of the time) various visual processing subsystems[1] in addition to more traditional linguistic processes. Demonstrating the involvement of visual processing, then, is an important step in drawing conclusions about the presence of imagistic representations. Thus, Experiment 4 was intended to look more directly at the very nature of the representations that people do in fact bring to bear upon understanding. In particular, the aim of this study was to obtain evidence with respect to possible modality-specific processing in simile comprehension. Because the figurative meanings of the similes used in this research are based primarily upon visual similarities, this goal was accomplished through a visual interference paradigm.

Visual interference

The rationale behind the use of visual interference is that burdening the visual processing system in some manner should reduce the resources available for other concurrent tasks that also require visual processing. The visual interference technique has been of particular use in exploring the general nature of visual working memory (Baddeley, Grant, Wight, & Thomson, 1975; Baddeley & Lieberman, 1980; Logie, 1986; Logie & Marchetti, 1991; Quinn, 1988; Quinn & McConnell, 1996, in press; McConnell & Quinn,

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1. Although particular attention is being paid to visual processing, this is not intended to suggest that mental images are anything other than multimodal (cf. Barsalou, in press).

in press; Toms, Morris & Foley, 1994). One model of working memory that has been particularly influential is Baddeley's (1986; Baddeley & Hitch, 1974) tripartite model, which postulates a limited-capacity central executive supported by two slave systems: a phonological loop and a visuo-spatial sketchpad (VSSP). The VSSP is considered responsible for the temporary storage and manipulation of visual information, and has been described as playing a potentially useful role in imagistic processing (Baddeley, 1988). Behavioral and neuropsychological evidence has suggested that the VSSP may actually be subdivided further into both a visual subsystem and a spatial subsystem (Baddeley & Lieberman, 1980; Farah, Hammond, Levine, & Calvanio, 1988; Logie, 1986; Toms, et al., 1994). For example, secondary tasks that clearly involve spatial processing, such as pursuit rotor tracking or pressing a keypad in particular sequential pattern, are more likely to interfere with a primary task that also has a spatial element, as compared to visually-oriented secondary tasks like brightness discrimination or hue judgments (Logie & Marchetti, 1991; Quinn, 1988). This dissociation suggests that visual and spatial tasks are handled by separate processing subsystems (cf. Kosslyn, 1994).

Visual interference techniques have also been used in exploring how visual processing might play a role in how people encode and understand linguistic material (Atwood, 1971; Drose and Allen, 1994; Eddy & Glass, 1981; Fincher-Kiefer, 1998; Glass, et al., 1985; Glass, et al., 1980; Klee & Eysenck, 1973; Kruley, Sciama, & Glenberg, 1994; Matthews, 1983). In an early study, Atwood (1971) demonstrated that a simultaneous visual task (i.e., participants were asked to retrieve the missing member of a visually-presented pair of digits) impaired recall of a set of high imagery (and somewhat bizarre) sentences such as *A nudist devoured a bird.* The same interference task presented auditorily, however, did not impair memory for the concrete sentences, but did interfere with recall of abstract sentences. Although Baddeley, et al. (1975) reported difficulty with replicating Atwood's results, similar effects were found by Janssen (1976) and Matthews

(1983) -- in both of these studies, a visually-oriented judgment task interfered with memory for sentences high in imagery. Drose and Allen (1994) also investigated memory for concrete and abstract sentences under visual interference, but found only a general decrement in performance due to the interference; there was no interaction between interference and sentence type. Their secondary task, however, involved tracking the beam of a flashlight as it moved across a screen, which may have primarily involved spatial processing and would have been therefore less likely to induce visual-specific interference.

Research using some type of visual interference to directly investigate sentence comprehension is relatively sparse. Klee and Eysenck (1973), in an early study, presented a series of sentences to participants simultaneously with a verbal or visual secondary task. The sentences varied in terms of both concreteness and meaningfulness. The interference task was introduced by interspersing either an auditory digit or a visual matrix between the words of the auditorily-presented sentences. After listening to each sentence, the participants were asked to judge the meaningfulness of the sentence and then had to recall the six stimuli (single digits or matrices) presented as part of the secondary task. The results revealed the expected interaction between sentence type and interference type -- although the primary locus of the effect was with the semantically anomalous distractor sentences, which makes this result difficult to interpret. For the meaningful sentences, decision latencies for the concrete sentences were indeed longer under visual interference, while latencies for the abstract sentences were only slightly longer under conditions of verbal interference. However, as pointed out by Holmes and Langford (1976), presentation times for the target sentences in this study had to be quite slow since the interference stimuli were presented between each word. As a result, processing of these sentences may have involved a substantial memory component.

Also, recall that the studies carried out by Glass and his colleagues, discussed previously, used an interference paradigm to explore visual processing in sentence comprehension. In particular, Glass, et al. (1980) found that comprehension of high imagery sentences interfered with performance on a visual secondary task, while Eddy and Glass (1981) found that the same sentences, when visually presented, took longer to verify than when they were presented auditorily. Glass et al. (1985) replicated this finding in a verification task, but failed, however, to show a similar pattern of interference when participants were asked to judge the meaningfulness of the sentences. The impact of visual interference upon processing, then, was clearest when the primary task involved explicit access to some store of visually-represented facts, such as verifying which hand holds the Statue of Liberty's torch. Conversely, when the experimental task or materials provides little intrinsic motivation to utilize perceptual knowledge, comprehension may be much less likely to involve visuospatial processing. In a similar vein, Kruley, et al. (1994) found that the construction of a mental model during text comprehension involves the visuospatial sketchpad, as revealed by interference with a secondary visual task. This interference, however, occurred primarily when participants were explicitly presented with a diagram that represented the associated text.

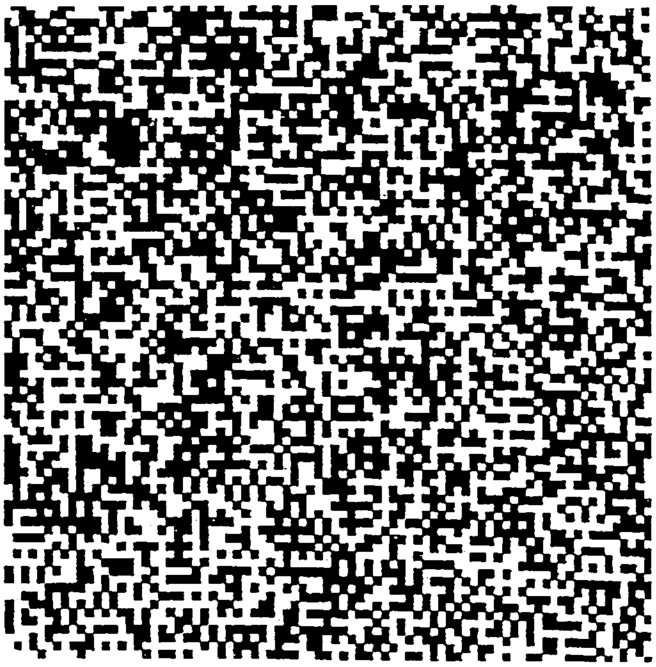
The texts used by Kruley, et al. were scientific expository passages that could be explicated by the accompanying illustration. Fincher-Kiefer (1998) found similar evidence for the use of visuospatial working memory in mental model construction for texts that were not explicitly visual. Her research took advantage of the "contradiction effect" described by O'Brien and Albrecht (1992). This effect is observed when readers spend longer reading target sentences that are inconsistent with earlier information, which demonstrates that readers' mental models are sensitive to the global coherence of a text. In two studies, Fincher-Kiefer (1998) presented readers with short texts that sometimes contained inconsistent target sentences. In one study, the participants were required to read the texts while loaded with either high or low imagery sentences for subsequent recall. In the second study, the load consisted of either a spatial array of dots or a set of letters. In both studies, the high imagery materials (either sentences or dots) eliminated the contradiction effect, suggesting interference with the construction of an adequate mental model. With the low imagery secondary task (either sentences or letters) the contradiction effect was still present. This demonstrates that generating a mental model for simple texts can indeed involve the use of visuospatial working memory.

It remains to be seen if such spontaneous construction of similar visual "mental models" can be found for other materials that might induce perceptual processing. It was this possibility, in essence, that was tested in Experiment 4, using the kinds of similes found in the previous two studies. If the understanding of figurative expressions like *A rope is like a snake* involves generating visual images of ropes and snakes and manipulating these representations to discover their similarities (i.e., constructing a mental model), then concurrent visual interference should reduce the efficiency with which people comprehend such similes.

Dynamic visual noise

In order to induce the requisite visual interference, it was decided to present participants with irrelevant visual noise as they took part in a simile comprehension task. This visual noise technique has been used by other researchers as a means of selectively inducing visual interference (Logie, 1986; Quinn & McConnell, 1996; in press; McConnell & Quinn, in press; Toms, Morris & Foley. 1994). In Quinn and McConnell (1996), participants memorized lists of words either by using rote verbal memory or via vivid imagistic mnemonics. Importantly, they carried out this task under conditions of either no interference or visual interference, as instantiated by a visually-presented, randomly-changing, 'checkerboard-like' pattern (see Figure 4 for a static depiction of this noise). Since visual material has been postulated to have obligatory access to the visuospatial sketchpad (Logie, 1986), this visual noise was expected to occupy resources necessary for processing the concurrently presented lists of words, which were all high in imagery and

Figure 4. A static reproduction of the dynamic visual noise used in Experiment 4.



frequency. Indeed, Quinn and McConnell found that, for participants who were instructed to use imagery mnemonics, the presence of the irrelevant visual material disrupted performance. Under rote memorization conditions, however, this visual noise did not disrupt memory. The fact that the visual noise did not interfere with this rote strategy suggests that the locus of the interference task was modality-specific, rather than having a general cognitive cost.

The advantages of the visual noise technique are that it can be presented simultaneously with the primary task of interest, it does not appear to tap into general processing (Logie, 1986), and it selectively interferes with visual processing in particular -- the spatial subsystem does not appear to be affected by visual noise (Logie & Marchetti, 1991, although see Toms, et al., 1994). The downside, however, is that this technique is relatively untested and has been used mainly in experiments involving a memory task. Other visual interference procedures appear problematic, however, in that they are either not concurrent with the primary task of interest, raising questions concerning the timing of the interference, or they require an additional decision component which would occupy general processing resources, possibly masking any effect due to purely visual processing. Using visual noise in this study will at the very least allow simile processing to proceed unhindered by the demand to undertake an additional monitoring or decision task.

Unlike Quinn and McConnell (1996), who asked participants to memorize lists of high imagery words under one of two strategy conditions, Experiment 4 varied the types of materials instead. That rationale was that, if figurative sentences high in perceptual content are necessarily understood via imagistic processing, then people may have no choice but to adopt an imagery "strategy" in order to understand them, as suggested by the results of Experiments 1 and 2. Such perceptually-based sentences, then, should demonstrate a clear effect due to the visual interference. For sentences in which concrete, visual content is low (or absent), comprehension should take place at a more conceptual level, in which case the visual noise should have a noticeably lesser effect. However, this assumption needed to be tested empirically, given theories of conceptual processing that suggest a role for perceptual representations even in relatively abstract contexts (Barsalou, in press).

Thus, Experiment 4 employed a wider range of items than the previous studies. In Experiments 1 and 2, the number and kind of usable sentences were limited by the fact that two distinct pictures had to be generated for each figurative vehicle. This next study included two additional groups of similes which had figurative meanings based primarily in abstract relationships, which Gentner and Clement (1988) called "relational" similes. Since perceptual resemblance should not play a role in how these sentences are understood, the visual noise was not expected to impair processing of these sentences. In addition, a distinction was made between relational similes that contained concrete and abstract components. This was done to investigate whether having concrete topics and vehicles would be sufficient to activate visual processing, in which case the visual noise should have an effect. If, however, the abstract, conceptual meanings of these two simile types are primary, regardless of the particular type of components involved, then the noise should not make much of a difference, if at all.

The most critical prediction was that the greatest impact upon processing from the visual noise should be observed for the perceptual similes, given that understanding these sentences is most likely to involve the use of perceptual information. For the mixed similes, though, it was unclear what kind of effect the visual interference might have. Based on Gentner and Clement (1988) and the results of Experiment 1, one might expect that these sentences would be understood primarily on a relational level, in which case the visual interference should have little impact. Experiment 2, however, hinted that perceptual information may be activated during the comprehension of these similes as well, despite the fact that such information plays a limited role in the eventual interpretation. If this is the case, then the presence of the visual noise could indeed have an impact upon processing of the mixed similes as well.

Another advantage of Experiment 4 is that it does not utilize pictures of any kind. This fact counters a possible criticism concerning Experiments 1 and 2, which is that perceptual processing may be induced in any experiment in which participants are presented with pictorial stimuli. In Experiment 4, however, the fact that the meanings of some of the similes involved perceptual similarities was not made apparent by the associated presentation of relevant pictures. As a result, any effect of the visual noise upon comprehension should be attributable primarily to interference with spontaneous visual processing, rather than as a task demand.

Method

Participants. Forty-three undergraduate students from the University of Chicago participated in this study. All were native speakers of English who had not participated in any previous experiments on figurative language. The data from three participants could not be used due to excessive error rates that exceeded 25% of their total responses. Therefore, the analyses reported here are based on data from 40 participants.

Materials. Four types of similes were used in this study. Two of these simile types, the perceptual and mixed similes, were identical to those used in Experiment 2. Items for the remaining two classes of similes were taken from previous studies in figurative language, or were generated specifically for this study. One group of similes involved expressions that contained at least partially concrete or visual topics and vehicles, but the meanings of which were conceptual or relational. These relational-concrete similes included expressions like *A mind is like a sponge* or *A diploma is like a doorway*. The final group of similes also involved abstract, conceptual figurative meanings, but the topics and vehicles of these expressions were also highly abstract. Two of these relational-abstract similes were *Crime is like a disease* and *Danger is like a spice*. Thus, the meanings of the similes used in this study were intended to span a continuum of perceptual and conceptual content, ranging from visual matches between concrete objects to highly conceptual relationships among abstract entities. Ten similes of each type were used, resulting in 40 experimental sentences altogether. Appendix A1 lists the perceptual and mixed similes used in this study (which were the same as those in Experiment 2), while Appendix A5 lists the relational-concrete and relational-abstract similes.

To motivate the meaningfulness judgment task, an equal number of "nonsense" similes were used that included a similar variety of concrete and abstract content words as the experimental similes. Twenty nonsense similes were taken directly from the nonsense sentences used in Experiment 1, and all contained highly concrete nouns in the topic and vehicle positions. Ten more nonsense similes were created to be partially concrete, in that either the topic or vehicle was a concrete noun while the other noun was generally some abstract concept. Finally, ten additional nonsense similes were created that used abstract concepts in both the topic and vehicle positions. The set of nonsense similes, taken as whole, was intended to mirror the type and proportion of concrete and abstract content possessed by the target similes, while still lacking any discernible meaning. For a list of the nonsense similes presented in Experiment 4, see Appendix A6.

Thus, there were 40 experimental similes (ten of each type) and 40 nonsense similes. These similes, along with an additional set of sentences intended to be practice items, were digitally recorded by a male speaker, using natural intonation, at a sampling frequency of 22kHz.

Procedure. The experimental task was generally similar to that of Experiment 1. Each trial began with an auditory tone that signaled the participant to prepare for the upcoming item, which played after a 500ms pause. Instructions directed participants to carefully listen to each sentence in order to decide whether or not it had a meaningful figurative interpretation. It was explained that all of the sentences would have the same general form and that many of the sentences would be meaningful similes, while others would be nonsensical. Participants indicated their decisions by pressing the appropriate response key, which was either the 'f' or 'j' key on the computer keyboard. The "yes" response was always mapped to the participant's dominant hand. After each response, there was a 2000ms pause before the next trial.

For the visual interference, the same visual noise paradigm described in Quinn and McConnell (1996) was used.[2] This involved presenting, in the center of a computer monitor, a 10.5 cm^2 display that consisted of an 80 x 80 grid, each cell of the grid measuring 4 x 4 pixels (see Figure 4). In Quinn and McConnell, these cells were subject to a continuous on/off rate of change of a random 291 cells per second. Pilot testing using this rate of change suggested that it may not generate a sufficient level of 'noise' to produce interference with the current task, and so this rate was increased to 1000 cells per second for this study. Although McConnell and Quinn (in press) found that increasing the rate of

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2. I wish to express my gratitude to Gerry Quinn for making available the visual noise program used in this study.

change in the visual noise from 640 to 1920 cells per second did not have an additional effect upon visual processing, Quinn (personal communication) has found further evidence indicating that the range tested in McConnell and Quinn may not be the upper limit of disruption provided by this technique.

For the block of sentences presented without the visual noise, the computer monitor was left blank and participants were told that they should simply concentrate on the sentence judgment task while looking at the screen. This was the no-interference condition. For the visual interference condition, the experimenter initiated the visual noise on the computer monitor and directed the participant to keep his or her eyes continually focused on the moving pattern for the duration of this block. It was emphasized that this was important for the purposes of the study and that they should try their best to keep watching the pattern as much as possible while responding to the sentences. The experimenter remained in the room throughout the experiment, and all participants seemed to keep their eyes focused on the screen while the visual noise was being displayed.

The presentation of the sentences and recording of the participants' responses were controlled by an Apple Centris 660AV computer running SuperLab. The presentation of the visual noise was handled by a separate computer, a Gateway 486SX PC, the monitor of which was placed in the experimental cubicle with the participant. The experimenter controlled presentation of the noise from the PC keyboard, which was outside the cubicle.

Design. Each participant responded to all 40 experimental items, which were randomly divided (according to simile type) into two complementary lists. These lists of sentences were presented in two counterbalanced blocks, such that half the participants saw one list accompanied by the visual noise, while the other half was presented without the noise, and vice versa for the other group of participants. The 40 filler nonsense similes were randomly divided among the two lists in a similar fashion. Furthermore, the order of presentation of the visual noise block was also counterbalanced across participants -- half of the participants saw the visual noise during the first block followed by the blank screen, while this order was reversed for the other half of the participants. In general, this study had a 2 (interference) x 4 (simile type) experimental design. Both interference and simile type were within-participant factors.

Results

Meaningfulness judgments. The primary measure of interest was the time it took participants to decide whether or not each target simile was in fact a meaningful sentence. Before analysis, outliers lying beyond three standard deviations of the overall mean were trimmed, removing 1.6% of the total data. The correct response times, averaged over simile type and interference condition, are presented in Table 8, along with the associated error rates. In initial analyses, the order of presentation of the blank screen and visual noise conditions did not interact with either of the other two factors, and so this aspect of the study will not be considered further.

The pattern of means in Table 8 indicate that the visual noise condition produced a small but consistent increase in participants' judgment times. The mean reaction times for items presented without and with the visual noise were 2273ms and 2314ms, respectively. However, two-way ANOVAs revealed a main effect of interference in the item analysis only ($F_1(1,39)=1.65$, MSe=25299, $p=.21$, $F_2(1,36)=6.41$, MSe=6995, $p<.02$). So

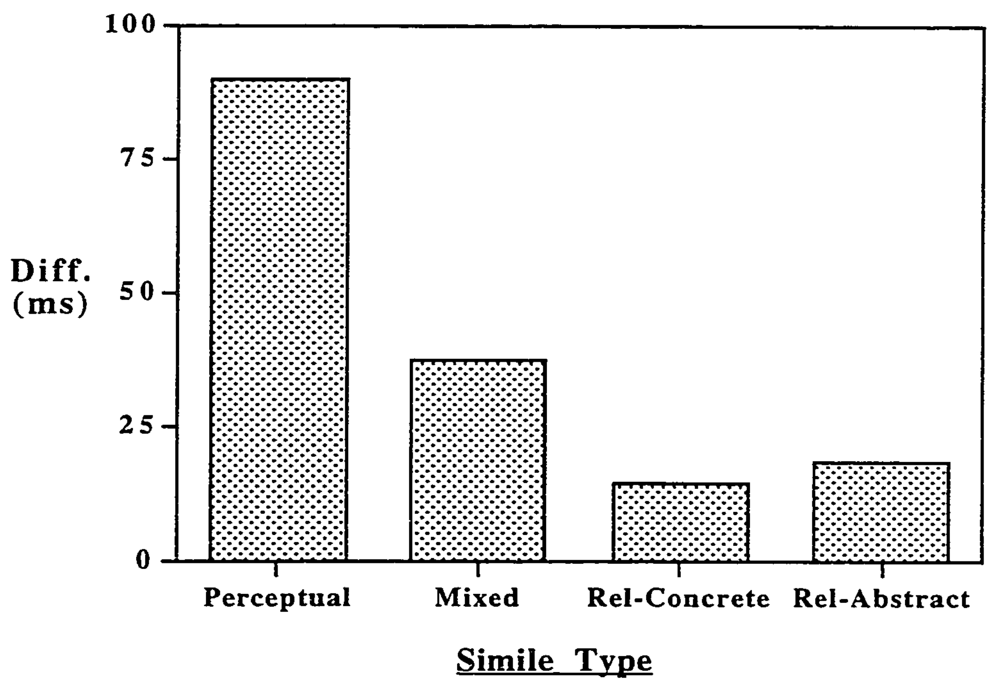
Table 8. Mean correct meaningfulness judgment latencies (in ms) in Experiment 4 as a function of sentence type and interference condition (error rates in parentheses).

	Interference		
Sentence Type	Blank	Noise	(difference)
Perceptual	2197 (.09)	2287 (.07)	90
Mixed	2283 (.09)	2321 (.11)	37
Relational-concrete	2311 (.17)	2325 (.18)	14
Relational-abstract	2308 (.20)	2326 (.23)	18

although the visual noise did have a effect when comparing across the same set of items, the equivalent effect across participants was not reliable, probably due to the greater variability in response times across individuals.

Further inspection of the pattern of differences between the blank screen and visual noise conditions in Table 8, however, shows that the effect of the noise differed greatly according to simile type. In particular, the visual noise had the largest effect upon the perceptual similes (90ms), with the next largest effect happening with the mixed similes (37ms). For the two groups of relational similes, the impact of the visual noise was similar for both and, more importantly, was smaller than either of the first two simile types (14ms and 18ms for the concrete and abstract items, respectively). This pattern of results (depicted in Figure 5) is exactly what was predicted given the initial assumptions concerning the degree of perceptual processing that should be necessary to understand each of these types of similes. Although the interaction between simile type and interference did

Figure 5. Mean differences (in ms) between the visual noise and blank screen conditions in Experiment 4, for each simile type.



not reach significance in the overall ANOVAs, planned contrasts were carried out between the two interference conditions for each of the four simile types. This difference was indeed significant for the perceptual similes ($F_1(1,117)=4.53$, MSe=38869, $p<.04$; $F_2(1,36)=6.29$, MSe=6995, $p<.02$). For each of the other three similes types, however, this contrast failed to reach significance. Thus, for the perceptual similes at least, the visual noise did appear to have a significant impact upon performance.

Error rates. Turning attention to the error rates obtained in this experiment, inspection of Table 8 shows that, across all item types, meaningful similes were rejected as nonsense 14% of the time. However, the two sets of relational similes were much more likely to have been misconstrued as nonsensical than either of the groups of relatively concrete similes. The rate of errors does not, however, seem overly affected by the presence or absence of the visual noise: the error rates for the blank screen and noise conditions were 13.4% and 14.6%, respectively. ANOVAs were carried out on the arcsine transformed proportions of errors, and revealed an effect of simile type only, and only in the participant analysis ($F_1(3,117)=17.2$, MSe=.019, $p<.0001$; $F_2(3,36)=1.49$, MSe=.056, $p=.23$). Post-hoc comparisons of the participant data showed that the perceptual and mixed simile groups did not differ in terms of their error rates, while all other comparisons were indeed strongly significant (all $ps<.01$).

Thus, although these statistics do not permit any firm conclusions, the pattern of error rates seems to suggest that the more abstract the similes were, the more likely they were to have been incorrectly rejected as meaningless. This tendency could have been the result of several factors. First, the fact that the items were presented as similes may have caused problems for comprehension of the more abstract sentences. Recall the earlier speculations concerning the relationship between the simile form and the perceptual content of figurative expressions (e.g., Aisenman, 1999). Perhaps hearing similes led participants to pitch their comprehension at the incorrect level of analysis, producing an overall expectation for "surface" relationships. In a similar vein, people may have been focusing, for whatever reason, on the visual aspects that characterized the meanings of many of these sentences, and were thus relatively unprepared to make speeded decisions about the more complex relational sentences. By focusing on the attributional matches between objects, comprehenders may have failed to appreciate these deeper conceptual relationships.

It might thus be simplest to conclude that these relational sentences were generally more difficult, if not for the fact that the higher error rates were not accompanied by substantially longer response times, as would be more consistent with increased difficulty. It is possible, however, that participants were in fact responding too quickly for sufficient comprehension of these more complex sentences. Presumably, with more time to respond, participants' error rates for the relational sentences would decrease. Finally, it should be noted that the visual noise, which would potentially cause greater interference with these more difficult items, did not seem to interact with simile type at all. This also works against the 'general difficulty' possibility.

Discussion

In this experiment, participants were asked to judge the meaningfulness of similes that varied in the degree to which their meanings were motivated by perceptual similarities. In addition, some of the time they carried out this task while faced with dynamic visual noise, which was intended to interfere specifically with any visual processing that might be necessary for successful comprehension. As predicted, the pattern of interference from the visual noise condition was consistent with the claim that the comprehension of figurative expressions having meanings directly dependent upon the appreciation of perceptual resemblances is most likely to involve visual processing. In particular, the greatest amount of visual interference was found for the perceptual similes. This finding provides strong support for the claim that part of the online comprehension of such expressions involves the use of visual mental images.

For the mixed similes, the visual noise may have had an impact as well, although this effect did not reach significance. The fact that the pattern of the interference effect for the mixed similes was intermediate between the perceptual and relational similes suggests that some degree of visual processing may have been taking place during understanding of these sentences as well, although clearly not as strongly as for the perceptual similes. Thus, the type of representations involved in comprehension of these similes remains somewhat unclear -- as in Experiment 2, the data are suggestive of the involvement of visual processing, but not strong enough to provide a definitive answer.

For the relational similes, both concrete and abstract, the visual noise had very little effect, if any. Although these items may have been generally more difficult to comprehend, as suggested by the high error rates, this difficulty did not seem to interact in any way with the visual noise. This is generally consistent with the possibility that comprehension of these more abstract, conceptual expressions does not involve visual processing to any substantial degree, at least as can be revealed using the current paradigm. Furthermore, the possibility that comprehension of the relational-concrete items would perhaps be affected by the visual noise was not borne out by this experiment. In general, to the extent that the meaning of a given simile was based primarily in a conceptual relationship between the topic and vehicle, comprehension proceeded relatively unhindered by the visual noise, regardless of whether the individual components were concrete or abstract or both.

Thus, Experiment 4 was able to establish a cline of sorts with respect to the degree of involvement of visual processing in the comprehension of simple similes. For those similes whose meanings are most clearly rooted in the apperception of visual resemblances, the degree of visual interference was greatest. The logical conclusion to draw from this pattern of results is that imagistic representations, and in particular visual representations, do play a role in the comprehension of certain figurative expressions.

CHAPTER 7
GENERAL DISCUSSION

The results of the studies presented in this dissertation converge upon the conclusion that simile comprehension can be mediated by imagistic processing. In doing so, this research goes beyond previous findings concerning the general relationship between imagery and figurative language and establishes a more definitive role for online perceptual processing. Instead of relying upon the results of post-comprehension rating and recall measures to draw inferences about the role of imagery in metaphor understanding, these experiments employed cognitive tasks that were able to directly demonstrate the use of imagistic information during comprehension. The strongest and most consistent evidence for the use of imagery was obtained for expressions that possess figurative meanings based primarily in perceptual resemblance. Specifically, the results of Experiments 1 and 2 showed the strongest facilitation in processing with these perceptual similes (with Experiment 3 controlling for the possibility that the particular set of consistent pictures may have driven this effect), while Experiment 4 demonstrated that the same perceptual similes were also most susceptible to concurrent visual interference. These findings support the claim made by Paivio (1986) that "[i]magery plays an essential role in the comprehension of concrete, high imagery verbal material *when comprehension depends on knowledge about the concrete properties of objects, their actions, or their spatial arrangements*, knowledge that is directly represented only in the imagery system" (p. 222, emphasis added). The perceptual similes used in these studies are prime examples of the kind of verbal material to which Paivio is referring. For the other similes (the mixed similes in particular), evidence indicating the presence of perceptual processing was much weaker or absent altogether. Comprehension of these other similes, therefore, seems not to have necessarily relied upon accessing imagistic information.

Connections with theories of metaphor comprehension

Given the diversity of possible metaphorical expressions, it should not be surprising that variation exists in how people understand them. It is this many-to-many mapping between form and process that makes the task of the psycholinguist interested in explaining metaphor comprehension so difficult. As a number of researchers have recently observed, it is important to identify the various dimensions along which metaphorical expressions can differ in order to examine how these differences impact processing (Blasko & Connine, 1993; Glucksberg, McGlone, & Manfredi, 1997; Onishi & Murphy, 1993). To that end, the current evidence supporting a role for perceptual processing in simile understanding suggests yet another important aspect of figurative language that must be considered (cf. Gibbs & Bogdonovich, 1999).

Existing theories of metaphor comprehension, then, must take into account the possibility of imagistic mediation. Prior psycholinguistic research on metaphor has focused mostly upon whether metaphor comprehension can be explained by a two-stage model that postulates an initial rejection of the literal meaning of a sentence on semantic grounds, followed by a search for figurative interpretations (see Gibbs, 1994). Although this literal-first model has been generally discredited, one consequence of this debate has been that much less attention has been paid to issues related to the representations underlying metaphorical processing. As the studies presented here reinforce, the nature of the representations involved in understanding figurative language are potentially very important for the type of process model one proposes to explain metaphor comprehension.

Most models of figurative language processing, like theories of language processing in general, have assumed that some type of standard propositional network underlies successful interpretation. One such model arises from the "structure-mapping" framework proposed by Gentner and her colleagues (Gentner & Markman, 1995; Gentner & Wolff, 1997). In this view, conceptual domains are represented as structured propositional representations, in which knowledge is organized as networked relations of predicates and arguments. Given this structure, metaphors can be understood by a comparison process between the topic and vehicle domains that searches for identical predicates and matches structurally consistent relations between the two domains, bringing them into alignment. Crucially, matches are made at the level of entire relational structures rather than between individual features (Gentner & Wolff, 1997).

Because such relational matches are thought to lead to richer and more systematic mappings between domains, this model predicts that metaphoric comparisons based upon relational similarities should be preferred at the expense of relatively simple mappings between surface features (Aisenman, 1999; Gentner & Clement, 1988). The fact, however, that people can understand simple metaphors based in surface attribute mappings suggests that this relational preference may be overridden in particular cases (Carbonell, 1982). Wisniewski and Love (1998), for example, investigated people's interpretations for novel noun-noun conceptual combinations and found little evidence consistent with a default relational preference. In their studies, when the combinational constituents were highly similar, or when a property interpretation strategy was primed by a prior property generation task, the proportion of property/attribute interpretations was greater than those based on relational aspects alone. Wisniewski and Love concluded that property-based interpretation cannot be a "last resort" strategy.

If attributes can be as important as relations in the interpretation of simple noun-noun phrases and in simile comprehension, then an important concern should be the manner in which such property matches are carried out. The data from the experiments presented here suggest that analog perceptual representations may be used to mediate this attribute-matching process. So, while the structure-mapping account does quite well in explaining the process of matching equivalent features in the interpretation of perceptual expressions, matches can potentially be made between representations other than strictly abstract propositions. Barsalou's (in press) perceptual symbols theory offers an account of perceptual representations that possess the kinds of structured, hierarchical properties that would allow them to participate in exactly the rich mappings described by Gentner and Wolff (1997), while still retaining analog characteristics to be used as needed. Such a hybrid approach may potentially account for how people interpret both perceptual and conceptual expressions using the same set of cognitive processes.

Another theory of metaphoric processing is the property attribution model proposed by Glucksberg and his colleagues (Glucksberg & Keysar, 1990; Glucksberg, McGlone & Manfredi, 1997). Unlike the structural alignment view, this model assumes that metaphors are exactly what they seem to be: class-inclusion statements. Thus, when somebody states that *Bill is an ice cube*, they are placing Bill in the class of cold, hard objects exemplified by ice cubes, in much the same way *An apple is a fruit* places apples in the class of fruits. The vehicle is considered to stand for the entire superordinate category (e.g., things that are cold) that encompasses not only the literal vehicle but comes to include the topic as well, via the metaphorical assertion. It is this superordinate category that constitutes the grounds of the metaphorical expression. When a metaphor is comprehended, properties typical of objects belonging to this superordinate category are attributed to the topic.

Although the property attribution model does not commit itself to a particular representational scheme, it must at the very least assume that concepts are represented in part by networks of semantic features. The question, then, is whether these features are necessarily represented only via abstract symbols or if there is a potential for imagistic representations as well. Again, an approach like that suggested by Barsalou (in press) could easily accommodate the property attribution model, because it assumes that perceptual symbols are integrated into frames, which are used to construct specific simulations of a category. Thus, the frame for "ice cube" would include perceptual simulations for aspects of one's experiences with ice cubes, as well as activating a larger frame for the category of cold things. A perceptual token, representing "Bill," could then be incorporated into this frame as well, producing an attribution of coldness.

The property attribution view, however, appears to have difficulty explaining other aspects of the comprehension of perceptually-based expressions. Two important elements of this model are the prototypicality of the vehicle with respect to the superordinate category and the manner in which it explains the nonreversibility of metaphors (Glucksberg & Keysar, 1990). For perceptual metaphors like *A rope is a snake*, it is not clear whether we should understand "snake" to be prototypical of the category of long winding things in the same way that "jail" is prototypical of confining situations. This issue is even more apparent for a metaphor like *A rainbow is a bridge*, given that bridges are certainly not prototypical of arched things. For this reason, a comparison view like structure-mapping (Gentner & Wolff, 1997) may have an advantage in explaining how these perceptual expressions are understood, because it assumes that properties of both the topic and the vehicle are necessary to arrive at an appropriate interpretation. For this to happen, a matching process between attributes may be more relevant than the generation of a superordinate category.

Another aspect of perceptual metaphors and similes is that they are generally more reversible than the kinds of metaphors primarily considered by existing theories. Glucksberg, et al. (1997) argue that metaphorical expressions are nonreversible for the simple fact that they are, in essence, class-inclusion statements. Just as it is uninformative to say *A fruit is an apple*, it is equally invalid to say *The sun is Juliet* and preserve the same meaning. It seems much less disturbing, however, to reverse perceptual similes, creating sentences like *A snake is like a rope* or *An umbrella is like a mushroom*. Not only do these reversed sentences still make sense, but very often they retain meanings similar to the original ordering. Shen (1989) makes a similar observation, noting that symmetric metaphoric comparisons are possible as long as the shared property is prominent for both the topic and vehicle concepts. In general, the grounds of these perceptual similes may be represented by a fused image that depicts the relevant perceptual qualities common to both the topic and the vehicle (cf. Verbrugge, 1977). As such, the direction of predication is not as important. Although this issue is somewhat orthogonal to the question of imagistic mediation in general, it is nevertheless reinforces the notion that a monolithic approach to metaphor comprehension is untenable. Most fundamentally, expressions based in direct perceptual similarity appear to have several properties which cannot be handled by existing models of metaphor comprehension.

These speculations concerning the manner in which models of metaphor comprehension could be expanded to handle the existence of perceptual representations have little to say, however, about how such perceptual representations are actually instantiated and used during processing. Clearly, this is an important issue that must be explored in order to offer a more complete account of the current findings. With this goal in mind, I will try to offer a description of "perceptual processing" that will allow me to specify the conditions under which such processing can be expected to play a role in comprehension. To begin, it will be necessary to review evidence concerning the nature of imagery and visual working memory.

Passive versus active mechanisms in visual working memory

As noted in the introduction to Experiment 4, Baddeley (1986; Baddeley & Hitch, 1974) has proposed a model of working memory that is composed of two slave systems, a phonological loop and a visuospatial sketchpad, under the control of a central executive. Recent evidence, however, has been interpreted as suggesting that both the phonological loop and the VSSP may be separable into a passive sensory store and active rehearsal processes (Logie, 1995). The passive store keeps sensory information available in a buffer, while the rehearsal processes maintain this sensory information as needed in order to prevent decay. This division of labor between a sensory store and rehearsal mechanisms that act upon the sensory information has been described by a number of researchers (Baddeley, 1986; Kosslyn, 1994; Logie, 1995; Quinn & McConnell, in press). For instance, Kosslyn's (1994) description of the human visual processing system includes a passive store and numerous active mechanisms. In Kosslyn's model, the "visual buffer" contains what are essentially retinotopic maps of visual stimuli, which can be either percepts or images constructed from information retrieved from long term memory. These images are generated by the "pattern activation subsystems," which are also responsible for their rehearsal and maintenance, through repeated activation of appropriate modality-specific pattern information.

Logie (1995) has proposed a similar model of visuospatial working memory that also posits a temporary visual store (a "visual cache"), which is subject to decay and to interference from subsequent visual input. Unlike Paivio's (1986) dual-coding account, in which both storage and processing functions are handled by the same coding systems (verbal or visual), Logie's model separates these functions, postulating modality-specific storage bins that are acted upon by separate rehearsal mechanisms (i.e., the phonological loop for verbal rehearsal and an 'inner scribe' for visual rehearsal). The visual cache provides temporary storage of visual information, while generating and maintaining an image are rehearsal functions that refresh the contents of the cache. In addition, Logie interprets a number of experimental results (e.g., Logie & Marchetti, 1991) as suggesting that these rehearsal processes may actually be spatial in nature, as opposed to the visual generation and storage functions. The spatial aspects of visuo-spatial working memory will not generally be considered further, however, since the primary interest is in the possible instantiation of visual information in the visual sketchpad.

For current purposes, then, the most salient aspect of these models of visual working memory is the separation between the passive store and the active control processes that act upon it. The temporary activation of modality-specific information in a given sensory store is considered to be an automatic process, while the maintenance and manipulation of that information is controlled and strategic. The workings of the active mechanisms in particular are analogous to aspects of Barsalou's (in press) model, in which perceptual simulations are assumed to be instantiated via active rehearsal components like the phonological loop (for verbal simulations) and the VSSP (for visual simulations), among others. In his model, however, the running of "highly compiled" simulations is considered to be automatic, whereas strategic processing involves the construction of a novel simulation using productive mechanisms.

Perceptual processing during language comprehension

What exactly constitutes a "highly compiled" simulation, then, turns out to be a crucial question. Barsalou (in press) proposes that such simulations are initiated in response to familiar, frequently-encountered entities. If this is true for most familiar concrete concepts (like "snake" and "bridge"), then it may be possible to assume that concrete materials automatically activate visual representations in the visual buffer. A similar assumption has been adopted by other researchers (notably Paivio, 1986), and forms the backbone for much of the research into visual imagery and linguistic processing. The most debatable aspect of this assumption may concern the automaticity of the presumed activation of visual representations in response to concrete words and phrases. Although both Denis and Le Ny (1986) and Medina (1988) found evidence for perceptual activation in sentence comprehension, Glass, et al. (1985) did not find similar activation for concrete sentences like *Huge clouds gathered on the horizon*. As a result, they proposed that sentences may vary with respect to the likelihood that they would invoke visual images, and that the generation of images for some concrete sentences may be relatively strategic.

Other researchers, though, have investigated the possible automatic activation of perceptual information with respect to different aspects of linguistic processing. One set of data comes from research on word recognition and semantic representation. For example, Strain, Patterson, and Seidenberg (1995) found that participants were faster to pronounce irregular low-frequency, highly-imageable words like *sword* (its "irregularity" comes from the fact that it does not possess simple orthographic-to-phonology structure) compared to irregular low-frequency abstract words like *suave*. They interpret this result as suggesting that speeded access to the phonological codes for high-imageability words was aided by the automatic activation of imagistic semantic representations. In contrast, the abstract words did not automatically generate similar activation because their meanings are more context-dependent. For regular, high-frequency words, phonological processing was too efficient for semantic information to have a similar impact, according to Strain et al. (1995). Thus, these findings reinforce the notion that concrete materials can automatically invoke perceptual-semantic information.

In a different experimental context, Schreuder, Flores D'Arcais, and Glazenborg (1984) found similar evidence for the automatic activation of perceptual information for concrete words. In several studies, they found that people were faster to respond to a target word like "cherry" after responding to a prime word such as "ball," seemingly because of the perceptual overlap between the two concepts (i.e., both cherries and balls are round). This result is surprising because most accounts of single-word semantic priming assume that the first word primes the target word via automatic spreading activation in a semantic network (i.e., "banana" would prime "cherry" because both are fruit; e.g., Anderson, 1983). Models of automatic semantic activation cannot easily account for priming between words that are based solely on perceptual similarity, given that there is no semantic relationship to facilitate responding (Shelton & Martin, 1992).

The surprising nature of these findings, combined with a number of perceived problems in the procedure and materials, prompted Pecher, Zeelenberg, and Raaijmakers (1998) to carry out a replication of Schreuder, et al. (1984). Using a more controlled set of items and a short SOA of 350ms, Pecher, et al. were not able to find evidence for perceptual priming between words, although associative priming was still quite robust. Thus, it appeared that perceptual features are not automatically activated for words independent of a given context. Subsequently, however, Pecher, et al. tested whether it was possible to induce people to activate their perceptual knowledge about words. They did this by first giving participants a perceptual orienting task (e.g., "Are these objects oblong?") followed by the standard word priming paradigm. Using this procedure, perceptual priming became apparent. Pecher et al. concluded that semantic priming can be affected by the context in which words appear. When the context is such that perceptual features of words are activated, automatic perceptual priming effects may then be observed. As other researchers have found, sentential context is a highly-influential determinant upon activation of word features (Denis & Le Ny, 1986; also Stanovich & West, 1983). Thus, when words are embedded in sentences that emphasize perceptual properties (as in *A rope is like a snake*), these perceptual features may be especially likely to become automatically activated.

What does this imply for sentences like *Huge clouds gathered on the horizon* or *A mind is like a sponge*? Are perceptual features of *clouds* and *sponge* activated in the context these sentences as well? Available empirical evidence (Glass, et al. (1985); the present Experiment 4) suggests that the answer should be "no." The description of perceptual processing developed above, however, suggests that perceptual activation may take place for these sentences as well. This would be in line with Paivio's (1986) dual-coding view, as well as the proposals of perceptual representations offered by Barsalou (in press) and Glenberg (1997). Given that comprehenders generally have no way of knowing beforehand whether or not interpretation of a given sentence will depend on accessing perceptual information, it would be most parsimonious to assume that the activation of perceptual information automatically takes place, regardless of context, for any sentence containing words that refer to concrete entities.

Such activation presumably consists of visual analog representations residing in the visual buffer (Kosslyn, 1994; Logie, 1995), as described above. Crucially, however, such activation may not be apparent to most behavioral measures unless subsequent processes act upon that information. This secondary assumption is intended to explain why perceptual effects were not apparent for Glass et al.'s (1985) concrete/effortful sentences and for the relational sentences in Experiment 4. My proposal is that "perceptual processing" implies more than the activation of modality-specific information in a sensory store like the visual buffer. In order for perceptual representations to play a role in cognitive processes like sentence comprehension, this information must enter working memory via active rehearsal and control mechanisms.

This functional description of perceptual processing has roots in earlier discussions concerning the definition of "imagery." At times, researchers have attempted to distinguish between imagery as a semantic attribute of particular words or sentences versus imagery as a cognitive process that can mediate comprehension of words and sentences. The former notion of imagery, as a descriptive attribute of verbal materials, has been referred to as *concreteness* (Paivio, Yuille, & Madigan, 1968). Baddeley, et al. (1975) suggested that while concreteness is a fundamental semantic feature of words and their representations in semantic memory, imagery itself should be thought of as a distinct type of *control process* (Atkinson & Shiffrin, 1968) that utilizes part of the visual system (e.g., the VSSP) to manipulate imagistic representations in the service of some cognitive function. In a similar vein, then, perceptual processing may best be thought of as a cognitive mechanism that can be applied to some input, rather than as an inherent characteristic of the material itself.

Perceptual representations, or images, may be generated constantly for many kinds of stimuli, but if these images are not subsequently acted upon in some manner, then it is inappropriate to speak of "perceptual processing."

Thus, the distinction between passive and active processing components offers a way to think about perceptual processing as referring not only to the activation of visual information in a passive buffer, but also to the control processes (i.e., perceptual simulations) that work upon this visual information. That is, in order for mental imagery to "play a role" in a cognitive process, this visual/perceptual information must be called upon by comprehension or simulation routines that take place in working memory. To apply this to simile comprehension, hearing a simile like *A mind is like a sponge* may automatically activate perceptual representations of both a brain (the visual analog of "mind") and a sponge in the visual buffer, but these images would not necessarily be called upon by subsequent control processes as part of comprehension (although could still be relevant for elaboration; Gibbs, 1994). Therefore, given the view developed here, it would be erroneous to describe perceptual processing as being part of understanding *A mind is like a sponge*. More precisely, it would be incorrect to say that visual processing was involved, as suggested by the results of Experiment 4. In Glenberg's terminology, because "mesh" can take place without access to perceptual properties, any visual information related to these concepts would not enter working memory. It is an open question, however, whether neuropsychological measures like PET or fMRI would show activation in the primary visual cortex during the comprehension of such sentences. Available evidence (Kosslyn, 1994; Kosslyn, et al., 1993) suggests that neural activation should be present as long as visual images are being instantiated in the visual buffer. Therefore, such measures might reveal the presence of such activation, in the absence of visual processing per se.

Perceptual processing in Experiments 1-4

How can this description of perceptual processing explain the results obtained in the current research? First, I will propose that perceptual similes quickly and automatically activate perceptual representations in the visual buffer. For Experiment 1, recall that the consistent pictures facilitated comprehension of the perceptual similes to a greater extent than the inconsistent pictures. The fact, though, that this effect was found only for the perceptual similes, while the mixed similes exhibited no differences according to picture type, suggests at first glance that perhaps only the perceptual similes in this study were activating modality-specific representations. This contradicts the assumption made above, that activation of representations in the visual buffer should take place for any sentence containing concrete elements. It is important to note, though, that each picture was on the computer screen for 750ms before the simile, which was then followed by the participant's response. Given other accounts concerning the time course of automatic versus controlled processing (Posner & Snyder, 1975), this is a more than sufficient interval for controlled processes to occur, obscuring any effects due to perceptual priming for the mixed similes. The relevant visual input from the consistent pictures may have speeded the activation of visual representations for both the perceptual and mixed similes, but since these activated representations would have been most relevant for comprehension of the perceptual similes, facilitation was only observed for these sentences. For the mixed similes, processing was less likely to require access to information active in the visual buffer, and so this information was not maintained to the same degree, resulting in roughly equal levels of facilitation for the two picture types.

In Experiment 2, the similes were presented prior to the pictures and could potentially facilitate their verification, so when a sentence was followed immediately by a picture, the representations generated in response to the sentence were presumably still present and active in the visual buffer. Following Kosslyn (1994), these visual representations consist of patterns of activation in the buffer that can be matched against the subsequent input from the picture target. The greater the extent to which these two patterns of visual activation "matched" (i.e., the more easily these visual patterns could be mapped onto one another by control processes acting upon the visual buffer), the faster participants could respond. The fact that substantial priming was found at the 0ms ISI for the perceptual similes is therefore consistent with the claim that the activation of perceptual knowledge for these sentences was early and automatic (Pecher, et al., 1998; Schreuder & Flores D'Arcais, 1989). Glenberg (1997) referred to priming effects as "perceptual anticipation," which seems an apt way to describe these results.

Evidence for perceptual priming was also found, if less emphatically, for the mixed similes, which is also consistent with automatic activation of perceptual representations for concrete sentences. Even though the individual components of the mixed similes were all quite concrete (e.g., lighthouse, candle), the fact that this effect was attenuated may have been due to interference from early conceptual interpretations of these similes, which diverted processing resources away from full consideration of the visual elements of these sentences. This is, however, admittedly speculative and demands further research.

The longer ISI condition of Experiment 2, though, was sufficiently extended (750ms) for controlled processing to have occurred, as in Experiment 1 (cf. Posner & Snyder, 1975). With such a delay, any activation of perceptual knowledge in response to the mixed similes may have undergone substantial decay, as demonstrated by the lack of facilitation under these circumstances. The continued advantage for the consistent picture targets with the perceptual similes is consistent with the explanation that, for these sentences, the active control mechanisms involved in comprehension were used to maintaining an adequate image of the critical concepts. In other words, even though perceptual representations were activated early in response to both the perceptual and mixed similes in Experiment 2, the presumed control processes active during comprehension resulted in a divergence of the kinds of information active at later stages of processing. Indeed, had this study somehow tested the activation of conceptual elements of "snakes" and "candles," for example, it might have shown an early equivalence in the degree of activation for these conceptual components across the two simile types, followed by a later divergence -- such that conceptual features would have remained active for the mixed similes, but not for the perceptual similes. Conceivably, this decrease in activation may be due to suppression rather than decay. Gernsbacher, Keysar, & Robertson (1995) presented evidence for the suppression of irrelevant features of vehicle concepts during metaphor comprehension. In a similar fashion, the perceptual features activated early for the mixed similes in Experiment 2 may have subsequently been suppressed in favor of relational features.

Finally, Experiment 4 demonstrated that the perceptual similes are vulnerable to concurrent visual noise, which confirmed the presence of visual processing. This experiment is of particular import because the visual noise paradigm has been described by Quinn and McConnell (in press) as interfering specifically with access to the passive visual store. Because each of the perceptual, mixed, and relational-concrete similes in this study possessed concrete elements, all three of these simile types may have activated representations in the visual buffer. However, as with the previous experiments, the crucial difference may have been in whether this visual information then entered into subsequent processing. For the relational-concrete items, the information in the passive store was not relevant for subsequent interpretation, and so these representations were presumably allowed to decay. Since access to the visual store was not necessary, the visual noise did not have an effect on the time necessary to comprehend these relational-concrete similes.

However, because such access was important for the other two simile types (the perceptual similes in particular), evidence of interference was observed. The fact that the interference with the mixed similes was weaker and non-significant may be due to noise in the data or to the probabilistic nature of interpretation -- given that other subsystems can achieve successful comprehension (i.e., through a nonvisual simulation of both roofs and hats providing protection, instantiated in other parts of working memory), the information in the visual store could be accessed only some of the time, depending on the initial conditions of the system and the person's processing goals. It is possible to speculate that, if participants in Experiment 4 had been explicitly informed that they should use imagery in interpreting the sentences, then the mixed similes would have exhibited interference effects more on par with the perceptual similes.

The generality of perceptual processing

As a broad observation, people are apparently quite flexible in how they deal with figurative statements. This flexibility extends to the kind and degree of processing engaged in during comprehension. As suggested by Glass, et al. (1985) and Pecher, et al. (1998), the relative weight given to imagery versus more conceptual semantic processing may be adjusted according to processing goals, context, and stimulus novelty (cf. Helstrup, 1995; Walter & Fox, 1981). Whether or not the particular contribution from imagery has an impact upon the final product of comprehension appears to depend to a great extent on the nature of the processes acting upon that information. As suggested above, we may initially generate perceptual representations for the concrete referents of relational similes like *A mind is a sponge* as a matter of course, but because such imagery cannot provide information relevant to a final product, resources allocated by control processes to the maintenance of these representations may diminish over the course of comprehension in favor of conceptual processing. For sentences like *A rope is a snake*, however, these initial imagistic representations would receive further activation as hypotheses concerning potential perceptual mappings are supported.

The presumed activation of perceptual information for all kinds of sentences coheres with the "perceptual" models of conceptual processing presented in the introduction (Barsalou, in press; Glenberg, 1997). In particular, these accounts suggest that people should engage in perceptual simulations for all types of language, not only for those that are particularly concrete. However, in the studies presented here, the relative lack of evidence for perceptual processing for sentences other than the perceptual similes seems inconsistent with such views. At first glance, these data are more consistent with Paivio's (1986) dual-coding view, which claims that processing can be mediated by both imaginal and verbal/conceptual representations, depending on the content of a particular sentence. Thus, the relational sentences may have been understood via the manipulation of amodal symbols, while the concrete sentences were understood via imagistic processes.

One explanation for this lack of a wider effect could be that the experimental paradigms and materials may not have been strong enough to reveal underlying perceptual processing. While this may certainly have been true, more interesting is the possibility that not all perceptual simulations are necessarily visual. Since the studies described here tested visual aspects of processing, they would have been unable to demonstrate perceptual processing taking place in other modalities. Thus, people's representations for the concepts in a given sentence presumably reflect different kinds of information. For concrete objects, these representations would contain information directly related to the shape and appearance of the referent objects, which could be encoded in an analog fashion via perceptual symbols. Given that the perceptual representations for concrete referents will instantiate on some level the neural states of the original percept (Barsalou, in press), this implies that any processing involving such representations would potentially involve visual processing subsystems (Kosslyn, 1994).

However, for most objects in the world, even highly concrete ones, our representations presumably contain other information that is not specifically visual -- such information might include temporal information or introspective information or haptic information, and so forth. To take a specific example, consider our representation for "sponge." Clearly, we have multiple visual experiences of all kinds of sponges, but we also have knowledge about the feel of sponges and the functions of sponges and the experience of buying a particular sponge last week. Barsalou would argue that all of this information becomes part of our simulation for "sponge." It is not clear, however, to what extent this other information is necessarily instantiated visually. In its current form, the perceptual symbols approach does not specify whether the perceptual simulations generated for particular concepts necessarily include a simulation of visual aspects of objects and events. Barsalou often describes concepts as being encoded as perceptually-experienced event sequences, implying that a visual component may always be present. However, he also states that other kinds of simulations are often important. For instance, "introspective" simulations of mental states are considered to be crucial for the representation of abstract concepts. Such simulations would certainly not be accomplished visually. Thus, in the final analysis, it does not seem that visual activation must necessarily be present for the perceptual symbols approach to work. Such nonvisual perceptual simulations may have been underlying the interpretation of the relatively abstract similes in the current experiments. This would explain why the visual noise did not have an effect upon such sentences in Experiment 4.

Conclusion

As I observed in the introduction, metaphorical language very often seems to be vivid and image-inducing, especially in contrast to ordinary, literal uses of language. Indeed, metaphor has been called "communicable imagery" (Wisjen, 1980, p. 118) -- not only do metaphors and related expressions allow us to communicate complex concepts, but they also extend our capacity to comment on and understand the world around us. A sentence like *Thought is a snake sliding and coiling on warming stones* easily conjures up an image of a snake writhing in the sun in a manner that effectively captures the elusive and ever-changing aspect of our mental experiences. But what is not immediately apparent is whether such imagery is intrinsic to the very process of understanding this sentence, or if these images are merely epiphenomenal. The findings presented in this dissertation suggest that imagery does have an important role to play in our understanding of expressions. In particular, imagery (or rather, perceptual representations) has been implicated in the comprehension of sentences that have meanings based in perceptual resemblances. This is one of the few clear demonstrations of the use of imagery in language comprehension of any kind. The fact that this relationship is not as apparent for other types of expressions suggests that more work will have to be done in order to discover the degree to which perceptual representations might be useful in other contexts as well. Even so, this initial demonstration of direct imagistic mediation has consequences for models of metaphor comprehension in particular and for language comprehension more generally, and also adds to our growing understanding of the interrelated nature of metaphor, perception, and language. Clearly, perceptual processing is a crucial aspect of our capacity to discover meaning in the world around us.

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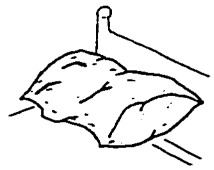
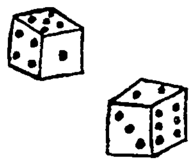
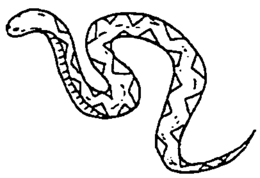
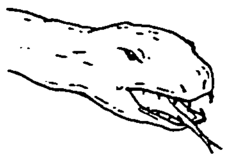
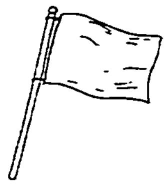
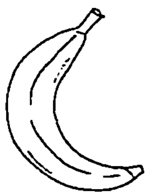
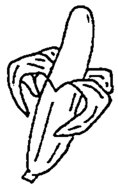
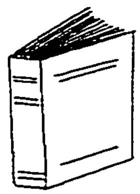
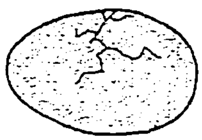
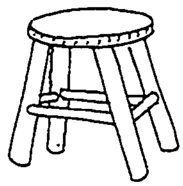
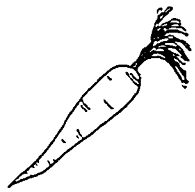
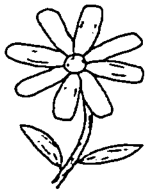
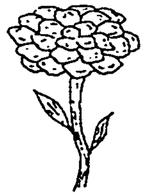
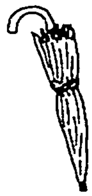
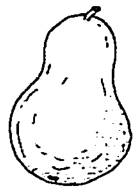
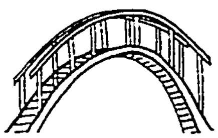
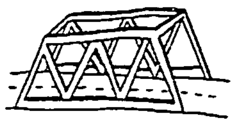
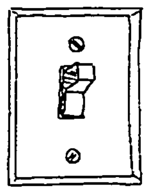
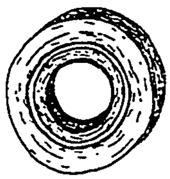
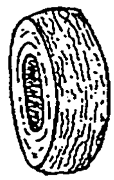
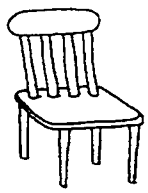
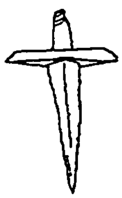
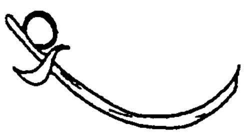
APPENDIX A: EXPERIMENTAL STIMULI

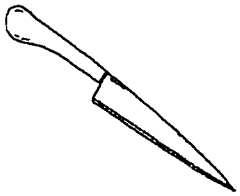
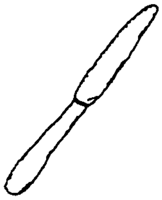
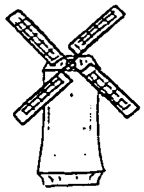
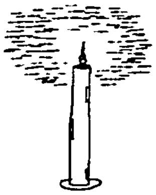
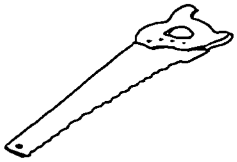
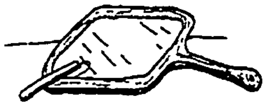
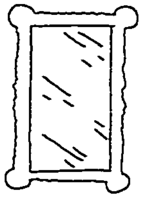
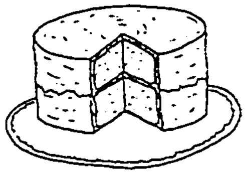
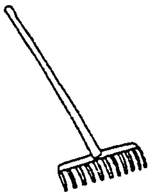
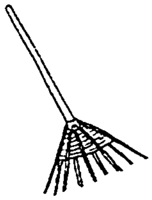
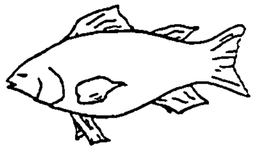
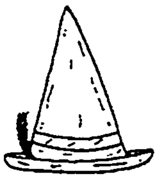
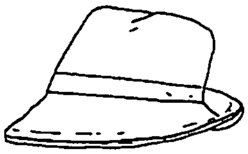
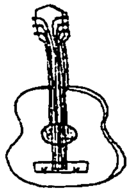
Appendix A1. List of the perceptual and mixed similes presented in Experiments 1 to 4, plus the pictures associated with each item in Experiments 1 to 3.

	Pictures		
	Consistent	Inconsistent	Unrelated *
Perceptual similes			
A marshmallow is like a pillow			
A rope is like a snake			
A crescent moon is like a banana			
A football is like an egg			
A cotton ball is like a cloud			

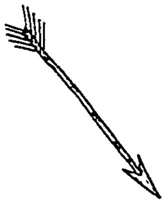
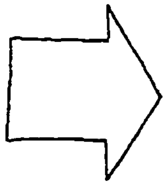
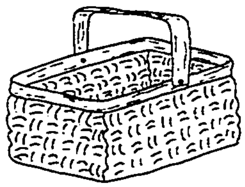
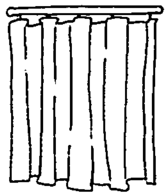
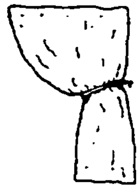
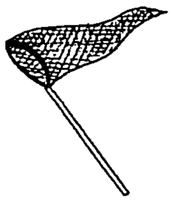
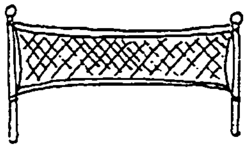
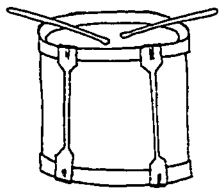
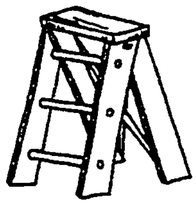
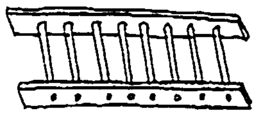
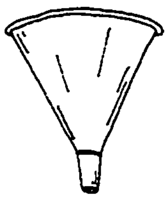
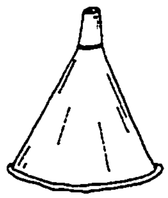
Appendix A1, continued.

	Pictures		
	Consistent	Inconsistent	Unrelated *
Perceptual similes			
A propeller is like a flower			
A mushroom is like an umbrella			
A rainbow is like a bridge			
A donut is like a tire			
An icicle is like a sword #			

Appendix A1, continued.

	Pictures		
	Consistent	Inconsistent	Unrelated *
Mixed similes			
A plow is like a knife			
A lighthouse is like a candle			
A still pond is like a mirror			
A comb is like a rake			
A roof (steeple) is like a hat **			

Appendix A1, continued.

	Pictures		
Mixed similes	Consistent	Inconsistent	Unrelated *
A lightning bolt is like an arrow			
A waterfall is like a curtain			
A spiderweb is like a net			
A hill is like a ladder			
A tornado is like a funnel #			

* The unrelated pictures were used only in Experiment 1.
# These two items were used only in Experiments 2 and 4.
** For this item, "roof" was changed to "steeple" in Experiments 2 and 4.

Appendix A2. List of nonsense similes and associated pictures presented in Experiment 1.

Anomalous similes	Picture type: Related	Picture type: Unrelated
An alligator is like a leaf	leaf	padlock
A bulldozer is like a thermometer	thermometer	saltshaker
A fishing pier is like a bell	bell	teakettle
An icepick is like a fireplace	fireplace	coatrack
A weathervane is like an envelope	envelope	bowl
An oriental rug is like an axe	axe	pipe
A courtyard is like a pumpkin	pumpkin	hanger
An igloo is like a telephone	telephone	battery
A gargoyle is like a ring	ring	corn
A grandfather clock is like a bathtub	bathtub	rolling pin
A honeycomb is like a swing	swing	refrigerator
A peach is like a telescope	telescope	paintbrush
A watch is like an ironing board	ironing board	baseball bat
A belt is like a school bus	bus	bread
A maze is like a pencil	pencil	mitten
Chocolate milk is like a suitcase	suitcase	couch
A cactus is like a balloon	balloon	wineglass
A screwdriver is like an apple	apple	domino
A trellis is like a lamp	lamp	key
A cathedral is like a skateboard	skateboard	can
A crowbar is like a sandwich	sandwich	trumpet
A typewriter is like a bottle	bottle	chicken
A moose is like an elevator	elevator	necktie
Soap is like a clothespin	clothespin	lifejacket

Appendix A3. List of filler similes and unrelated pictures presented in Experiment 2.

Filler similes	Unrelated picture
Rage is like a volcano	padlock
A fashion model is like a twig	saltshaker
A beach is like a grill	teakettle
A river is like a ribbon	coatrack
A sprinter is like a cheetah	hanger
An extension cord is like a vine	pipe
An igloo is like a baseball cap	bowl
A giraffe is like a skyscraper	battery
A snowdrift is like a blanket	corn
A kangaroo is like a yo-yo	rolling pin
A sentry is like a fencepost	refrigerator
A tree is like a drinking straw	paintbrush
An eye is like a window	trumpet
A kite is like a bird	bread
A desert is like an oven	mitten
A cigarette is like a pacifier	couch
A city is like a beehive	wineglass
A rooster is like an alarm clock	domino
A dancer is like a butterfly	key
An insult is like a razor	necktie

Appendix A4. List of literal sentences presented in Experiment 3.

Perceptual controls	Mixed controls
The wife straightened a pillow	The couple replaced a knife
The hikers discovered a snake	The actor carried a candle
The monkey smelled the banana	The lady bought a mirror
The customer ate an egg	The gardener picked up a rake
The plane flew behind a cloud	The saleswoman sold a hat
The tourist picked a flower	The man drew an arrow
The teacher carried an umbrella	The woman hung a curtain
The family crossed the bridge	The wind tugged at the net
The mechanic inflated the tire	The painter got out the ladder
The fighter lifted the sword	The assistant knocked over a funnel

Filler control sentences	
The scientist climbed a volcano	The driver hit a fencepost
The dog retrieved a twig	The hostess brought a drinking straw
The father lit the grill	The branch hit a window
The girl tied a ribbon	The children watched a bird
The darkness concealed the cheetah.	The owner threw out an oven
The squirrel nibbled a vine	The toddler bit the pacifier
The boy washed a baseball cap	The cat avoided a beehive
The banker admired the skyscraper	The student borrowed an alarm clock
The flight attendant folded a blanket	The leaf hid a butterfly
The clown twirled a yo-yo	The man changed the razor

Note: the associated pictures in Experiment 3 were the same as those presented with the original similes in Experiment 2.

Appendix A5. List of relational-concrete and relational-abstract similes presented in Experiment 4.

Relational-concrete similes	Relational-abstract similes
An ant is like a bulldozer	Evolution is like a lottery
A mind is like a sponge	Money is like a lubricant
Alcohol is like a crutch	A rumor is like a plague
A family is like an anchor	Trust is like an adhesive
A slum is like a tumor	Crime is like a disease
A cigarette is like a pacifier	A long life is like a journey
A diploma is like a doorway	Deceit is like an ambush
A judge is like a balance	Time is like a physician
A beach is like a grill	Danger is like a spice
A good friend is like a bar of gold	An artist is like a god

Appendix A6. List of nonsense similes presented in Experiment 4.

Fully concrete nonsense similes	
An alligator is like a leaf	A peach is like a telescope
A bulldozer is like a thermometer	A belt is like a school bus
A fishing pier is like a bell	A maze is like a pencil
Soap is like a fireplace	Chocolate milk is like a suitcase
A weathervane is like an envelope	A cactus is like a balloon
A rug is like an igloo	A screwdriver is like an apple
A courtyard is like a pumpkin	A cathedral is like a skateboard
A gargoyle is like a ring	A crowbar is like a sandwich
A grandfather is like a bathtub	A typewriter is like a bottle
A honeycomb is like a swing	A moose is like an elevator

Concrete/abstract nonsense similes	Fully abstract nonsense similes
A formula is like an iceberg	A legal contract is like an emotion
A peace treaty is like a watermelon	A foreign language is like an attitude
A disaster is like a skirt	A paradox is like an oath
A telephone call is like a tower	A myth is like an opportunity
A dare is like a sleeping bag	An investment is like a soul
A needle is like a celebration	Greed is like a category
A strong breeze is like a fortune	Research is like an omen
A tiger is like a symphony	A virtue is like a correlation
Insanity is like an atom	Education is like a tendency
A flag is like a burden	A conscience is like a trend

IMAGE EVALUATION
TEST TARGET (QA-3)

150mm

6"