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Hemisphere differences in idiom comprehension: The influence of ambiguity, transparancy, and familiarity

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HEMISPHERIC DIFFERENCES IN IDIOM COMPREHENSION: THE INFLUENCE OF AMBIGUITY, TRANSPARENCY, AND FAMILIARITY

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VITA

The author was born in Walnut Ridge, Arkansas on December 7, 1980. He graduated with honors from Walnut Ridge High School in 1999. In 2003, he received his Bachelor of Arts degree, *cum laude*, from Lyon College in Batesville, Arkansas. He earned his *Master of Science* degree in psychology from The University of Memphis in 2007.

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CHAPTER I

INTRODUCTION

When comprehending a narrative text, readers may encounter an idiom, or a phrase that must be interpreted figuratively such as "to bury the hatchet" (i.e., to reconcile) (Gibbs, 1999; Titone & Connine, 1999). It is essential that readers correctly interpret idioms so that they can successfully comprehend the intended meaning of a text (Dews et al., 1996; Rankin et al., 2008; Winner, Brownell, Happe, Blum, & Pincus, 1998). For example, if readers misinterpret the idiomatic[1] phrase “Stacy is in hot water” (i.e., “to be in trouble”), they may incorrectly believe that Stacy is literally submerged in hot water (Brinton et al., 1985; Huber-Okrainec & Dennis, 2003). Because idioms are ubiquitous in everyday communication (Antaki, 2007; Billig & MacMillan, 2005; Lim et al., 2009), it is important to understand how idioms are processed to form a more complete understanding of written communication and language. Previous research suggests that the literal plausibility of an idiom (i.e., the level of ambiguity), the degree to which an idiom’s literal meaning contributes to the figurative meaning (i.e., the level of transparency), or readers’ familiarity with an idiomatic phrase (i.e., the level of familiarity) influences how idioms are processed during text comprehension (Cronk, Lima, & Schweigert, 1993; Giora & Fein, 1999; Titone & Connine, 1999). Although it is known that idiom ambiguity, transparency, or familiarity may influence idiom comprehension, it is

[1] Here, "idiomatic" refers to "resembling or having the nature of an idiom" (*American Heritage Dictionary*, 1991).

currently unclear how idioms are processed in the left and right cerebral hemispheres (Papagno et al., 2004; Myers & Linebaugh, 1981). In the current series of experiments, I examine how idioms with varying levels of ambiguity, transparency, or familiarity are processed in the hemispheres.

From a linguistic perspective, idioms are groups of words that are frequently encountered together (i.e., collocations). In English, text may convey one or more of seven types of meaning (Leech, 1974). For example, a text can convey *a conceptual meaning*, or the literally defined features of the word. For example, the conceptual meaning of "man" would be "a human, male adult." The *stylistic meaning* of a text refers to the text's social implications. For example, "steed" may conceptually mean the same thing as "horse," but "steed" has a more poetic connotation than "horse" (Leech, 1974). Text may also contain an *affective meaning*, which conveys an individual's attitude toward the subject or audience. For example, "Would you please be quiet," may suggest more politeness than "Shut up!" The *reflected meaning* of a text refers to the tendency for the meaning of a particular word or phrase to be influenced by the word or phrase's alternate conceptual meanings. For example, when an individual reads the phrase "Holy Ghost" and envisions the disincarnate specter of a deceased person, the conceptual meaning of a "ghost" as a spirit of the dead is reflected onto the meaning of the Holy Ghost as the third person in the Christian Trinity (Leech, 1974). Text may also convey a *thematic meaning* depending on how information is organized, such as when a sentence is phrased using passive or active voice. Finally, text may convey a

collocative meaning if the words in a text tend to be encountered together (i.e., words that *co-occur*). For example, "pretty woman" and "handsome man" are *collocations*. Although "pretty" and "handsome" both mean "good looking," the word "pretty" tends to be collocated more often with "woman" than "man," and the word "handsome" tends to be collocated more often with "man" than "woman" (Leech, 1974). Collocations may also produce a meaning that is distinct from the conceptual meanings of its constituent words.

Similarly, idioms are collocations, and the figurative meaning of an idiom's collocation is often distinct from its literal meaning. For example, the idiom "to kick the bucket" (meaning "to die") is collocative because "kick" and "bucket" frequently co-occur in English. Further, the figurative meaning for "kick the bucket" is distinct from the conceptual meanings of "kick" and "bucket." Because idioms are phrases comprised of words that often co-occur in text, the current study is primarily interested in the collocative meaning of idioms.

Although idioms can be considered a type of collocation, it is important to distinguish idioms from other collocations, both literal and figurative. Idioms are collocated verb phrases that must be interpreted figuratively. In contrast, a verb phrase such as "to drive a car" may be collocative because "drive" and "car" frequently co-occur, but the phrase is not idiomatic because no figurative interpretation is required to understand "drive a car." Conversely, a verb phrase such as "to drive me bananas" is idiomatic because "drive" and "bananas" frequently co-occur, and because a

figurative meaning must be understood for the phrase to be correctly interpreted. Idioms may be distinguished from other types of figurative collocations by the idiom's inclusion of a verb phrase. For example, "iron fist" is a collocation that compares the literal hardness of iron to the figurative hardness of a ruler. However, this phrase lacks a verb phrase, and so it is more similar to metaphor than idiom for the purposes of this research. But the phrase, "to rule with an iron fist" is a collocation, a verb phrase, and must be interpreted figuratively, and thus may be considered idiomatic. In sum, idioms are verb phrases in which the constituent words frequently co-occur and which must be interpreted figuratively.

Early studies of idiom comprehension assumed that all idioms were processed using similar cognitive mechanisms. For example, the *noncompositional approach* states that all idiomatic phrases are stored and processed as if they are single, long words (Bobrow & Bell, 1973). According to the noncompositional approach, an idiom such as "to kick the bucket" should be stored, retrieved, and processed as if it were semantically and syntactically similar to the idiom's figurative meaning (“to die”). Specifically, the noncompositional approach claims that idioms are processed as if each phrase were a single *lexical item.* Further, the noncompositional approach states that the individual words of an idiom do not contribute to the idiom’s figurative meaning. In contrast, the *compositional approach* states that idioms are not stored as if they were lexical entries, and that the component words of an idiom individually contribute to the idiom’s figurative meaning (Cacciari &

Tabossi, 1998). For example, the word “law” in “to lay down the law” is related to the idiom’s figurative meaning (“to tell somebody what to do”) and therefore the individual words contribute to the idiom’s figurative meaning. Although the compositional and noncompositional approaches to idiom processing make different predictions about how readers process idioms during text comprehension, neither theory predicts that an idiom’s individual characteristics will influence idiom comprehension.

Although some early studies of idiom comprehension did not predict that different types of idioms are processed differently, recent evidence suggests that a number of characteristics may influence how an individual idiom is comprehended. First, idioms differ in the degree to which an idiom can be literally interpreted (i.e., the level of ambiguity). For example, "to break the ice" would be considered ambiguous because an individual can either literally break a piece of ice or figuratively initiate social contact with strangers. In contrast, "talk a blue streak" is considered unambiguous because an individual cannot literally "talk a blue streak" and the only plausible interpretation is a figurative one. Second, idioms may differ in the degree to which the literal meaning contributes to the figurative meaning (i.e., the level of transparency). For example, "to blaze a trail" is transparent because "trail" is related to ideas of movement, which in turn is related to the figurative meaning of "leading the way." In contrast, "to kick the bucket" is low in transparency because neither "kick" nor "bucket" relate to the figurative meaning of "dying." Finally, idioms may differ in the frequency with which

they are encountered and used (i.e., familiarity). For example, idioms such as "to slip one's mind" are rated as being seen, heard, and used more frequently than idioms such as "to go the whole hog" (Titone & Connine, 1994a). Previous research has found that naïve readers are able to reliably sort and classify idioms according to ambiguity, transparency, and familiarity (Titone & Connine, 1994a), which suggests that readers are sensitive to these different features. Therefore, it is likely that idioms may be processed differently based on the idiom's level of ambiguity, transparency, and familiarity.

Previous research has demonstrated that high ambiguity idioms may be comprehended differently than low ambiguity idioms. For example, when participants are instructed to read texts containing either high ambiguity idioms or low ambiguity idioms, reading times are longer for high ambiguity idioms than low ambiguity idioms (Cronk, Lima, & Schweigert, 1993; Mashal et al., 2008). It is possible that the extra time needed to process high ambiguity idioms as opposed to low ambiguity idioms reflects the additional time readers need to select the appropriate (i.e., figurative) meaning of a high ambiguity idiom. Specifically, readers may not need as much time to process the figurative meaning of low ambiguity idioms (e.g., "to talk a blue streak") because there is no literal interpretation of low ambiguity idioms. Readers likely would not need to expend additional cognitive resources to understand the correct meaning of low ambiguity idioms. Conversely, readers may need more time to process the figurative meaning of high ambiguity idioms (e.g., "to break the ice") because high ambiguity idioms have a plausible literal

interpretation, likely requiring the reader to expend additional cognitive resources to select the appropriate meaning. Thus, readers may employ different cognitive mechanisms to understand an idiom depending on the idiom's level of ambiguity.

Previous research also suggests that idioms may be processed differently depending on the transparency of the idiom's figurative meaning. Specifically, the *hybrid model* of idiom processing states that low transparency idioms should be processed as if they were long words (similar to the noncompositional approach), whereas high transparency idioms should be processed based on the meaning of the idioms' individual words (similar to the compositional approach) (Titone & Connine, 1999). Further, the hybrid model states that the collocation of words in low transparency idioms should be strongly related to an idiom's figurative meaning, but that the individual words of a high transparency idiom's literal meaning should be weakly related to the idiom's figurative meaning (Cailles & Butcher, 2007). According to the hybrid model, the figurative meaning of low transparency idioms should be more directly accessible to readers than the figurative meaning of high transparency idioms. Evidence for the hybrid model comes from a study in which individuals read texts that contained a low transparency idiom in a context that was biased toward the figurative meaning (e.g., "After being ill for months, she finally kicked the bucket") or in a context that was biased towards the literal meaning (e.g., "Forgetting to move it from the path, she finally kicked the bucket") (Titone & Connine, 1999). Participants also read

high transparency idioms in a context that was biased towards the figurative meaning (e.g., “By getting his work done on time, he tried to save his skin”), or in a context that was biased towards the literal meaning (e.g., “By avoiding the tanning salons, he tried to save his skin”) (Titone & Connine, 1999). Participants were slower to process low transparency idioms (as measured by reading time) embedded in a context that was biased toward the literal meaning than when low transparency idioms were in a context that was biased toward the figurative meaning. However, no reading time differences were found for high transparency idioms between the figurative and literally biasing contexts. These findings suggest that that the figurative meaning of low transparency idioms may be stored as if the components were a single lexical item, whereas the figurative meaning of high transparency idioms may be generated sequentially during text comprehension. Therefore, it is likely that high transparency idioms are processed differently than low transparency idioms during text comprehension.

Finally, evidence suggests that idioms may be processed differently depending on a reader’s familiarity with the idiom. Specifically, the graded salience hypothesis predicts that readers process the meaning of words or phrases differently depending on the familiarity, frequency, or conventionality of the word or phrases’ intended meaning (Giora, 1997; Giora, 2003). This hypothesis states that words or phrases often have multiple meanings—some of which are more frequent, familiar, or conventional (i.e., more salient), whereas other meanings are less frequent, familiar, or conventional (i.e., less

salient). For example, the meaning of “jail” in “Alcatraz is a jail” should be more salient than the meaning of “jail” in “My job is a jail” because the literal meaning of a jail is more frequently encountered during text comprehension than the figurative meaning (adapted from Giora, 1997). When comprehending text in which the salient meaning is the intended meaning, readers will activate only the salient meaning of the text. In contrast, when readers comprehend text in which the less salient meaning is the intended meaning, readers must first activate both salient and less salient meanings and then select the contextually appropriate meaning of the text (Giora, 2003). Further, the graded salience hypothesis predicts that the figurative meaning of familiar idioms should be more salient than the figurative meaning of less familiar idioms, because familiar idioms are encountered more frequently than less familiar idioms. Support for the role of familiarity in idiom processing comes from several studies in which reading times for familiar and less familiar idioms were measured. These studies found that when readers process text containing either familiar or less familiar idioms, familiar idioms are read more quickly than less familiar idioms (Cronk, Lima, & Schweigert, 1993; Gibbs, 1994; Giora & Fein, 1999; Schraw et al., 1989). Because familiar idioms are read more quickly than less familiar idioms, it is likely that readers need extra cognitive effort to process idioms that are encountered or used less frequently. These findings suggest that familiar idioms should be more salient than less familiar idioms. Thus, readers may rely on different processes when comprehending the less salient figurative meaning of less

familiar idioms than when comprehending the salient meaning of familiar idioms.

Idiom Processing in the Cerebral Hemispheres

It is possible that behavioral differences observed when readers comprehend idioms that differ in terms of ambiguity, transparency, or familiarity may reflect differences in how idioms are processed in the cerebral hemispheres. Traditionally, the left hemisphere has been viewed as the dominant hemisphere during language processing (Grodzinsky & Santi, 2002; Pulvermüller, 2005) and word retrieval (Fiez, 1997; Paulesu et al., 1997; Perani et al., 1999). However, a growing body of evidence suggests that the right hemisphere contributes to many aspects of language comprehension. In addition, the right and left hemispheres are responsible for separate types of linguistic processing (Federmeier, Wlotko, & Meyer, 2008; Lindell, 2006). For example, the right hemisphere has been found to play a role in processing nonliteral language such as sarcasm (Giora et al., 2000; McDonald, 2000; Shamay-Tsoory et al., 2005), metaphors (Bryan, 1988; Stringaris et al., 2006), langauge-based humor (Shami & Stuss, 1999) and puns (Coulson & Severns, 2007). In sum, recent research suggests that the right hemisphere may play an important role when processing figurative language.

Although the right hemisphere may be dominant for processing several types of figurative language (e.g., Shami & Stuss, 1999), it is currently unclear how idioms are processed in the left and right hemispheres. For example, individuals who have right hemisphere damage are less accurate at

comprehending idioms than individuals who have left hemisphere damage (Myers & Linebaugh, 1981; Van Lancker & Kempler, 1987). This finding suggests that, compared to the left hemisphere, the right hemisphere may be dominant during idiom comprehension. However, other studies suggest that the left hemisphere plays a more dominant role when compared to the right hemisphere during idiom processing. For example, in a recent study (Oliveri & Papagno, 2004), participants received repeated transcranial magnetic stimulation (rTMS) in their left or right hemisphere, which disrupts language comprehension in the stimulated hemisphere. Participants then listened to a spoken idiom and subsequently viewed a picture that related to the idiom's figurative meaning, literal meaning, or an unrelated meaning. Participants were instructed to select the picture that correctly matched the meaning of the idiom. Participants were less accurate at selecting the appropriate picture when rTMS was applied to the left hemisphere than when rTMS was applied to the right hemisphere (Oliveri & Papagno, 2004). This finding suggests that the left hemisphere plays a key role in idiom comprehension. Other studies show that individuals who have left hemisphere damage are less accurate when listening to an idiom and selecting the picture containing the idiom's appropriate meaning than individuals who have right hemisphere damage (Papagno et al., 2006). One possible reason for these conflicting results may be due to the different types of idioms presented across different experiments. For example, the studies finding a left hemisphere advantage for processing idioms only used idioms that were low in ambiguity, low in transparency, and

high in familiarity (Oliveri & Papagno, 2004; Papagno et al., 2006). In contrast, the studies finding a right hemisphere advantage for idioms did not specifically control for the idioms' levels of ambiguity, transparency, or familiarity (e.g., Myers & Linebaugh, 1981). Thus, it is important to investigate how idioms that differ in their levels of ambiguity, transparency, or familiarity affect comprehension in the hemispheres.

The Fine-Coarse Semantic theory can be used to explain how the hemispheres process idioms during text comprehension (Beeman et al., 1994). This theory proposes that when individuals read a word, the left hemisphere activates meanings that are commonly associated with the word's denotation (i.e., fine semantic coding), whereas the right hemisphere activates meanings that are less commonly associated with the word's denotation (i.e., coarse semantic coding). For example, when the word "foot" is presented to the left hemisphere, strongly related words (such as "toe") should be activated. However, when the word "foot" is presented to the right hemisphere, weakly related words (such as "pay" as in "foot the bill") should be activated (See Figure 1 for an illustration; Beeman et al., 1994). Early studies testing the Fine-Course Semantic Coding Theory suggest that the right hemisphere is dominant for nonliteral language processing (Beeman, 1998; Beeman & Chiarello, 1998). However, later studies testing the Fine-Coarse Semantic Coding Theory propose that the left hemisphere is dominant for processing idioms because the figurative meaning of an idiom is more salient (and thus more closely related to the idiom) than the literal meaning of the idiom

(Mashal et al., 2008). By studying how the hemispheres process idioms that differ in terms of ambiguity, familiarity, or transparency, researchers can gain more knowledge about how these factors influence the semantic relationship between an idiom and its figurative meaning.

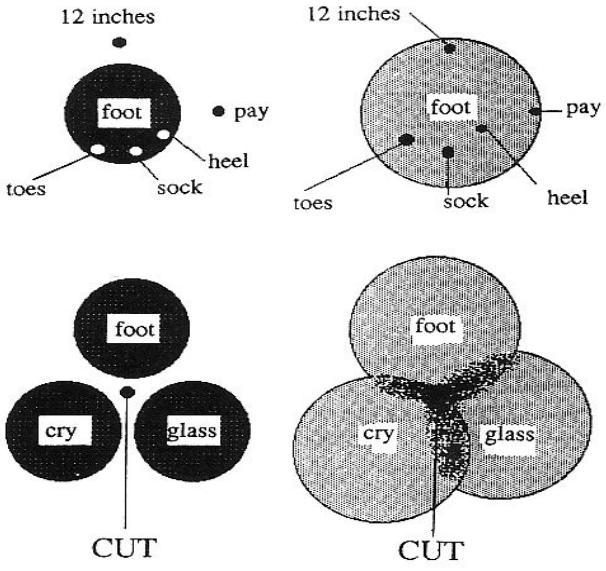

Figure 1. The Fine-Coarse Semantic Coding Theory. The two images on the left represent semantic processing in the left hemisphere. The two images on the right represent semantic processing in the right hemisphere. (Reproduced with permission from Beeman et al., 1994).

It is possible that idioms will be processed differently in the hemispheres based on their level of ambiguity. Previous studies have found that when readers encounter an ambiguous word (e.g. "bank"), the dominant meaning (e.g., "a financial institution") is activated in the left hemisphere (as measured by faster response responses to related target words as compared to unrelated target words, i.e. *priming*) (Burgess & Simpson, 1988; Faust & Chiarello, 1998). However, both the dominant and subordinate meanings (e.g. "a financial institution" and "the edge of a river") are activated in the right

hemisphere (Burgess & Simpson, 1988; Faust & Chiarello, 1998). The left hemisphere activation found for dominant meanings suggests that the left hemisphere may play a key role when readers select the appropriate meaning of an ambiguous word. The right hemisphere activation found for both dominant and subordinate meanings suggests that the right hemisphere may not play an important role in meaning selection (Coney & Evans, 2000; Copland et al., 2002; Copland et al., 2007; Faust & Chiarello, 1998; Peleg & Eviatar, 2007). Thus, the right hemisphere may activate both dominant and subordinate meanings when readers process an ambiguous word, but it is currently unclear how this right hemisphere activation contributes to resolving ambiguity when readers process idioms.

Although some evidence suggests that the left hemisphere is dominant during ambiguity resolution, findings from several brain damage studies suggest that the right hemisphere may be dominant in processing ambiguity. For example, patients with right hemisphere damage viewed a sentence with an ambiguous word and were then presented with the contextually inappropriate meaning of that word (Tompkins, 1997; Tompkins, 2001). Next, patients indicated whether the target word fit the context. Participants with right hemisphere damage were slower at rejecting the inappropriate target words compared to non-brain damaged individuals. Further, patients with right hemisphere damage have more difficulty than patients with left hemisphere damage at suppressing the inappropriate meaning of ambiguous words (Grinrod & Baum, 2005). These findings suggest that individuals with

right hemisphere damage may experience difficulty suppressing the inappropriate meaning of ambiguous words (Grinrod & Baum, 2005; Tompkins et al., 1997; 2001). Because patients with right hemisphere damage may be less accurate at rejecting the inappropriate meaning of an ambiguous word, it is possible that the right hemisphere activates the appropriate meanings of ambiguous words or phrases words under specific circumstances. Thus, it is likely that the right and left hemispheres process ambiguity differently, and that the right hemisphere may play a key role when processing ambiguous idioms.

The degree to which the right hemisphere activates the appropriate meaning of an ambiguous word may be influenced by the surrounding context of the text (i.e., the sentence, paragraph, or topic within which an ambiguous word appears). For example, many studies that show a left hemisphere advantage for activating an ambiguous word's appropriate meaning have either examined ambiguous words without any context (Copland et al., 2002), or the ambiguous word was presented in one sentence without any other supporting context (Coney & Evans, 2000; Faust & Chiarello, 1998). It is possible that the left hemisphere advantage found during the processing of dominant meanings is due to the limited context in which readers processed the ambiguous words. For example, the left hemisphere is dominant for processing words and phrases that appear in limited context (Lindell, 2006; Pulvermüller, 2005). However, when readers are provided with a more detailed context in which to resolve semantic ambiguity (i.e., when they

process meaning on the *discourse* level), the right hemisphere may contribute to resolution of the ambiguity. Support for this idea comes from findings showing a right hemisphere advantage when readers need to integrate context (such as a title) to understand a text's meaning (St. George et al., 1999) and when readers comprehend the meaning of words or phrases at the discourse level (Beeman & Chiarello, 1998). The right hemisphere may therefore play a key role in ambiguity resolution when readers are given several sentences of context from which to resolve the ambiguity. Further, it is possible that readers need more context to successfully comprehend high ambiguity idioms than to successfully comprehend low ambiguity idioms. For example, because no plausible literal interpretation exists for a low ambiguity idiom (such as "to lose face"), readers may not need any context to understand these low ambiguity idioms. However, because a plausible literal interpretation exists for high ambiguity idioms (such as "to kick the bucket"), readers may need to rely to a greater extent on the context in which the idiom appears for successful comprehension (Titone & Connine, 1994b; 1999). Thus, it is likely that the right hemisphere will show an advantage when readers process high ambiguity (but not low ambiguity) idioms because readers likely need more context to successfully understand the meaning of a high ambiguity idiom.

Previous studies have examined the processing of high ambiguity idioms in the hemispheres, but these studies have yet to explore how idioms are processed when presented in a larger context. For example, greater neural activity is evident in the right hemisphere than in the left hemisphere when

readers comprehend high ambiguity idioms (Hillert & Burucas, 2008). However, participants read these idioms in a relatively limited context (e.g., in idiomatic phrases such as “They were in the same league”), and therefore it is possible that participants processed these phrases literally or figuratively. Support for this idea comes from a recent study which found that when idioms are presented without context (e.g., “tie the knot”), no priming differences are found between the right and left hemispheres when readers responded to target words related to the figurative meanings of high ambiguity idioms (Mashal et al., 2008). Without enough context provided in a text, it is difficult for readers to determine whether the presented idioms were meant to be interpreted figuratively or literally.

Although it is currently unclear how high ambiguity idioms are processed in the right and left hemispheres, there is evidence that the left hemisphere has an advantage over the right hemisphere when readers process low ambiguity idioms. For example, when repeated transcranial magnetic stimulation (rTMS) is applied to the left hemisphere, low ambiguity idioms are more difficult to understand than when rTMS is applied to the right hemisphere (Oliveri & Papagno, 2004). In addition, individuals who have left hemisphere damage are less accurate at comprehending low ambiguity idioms than individuals who have right hemisphere damage (e.g., Papagno et al., 2006). Taken together, these studies suggest that the left hemisphere may be dominant when readers process low ambiguity idioms.

Idioms may also be processed differently in the hemispheres based on differences in the idiom's level of transparency. Specifically, the hybrid model predicts that low transparency idioms are processed as if each idiom were a single, long word, the meaning of which should be strongly related to the idiom's figurative meaning (Cailles & Butcher, 2007; Titone & Connine, 1999). In contrast, the hybrid model predicts that high transparency idioms are not stored as if they were single words, and that the idiom's constituent words are weakly related to the idiom's figurative meaning (Cailles & Butcher, 2007; Titone & Connine, 1999). This distinction between high and low transparency items is important given the Fine-Coarse Semantic Coding Theory's prediction of a left hemisphere advantage for strongly related meanings and a right hemisphere advantage for weakly related meanings (Beeman et al., 1994). Thus, the left hemisphere may be dominant when readers process low transparency idioms and the right hemisphere may be dominant when readers process high transparency idioms.

Finally, idioms also may be processed differently in the hemispheres depending on the frequency with which they are encountered (i.e. their *familiarity*). The graded salience hypothesis predicts a left hemisphere advantage for salient (in this case, familiar) meanings, but a right hemisphere advantage for less salient (in this case, less familiar) meanings (Giora, 2003). Previous research has demonstrated that the right and left hemispheres process other types of figurative language (such as metaphors) differently based on readers' familiarity with the figurative phrase. For example, highly familiar

metaphoric expressions (e.g. “iron fist”) are processed more quickly and accurately in the left hemisphere, whereas less familiar, novel metaphoric expressions (e.g. “conscience storm”) are processed more quickly and accurately in the right hemisphere (Faust & Mashal, 2007; Mashal, Faust, & Hendler, 2005). Thus, the left hemisphere may be dominant for processing familiar idioms, whereas the right hemisphere may be dominant for processing less familiar idioms. Further, the left hemisphere shows an advantage when readers process familiar sentences as opposed to unfamiliar sentences (Schmidt et al., 2007; Schmidt et al., 2009). This finding suggests that the right hemisphere has an advantage when readers process less familiar phrases, whereas the left hemisphere has an advantage when readers process more familiar phrases. Based on previous research, an idiom's level of familiarity may influence how the left and right hemispheres process idioms during language comprehension.

In summary, previous research suggests that the right hemisphere may be dominant when readers process the figurative meaning of high ambiguity idioms, high transparency idioms, or low familiarity idioms, whereas the left hemisphere may be dominant when readers process the figurative meaning of low ambiguity, low transparency, or high familiarity idioms.

RATIONALE

The proposed set of experiments examined the hemispheric processing of idioms that vary in the level of ambiguity, transparency, or familiarity. Currently it is unclear how the right and left hemispheres process information

related to the figurative meaning of idioms that differ in terms of these three features. Some previous research shows right hemisphere dominance when readers process idioms; however, these studies did not control for the ambiguity, transparency, or familiarity of the idioms presented to participants (e.g., Myers & Linebaugh, 1981). Conversely, other previous research shows left hemisphere dominance when readers process idioms, but these studies only presented participants with low ambiguity, low transparency, high familiarity idioms (e.g. Papagno et al., 2006). Because the right hemisphere likely has an advantage when readers need to resolve ambiguity in a text (e.g. Tompkins et al. 2001), when readers process distant semantic relations (e.g., Beeman et al., 1994), or when readers process less familiar meanings of words or phrases (Giora, 2003), the hemispheres may process idioms differently based on the level of ambiguity, familiarity, or transparency of the idiom. Therefore the current study investigated how the hemispheres process idioms that differ in level of ambiguity (Experiment 1), transparency (Experiment 2) and familiarity (Experiment 3).

STATEMENT OF HYPOTHESES

In Experiment 1, I investigated how the left and right hemispheres process idioms that are high or low in ambiguity. If the right hemisphere is dominant for processing high ambiguity idioms and the left hemisphere is dominant for processing low ambiguity idioms, then high ambiguity idioms should be processed more quickly and accurately in the right hemisphere than

in the left hemisphere, and low ambiguity idioms should be processed more quickly and accurately in the left hemisphere than in the right hemisphere.

Hypothesis Ia: If the right hemisphere is dominant for processing high ambiguity idioms, then target words related to high ambiguity idioms should be processed more quickly when presented to the right hemisphere than when presented to the left hemisphere. If the left hemisphere is dominant for processing low ambiguity idioms, then target words related to low ambiguity idioms should be processed more quickly when presented to the left hemisphere than when presented to the right hemisphere. See Figure 2 for an illustration of Hypothesis 1a.

Hypothesis Ib: If the right hemisphere is dominant for processing high ambiguity idioms, then target words related to high ambiguity idioms should be processed more accurately when presented to the right hemisphere than when presented to the left hemisphere. If the left hemisphere is dominant for processing low ambiguity idioms, then target words related to low ambiguity idioms should be processed more accurately when presented to the left hemisphere than when presented to the right hemisphere.

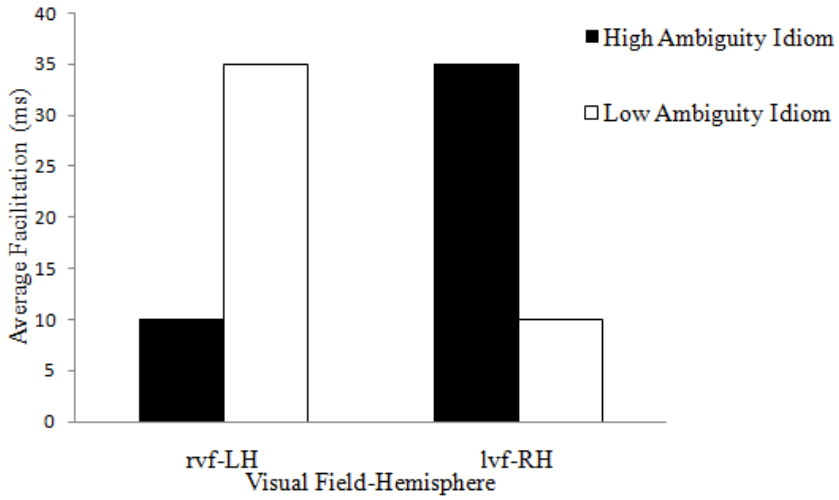

Figure 2. Predicted direction of facilitation results in Experiment 1 (Hypothesis Ia). Larger scores indicate faster processing. Note: rvf-LH refers to the right visual field-left hemisphere and lvf-RH refers to the left visual field-right hemisphere.

In Experiment 2, I investigated how the left and right hemispheres process idioms that are high or low in transparency. If the right hemisphere is dominant for processing high transparency idioms and the left hemisphere is dominant for processing low transparency idioms, then high transparency idioms should be processed more quickly and accurately in the right hemisphere than in the left hemisphere, and low transparency idioms should be processed more quickly and accurately in the left hemisphere than in the right hemisphere.

Hypothesis IIa: If the right hemisphere is dominant for processing high transparency idioms, then target words related to high transparency idioms should be processed more quickly when presented to the right hemisphere than when presented to the left hemisphere. If the left hemisphere is dominant for processing low transparency idioms, then target words related

to low transparency idioms should be processed more quickly when presented to the left hemisphere than when presented to the right hemisphere. See Figure 3 for an illustration of Hypothesis IIa.

Hypothesis IIb: If the right hemisphere is dominant for processing high transparency idioms, then target words related to high transparency idioms should be processed more accurately when presented to the right hemisphere than when presented to the left hemisphere. If the left hemisphere is dominant for processing low transparency idioms, then target words related to low transparency idioms should be processed more accurately when presented to the left hemisphere than when presented to the right hemisphere.

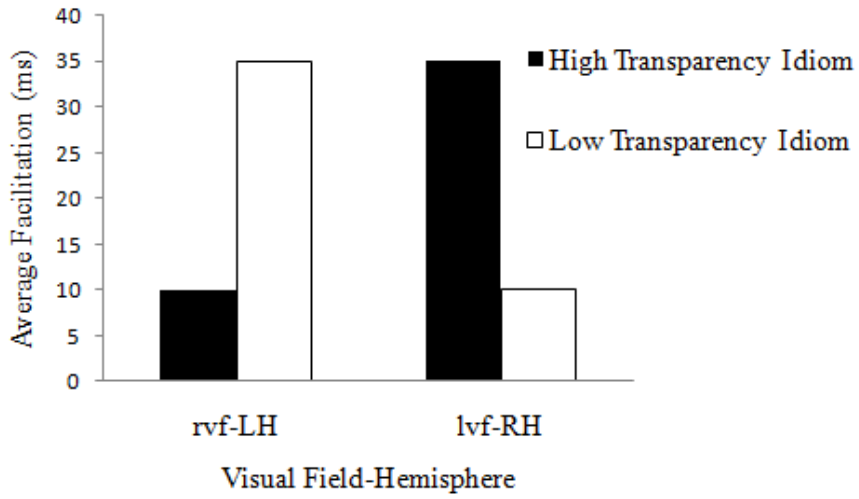

Figure 3. Predicted direction of facilitation results in Experiment 2 (Hypothesis IIa). Larger scores indicate faster processing. Note: rvf-LH refers to the right visual field-left hemisphere and lvf-RH refers to the left visual field-right hemisphere.

In Experiment 3, I investigated how the left and right hemispheres process idioms that are familiar or less familiar. If the right hemisphere is dominant for processing less familiar idioms and the left hemisphere is

dominant for processing familiar idioms, then less familiar idioms should be processed more quickly and accurately in the right hemisphere than in the left hemisphere, and familiar idioms should be processed more quickly and accurately in the left hemisphere than in the right hemisphere.

Hypothesis IIIa: If the right hemisphere is dominant for processing less familiar idioms, then target words related to less familiar idioms should be processed more quickly when presented to the right hemisphere than when presented to the left hemisphere. If the left hemisphere is dominant for processing familiar idioms, then target words related to familiar idioms should be processed more quickly when presented to the left hemisphere than when presented to the right hemisphere. See Figure 4 for an illustration of Hypothesis IIIa.

Hypothesis IIIb: If the right hemisphere is dominant for processing less familiar idioms, then target words related to less familiar idioms should be processed more accurately when presented to the right hemisphere than when presented to the left hemisphere. If the left hemisphere is dominant for processing familiar idioms, then target words related to familiar idioms should be processed more accurately when presented to the left hemisphere than when presented to the right hemisphere.

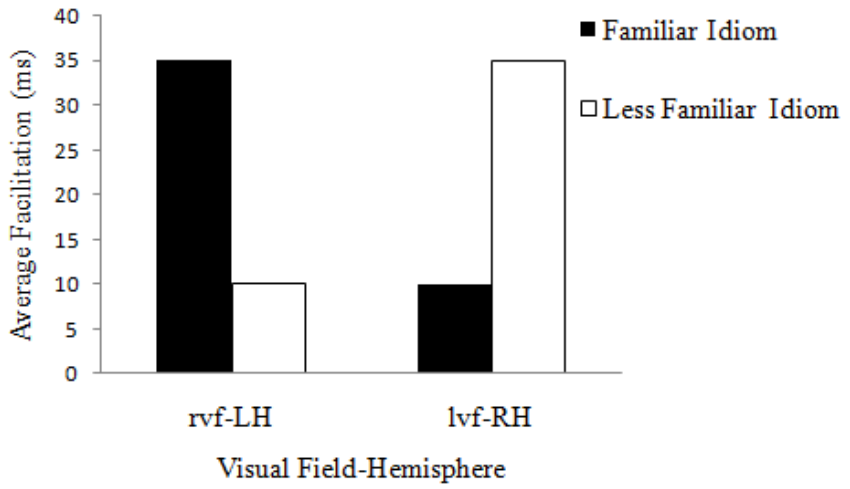

Figure 4. Predicted direction of facilitation results in Experiment 3 (Hypothesis IIIa). Larger scores indicate faster processing. Note: rvf-LH refers to the right visual field-left hemisphere and lvf-RH refers to the left visual field-right hemisphere.

CHAPTER II

METHOD

Experiment 1

Participants

One hundred fifteen undergraduate students from a Midwestern university participated in this study in exchange for course credit in an introductory psychology course. Of the 115 participants, 23 participants were male and 92 participants were female. All participants were native speakers of English. Participants were right handed as measured by the Edinburgh handedness inventory. In this handedness inventory, participants were presented with a list of activities (e.g., writing, throwing a ball, etc.), and were asked to indicate whether they use their right or left hand for that activity. Scores on the Edinburgh handedness inventory range from -1 (completely left handed) to 1 (completely right handed). All participants included in the experiment were right handed (mean laterality quotient = .79) (Oldfield, 1971). Further, all participants had no history of brain damage and had normal or corrected-to-normal vision.

Materials

Texts. Forty-eight sets of text were created for this experiment. Each set contained two conditions: *an idiom condition* and *a neutral condition.* The first sentence in each text was the same for both conditions and served as an introduction sentence that described a specific event. The second sentence in each text differed across the two experimental conditions. In the idiom

condition, the second sentence contained an idiomatic phrase (e.g., “he kicked the bucket”). In the neutral condition, the second sentence did not contain an idiom (e.g. “he came to a stop”) (See Table 1 for an example of an idiomatic and neutral text). The final sentences in the idiom condition contained the same number of syllables (M = 10.46, SE = .33) as the neutral condition (M = 10.42, SE = .31), $t(47) = .47$, $p = .64$.

Table 1

Example high ambiguity idiom, low ambiguity idiom, and neutral conditions

High Ambiguity Condition
Idiom: Max was driving down the road. He hit a sharp curve and kicked the bucket.
Neutral: Max was driving down the road. He hit a sharp curve and came to a stop.
Target die
Low Ambiguity Condition
Idiom: Jim had come home early from his job. He'd been feeling under the weather.
Neutral: Jim had come home early from his job. He'd been wanting to watch the ball game.
Target sick

All of the idioms used in this experiment were taken from a database of idiomatic phrases (Titone & Connine, 1994a). Idiom ambiguity was measured using the database’s previous pilot of descriptive norms for the 171 idioms. In this previous pilot study (Titone & Connine, 1994a), participants

read each of the 171 idiomatic phrases and rated the plausibility of each idiom's literal interpretation on a scale of 1 (extremely implausible) to 7 (extremely plausible). Twenty-four high ambiguity idioms and twenty-four low ambiguity idioms were selected from these pilot ratings. A Wilcoxon signed ranks test indicated that ratings for the high ambiguity idioms (M = 6.28, SE = .21) were significantly higher than ambiguity ratings for the low ambiguity idioms (M = 1.90, SE = .23), Z = 4.29, p = .00. The ratings from this pilot study suggest that idioms in the high ambiguity condition were more ambiguous than idioms in the low ambiguity condition.

Importantly, idioms in the high ambiguity condition did not significantly differ from idioms in the low ambiguity condition in terms of transparency or familiarity. Transparency ratings were taken from pilot ratings in a database of descriptive norms for idioms (Titone & Connine, 1994a). For these transparency ratings, participants read each of the 171 idioms, and for each idiom indicated whether or not the idiom's individual words contributed to the idiom's figurative meaning by sorting each idiom into either a "transparent" list or a "not transparent" list. The transparency ratings were then calculated as a percentage of participants who had judged the idiomatic phrase as transparent, which could range from 0% (not transparent at all) to 100% (completely transparent). Specifically, transparency scores did not differ between the high ambiguity idioms (M = 26.84, SE = 4.58) and the low ambiguity idioms (M = 35.33, SD = 4.42), $t(46) = 1.33$, p = .19, suggesting that the idioms in the high ambiguity idiom condition and the low ambiguity

idiom condition were similar in terms of transparency. In addition, familiarity ratings were taken from a separate pilot study. In this pilot study, 30 participants (who did not participate in the main experiment) read 171 idiomatic phrases (taken from Titone & Connine, 1994a). For each idiomatic phrase, participants indicated how often they had seen, heard, or used the phrase, on a scale of 1 (extremely unfamiliar) to 7 (extremely familiar). A Wilcoxon signed ranks test found no differences in familiarity ratings between the high ambiguity idioms (M = 5.15, SE = .18) and the low ambiguity idioms (M = 4.67, SE = .28), Z = 1.06, p = .29, suggesting that the idioms in the high ambiguity idiom condition and the low ambiguity idiom condition were equally familiar.

Targets. Each experimental text was followed by a corresponding target word. The high ambiguity idiom and neutral texts contained the same target word for each set, and the low ambiguity idiom and neutral texts contained the same target word for each set. In the high ambiguity and low ambiguity idiom conditions, the target word was related to the meaning of the second sentence in the text (e.g., the target “die” was related to the figurative meaning of “kick the bucket”). In the neutral condition, the target word was unrelated to the meaning of the second sentence in the text (e.g., the target “die” was not related to the phrase “came to a stop”). This neutral condition was essential to obtain a baseline measurement of how quickly participants responded to the same target word in each visual field-hemisphere. Thus, response times to target words in the neutral condition may be compared to

response times to the same target words in the idiom condition (i.e., *facilitation*).

To ensure that the target words closely matched the intended meaning of each text, a pilot study was conducted. In this pilot study, 30 participants (who did not participate in the main experiment) read 48 texts. The texts were counterbalanced to ensure that each participant saw only one version of each text. After reading each text, participants wrote down the main idea of the text. Each participant's response was assigned a value ranging from 0 to 3 according to how well the participant's response matched the intended meaning of the second sentence of the text. For example, responses (e.g., "Max died"*)* that matched the target word (e.g., "die") were assigned a 3, responses that included a synonym of the target word (e.g., "Max was killed") were assigned a 2, and responses that were related to the target word (e.g., "Max crashed his car") were assigned a 1. Incorrect or irrelevant responses were assigned a 0. Target words that received a rating of 1.75 or higher were included in the experimental materials. Incorrect or irrelevant responses were assigned a 0. Target words that received a rating of 1.75 or higher were included in the experimental materials. Ratings for the targets did not significantly differ between the high ambiguity idioms and the low ambiguity idioms, $t(47) = 1.29$, $p = .19$, ensuring that the target words were equally related to the idioms in both the high ambiguity idiom texts and the low ambiguity idiom texts.

To ensure that the words in the idiomatic version of each text were not more semantically related than the words in the neutral version of each text to the target word, the final sentence of the idiomatic and neutral versions of each text were compared to the target word using Latent Semantic Analysis (Landauer, Foltz, & Laham, 1998). This comparison produces a cosine between the target word and the idiom and neutral texts, which provides a metric of semantic relatedness. The cosine between the idiomatic version and the target word (M = .31, SE = .02) did not significantly differ from the cosine between the neutral version and the target word, (M = .32, SE = .02), $t(47)$ = 1.95, p = .06. Because the idiomatic version of each text is not more semantically related than the neutral version of each text to the target word, this finding helps ensure that any observed differences between the idiomatic and neutral versions are not due to semantic relatedness between each text's individual words and the target word.

Additionally, 48 target nonwords were created for each of the 48 filler texts. Nonword targets were created by finding words with similar frequencies to the target words and then rearranging the letters to create pronounceable nonwords (e.g., “codument”). When the nonword targets were presented, participants needed to make a “no” response during the lexical decision task. This was important because if all targets presented were real words (i.e., if all targets required a “yes” response), then participants would have been likely to respond to the targets without needing to actually read the target (i.e., participants would have developed a *response bias* to the “yes” response).

Procedure

This study employed a priming paradigm, in which participants were presented with texts that were either related or unrelated to the meaning of a subsequently presented word (i.e., the *target word*) (McKoon & Ratcliff, 1992). Research suggests that participants are quicker to recognize a given target word if the word is preceded by a text that was related in meaning to the target word (Friederici, Steinhauer, & Frisch, 1999). Of specific interest to the current study, it has been demonstrated that idioms can prime words related to the figurative meaning of those idioms. For example, participants more quickly recognize "die" when it is preceded by the "kick the bucket" than if it is preceded by an unrelated sentence (Titone, Holzman, & Levy, 2002). In this study, texts containing idioms were used to prime target words that related to the idiom's figurative meaning.

To investigate how idioms are processed in the right and left cerebral hemispheres, the current experiments used the divided visual field paradigm (Bourne, 2006). In this paradigm, idiom-related words were presented to either the left or right visual field. When a target stimulus is quickly presented to one visual field, that information is initially processed in the opposite hemisphere. Specifically, information presented to the right visual field is initially processed in the left hemisphere, whereas information presented to the left visual field is initially processed in the right hemisphere. An illustration of how information is processed using the divided visual field paradigm is shown in Figure 5. In the current experiments, target words or

nonwords were presented to either the left or the right hemisphere, and participants then decided whether the target is a word or nonword (i.e., perform a *lexical decision task*).

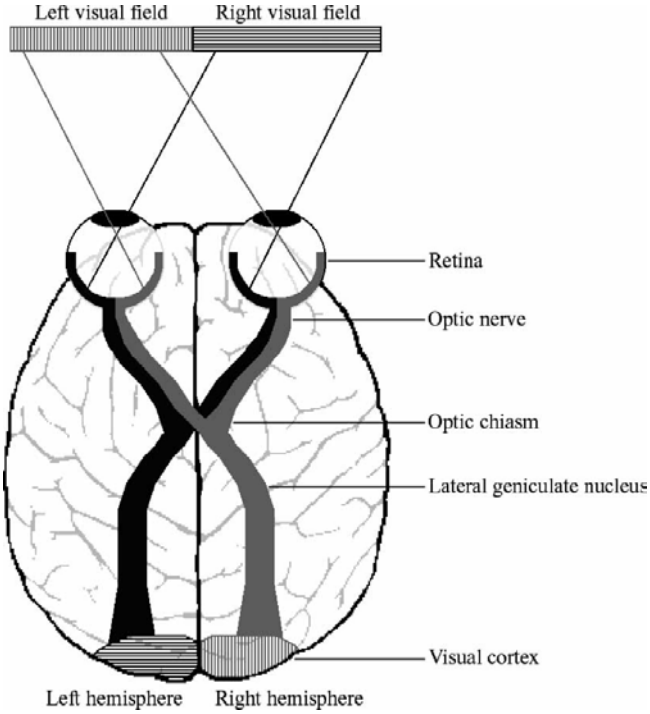

Figure 5: The Divided Visual Field. (Reproduced with permission from Bourne, 2006)

Participants in the current study were seated 50 cm from a computer screen and placed their head in a chin rest to maintain this distance throughout the experiment. The experiment was run on a PC using E-Prime software (Schneider, Eschman, & Zuccolotto, 2002). The texts were counterbalanced across four lists. These lists were created so that the order in which the texts were read and the condition the targets appeared in was presented an equal number of times across participants. Each text was presented one sentence at a time in the center of the computer screen. When participants finished reading

the first sentence, they pressed a button to continue to the second sentence. After the second sentence was presented, a central fixation "+" sign appeared for 750 ms. Requiring participants to focus on the "+" helped ensure that participants' eyes were focused in the center of the screen, thus allowing the target to be presented to only one visual field-hemisphere. After the fixation "+" disappeared, the target word or nonword was presented to either to the right or the left side of the screen for 176 ms. This amount of time was used so participants could not fixate their eyes on the center of the target and ensured that the target was presented to only one visual field-hemisphere (Bourne, 2006). Targets were presented 3.4 degrees of visual angle from the center of the computer screen. Participants were instructed to decide as quickly but as accurately as possible if the target was an English word or nonword (i.e., perform a lexical decision task). Participants made their responses by pressing one of two buttons on a serial response box. Half of the participants used their left hand to respond and half of the participants used their right hand to respond during the lexical decision task. To ensure that participants adequately comprehended the texts, comprehension questions were presented after a subset of texts throughout the experiment.

Experiment 2

Participants

One hundred undergraduate students from a Midwestern university participated in this study in exchange for course credit in an introductory psychology course. Of the 100 participants, 21 were male and 79 were female.

All participants were native speakers of English. Participants were right handed as measured by the Edinburgh handedness inventory. In this handedness inventory, participants were presented with a list of activities (e.g., writing, throwing a ball, etc.), and were asked to indicate whether they use their right or left hand for that activity. Scores on the Edinburgh handedness inventory range from -1 (completely left handed) to 1 (completely right handed). All participants included in the experiment were right handed (mean laterality quotient = .88) (Oldfield, 1971). All participants had no history of brain damage and had normal or corrected-to-normal vision.

Materials

Texts. Forty-eight sets of text were created for this experiment. Each set contained two conditions: *an idiom condition* and *a neutral condition.* The first sentence in each text was the same for both conditions and served as an introduction sentence that described a specific event. The second sentence in each text differed across the two experimental conditions. In the idiom condition, the second sentence contained an idiomatic phrase. In the neutral condition, the second sentence did not contain an idiom. (See Table 2 for an example of an idiomatic and neutral text). The final sentence contained the same number of syllables in the idiom condition (M = 10.25; SE = .31) as the neutral condition, (M = 10.33; SE = .33), $t(47) = .70$, $p = .49$.

Table 2

Example high transparency idiom, low transparency idiom, and neutral conditions

High Transparency Condition
Idiom: The professor asked Beth what she thought of the test. He told her to speak her mind.
Neutral: The professor asked Beth what she thought of the test. He hoped it wasn't too easy.
Target honest
Low Transparency Condition
Idiom: Sally was sitting next to a stranger on the bus. So she decided to break the ice.
Neutral: Sally was sitting next to a stranger on the bus. So she decided to read a book.
Target social

All the idioms used in Experiment 2 were taken from a database of idiomatic phrases (Titone & Connine, 1994a). Transparency ratings were taken from Titone and Connine's database. For these transparency ratings, participants read each of the 171 idiomatic phrases, and for each phrase indicated whether or not the idiom's individual words contributed to the idiom's figurative meaning by sorting each idiom into either a "transparent" list or a "not transparent" list. The transparency ratings were then calculated as a percentage of participants who had judged the idiomatic phrase as transparent, which could range from 0% (not transparent at all) to 100%

(completely transparent). Twenty-four high transparency idioms and twenty-four low transparency idioms were selected for the high and low transparency idiom conditions, respectively. The idioms in the high transparency condition (M = 78.21, SE = 2.09) were rated as significantly more transparent than the idioms in the low transparency condition (M = 6.32, SE = .93), $t(46) = 31.58$, $p = .00$, suggesting that the idioms in the high and low transparency conditions were significantly different in terms of transparency.

Importantly, idioms in the high and low transparency conditions did not significantly differ from each other in terms of ambiguity or familiarity. Ambiguity ratings were taken from pilot ratings in a database of descriptive norms for idioms (Titone & Connine, 1994a). In this previous pilot study, participants read each of the 171 idiomatic phrases and rated the plausibility of each idiom's literal interpretation on a scale of 1 (extremely implausible) to 7 (extremely plausible). A Wilcoxon signed ranks test indicated that the ambiguity ratings for idioms in the high transparency condition (M = 4.19, SE = .28) did not significantly differ from the ambiguity ratings for idioms in the low transparency condition (M = 4.09, SE = .33), $Z = .26$, $p = .79$, suggesting that the idioms in the high transparency idiom condition and the low transparency idiom condition were similar in terms of ambiguity. Familiarity ratings were taken from a separate pilot study. In this pilot study, 30 participants (who did not participate in the main experiment) read 171 idiomatic phrases (taken from Titone & Connine, 1994a). For each idiomatic

phrase, participants indicated how often they had seen, heard, or used the phrase, on a scale of 1 (extremely unfamiliar) to 7 (extremely familiar). A Wilcoxon signed ranks test indicated that the familiarity ratings for idioms in the high transparency condition (M = 5.69, SE = .18) did not significantly differ from familiarity ratings for idioms in the low transparency condition, (M = 5.11, SE = .29), Z = 1.59, p = .11, suggesting that the idioms in the high transparency idiom condition and the low transparency idiom condition were similarly familiar.

Targets. Each experimental text was followed by a corresponding target word. The high transparency idiom and neutral texts in contained the same target word for each set, and the low transparency idiom and neutral texts contained the same target word for each set. In the high transparency and low transparency idiom conditions, the target word was related to the meaning of the second sentence in the text. In the neutral condition, the target word was unrelated to the meaning of the second sentence in the text. This neutral condition was essential to obtain a baseline measurement of how quickly participants responded to the same target word in each visual field-hemisphere. Thus, response times to target words in the neutral condition may be compared to response times to the same target words in the idiom condition (i.e., *facilitation*).

To ensure that the target words were sufficiently related to the idioms, a pilot study was conducted. In this pilot study, 30 participants (who did not participate in the main experiment), read 48 texts. The texts were

counterbalanced to ensure that each participant saw only one version of each text. After reading each text, participants wrote down the main idea of the text. Each participant's response was assigned a value ranging from 0 to 3 according to how well the participant's response matched the intended meaning of the second sentence of the text. Responses (e.g., "He wanted her to be honest") that matched the target word (e.g., "honest") were assigned a 3, responses that included a synonym of the target word (e.g., "She told the truth") were assigned a 2, and responses that were related to the target word (e.g., "He wanted Sally's real opinion") were assigned a 1. Incorrect or irrelevant responses were assigned a 0. Target words that received a rating of 1.75 or higher were included in the experimental materials. Ratings for the targets did not significantly differ across the high transparency and low transparency conditions, $t(47) = 1.13$, $p = .31$, ensuring that the target words were equally related to the idioms in both the high transparency idiom texts and the low transparency idiom texts.

To ensure that the words in the idiomatic version of each text were not more semantically related than the words in the neutral version of each text to the target word, the final sentence of the idiomatic and neutral versions of each text were compared to the target word using Latent Semantic Analysis (Landauer, Foltz, & Laham, 1998). This comparison produces a cosine between the target word and the idiom and neutral texts, which provides a metric of semantic relatedness. The cosine between the idiomatic version and the target word ($M = .37$, $SE = .02$) did not significantly differ from the cosine

between the neutral version and the target word, (M = .36, SE = .02), $t(47)$ = 1.01, p = .28. Because the idiomatic version of each text is not more semantically related than the neutral version of each text to the target word, this finding helps ensure that any observed differences between the idiomatic and neutral versions are not due to semantic relatedness between each text's individual words and the target word.

Additionally, 48 target nonwords were created for the 48 filler texts. When the nonword targets were presented, participants needed to make a "no" response during the lexical decision task. This was important because if all targets presented were real words (i.e., if all targets required a "yes" response), then participants would have been likely to respond to the targets without needing to actually read the target (i.e., participants would have developed a response bias for the "yes" button).

Procedure

Participants in Experiment 2 were seated 50 cm from a computer screen and placed their head in a chin rest to maintain this distance throughout the experiment. The experiment was run on a PC using E-Prime software (Schneider, Eschman, & Zuccolotto, 2002). The texts were counterbalanced across four lists. These lists were created so that the order in which the texts were read and the condition the targets appeared in was presented an equal number of times across participants. Each text was presented one sentence at a time in the center of the computer screen in a self-paced manner. When participants finished reading the first sentence, they pressed a button to

continue to the second sentence. After the second sentence was presented, a central fixation "+" sign appeared for 750 ms. Requiring participants to focus on the "+" helped ensure that participants' eyes were focused in the center of the screen, thus allowing the target to be presented to only one visual field-hemisphere. After the fixation "+" disappeared, the target word or nonword was presented to either to the right or the left side of the screen for 176 ms. This amount of time was used so participants could not fixate their eyes on the center of the target and ensured that the target was presented to only one visual field-hemisphere (Bourne, 2006). Targets were presented 3.4 degrees of visual angle from the center of the computer screen. Participants were instructed to decide as quickly but as accurately as possible if the target was an English word or nonword (i.e., perform a lexical decision task). Participants made their responses by pressing one of two buttons on a serial response box. Half of the participants used their left hand to respond and half of the participants used their right hand to respond during the lexical decision task. To ensure that participants adequately comprehended the texts, comprehension questions were presented after a subset of texts throughout the experiment.

Experiment 3

Participants

One hundred three undergraduate students from a Midwestern university participated in this study in exchange for course credit in an

introductory psychology course. Of the 103 participants, 19 participants were male and 84 participants were female. All participants were native speakers of English. Participants were right handed as measured by the Edinburgh handedness inventory. In this handedness inventory, participants were presented with a list of activities (e.g., writing, throwing a ball, etc.), and were asked to indicate whether they use their right or left hand for that activity. Scores on the Edinburgh handedness inventory range from -1 (completely left handed) to 1 (completely right handed). All participants included in the experiment were right handed (mean laterality quotient = .84) (Oldfield, 1971). Further, all participants had no history of brain damage and had normal or corrected-to-normal vision.

Materials

Texts. Forty-eight sets of text were created for this experiment. Each set contained two conditions: *an idiom condition* and *a neutral condition.* The first sentence in each text was the same for both conditions and served as an introduction sentence that described a specific event. The second sentence in each text differed across the two experimental conditions. In the idiom condition, the second sentence contained an idiomatic phrase (e.g., “He was starting to have cold feet”). In the neutral condition, the second sentence did not contain an idiom (e.g. “He was having dinner with his friends”) (See Table 3 for an example of an idiomatic and neutral text). The final sentences in the idiom condition contained the same number of syllables (M = 9.40, SE = .34) as the neutral condition (M = 10.00, SE = .30), $t(47) = .59$, $p = .55$.

Table 3

Example familiar idiom, less familiar idiom, and neutral conditions

Familiar Condition
Idiom: Victor would marry his girlfriend in a week. He was starting to have cold feet.
Neutral: Victor would marry his girlfriend in a week. He was having dinner with his friends.
Target nervous
Less Familiar Condition
Idiom: Dave wanted to have fun after work. He went home and hit the sauce.
Neutral: Dave wanted to have fun after work. He went home and watched a movie.
Target drinking

All of the idioms used in this experiment were taken from a database of idiomatic phrases (Titone & Connine, 1994a). Familiarity ratings were taken from a separate pilot study. In this pilot study, 30 participants (who did not participate in the main experiment) read 171 idiomatic phrases (taken from Titone & Connine, 1994a). For each idiomatic phrase, participants indicated how often they had seen, heard, or used the phrase, on a scale of 1 (extremely unfamiliar) to 7 (extremely familiar). Based on these pilot ratings, twenty-four familiar idioms and twenty-four less familiar idioms were selected for the experimental items in Experiment 3. A Wilcoxon signed ranks test indicated that the idioms in the familiar condition (M = 6.66, *SE* = .03)

were more familiar to participants than the idioms in the less familiar condition (M = 2.97, *SE* = .03), *Z* = 4.27, *p* = .00.

Importantly, the idioms in the familiar condition did not differ from the idioms in the less familiar condition in terms of ambiguity or transparency. Ambiguity ratings were taken from the pilot ratings in a database of descriptive norms for idioms (Titone & Connine, 1994a). In this previous pilot study, participants read each of the 171 idiomatic phrases and rated the plausibility of each idiom's literal interpretation on a scale of 1 (extremely implausible) to 7 (extremely plausible). A Wilcoxon signed ranks test indicated that the ambiguity ratings did not significantly differ between idioms in the familiar condition (*M* = 3.75, *SE* = .33) and idioms in the less familiar condition (*M* = 4.31, *SE* = .24), *Z* = 1.47, *p* = .14. Transparency ratings were taken from a pilot study from in database of descriptive norms for idioms (Titone & Connine, 1994a). For these transparency ratings, participants read each of the 171 idiomatic phrases, and for each phrase indicated whether or not the idiom's individual words contributed to the idiom's figurative meaning by sorting each idiom into either a "transparent" list or a "not transparent" list. The transparency ratings were then calculated as a percentage of participants who had judged the idiomatic phrase as transparent, which could range from 0 % (not transparent at all) to 100% (completely transparent). Transparency scores did not differ between the familiar idioms (*M* = 37.46, *SE* = 4.76) and the less familiar idioms (*M* = 24.03, *SE* = 4.90), *t*(46) = 1.27, *p* = .21.

Targets. Each experimental text was followed by a corresponding target word. The familiar idiom and neutral texts contained the same target word for each set, and the low familiar idiom and neutral texts contained the same target word for each set. In the familiar and less familiar idiom conditions, the target word was related to the meaning of the second sentence in the text (e.g., the target "identical" was related to the figurative meaning of "the spitting image"). In the neutral condition, the target word was unrelated to the meaning of the second sentence in the text (e.g., the target "identical" was not related to the phrase "this is very old"). This neutral condition was essential to obtain a baseline measurement of how quickly participants responded to the same target word in each visual field-hemisphere. Thus, response times to target words in the neutral condition may be compared to response times to the same target words in the idiom condition, providing a measure of how quickly the target words are processed in the idiom condition compared to the neutral condition (i.e., *facilitation*).

To ensure that the target words closely matched the intended meaning of each text, a pilot study was conducted. In this pilot study, 30 participants (who did not participate in the main experiment) read 48 texts. The texts were counterbalanced to ensure that each participant saw only one version of each text. After reading each text, participants wrote down the main idea of the text. Each participant's response was assigned a value ranging from 0 to 3 according to how well the participant's response matched the intended meaning of the second sentence of the text. For example, responses (e.g.,

"Matt thought Doug and his father were identical"*)* that matched the target word (e.g., "identical") were assigned a 3, responses that included a synonym of the target word (e.g., "Doug looks the same as his father") were assigned a 2, and responses that were related to the target word (e.g., "Matt can tell they're related") were assigned a 1. Incorrect or irrelevant responses were assigned a 0. Target words that received a rating of 1.75 or higher were included in the experimental materials. Ratings for the targets did not significantly differ between the high ambiguity idioms and the low ambiguity idioms, $t(47) = 1.29$, $p = .19$, ensuring that the target words were equally related to the idioms in both the high ambiguity idiom texts and the low ambiguity idiom texts.

To ensure that the words in the idiomatic version of each text were not more semantically related than the words in the neutral version of each text to the target word, the final sentence of the idiomatic and neutral versions of each text were compared to the target word using Latent Semantic Analysis (Landauer, Foltz, & Laham, 1998). This comparison produces a cosine between the target word and the idiom and neutral texts, which provides a metric of semantic relatedness. The cosine between the idiomatic version and the target word ($M = .31$, $SE = .03$) did not significantly differ from the cosine between the neutral version and the target word, ($M = .30$, $SE = .02$), $t(47) = .92$, $p = .37$. Because the idiomatic version of each text is not more semantically related than the neutral version of each text to the target word, this finding helps ensure that any differences between the idiomatic and

neutral versions are not due to semantic relatedness between each text's individual words and the target word.

Additionally, 48 target nonwords were created for each of the 48 filler texts. When the nonword targets were presented, participants needed to make a “no” response during the lexical decision task. This was important because if all targets presented were real words (i.e., if all targets required a “yes” response), then participants would have been likely to respond to the targets without needing to actually read the target (i.e., they would have developed a response bias for the “yes” button).

Procedure

Participants in Experiment 3 were seated 50 cm from a computer screen and placed their head in a chin rest to maintain this distance throughout the experiment. The experiment was run on a PC using E-Prime software (Schneider, Eschman, & Zuccolotto, 2002). The texts were counterbalanced across four lists. These lists were created so that the order in which the texts were read and the condition the targets appeared in was presented an equal number of times across participants. Each text was presented one sentence at a time in the center of the computer screen in a self-paced manner. When participants finished reading the first sentence, they pressed a button to continue to the second sentence. After the second sentence was presented, a central fixation “+” sign appeared for 750 ms. Requiring participants to focus on the “+” helped ensure that participants’ eyes were focused in the center of the screen, thus allowing the target to be presented to only one visual field-

hemisphere. After the fixation "+" disappeared, the target word or nonword was presented to either to the right or the left side of the screen for 176 ms. This amount of time was used so participants could not fixate their eyes on the center of the target and ensured that the target was presented to only one visual field-hemisphere (Bourne, 2006). Targets were presented 3.4 degrees of visual angle from the center of the computer screen. Participants were instructed to decide as quickly but as accurately as possible if the target was an English word or nonword (i.e., perform a lexical decision task). Participants made their responses by pressing one of two buttons on a serial response box. Half of the participants used their left hand to respond and half of the participants used their right hand to respond during the lexical decision task. To ensure that participants adequately comprehended the texts, comprehension questions were presented after a subset of texts throughout the experiment.

CHAPTER III

RESULTS

Experiment 1

Response times to lexical decisions were collected and analyzed. Only correct responses were included in these analyses. Seven participants were removed from the analyses for having less than 70% accuracy in the lexical decision task, and six participants were removed from the analyses for not following instructions. Therefore, 103 participants (19 male and 84 female) were included in the final analyses. The top and bottom 1% of the response times per condition were removed prior to analyses to minimize the influence of outliers (see Ratcliff, 1993 for a description of this procedure). For all analyses reported, an alpha level of .05 was used to determine significance. All analyses included the between participant variables of gender, hand used to respond, and counterbalanced list. There were no effects of gender, hand used to respond, or counterbalanced list, so these analyses are not reported. See Table 4 for mean response time and accuracy rates in Experiment 1. Analyses were conducted for both participants (F_1) and items (F_2).

Table 4

Mean response time (in ms) and accuracy (in percent correct) for targets in the high ambiguity idiom, low ambiguity idiom, and neutral conditions by visual field-hemisphere

	rvf-LH		lvf-RH	
Condition	RT	AC	RT	AC
High Ambiguity Idiom	463.50 (13.88)	.93 (.01)	509.09 (14.19)	.86 (.04)
High Ambiguity Neutral	458.13 (12.92)	.92 (.02)	538.70 (16.88)	.87 (.01)
Low Ambiguity Idiom	441.04 (12.27)	.95 (.01)	498.26 (13.59)	.87 (.04)
Low Ambiguity Neutral	498.81 (12.16)	.92 (.01)	498.81 (12.16)	.89 (.02)

Note. Right visual field-left hemisphere is abbreviated: rvf-LH and left visual field-right hemisphere is abbreviated: lvf-RH. RT refers to response times and AC refers to accuracy. Values in parentheses represent standard errors.

Response Time Effects

A two way repeated measures ANOVA was conducted on the lexical decision response times. The independent variables were idiom ambiguity (high ambiguity idiom, high ambiguity neutral, low ambiguity idiom, and low ambiguity neutral) and visual field-hemisphere (right visual field-left hemisphere, rvf-LH; left visual field-right hemisphere, lvf-RH). There was a significant main effect of idiom ambiguity by participants, $F_1(3, 309) = 5.74$, $MSe = 5040.20$, $p = .00$; $F_2(3, 69) = 1.35$, $MSe = 5203.16$, $p = .27$. There was also a significant main effect of visual field-hemisphere, $F_1(1, 103) = 54.19$, $MSe = 10954.47$, $p = .00$; $F_2(1, 23) = 38.21$, $MSe = 2629.55$, $p = .00$. Most importantly, the interaction between ambiguity and visual field-hemisphere was significant by participants, $F_1(3, 309) = 3.84$, $MSe = 5954.93$, $p = .01$; $F_2(3, 69) = .64$, $MSe = 4631.85$, $p = .59$.

Follow-up paired samples *t*-tests revealed that response times for the high ambiguity idiom condition were faster in the rvf-LH than the lvf-RH, $t(103) = 4.42$, $p = .00$. Response times for the high ambiguity neutral condition were faster in the rvf-LH than the lvf-RH, $t(103) = 5.20$, $p = .00$. Response times for the low ambiguity idiom condition were faster in the rvf-LH than in the lvf-RH, $t(103) = 6.09$, $p = .00$. Response times for the low ambiguity neutral condition were faster in the rvf-LH than the lvf-RH, $t(103) = 2.89$, $p = .00$. Within the lvf-RH, there was no difference in response times between the high ambiguity idiom condition and the low ambiguity idiom condition, $t(103) = 1.04$, $p = .30$. Also within the lvf-RH, response times were faster for the high ambiguity idiom condition than the high ambiguity neutral condition, $t(103) = 2.82$, $p = .01$. There was no difference between response times within the lvf-RH between the low ambiguity idiom and low ambiguity neutral conditions, $t(103) = .06$, $p = .95$. Within the rvf-LH, response times were significantly faster for the high ambiguity idiom condition than the low ambiguity idiom condition, $t(103) = 2.88$, $p = .00$. There was no difference between response times for the high ambiguity idiom condition and the high ambiguity neutral condition within the rvf-LH. Finally, response times within the rvf-LH were significantly faster in the low ambiguity idiom condition than the low ambiguity neutral condition, $t(103) = 3.11$, $p = .00$.

Facilitation Effects

Facilitation effects were calculated by subtracting the response times in the neutral conditions from the response times in the idiom conditions.

These facilitation scores represent how quickly target words are processed in the idiom conditions as compared to when the target word is unrelated to the preceding text (i.e., the neutral conditions). For facilitation effects, larger scores represent faster processing relative to the neutral condition. To explore facilitation effects for high ambiguity and low ambiguity idioms in each visual field-hemisphere, a two way repeated measures ANOVA was conducted on the facilitation effects. The independent variables were idiom ambiguity (high ambiguity, low ambiguity) and visual field-hemisphere (right visual field-left hemisphere, rvf-LH; left visual field-right hemisphere, lvf-RH). Please see Figure 6 for the average facilitation (in ms) in the high ambiguity and low ambiguity idiom conditions by visual field-hemisphere.

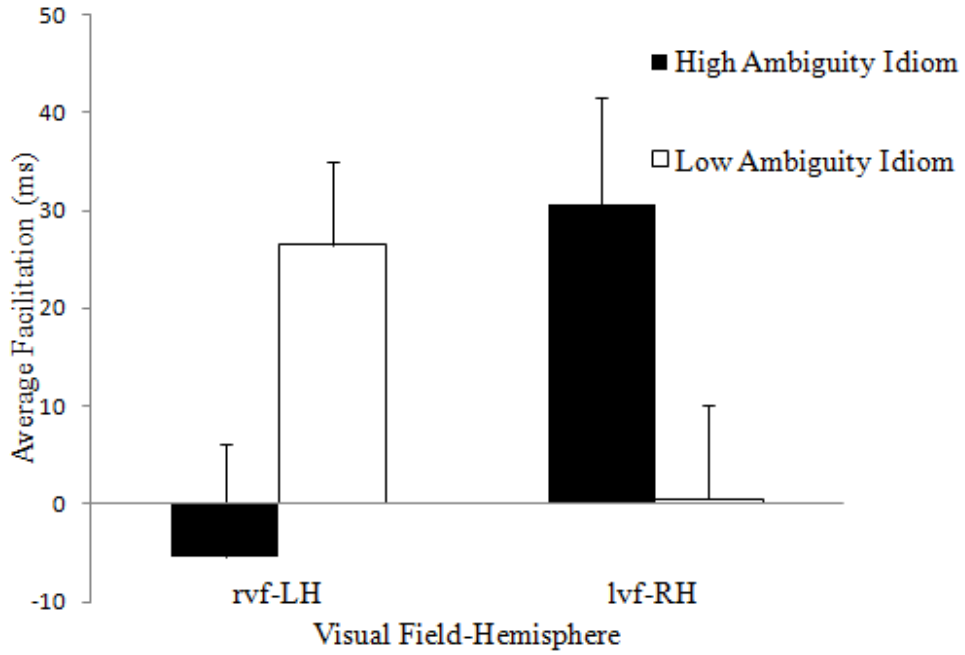

Figure 6. Average facilitation (in ms) in the high ambiguity and low ambiguity idiom conditions by visual field-hemisphere. Note: rvf-LH refers to right visual field-left hemisphere; lvf-RH refers to left visual field-right hemisphere.

There was no main effect for idiom ambiguity, $F_1(1, 103) = .01$, $MSe = 10423.23$, $p = .93$, $F_2(1, 23) = .16$, $MSe = 5661.19$, $p = .69$. There was no main effect for visual field-hemisphere, $F_1(1, 103) = .27$, $MSe = 2635.62$, $p = .60$; $F_2(1, 23) = .21$, $MSe = 2721.51$ $p = .65$. Importantly, however, there was a significant interaction between idiom ambiguity and visual field-hemisphere by participants, $F_1(1, 103) = 8.63$, $MSe = 11725.45$, $p = .00$; $F_2(1, 23) = 1.37$, $MSe = 5221.19$, $p = .25$.

Follow-up paired samples *t*-tests indicated that facilitation for the high ambiguity idiom condition was significantly greater in the lvf-RH ($M = 30.61$, $SE = 10.87$) than in the rvf-LH ($M = -5.27$, $SE = 11.87$), $t(103) = 2.17$, $p = .03$. For the low ambiguity idiom condition, facilitation was significantly greater in the rvf-LH ($M = 26.46$, $SE = 8.50$) than in the lvf-RH ($M = .56$, $SE = 9.51$), $t(103) = 2.21$, $p = .01$.

One-sample *t*-tests were conducted to investigate if facilitation effects for the high and low ambiguity idiom conditions were significantly different from zero in each visual field-hemisphere. Within the rvf-LH, facilitation was significantly greater than zero for the low ambiguity idiom condition ($M = 26.46$, $SE = 8.50$), $t(103) = 3.11$, $p = .00$, but facilitation was not significantly different from zero for the high ambiguity idiom condition ($M = -5.27$, $SE = 11.87$), $t(103) = -.46$, $p = .64$. Within the lvf-RH, facilitation was significantly greater than zero for the high ambiguity idiom condition ($M = 26.46$, $SE = 8.50$), $t(103) = 2.82$, $p = .01$, but facilitation was not significantly different

from zero for the low ambiguity idiom condition (M = .56, SE = 9.51), t(103) = .06, p = .95.

Accuracy Effects

To explore accuracy effects for each condition and visual field-hemisphere, a two way repeated measures ANOVA was conducted on the proportion of correct responses in the lexical decision task. The independent variables were idiom ambiguity (high ambiguity idiom, high ambiguity neutral, low ambiguity idiom, and low ambiguity neutral) and visual field-hemisphere (right visual field-left hemisphere, rvf-LH; left visual field-right hemisphere, lvf-RH). There was no main effect of idiom ambiguity, F_1(3, 309) = 1.54, MSe = .01, p = .20, F_2 (3, 66) = .23, p = .88. There was a significant main effect of visual field-hemisphere, F_1 (1, 103) = 27.08, p = .00, F_2 (1, 22) = 13.45, p = .00. The interaction between idiom ambiguity and visual-field hemisphere was not significant, F_1(3, 309) = 1.14, p = .33; F_2 (3, 66) = .15, p = .93.

Follow-up paired samples t tests revealed that no accuracy difference was evident for the high ambiguity idiom condition between the rvf-LH and the lvf-RH, t(103) = 1.61, p = .12. Accuracy was significantly greater for the high ambiguity neutral condition in the rvf-LH than in the lvf-RH, t(103) = 3.34, p = .00. There was no accuracy difference for the low ambiguity idiom condition between the rvf-LH and the lvf-RH, t(103) = 1.68, p = .11. Finally, accuracy was significantly greater for the low ambiguity neutral condition in the rvf-LH than in the lvf-RH, t(103) = 2.18, p = .04.

Sentence Reading Time Effects

To explore reading time differences for the final sentence in the idiom and neutral versions of each text, a two-way repeated measures ANOVA was conducted on the final sentence reading times. The independent variables were idiom ambiguity (high ambiguity, low ambiguity) and text version (idiom, neutral). The main effect of idiom ambiguity was not significant, $F_1(1, 103) = .08$, $MSe = 39263.38$, $p = .78$; $F_2(1, 23) = .76$, $MSe = 805865.53$, $p = .39$. The main effect of text version was not significant, $F_1(1, 103) = .45$, $MSe = 52602.71$, $p = .83$; $F_2(1, 23) = .23$, $MSe = 740067.349$, $p = .64$. The interaction between idiom ambiguity and text version was not significant, $F_1(1, 103) = .14$, $MSe = 33160.46$, $p = .91$; $F_2(1, 23) = .29$, $MSe = 504331.89$, $p = .59$.

Experiment 2

Response times to lexical decisions were collected and analyzed. Only correct responses were included in these analyses. Eight participants were removed from the analyses for having less than 70% accuracy in the lexical decision task, and ten participants were removed from the analyses for not following instructions. Therefore, 82 participants (17 male and 65 female) were included in the final analyses. The top and bottom 1% of the response times per condition were removed prior to analyses to minimize the influence of outliers (see Ratcliff, 1993 for a description of this procedure). For all analyses reported, an alpha level of .05 was used to determine significance. All analyses included the between participant variables of gender, hand used

to respond, and counterbalanced list. There were no effects of gender, hand used to respond, or counterbalanced list, so these analyses are not reported. See Table 5 for mean response time and accuracy rates in Experiment 2. Analyses were conducted for both participants (F_1) and items (F_2).

Response Time Effects

A two way repeated measures ANOVA was conducted on the lexical decision response times. The independent variables were idiom transparency (high transparency idiom, high transparency neutral, low transparency idiom, and low transparency neutral) and visual field-hemisphere (right visual field-left hemisphere, rvf-LH; left visual field-right hemisphere, lvf-RH). The main effect of idiom transparency was not significant, $F_1(3, 243) = 2.20$, $MSe = 12488.90$, $p = .09$; $F_2(3, 69) = 1.95$, $MSe = 8829.11$, $p = .13$. The main effect of visual field-hemisphere was not significant, $F_1(1, 81) = 1.47$, $MSe = 20884.26$, $p = .23$; $F_2(1, 23) = .07$, $MSe = 5207.68$, $p = .79$. Finally, the interaction between idiom transparency and visual field-hemisphere was not significant, $F_1(3, 243) = 1.42$, $MSe = 21004.77$, $p = .24$; $F_2(3, 69) = .54$, $MSe = 5987.47$, $p = .66$.

Table 5

Mean response time (in ms) and accuracy (in percent correct) for targets in the high transparency idiom, low transparency idiom, and neutral conditions by visual field-hemisphere

Condition	rvf-LH		lvf-RH	
	RT	AC	RT	AC
High Transparency Idiom	465.19 (15.02)	.95 (.01)	497.90 (18.32)	.97 (.01)
High Transparency Neutral	509.55 (21.64)	.94 (.01)	490.93 (18.46)	.93 (.01)
Low Transparency Idiom	468.11 (19.21)	.96 (.01)	469.91 (16.55)	.93 (.01)
Low Transparency Neutral	460.71 (17.83)	.94 (.01)	499.82 (21.71)	.93 (.02)

Note. Right visual field-left hemisphere is abbreviated: rvf-LH and left visual field-right hemisphere is abbreviated: lvf-RH. RT refers to response times and AC refers to accuracy. Values in parentheses represent standard errors.

Facilitation Effects

Facilitation effects were calculated by subtracting the response times in the neutral conditions from the response times in the idiom conditions. These facilitation scores represent how quickly target words are processed in the idiom conditions as compared to when the target word is unrelated to the preceding text (i.e., the neutral conditions). For facilitation effects, larger scores represent faster processing relative to the neutral condition. The independent variables were idiom transparency (high transparency idiom, and low transparency idiom) and visual field-hemisphere (right visual field-left hemisphere, rvf-LH; left visual field-right hemisphere, lvf-RH). See Figure 7 for the average facilitation (in ms) in the high transparency and low transparency idiom conditions by visual field-hemisphere. The main effect of idiom transparency was not significant, $F_1(1, 82) = .18$, MSe = 25981.36, p =

.67; $F_2(1, 23) = 2.80$, $MSe = 22171.51$, $p = .13$. The main effect of visual field-hemisphere was not significant, $F_1(1, 81) = .15$, $MSe = 25839.82$, $p = .70$; $F_2(1, 23) = 1.24$, $MSe = 1256.65$, $p = .28$. Importantly, however, the interaction between idiom transparency and visual field-hemisphere was significant by participants, $F_1(1, 81) = 6.98$, $MSe = 22984.54$, $p = .01$; $F_2(1, 23) = .09$, $MSe = 13379.42$, $p = .76$.

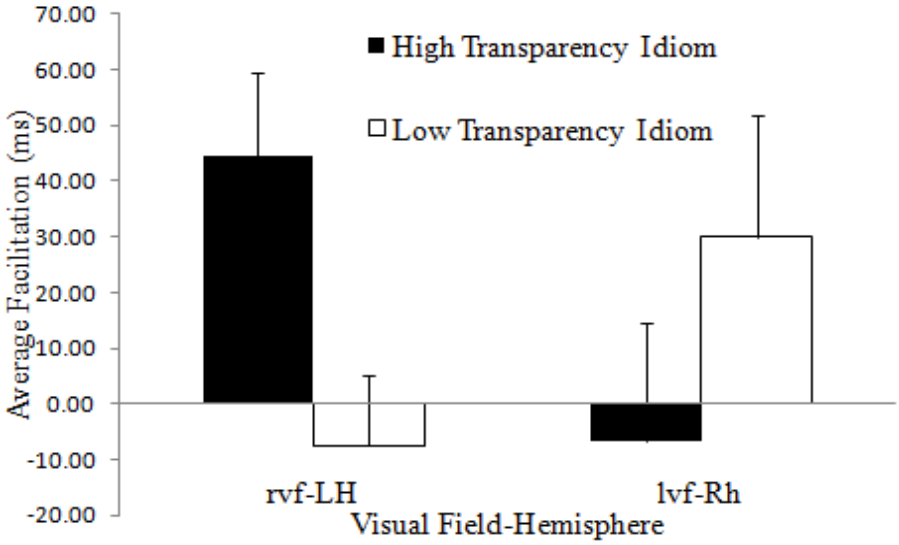

***Figure 7*. Average facilitation (in ms) in the high transparency and low transparency idiom conditions by visual field-hemisphere. Note: rvf-LH refers to right visual field-left hemisphere; lvf-RH refers to left visual field-right hemisphere.**

Follow-up paired samples *t*-tests revealed that facilitation was greater for the high transparency idiom condition in the rvf-LH ($M = 44.06$, $SE = 15.04$) than in the lvf-RH ($M = -6.77$, $SE = 21.26$), $t(81) = 2.02$, $p = .04$. There was no difference in facilitation for the low transparency idiom condition between the rvf-LH ($M = -7.40$, $SE = 12.69$) and the lvf-RH ($M = 21.90$, $SE = 22.00$), $t(81) = 1.59$, $p = .12$. Within the rvf-LH, facilitation was greater for the high transparency idiom condition ($M = 44.06$, $SE = 15.04$) than the low

transparency idiom condition (M = -7.40, SE = 12.69), $t(81) = 2.66$, $p = .01$. Finally, there was no difference in facilitation within the lvf-RH between the high transparency idiom condition (M = -6.77, SE = 21.26) and the low transparency idiom condition, (M = 21.90, SE = 22.00), $t(81) = 1.28$, $p = .20$.

One-sample *t*-tests were conducted to investigate if facilitation effects for the high and low transparency idiom conditions were significantly different from zero in each visual field-hemisphere. Within the rvf-LH, facilitation was significantly greater than zero for the high transparency idiom condition, (M = 44.06, SE = 15.04), $t(81) = 2.95$, $p = .00$; but facilitation was not significantly different from zero for the low transparency idiom condition, (M = -7.40, SE = 12.69), $t(81) = .58$, $p = .56$. Within the lvf-RH, facilitation was not significantly different from zero for the high transparency idiom condition, (M = -6.77, SE = 21.26), $t(81) = .32$, $p = .75$; and facilitation was not significantly different from zero for the low transparency idiom condition, (M = 21.90, SE = 22.00), $t(81) = 1.36$, $p = .18$.

Accuracy Effects

To explore accuracy effects for each condition and visual field-hemisphere, a two way repeated measures ANOVA was conducted on the proportion of correct responses in the lexical decision task. The independent variables were idiom transparency (high transparency idiom, high transparency neutral, low transparency idiom, and low transparency neutral)

and visual field-hemisphere (right visual field-left hemisphere, rvf-LH; left visual field-right hemisphere, lvf-RH). The main effect of idiom transparency was not significant, $F_1(3, 243) = 1.92$, $MSe = .01$, $p = .12$; $F_2(3, 69) = 1.43$, $MSe = .01$, $p = .24$. The main effect of visual field-hemisphere was not significant, $F_1(1, 81) = .05$, $MSe = .02$, $p = .82$; $F_2(1, 23) = 3.02$, $MSe = .00$, $p = .10$. Finally, the interaction between idiom transparency and visual field-hemisphere was not significant, $F_1(3, 243) = 1.47$, $MSe = .01$, $p = .23$; $F_2(3, 69) = 1.15$, $MSe = .01$, $p = .33$.

Sentence Reading Time Effects

To explore reading time differences for the final sentence in the idiom and neutral versions of each text, a two-way repeated measures ANOVA was conducted on the final sentence reading times. The independent variables were idiom transparency (high transparency, low transparency) and text version (idiom, neutral). The main effect of idiom transparency was not significant, $F_1(1, 82) = 2.64$, $MSe = 30204.48$, $p = .11$; $F_2(1, 23) = 1.89$, $MSe = 448734.12$, $p = .18$. The main effect of text version was not significant, $F_1(1, 81) = 1.92$, $MSe = 94309.37$, $p = .17$; $F_2(1, 23) = .07$, $MSe = 360321.05$, $p = .79$. The interaction between idiom transparency and text version was not significant, $F_1(1, 81) = 2.14$, $MSe = 24465.468$, $p = .15$; $F_2(1, 23) = 1.15$, $MSe = 502837.29$, $p = .29$.

Experiment 3

Response times to lexical decisions were collected and analyzed. Only correct responses were included in these analyses. Five participants were removed from the analyses because they had less than 70% accuracy in the lexical decision task and eight participants were removed from the analyses for not following instructions. Therefore, 90 participants (17 male and 73 female) were included in the final analyses. The top and bottom 1% of the response times were removed prior to analyses to minimize the influence of outliers (see Ratcliff, 1993 for a description of this procedure). For all analyses reported, an alpha level of .05 was used to determine significance. All analyses included the between participant variables of gender, hand used to respond, and counterbalanced list. There were no effects of gender, hand used to respond, or counterbalanced list, so these analyses are not reported. Analyses were conducted for both participants (F_1) and items (F_2). See Table 6 for the mean response times and accuracy proportions in Experiment 3.

Table 6

Mean response time (in ms) and accuracy (in percent correct) for targets in the familiar idiom, less familiar idiom, and neutral conditions by visual field-hemisphere

Condition	rvf-LH		lvf-RH	
	RT	AC	RT	AC
Familiar Idiom	485.74 (13.73)	.98 (.01)	542.75 (16.31)	.94 (.01)
Familiar Neutral	520.97 (16.20)	.93 (.01)	540.99 (14.73)	.88 (.01)
Less Familiar Idiom	492.98 (13.98)	.95 (.01)	546.42 (14.79)	.92 (.01)
Less Familiar Neutral	522.87 (17.52)	.95 (.01)	538.52 (15.72)	.93 (.01)

Note. Right visual field-left hemisphere is abbreviated: rvf-LH and left visual field-right hemisphere is abbreviated: lvf-RH. RT refers to response times and AC refers to accuracy. Values in parentheses represent standard errors.

Response Time Effects

A two way repeated measures ANOVA was conducted on the lexical decision response times. The independent variables were idiom familiarity (familiar idiom, familiar neutral, less familiar idiom, and less familiar neutral) and visual field-hemisphere (right visual field-left hemisphere, rvf-LH; left visual field-right hemisphere, lvf-RH). The main effect of idiom familiarity was not significant, $F_1(3, 267) = 1.84$, $MSe = 6754.25$, $p = .14$; $F_2(3, 66) = 1.04$, $MSe = 7435.69$, $p = .38$. The main effect of visual field-hemisphere was significant, $F_1(1, 89) = 12.02$, $MSe = 19990.76$, $p = .00$; $F_2(1, 22) = 5.39$, $MSe = 6352.70$, $p = .03$. Finally, the interaction between idiom familiarity and visual field-hemisphere was significant by participants, $F_1(3, 267) = 3.23$, $MSe = 6558.56$, $p = .02$; $F_2(3, 66) = .79$, $MSe = 8241.60$, $p = .51$.

Follow-up paired samples *t*-tests revealed that response times for the familiar idiom condition were significantly faster in the rvf-LH than the lvf-RH, $t(89) = 3.76$, $p = .00$. There was no difference between response times for the familiar neutral condition in the rvf-LH and in the lvf-RH, $t(89) = 1.36$, $p = .18$. Response times were significantly faster for the less familiar idiom condition in the rvf-LH than in the lvf-RH, $t(89) = 3.81$, $p = .00$. The difference between response times for the less familiar neutral condition between the rvf-LH and the lvf-RH was not significant, $t(89) = 1.02$, $p = .31$. Within the lvf-RH, there were no response times differences between the familiar idiom condition and the less familiar idiom condition, $t(89) = .69$, $p = .49$. Response times for the familiar idiom condition were significantly faster than the familiar neutral condition within the rvf-LH, $t(89) = 3.21$, $p = .00$. Response times within the lvf-RH were also significantly faster for the less familiar idiom condition than the less familiar neutral condition, $t(89) = 2.27$, $p = .03$. Within the lvf-RH, there was no difference in response times between the familiar idiom condition and less familiar idiom condition, $t(89) = .30$, $p = .77$. There was no difference in response time within the lvf-RH between the familiar idiom condition and the familiar neutral condition, $t(89) = .15$, $p = .88$. Finally, within the lvf-RH there was no difference in response time between the less familiar idiom condition and less familiar neutral condition, $t(89) = .60$, $p = .55$.

Facilitation Effects

Facilitation effects were calculated by subtracting the response times in the neutral conditions from the response times in the idiom conditions. These facilitation scores represent how quickly target words are processed in the idiom conditions as compared to when the target word is unrelated to the preceding text (i.e., the neutral conditions). For facilitation effects, larger scores represent faster processing relative to the neutral condition. To explore facilitation effects for familiar idioms and less familiar idioms in each visual field-hemisphere, a two way repeated measures ANOVA was conducted on the facilitation effects. The two independent variables were idiom familiarity (familiar idiom, and less familiar idiom) and visual field-hemisphere (right visual field-left hemisphere, rvf-LH; and left visual field-right hemisphere, lvf-RH). Please see Figure 8 for the average facilitation (in ms) in the familiar and less familiar idiom conditions by visual field-hemisphere.

There was no main effect for idiom familiarity, $F_1(1, 89) = .22$, $MSe = 13653.28$, $p = .65$; $F_2(1,23) = .37$, $MSe = 19739.21$, $p = .55$. There was a significant main effect of visual field-hemisphere by participants, $F_1(1, 89) = 10.64$, $MSe = 11831.55$, $p = .00$; $F_2(1,23) = 3.48$, $MSe = 12355.15$, $p = .08$. The interaction between idiom familiarity and visual field-hemisphere was not significant, $F_1(1, 89) = 0.00$, $MSe = 12986.78$, $p = .57$; $F_2(1, 23) = .34$, $MSe = 25551.12$, $p = .57$.

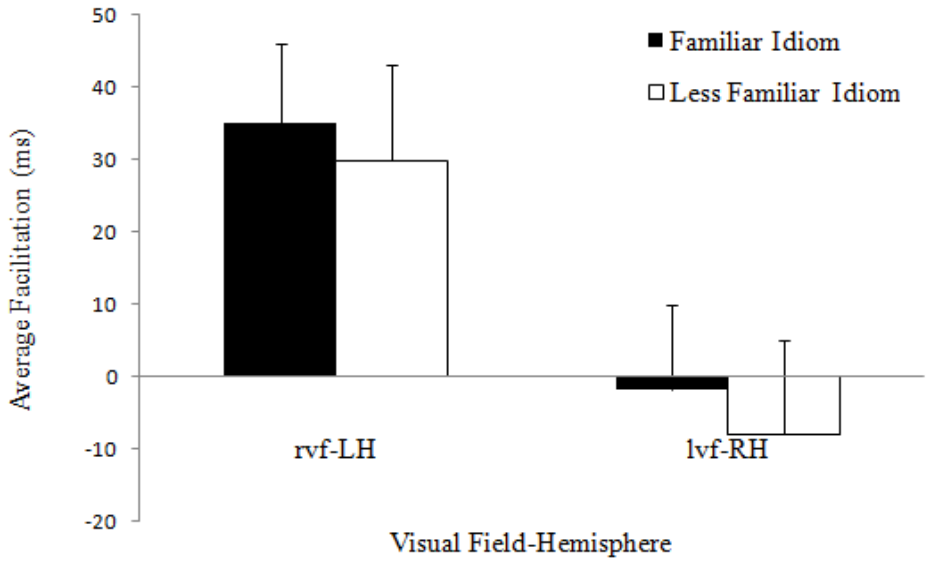

Figure 8. **Average facilitation (in ms) in the familiar idiom and less familiar idiom conditions by visual field-hemisphere. Note: rvf-LH refers to the right visual field-left hemisphere; lvf-RH refers to the left visual field-right hemisphere.**

Follow-up paired samples *t*-tests showed that for the familiar idiom condition, there was greater facilitation in the rvf-LH (M = 35.23, SE = 10.98) than in the lvf-RH (M = -1.77, SE = 11.18),$t(89) = 2.45$, $p = .02$. In addition, for less familiar idioms, greater facilitation was evident in the rvf-LH (M = 29.18, SE = 13.18) than in the lvf-RH (M = -7.89, SE = 11.10), $t(89) = 2.10$, $p = .04$. There was no difference in facilitation between familiar and less familiar idiom conditions in the rvf-LH, $t(89) = .31$, $p = .76$. Finally, there was no difference in facilitation between the familiar and less familiar idiom conditions in the lvf-RH, $t(89) = .36$, $p = .72$.

One-sample *t*-tests were conducted to investigate if facilitation effects for the familiar and less familiar idiom conditions were significantly different

from zero in each visual field-hemisphere. In the rvf-LH, facilitation was greater than zero for the familiar idiom condition (M = 35.23, SE = 10.98), $t(89) = 3.21$, $p = .00$, and facilitation was greater than zero for the less familiar idiom condition (M = 29.18, SE = 13.18), $t(89) = 2.27$, $p = .03$. In the lvf-RH, facilitation was not significantly different from zero for the familiar idiom condition (M = -1.77, SE = 11.18), $t(89) = .15$, $p = .82$, and facilitation was not significantly different from zero for the less familiar idiom condition (M = -7.89, SE = 11.10), $t(89) = .6$, $p = .55$.

Accuracy Effects

To explore accuracy effects for each condition and visual field-hemisphere, a two way repeated measures ANOVA was conducted on the proportion of correct responses in the lexical decision task. The independent variables were idiom familiarity (familiar idiom, familiar neutral, less familiar idiom, and less familiar neutral) and visual field-hemisphere (right visual field-left hemisphere, rvf-LH; and left visual field-right hemisphere, lvf-RH). The main effect of idiom familiarity was significant by participants, $F_1(3, 267) = 8.31$, $MSe = .01$, $p = .00$, $F_2(3, 69) = .1.8$, $MSe = .02$, $p = .15$. The main effect of visual field-hemisphere was also significant by participants, $F1(1, 89) = 12.97$, $p = .00$; $F_2(1, 23) = .86$, $MSe = .17$, $p = .36$. However, the interaction between idiom familiarity and visual-field hemisphere was not significant, $F_1(3, 267) = 1.18$, $MSe = .01$, $p = .43$; $F_2(3, 69) = .66$, $MSe = .02$, $p = .58$.

Follow-up paired samples *t*-tests showed that accuracy was greater for the familiar idiom condition in the rvf-LH than in the lvf-RH, $t(89) = 2.80$. Accuracy was also greater for the familiar neutral condition in the rvf-LH than the lvf-RH, $t(89) = 3.43$, $p = .00$. No differences in accuracy were evident for the less familiar idiom condition between the rvf-LH and the rvf-LH, $t(89) = 1.80$, $p = .07$. Finally, no differences in accuracy were evident for the less familiar neutral condition between the rvf-LH and the lvf-RH, $t(89) = .89$, $p = .38$.

Sentence Reading Time Effects

To explore reading time differences for the final sentence in the idiom and neutral versions of each text, a two-way repeated measures ANOVA was conducted on the final sentence reading times. The independent variables were idiom familiarity (familiar, less familiar) and text version (idiom, neutral). The main effect of idiom familiarity was not significant, $F_1(1, 89) = .11$, $MSe = 36233.81$, $p = .92$; $F_2(1,23) = .38$, $MSe = 811938.81$, $p = .54$. The main effect of text version was not significant, $F_1(1, 89) = 3.01$, $MSe = 32328.53$, $p = .09$; $F_2(1,23) = .29$, $MSe = 693921.47$, $p = .59$. The interaction between idiom familiarity and text version was not significant, $F_1(1, 89) = .62$, $MSe = 42818.46$, $p = .43$; $F_2(1, 23) = 2.11$, $MSe = 971184.95$, $p = .15$.

CHAPTER IV

DISCUSSION

Experiment 1

In Experiment 1, I investigated how the right and left cerebral hemispheres process high ambiguity and low ambiguity idioms. I hypothesized that high ambiguity idioms would be processed more quickly in the right hemisphere than the left hemisphere, whereas low ambiguity idioms would be processed more quickly in the left hemisphere than the right hemisphere (Hypothesis Ia). Hypothesis Ia was supported by the facilitation results. Specifically, facilitation was significantly greater in the lvf-RH than the rvf-LH when readers responded to idiom-related target words in the high ambiguity idiom condition. Further, facilitation was significantly greater in the rvf-LH than the lvf-RH when readers responded to idiom-related target words in the low ambiguity condition. In sum, the left hemisphere appears to play a dominant role during the processing of idioms that do not have a plausible literal interpretation, whereas the right hemisphere appears to play a dominant role during the processing of idioms that have a literally plausible interpretation.

A secondary hypothesis of Experiment 1 was that the hemispheres would show accuracy differences when readers processed high and low ambiguity idioms. Specifically, I predicted that accuracy for targets in the high ambiguity idiom condition would be greater in the lvf-RH than the rvf-LH, but that accuracy for targets in the low ambiguity idiom condition would

be greater in the rvf-LH than the lvf-RH (Hypothesis Ib). However, no accuracy differences were observed between the hemispheres for either the high ambiguity or low ambiguity idiom conditions. Further, accuracy was significantly greater for the high ambiguity neutral condition in the rvf-LH than in the lvf-RH. Accuracy was also significantly greater for the low ambiguity neutral condition in the rvf-LH than the lvf-RH. These accuracy differences likely reflect the left hemisphere's general tendency to recognize words more accurately than the right hemisphere (Beeman & Chiarello, 1998). Specifically, the left hemisphere plays a more dominant role processing text at the word level, whereas the right hemisphere plays a more dominant role for processing individual letters in a word (Lindell, 2006). Therefore, it is not surprising that participants' responses in the neutral conditions would be more accurate in the left hemisphere than the right hemisphere. Importantly, because the high and low ambiguity idiom conditions were processed with similar accuracy levels in both hemispheres, these results suggest that participants were not simply responding to the target words without attempting to comprehend the targets themselves. In other words, the facilitation findings in Experiment 1 do not seem to be due to a speed-accuracy tradeoff.

The findings in Experiment 1 suggest that the right hemisphere plays a key role when readers process high ambiguity idioms, but that the left hemisphere plays a key role when readers process low ambiguity idioms. This finding of a right hemisphere advantage for high ambiguity idioms is

consistent with previous findings suggesting that the right hemisphere contributes to the resolution of ambiguous words or phrases during text comprehension (e.g., Grinrod & Baum, 2005). It seems likely that when readers encounter an idiom with a plausible literal interpretation during text comprehension, that the right hemisphere activates information related to the figurative meaning of high ambiguity idioms. Conversely, the left hemisphere advantage found for low ambiguity idioms is consistent with previous findings showing a left hemisphere advantage when readers process low ambiguity idioms (e.g. Papagno et al., 2006). Thus, the findings of Experiment 1 contribute to the existing knowledge of how idioms are processed during reading by demonstrating that the level of ambiguity may be a key factor in determining how idioms are processed in the cerebral hemispheres.

In Experiment 1, the right hemisphere facilitation evident for high ambiguity idioms is consistent with previous findings showing a right hemisphere advantage for resolving lexical ambiguity (Tompkins, 2001). For example, when a reader encounters an ambiguous word, the right hemisphere often processes multiple interpretations of the word (Coney & Evans, 2000; Faust & Chiarello, 1998; Peleg and Eviatar, 2007). Although it has been speculated that the left hemisphere is the dominant hemisphere for selecting the most appropriate meaning when readers resolve lexical ambiguity (Copland et al., 2002), the results of Experiment 1 suggest that the right hemisphere is also dominant when readers resolve ambiguity in idiomatic phrases. These results suggest that the right hemisphere may not simply

activate all meanings of an ambiguous word or phrase indiscriminately, but may in fact play a key role in selecting the most contextually appropriate meaning of an ambiguous word or phrase.

The results of Experiment 1 may be contrasted with previous studies that found either a left hemisphere advantage or no hemisphere advantage for high ambiguity idioms. For example, a recent fMRI study found a left hemisphere advantage when participants read ambiguous idiomatic phrases and determined whether those phrases had a meaningful interpretation (Hillert & Buracas, 2009). However, the idioms were presented in a limited context (e.g., in idiomatic phrases such as “They were in the same league”), such that the idioms could have been interpreted either literally or figuratively. When presented within a limited context such as this, it is possible that the left hemisphere advantage found was the result of participants interpreting the phrases literally, because the left hemisphere has an advantage for literal interpretation of words or phrases (Giora, 2003). Similarly, a recent divided visual field study that presented readers with ambiguous idioms in a limited context found no hemispheric differences for these ambiguous idioms (Mashal et al., 2008). Specifically, Mashal and colleagues presented target words 200 ms after presentation of an idiom. This short amount of time between the presentation of the idiom and the target word may not have allowed adequate time for the idioms to be processed in the right hemisphere (Beeman et al., 1994). Thus, it is possible that the hemispheres may process ambiguous idioms differently depending on whether the idiom is presented in a limited

context, and may also vary depending on the length of time between the presentation of the idiom and the idiom-related target word.

In addition to providing evidence for how the hemispheres process the figurative meaning of idioms, the results of Experiment 1 provide indirect evidence for how the hemispheres may process the literal interpretation of an idiom. For example, the direct access model of figurative language comprehension predicts that the figurative meaning of an idiom should be the most dominant meaning (Gibbs, 1980; 1986) and that an idiom's constituent words will not be processed literally (Gibbs et al., 1980). In contrast, the compositional hypothesis suggests that readers generate both a literal and a figurative interpretation of an idiom (Cacciari & Tabossi, 1998). Because the figurative meaning of low ambiguity idioms showed greater facilitation in the left hemisphere than in the right hemisphere in Experiment 1, perhaps the figurative meaning of low ambiguity idioms may be the most accessible meaning. The possibility that the figurative meaning of low ambiguity idioms may be more accessible than the literal meaning is important because the left hemisphere is dominant for processing the most accessible meaning of a word or phrase (Beeman & Chiarello, 1998; Faust & Chiarello, 1998). However, because high ambiguity idioms showed greater priming in the right hemisphere than the left hemisphere in Experiment 1, this finding suggests that readers might need to engage in a selection process to determine the correct meaning of an idiom. Previous research has demonstrated that the right hemisphere has an advantage when readers need to select the appropriate

meaning of a text at the discourse level (Beeman & Chiarello, 1998). Thus, the current results suggest that the right hemisphere is predominant in the processing of high ambiguity idioms.

Experiment 2

In Experiment 2, I investigated how the right and left cerebral hemispheres process high transparency and low transparency idioms. I hypothesized that high transparency idioms would be processed more quickly in the right hemisphere than the left hemisphere, and that low transparency idioms would be processed more quickly in the left hemisphere than the right hemisphere (Hypothesis IIa). However, this hypothesis was not supported. Instead, facilitation for idiom-related targets in the high transparency idiom condition was significantly greater in the left hemisphere than the right hemisphere. Facilitation was not significantly different between the hemispheres for the low transparency idiom condition, although there was a non-significant trend for facilitation to be greater in the right hemisphere than the left hemisphere for low transparency idioms. Thus, these results suggest that the left hemisphere may play a greater role than the right hemisphere when readers comprehend high transparency idioms, but neither hemisphere appears to play a dominant role when readers process low transparency idioms.

I also predicted that in Experiment 2, accuracy would be greater for the low transparency idiom condition in the left hemisphere than the right hemisphere, and that accuracy for the high transparency idiom condition

would be greater in the right hemisphere than the left hemisphere (Hypothesis IIb). However, accuracy was generally high across both hemispheres and all conditions, and no hemispheric differences for accuracy were observed for either the high or low transparency idiom conditions. Thus, Hypothesis 2a was not supported. Finally, the lack of accuracy effects in Experiment 2 suggest that participants were not responding "yes" to the targets during the lexical decision task without actually comprehending the words (i.e., the results were not due to a speed-accuracy tradeoff).

The results of Experiment 2 help explain how idioms that differ in the level of transparency are processed during text comprehension. For example, the hybrid model of idiom processing suggests that low transparency idioms are stored as long words and that the idiomatic phrase is strongly associated with the idiom's figurative meaning (Titone & Connine, 1999).In contrast, the hybrid model suggests that high transparency are not stored as lexical items, and the individual words are weakly associated with the idiom's figurative meaning (Titone & Connine, 1999). However, if this prediction about the semantic association of high and low transparency idioms is correct, then a left hemisphere advantage for low transparency idioms and a right hemisphere advantage for high transparency idioms would have been evident in Experiment 2. However, the results of Experiment 2 are more consistent with the predictions of the *new hybrid model* of idiom processing (Cailles & Butcher, 2007). According to the New Hybrid Model, both high and low transparency idioms are processed at the phrase level, but only high

transparency idioms are processed at both the phrase level and the word level. If the New Hybrid Model of idiom processing is correct, then high transparency idioms should be more strongly related to their figurative meaning than low transparency idioms. Thus, the results of Experiment 2 provide support for the new hybrid model of idiom processing.

The lack of a left hemisphere advantage for the low transparency idiom condition in Experiment 2 is consistent with studies of patients whose corpus callosum is either undeveloped or underdeveloped (i.e., corpus callosum agenesis). For example, patients with corpus callosum agenesis are less accurate at interpreting low transparency idioms than high transparency idioms (Huber-Okrainec et al., 2004). Because patients with corpus callosum agenesis must often rely on left hemisphere processes for communication (Huber-Okrainec et al., 2004), this difficulty of interpreting low transparency idioms suggests that the right hemisphere may contribute to the comprehension of low transparency idioms. The possibility that the right hemisphere contributes to low transparency idiom comprehension may be supported by the (non-significant) trend found in Experiment 2 showing greater facilitation for low ambiguity idioms in the right hemisphere than the left hemisphere.

The results of Experiment 2 are inconsistent with studies that have observed left hemisphere dominance for processing low transparency idioms. For example, several studies have found that low transparency idioms are more difficult to comprehend if the left hemisphere has been damaged

(Papagno et al., 2006) or if the left hemisphere is stimulated by repeated transcranial magnetic stimulation (Oliveri & Papagno, 2004). However, the idioms used in these studies were not only low in transparency, but were also low in ambiguity and high in familiarity. Given that the results of Experiment 1 suggest that the left hemisphere has an advantage when readers process low ambiguity idioms, it is unclear whether the left hemisphere advantage found for idioms in previous studies was due to the level of ambiguity, transparency, or familiarity. It is possible that the left hemisphere advantage observed in previous studies was due to the idioms' low ambiguity and high familiarity, and not due to the idioms' low transparency.

Experiment 3

In Experiment 3, I investigated how the right and left cerebral hemispheres process familiar and less familiar idioms. I hypothesized that familiar idioms would be processed more quickly in the right visual field-left hemisphere than the left visual field-right hemisphere, and that less familiar idioms would be processed more quickly in the left visual field-right hemisphere than the right visual field-left hemisphere (Hypothesis IIIa). The facilitation results of Experiment 3 provide partial support for Hypothesis IIIa. As predicted, facilitation for the familiar idiom condition was greater in the left hemisphere than the right hemisphere. However, facilitation for the less familiar idiom condition was also greater in the left hemisphere than the right hemisphere. These facilitation results suggest that the left hemisphere may be dominant when readers process both familiar and less familiar idioms.

Further, I hypothesized that accuracy would be greater for familiar idioms in the left hemisphere than the right hemisphere, and that accuracy would be greater for less familiar idioms in the right hemisphere than the left hemisphere (Hypothesis IIIb). However, Hypothesis 2a was not supported. Instead, participants were more accurate when responding to the familiar idiom condition than when responding to the less familiar idiom condition in both hemispheres. These results suggest that familiar idioms are easier to recognize than less familiar idioms. Further, in Experiment 3, accuracy was higher for the familiar idiom condition in the left hemisphere than the right hemisphere, but there were no accuracy differences for the less familiar idiom condition between the hemispheres. These findings suggest that the left hemisphere may have an advantage when readers process familiar idioms. In addition, there were no accuracy differences observed between the hemispheres for the less familiar idiom condition. These results suggest that participants were not simply responding to the target words without attempting to comprehend the targets themselves. In other words, the facilitation findings in Experiment 3 do not seem to be due to a speed-accuracy tradeoff.

The finding that the left hemisphere is dominant when readers process either familiar or less familiar idioms is inconsistent with previous studies that have demonstrated a right hemisphere advantage for other types of figurative language, such as when readers comprehend sarcastic text (Eviatar & Just, 2006). Based on the results of Experiment 3, it seems likely that idioms may

be processed differently than other types of figurative language. Thus, the findings from Experiment 3 provide evidence that the left hemisphere plays an essential role during the comprehension of both familiar and less familiar idioms during text comprehension.

In Experiment 3, the left hemisphere advantage found when readers processed both familiar and less familiar idioms is inconsistent with previous research showing a right hemisphere advantage for other types of less familiar figurative language, such as when readers process metaphors they have not previously encountered (Mashal & Faust, 2007). It is possible that the left hemisphere showed an advantage for processing less familiar idioms in Experiment 3 because even less familiar idioms have familiar figurative meanings (Bowdle & Gentner, 2005). For example, in the pilot study to test the target words (described in Experiment 3), participants were able to reliably identify the figurative meaning of the less familiar idioms. The finding that participants were able to successfully comprehend both the familiar and less familiar idioms, as demonstrated in Experiment 3's pilot study, suggests that the participants were at least somewhat familiar with even the less familiar idioms. The possibility that readers had previously encountered the less familiar idioms is important because readers may need only a limited amount of exposure to a less familiar idiom to easily comprehend its figurative meaning. Research suggests that the right hemisphere advantage for less familiar figurative language is greatly diminished after exposure to a figurative phrase, even if the exposure is very limited (Faust, Arzouan, &

Goldstein, 2009). In fact, a recent study demonstrated that the right hemisphere advantage for novel metaphors is eliminated after participants explained the meaning of the novel metaphor just once (Faust, Arzouan, & Goldstein, 2009). Because participants were able to successfully interpret even less familiar idioms in the current study, it is possible that less familiar idioms (as well as familiar idioms) showed a left hemisphere advantage because the left hemisphere plays a key role in processing the figurative meaning of previously-encountered idioms.

Although the results of Experiment 3 suggest that the left hemisphere may have an advantage when readers process both familiar and less familiar idioms, it is possible that the right hemisphere may play a significant role when readers comprehend novel idioms. For example, when participants are presented with novel idioms (e.g., “the goose hangs high”) (Keysar & Bly, 1999), they generate a figurative interpretation that is less salient than the idiom’s literal meaning. For example, a reader who encounters “the goose hangs high” for the first time may initially activate a literal meaning, and then possibly understand based on the surrounding context that a goose is not literally hanging. Because novel idioms are unfamiliar to participants, they likely need to interpret these idioms based on the surrounding context and generate a new, less salient meaning for the idiomatic phrase. Because the right hemisphere is dominant for processing less salient meanings (Giora, 2003), it is likely that the right hemisphere would have an advantage for processing novel idioms.

General Discussion

In the current set of experiments, I investigated how three factors known to influence idiom processing (the level of ambiguity, transparency, and familiarity) reflect differences in how idioms are processed in the cerebral hemispheres. In each experiment, participants read texts that contained idioms (or read neutral texts that did not contain an idiom) and made lexical decision responses to idiom-related target words presented to either the right visual field-left hemisphere or the left visual field-right hemisphere. In Experiment 1, the idioms were either high or low in ambiguity (and transparency and familiarity levels were controlled). In Experiment 2, the idioms were either high or low in transparency (and ambiguity and familiarity levels were controlled). Finally, in Experiment 3 the idioms were either familiar or less familiar (and ambiguity and transparency levels were controlled). I hypothesized that the left hemisphere would be dominant when readers processed idioms that were low in ambiguity, low in transparency, or familiar, whereas the right hemisphere would be dominant when readers processed idioms that were high in ambiguity, high in transparency, or less familiar. In Experiment 1, facilitation was greater in the left visual field-right hemisphere than in the right visual field-left hemisphere for processing high ambiguity idioms, but facilitation was greater in the right visual field-left hemisphere than in the left visual field-right hemisphere for processing low ambiguity idioms. In Experiment 2, facilitation was greater in the right visual field-left hemisphere than the left visual field-right hemisphere for high transparency

idioms, but facilitation was not significantly different between the hemispheres when readers processed low transparency idioms. In Experiment 3, facilitation was greater in the right visual field-left hemisphere than the left visual field-right hemisphere for both familiar and less familiar idioms. The results of these experiments suggest that idioms may be processed differently in the hemispheres based on the idiom's level of ambiguity or transparency, but not the idiom's familiarity.

Taken together, these results suggest that idioms that differ in terms of ambiguity or transparency may be comprehended using different processes during text comprehension. Specifically, previous studies have found reading time differences between high and low ambiguity idioms (Cronk, Lima, & Schweigert, 1993) and between high and low transparency idioms (Titone & Connine, 1999), but previously it had not been clear whether these differences in reading times reflected differences in comprehension processes. For example, it is possible that high and low ambiguity idioms were comprehended by readers using similar processes, but that high ambiguity idioms simply required more cognitive effort to process than low ambiguity idioms, which lead to longer reading times for high ambiguity idioms than low ambiguity idioms (Cronk, Lima, & Schweigert, 1993). However, the hemispheric differences observed for high and low idioms (in Experiment 1) and high transparency idioms (in Experiment 2) suggest that high and low transparency idioms of idioms are comprehended using different processes. Specifically, the figurative meaning of high transparency idioms and low

ambiguity idioms seems to be easily accessible and highly related to the idiom's figurative meaning, because the left hemisphere has an advantage for accessible, highly related meanings (Beeman et al., 1994). In contrast, the figurative meaning of high ambiguity idioms may be less accessible than the figurative meaning of low ambiguity idioms, because the right hemisphere has an advantage when readers need to select one of several potential meanings (Giora, 2003; Tompkins, 2001).

The finding in the current set of experiments that idioms are processed differently in the hemispheres is consistent with previous research on how the hemispheres process figurative language. For example, previous studies show a left hemisphere advantage when readers process familiar metaphors, but a right hemisphere advantage when readers process unfamiliar metaphors (Mashal & Faust, 2008; Pobric et al., 2008). However, it should be noted that although familiar and less familiar metaphors are processed differently in the hemispheres, in Experiment 3 both familiar and less familiar idioms showed a left hemisphere advantage. It is possible that the factors that influence the hemispheric processing of metaphors may be different than the factors that influence the hemispheric processing of idioms. For example, readers often need more time to process metaphoric texts than literal texts, but need less time to process idiomatic texts than literal texts (Ortony et al., 1978), which suggests that metaphors may require different cognitive resources to process than idioms.

Given that at least some right hemisphere facilitation was evident in Experiment 1 (for high ambiguity idioms) and Experiment 2 (for low transparency idioms), it is surprising that no right hemisphere facilitation was observed for either familiar or less familiar idioms in Experiment 3. Because the familiar and less familiar idioms had equivalent levels of ambiguity and transparency, it might have been reasonable to expect that right hemisphere facilitation in Experiment 3 would be close to the average right hemisphere facilitation observed in Experiments 1 and 2. It is possible that no right hemisphere facilitation was observed in Experiment 3 because there may be a threshold level of ambiguity or transparency that needs to be exceeded before any right hemisphere facilitation is observed. For example, it may not be the case that a moderate level of ambiguity results in moderate right hemisphere facilitation and that a high level of ambiguity results high right hemisphere facilitation. Instead, right hemisphere facilitation may only be evident for high but not moderate levels of ambiguity. Thus, the idioms explored in Experiment 3 may have not featured high enough ambiguity or low enough transparency to elicit right hemisphere facilitation.

Finally, previous studies have observed a right hemisphere advantage for idiom processing (e.g. Myers & Linebaugh, 1981), but it is important to note that a significant right hemisphere advantage was observed only for high ambiguity idioms in the current experiments. These results are inconsistent with previous claims that the right hemisphere is the dominant hemisphere for processing most kinds of idioms (Van Lancker & Kemper, 1988). The left

hemisphere advantage observed for low ambiguity, high transparency, familiar, or less familiar idioms is more consistent with studies that have found left hemisphere dominance for processing idioms (e.g. Papagno et al., 2006). Taken together, these results suggest that the right hemisphere may only play a role in idiom comprehension if the idiom is high in ambiguity. Therefore, it is likely that high ambiguity idioms are processed differently than other types of idioms, likely because of the plausible literal interpretation of high ambiguity idioms, suggesting a right hemisphere role for selecting between a high ambiguity idiom's figurative and literal meanings.

Theoretical Implications

The results of the current set of experiments have several implications for theories of how the left and right hemispheres process language. First, the Fine-Coarse Semantic Coding Theory states that the left hemisphere has an advantage when readers process close semantic associates of a word or phrase, whereas the right hemisphere has an advantage when readers process distant semantic associates of a word or phrase (Beeman et al., 1994). Over the years, there has been some disagreement about how the fine-coarse semantic coding theory can accurately account for idiom processing (Beeman & Chiarello, 1998; Mashal et al., 2008). For example, some researchers have proposed that the figurative meaning of idioms should contain distant semantic associates of an idiomatic phrase, showing a right hemisphere advantage for idioms during text comprehension (Beeman et al., 1994). Other researchers have proposed that the figurative meanings of idioms should contain close semantic

associates of idiomatic phrase, showing a left hemisphere advantage for figurative language during text comprehension (Mashal et al., 2008). In the current study, the left hemisphere advantage observed for both familiar and less familiar idioms suggests that the figurative meaning of an idiom may be semantically close to the idiomatic phrase, even when the idiom is less familiar. These results are consistent with researchers who claim that the figurative meaning of idioms should be the most accessible meaning (Mashal et al., 2008). However, Experiment 1's findings show a right hemisphere advantage for high ambiguity idioms, but a left hemisphere advantage for low ambiguity idioms. The findings from Experiment 1 suggest that the semantic distance between an idiom and its figurative meaning seems to vary as a function of the level of ambiguity. Specifically, the figurative meaning of low ambiguity phrases may be semantically close to the literal meaning, whereas the figurative meaning of high ambiguity idioms may be semantically distant to the literal meaning. The right hemisphere advantage observed for high ambiguity idioms is consistent with early studies exploring Fine-Coarse Semantic Coding Theory (Beeman et al., 1994). Further, the left hemisphere dominance for high transparency idioms observed in Experiment 2 suggests that the figurative meaning of high transparency idioms may be more semantically close to the idiomatic phrase than the figurative meaning of low transparency idioms. The left hemisphere advantage for low ambiguity, high transparency, familiar, or less familiar idioms is consistent with later studies of the Fine-Coarse Semantic Coding Theory (Mashal et al., 2008). Thus, an

idiom's level of ambiguity or transparency may influence the semantic distance between the idiom and the figurative meaning.

The Fine-Coarse Semantic Coding Theory (Beeman et al., 1994) may help explain why a right hemisphere advantage was found for the figurative meaning high ambiguity idioms in the current experiment, and why a right hemisphere advantage has been observed for the literal meaning of high ambiguity idioms in previous studies. It is possible that the right hemisphere advantage observed for high ambiguity idioms in Experiment 1 may represent important differences in the semantic distance between a high ambiguity idiom, its figurative meaning, and its literal meaning. Previous research has found greater neural activity in the right hemisphere when readers process the literal meaning of high ambiguity idioms (Mashal et al., 2008), suggesting that high ambiguity idioms are weakly related to their literal meanings. However, the results of the current Experiment 1 suggest that high ambiguity idioms may also be weakly related to their figurative meanings. The possibility that high ambiguity idioms are weakly related to both their figurative and literal meaning has interesting implications for the Fine-Coarse Semantic Coding Theory (Beeman et al., 1994). For example, it is possible that context in which the idiom is presented may play a key role in the temporary strength between a high ambiguity idiom and its literal or figurative meaning. For example, previous studies that have examined comprehension of high ambiguity idioms in limited context have found either no hemispheric differences (Mashal et al., 2008) or a left hemisphere advantage (Hillert &

Buracas, 2009) when readers are primed with a target word related to the figurative meaning. When presented with limited context, it may be difficult for a reader to determine if the idiom was meant figurative or literally. However, when provided with a context that favors the figurative meaning, such as in the current study's Experiment 1, readers may easily understand that the idiom is meant figuratively. Further support for the role of the right hemisphere in integrating context comes from studies in which patients with right hemisphere damage choose the literal meaning of a phrase over its contextually appropriate meaning (Beeman, 1993) and from studies in which right hemisphere damage patients choose non-sequitur endings for jokes instead of surprising but contextually coherent endings (Brownell et al., 1983). Thus, when both potential meanings of a phrase are weakly related to the phrase (as may be the case with high ambiguity idioms), context may facilitate the selection of the contextually appropriate meaning. Therefore, it may be beneficial for the Fine-Coarse Semantic Coding Theory to include predictions of how context affects selection between multiple weakly-related meanings of a text.

The Fine-Coarse Semantic Coding theory predicts that the left hemisphere will select only the "frequently intended semantic features of words" (Beeman, 1994; p. 28), but there was no evidence for left hemisphere facilitation when readers processed high ambiguity idioms. This finding is inconsistent with the Fine-Coarse Semantic Coding Theory's predictions, because the figurative meaning of idioms should be well known to readers

(Mashal et al., 2008). It is possible that the right hemisphere played a greater role in the left hemisphere when processing high ambiguity idioms in Experiment 1 because the hemispheres process multi-word phrases differently. According to this theory, the coarse semantic activation in the right hemisphere makes allows that hemisphere to be "sensitive to overlap of peripheral semantic features activated by multiple words in the discourse" (Beeman, 1994; p. 29). It is possible that the high ambiguity idioms comprehended using the right hemisphere's sensitivity to the co-occurrence of the idiom's component words. If this is the case, then the right hemisphere role in processing high ambiguity idioms may be consistent with the Fine-Coarse Semantic Coding Theory's predictions. However, the possibility that idioms are activated based on the semantic overlap of their individual words does not explain the left hemisphere role observed for processing low ambiguity, high transparency, familiar, or less familiar idioms.

The left hemisphere advantage observed for some idioms in the current experiments may seem to argue against the Fine-Coarse Semantic Coding Theory's prediction of a right hemisphere advantage for multiword phrases, but theories of the compositional and noncompositional idiom processing may help explain these results. The noncomposonitial approach to idiom processing predicts that idioms are stored as if they were simply long words and that the reader does not analyze the idiom's individual words (Bobrow & Bell, 1973). In contrast, the noncompositional approach predicts that idioms are not stored as if they were long words, and that readers analyze the

individual words of the idiom (Cacciari & Tabossi, 1998). Based on the results of the current experiment, it is possible that some types of idioms may be stored more noncompositionally than others. For example, because the left hemisphere has an advantage for processing individual words whereas the right hemisphere has an advantage for processing multiword phrases (Beeman et al., 1994). It is possible that idioms that are low in ambiguity, high in transparency, or high or low in familiarity are stored as if they were lexical items, given the left hemisphere advantage observed for these idioms in the current experiments. It should be noted, however, that the possibility that these idioms are stored noncompositionally does not necessarily preclude the possibility of the same idioms being stored compositionally as well. For example, the new hybrid model of idiom processing predicts that high transparency idioms should be stored both compositionally and noncompositionally, resulting in a stronger connection between high transparency idioms and their figurative meaning than between low transparency idioms and their figurative meaning. Thus, it is possible that the left hemisphere advantage observed for low ambiguity, high transparency, familiar, or less familiar idioms is consistent with the Fine-Coarse Semantic Coding theory's predictions if these idioms are stored and retrieved noncompositionally.

The current experiments' results also have implications for connectionist models of semantic processing. According to connectionist models, a word or phrase's semantic concepts are represented in the mental

lexicon as units of meaning or (i.e., *nodes*) that are connected to other nodes in a semantic space. According to the Collins and Loftus model of semantic processing, the relationship between these nodes is based on the strength of their association (Collins & Loftus, 1975). For example, the nodes for "dog" and "cat" would be more strongly connected than the nodes for "dog" and "jungle" according to the Collins and Loftus model. Thus, when a particular word or phrase is encountered in text, nodes closely related to the word or phrase are activated, which in turn activate other nodes (i.e., *spreading activation*). Spreading activation has particularly interesting implications for high ambiguity idioms. Several spreading activation accounts of ambiguity resolution suggests that even when context supports one interpretation of the ambiguous word over the other, nodes related to multiple potential meanings are still activated (Kawamoto, 1993; McDonald et al., 1994). It is possible that when readers encounter a high ambiguity idiom, that nodes related to both the figurative and literal meaning are activated. In contrast, when readers encounter a low ambiguity idiom, it is possible that nodes only related to the figurative meaning are activated, since there is no plausible literal interpretation for low ambiguity idioms. If both the literal and figurative meaning of high ambiguity idioms are activated, this may help explain the right hemisphere advantage observed for high ambiguity idioms in Experiment 1, given the right hemisphere's role when readers must choose between several potential interpretations (Giora, 2003; Grinrod & Baum, 2005).

Connectionist accounts of semantic processing may also help explain the different patterns of hemispheric facilitation observed for high and low transparency idioms in Experiment 2. According to the *interactive activation and competition* model of semantic processing, nodes have both positive and negative associations with other nodes (McLelland & Rumelhart, 1981; Rumelhart & McLelland, 1982). Positive associations increase the likelihood of a node being activated, and negative associations decrease the likelihood of a node being activated. Thus, when a word or phrase is encountered, certain meanings are facilitated while other meanings are inhibited, allowing readers to select the text's intended meaning. These patterns of activation and inhibition are important because the figurative meaning of low transparency idioms may need to be activated whereas their literal meaning may need to be inhibited in order to comprehend the idiom, because the literal meanings of low transparency idioms' individual words do not contribute to the overall figurative meaning (Titone & Connine, 1999). In contrast, the literal meaning of a high transparency idiom would not need to be inhibited, because the literal meaning contributes to the figurative meaning of high transparency idioms (Titone & Connine, 1999). This greater need for inhibition when processing low transparency as opposed to high transparency idioms may help explain the non-significant trend towards right hemisphere facilitation observed for low transparency idioms. Given the right hemisphere's dominance for inhibiting potential (but incorrect) meanings of texts (Aron et al., 2004; Tompkins et al., 2001), it is possible that the slight right hemisphere

facilitation observed for low transparency idioms was due in part to the inhibition of the low transparency idiom's literal meaning.

The results of the current study also have implications for salience-based models of how the hemispheres process language. For example, the graded salience hypothesis (Giora, 1997; 2003) predicts that frequent, familiar, or conventional meanings of words or phrases (i.e., salient meanings) should show a left hemisphere advantage, whereas less frequent, familiar, or conventional meanings of words or phrases (i.e., less salient meanings) should show a right hemisphere advantage. Based on the graded salience hypothesis, the left hemisphere should have an advantage when readers process familiar idioms and the right hemisphere should have an advantage when readers process less familiar idioms. However, the results of Experiment 3 suggest that the left hemisphere has a processing advantage for the figurative meaning of both familiar and less familiar idioms.

Although the left hemisphere facilitation for less familiar idioms may seem incompatible with the graded salience hypothesis' prediction of a right hemisphere advantage for less salient texts, it is possible that the less familiar idioms in Experiment 3 featured meanings that were still somewhat salient. For example, the graded salience hypothesis predicts meanings that have been previously encountered (i.e., stored meanings) should be more salient than meanings that have never been encountered before (i.e., novel meanings). If readers had encountered these less familiar idioms previous to participating in the experiment, then it is likely that the figurative meaning of these less

familiar idioms had been stored in the readers' mental lexicon. Thus, the figurative meaning of less familiar idioms may have been salient, even if they were somewhat less salient than the figurative meaning of familiar idioms. Salience is not binary according to the graded salience hypothesis, but rather it exists on a continuum. It is therefore possible that the figurative meanings of less familiar idioms are still salient enough to elicit the left hemisphere advantage predicted by the graded salience hypothesis for salient meanings of texts.

The results of Experiment 2 are partially consistent with the graded salience hypothesis' prediction of a left hemisphere advantage for easily accessible meanings a right hemisphere advantage for less accessible meanings. The literal meaning of high transparency idioms should be more strongly related to the figurative meaning than for low transparency idioms. Thus, it is possible that the figurative meanings of high transparency idioms are highly salient (Cailles & Butcher, 2007). In contrast, the figurative meaning of low transparency idioms may be less salient, because the figurative meaning is not easily interpretable from the literal meaning (Cailles & Butcher, 2007). However, the graded salience hypothesis does not currently specifically account for the transparency of figurative phrases. The graded salience hypothesis may therefore benefit from considering the effects of transparency on the salience of figurative phrases.

The finding of a left hemisphere advantage for low ambiguity idioms and a right hemisphere advantage for high ambiguity idioms in Experiment 1

poses an interesting question about the graded salience hypothesis. The graded salience hypothesis predicts that both the figurative and the literal meaning of a figurative phrase will be activated. However, the results of Experiment 1 suggest that the activation of an idiom's literal meaning may differ depending on the plausibility of its literal interpretation. For example, it seems likely that the literal meaning of a high ambiguity idiom is activated during idiom comprehension, given the right hemisphere activation observed for high ambiguity idioms. Because the right hemisphere plays a key role in selecting between multiple potential meanings (Aron, 2004; Tompkins, 2001), this finding for high ambiguity idioms suggests that both the literal and figurative meanings are activated during comprehension. However, the lack of evidence for activation of low ambiguity idioms in the right hemisphere suggests that the literal meaning is not activated during the comprehension of low ambiguity idioms. It is possible that a figurative phrase's literal meaning is activated depending on whether the literal meaning is plausible. Thus, the graded salience hypothesis may benefit from exploring how literal meanings of figurative texts are activated when the literal meaning is or is not a plausible candidate.

Future Studies

In the current set of studies, each experiment examined one of three factors in idiom processing (ambiguity, transparency, and familiarity), while controlling for the other two factors. However, idioms often vary in terms of all three of these factors (Titone & Connine, 1994a) and it is possible that

these factors may interact with each other when individuals comprehend idioms in a text. Future research may be needed to investigate how idioms vary on two or more of the dimensions explored in the current set of experiments. For example, participants could read idioms that are high in ambiguity and high in transparency, high in ambiguity but low in transparency, low in ambiguity but high in transparency, or low in ambiguity and low in transparency. It is possible that the left hemisphere would be dominant for processing idioms that are low in ambiguity but high in transparency, because a left hemisphere advantage was observed for both low ambiguity and high transparency idioms in the current study. However, it is unclear how the hemispheres would process idioms that are high in transparency but also high in ambiguity. If a left hemisphere advantage were observed for high transparency, high ambiguity idioms, this finding would suggest that transparency may be more influential than ambiguity in determining how the hemispheres process idioms. However, if the right hemisphere is dominant for processing high transparency, high ambiguity idioms, this finding would suggest that ambiguity may be more influential than transparency in determining how the hemispheres process idioms. Such an experiment would provide valuable information about how different levels of an idiom's ambiguity and transparency interact with each other during text comprehension.

Second, future studies could examine how the hemispheres process the figurative meanings of completely novel idioms. In Experiment 3, the left

hemisphere played a greater role than the right hemisphere when readers processed both familiar and less familiar idioms. However, it is possible that the right hemisphere may be dominant when readers comprehend idioms that have not been previously encountered. Evidence for a possible right hemisphere advantage when readers process novel idioms comes from several studies which have found a right hemisphere advantage when readers comprehend novel metaphors as opposed to well-known metaphors (Faust & Mashal, 2007; Pobric et al, 2008). Thus, future studies may observe a right hemisphere advantage when readers comprehend novel idioms during text comprehension.

Conclusion

In summary, the current set of experiments demonstrates how the hemispheres process idioms that differ in terms of ambiguity, transparency, or familiarity. In Experiment 1, the left hemisphere was dominant for processing low ambiguity idioms, and the right hemisphere was dominant for processing high ambiguity idioms. In Experiment 2, the left hemisphere was dominant for processing high transparency idioms, and no hemispheric differences were observed for processing low transparency idioms. In Experiment 3, the left hemisphere was dominant for processing both familiar and less familiar idioms. Thus, an idiom's level of ambiguity or transparency (but not familiarity) seems to influence how idioms are processed in the cerebral hemispheres. Further, these results suggest that low ambiguity or high transparency idioms may be more closely associated with their figurative

meanings than their literal meanings, given that the left hemisphere has an advantage for processing close semantic relations (Beeman et al., 1994). Conversely, high ambiguity idioms may be less closely associated with their figurative meanings, and may require reinterpretation to be understood figuratively, given the right hemisphere's advantage for linguistic reinterpretation (Giora, 2003). Thus, low ambiguity idioms and high transparency idioms may be comprehended by directly accessing the idiom's figurative meaning, whereas high ambiguity idioms may be comprehended by analyzing both the literal and figurative meaning, and selecting the appropriate interpretation.

CHAPTER V

SUMMARY

Idioms are verb phrases that must be interpreted figuratively, such as "to bury the hatchet" (Gibbs, 1999). Recent findings suggest that the right hemisphere may have an advantage when readers comprehend language that must be understood figuratively (McDonald, 2000). However, it is currently unclear how idioms are processed in the right and left hemispheres. It is possible that not all idioms are processed similarly in the hemispheres, and that several factors between idioms may affect hemispheric processing. First, the plausibility of an idiom's literal interpretation (i.e., ambiguity) may influence processing in the hemispheres. For example, some idioms have plausible literal interpretations (such as to "break the ice") and are classified as high ambiguity idioms, whereas other idioms do not have literal interpretations (such as "to feel under the weather") and are classified as low ambiguity idioms (Titone & Connine, 1999). Second, the extent to which an idiom's literal meaning contributes to its figurative meaning (i.e., transparency) may influence hemispheric processing during idiom comprehension. For example, "to blaze a trail" is high in transparency, because "trail" relates to "blaze a trail's" figurative meaning ("to lead the way"). However, "to kick the bucket" is low in transparency, because no word in "to kick the bucket" relates to the figurative meaning ("to die") (Titone & Connine, 1999). Third, of the level of familiarity of an idiom may influence the hemispheric processing of idioms. For example, some idioms are

encountered more frequently and are more easily recognizable than other idioms (Titone & Connine, 1999). Thus, the current set of experiments investigated how idioms that differ in the level of ambiguity, transparency, or familiarity are processed in the left and right cerebral hemispheres during text comprehension.

To investigate how idioms are processed in the cerebral hemispheres, the current study used a divided visual field paradigm to investigate how participants respond to idiom-related targets words presented to either visual field-hemisphere. In Experiment 1, participants read texts containing high ambiguity idioms, low ambiguity idioms, or texts with no idioms. Next participants made lexical decisions to related target words presented to the left visual field-right hemisphere or the right visual field-left hemisphere. In Experiment 2, participants read texts containing high transparency idioms, low transparency idioms, or texts with no idioms. In Experiment 3, participants read texts containing familiar idioms, less familiar idioms, or texts with no idioms.

Findings from the current study showed evidence that the right and left hemispheres process idioms that differ in their levels of ambiguity or transparency differently, but no hemispheric differences were found between familiar and less familiar idioms. Greater facilitation was found for low ambiguity idioms in the left hemisphere than in the right hemisphere, but greater facilitation was found for high ambiguity idioms in the right hemisphere than in the left hemisphere. Facilitation was greater for high

transparency idioms in the left hemisphere than the right hemisphere, but no hemispheric differences were evident for low transparency idioms. Finally, greater facilitation was evident in the left hemisphere for both familiar and less familiar idioms compared to the right hemisphere. These findings suggest that the left hemisphere may be dominant when readers process low ambiguity idioms, high transparency idioms, familiar idioms, and less familiar idioms, whereas the right hemisphere may be dominant when readers process high ambiguity idioms. Specifically, the figurative meaning of high transparency idioms and low ambiguity idioms seems to be easily accessible and highly related to the idiom's figurative meaning, because the left hemisphere has an advantage for accessible, highly related meanings (Beeman et al., 1994). In contrast, the figurative meaning of high ambiguity idioms may be less accessible than the figurative meaning of low ambiguity idioms, because the right hemisphere has an advantage when readers need to select one of several potential meanings (Giora, 2003; Tompkins, 2001).

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Appendix: Materials

EXPERIMENTAL ITEMS

Experiment 1: Idiom Ambiguity Items

Low Ambiguity Condition

1. Pam told her assistant that she would have to let him go.

Idiom: She didn't make any bones about it.

Neutral: She told him she was sorry about it.

Target: direct

2. Martin had come home early from work.

Idiom: He'd been feeling under the weather.

Neutral: He'd been wanting to watch the ball game.

Target: sick

3. Jim worked hard on the new report.

Idiom: But his coworker Bill stole Jim's thunder.

Neutral: His coworker Bill has been at lunch.

Target: credit

4. Jane told Jim she was moving to Seattle.

Idiom: She told him about her decision right out of the blue.

Neutral: She told him about her decision right after dinner.

Target: surprise

5. John came home from the grocery store.

Idiom: At the store, he'd paid through the nose.

Neutral: At the store, he'd paid with loose change.

Target: expensive

6. Alistair was caught cheating on a test.

Idiom: He knew he had to face the music.

Neutral: He knew he could avoid punishment.

Target: accept

7. Butch and Pam had been talking the whole evening.

Idiom: By the end of the night, he was on cloud nine.

Neutral: By the end of the night, he wished he hadn't.

Target: happy

8. Terrence and Jane had been dating each other.

Idiom: Finally, Terrence popped the question.

Neutral: Finally, Terrence wanted to leave.

Target: propose

9. Erica had a disastrous first date with a fellow student.

Idiom: She felt like she had lost face.

Neutral: She felt like he talked too much.

Target: embarrassed

10. Richard was looking at the sales figures.

Idiom: He came up with a solution, but only after racking his brains.

Neutral: He came up with a solution in a very short amount of time.

Target: effort

11. Pam had seen Jenny walking in the park.

Idiom: When Jenny saw Pam, they stopped and shot the breeze.

Neutral: When Jenny saw Pam, she tried to ignore her.

Target: talk

12. Jack was filing for taxes, but forgot how much he spent per week on donations.

Idiom: So he used a rule of thumb.

Neutral: So he looked for his receipts.

Target: estimate

13. Miriam showed her husband her new dress.

Idiom: He thought the dress was the cat's meow.

Neutral: He thought the dress was much too gaudy.

Target: cool

14. Wade was telling Samantha about his life philosophy.

Idiom: Samantha said Wade blew her mind.

Neutral: Samantha said Wade was very wrong.

Target: amaze

15. Valerie accidentally broke her dad's coffee mug.

Idiom: When he came home, he blew his top.

Neutral: When he came home, he understood.

Target: angry

16. Preston accused Billy of stealing five dollars.

Idiom: Later, Preston had to eat his words.

Neutral: Later, Preston had to do some shopping.

Target: wrong

17. Billy cheered loudly at the baseball game.

Idiom: He woke up the next morning with a frog in his throat.

Neutral: He woke up the next morning and went to his job.

Target: sore

18. Eli paid much more than he expected for his new car.

Idiom: The salesman really drove a hard bargain.

Neutral: The salesman helped him as much as he could.

Target: demanding

19. Jacob looked frustrated about his performance at the race.

Idiom: His friend Ethan decided to lend him an ear.

Neutral: His friend Ethan decided to not go near him.

Target: attention

20.Arnold had insulted his friend Tina.

Idiom: He went to her house to swallow his pride.

Neutral: He had decided he didn't like her.

Target: sorry

21.Joshua's girlfriend told him she wanted kids, and he agreed with her.

Idiom: But in reality, he was just paying lip service.

Neutral: But in reality, he wanted them more than she did.

Target: fake

22. Matt saw a picture of his friend Doug's father.

Idiom: Matt said to Doug, "Wow, you're his spitting image!"

Neutral: Matt said to Doug, "Wow, this picture is old!"

Target: identical

23. The scientist had been mixing chemicals in the lab all day.

Idiom: That evening, the lab was blown to kingdom come.

Neutral: That evening, he went home satisfied with his work.

Target: destroy

24. Maria saw her ex boyfriend Carlos at a friend's birthday party.

Idiom: While she was there, she gave him the cold shoulder.

Neutral: While she was there, she gave him her phone number.

Target: ignore

High Ambiguity Condition

25. Tyler had been working hard all day.

Idiom: When he went home, he immediately hit the sack.

Neutral: When he went home, he immediately got a beer.

Target: sleep

26. Anthony's friends were all excited about the election.

Idiom: Anthony was still on the fence.

Neutral: Anthony had already voted.

Target: undecided

27. Ashley went to a party where she didn't know anybody.

Idiom: So she decided to break the ice.

Neutral: So she decided to read a book.

Target: socialize

28. Andrew was about to go on a date with a girl he'd met at the bar.

Idiom: His roommate told him he was playing with fire.

Neutral: His roommate told him he thought she was very nice.

Target: dangerous

29. Sally's boss seemed reluctant to give her a raise.

Idiom: So she took the bull by the horns.

Neutral: So she went out to have a drink.

Target: determined

30. The robber knew the police were chasing him.

Idiom: But he knew how to cover his tracks.

Neutral: But he decided to surrender.

Target: escape

31. Henry had told his friend Noah a secret.

Idiom: That night at a party, Noah let the cat out of the bag.

Neutral: That night at a party, Noah only talked about sports.

Target: gossip

32. Alice made a joke about her sister.

Idiom: Their friends agreed that Alice's remark had been below the belt.

Neutral: Their friends agreed that Alice's remark had been justified.

Target: mean

33. Max did not want to go fishing with his dad.

Idiom: But his father continued twisting Adam's arm.

Neutral: But his father convinced Adam it would be fun.

Target: force

34. Logan had sworn he didn't like Stacy.

Idiom: Soon he was dancing to a different tune.

Neutral: Soon he was going to see a movie.

Target: dating

35. Kristen and her daughter Kim had been arguing for months.

Idiom: They decided to bury the hatchet.

Neutral: They decided it was best for Kim to leave.

Target: truce

36. Frank had forgotten Jen's birthday, so he bought her a puppy.

Idiom: Jen hated dogs, so it added fuel to the fire.

Neutral: Jen hated dogs, but she appreciated the thought.

Target: worse

37. Nathan rushed to the store to a bouquet of roses.

Idiom: When he got there, the clerk told him he'd missed the boat.

Neutral: When he got there, the clerk told him he had plenty left.

Target: late

38. Vic would marry his girlfriend in a week.

Idiom: He had been starting to have cold feet.

Neutral: He was having dinner with his friends.

Target: nervous

39. Skip didn’t want to tell people about his new job yet.

Idiom: But at the party, he spilled the beans.

Neutral: At the party, he didn't tell anyone.

Target: reveal

40. Frank and Lisa had been dating for three years.

Idiom: Finally, they decided to tie the knot.

Neutral: Finally, they decided to separate.

Target: marry

41. Albert asked his sister how her softball game had gone.

Idiom: She told him it had been a piece of cake.

Neutral: She told him it had been extremely close.

Target: easy

42. Lily was about to take the biology exam.

Idiom: She soon knew she was in hot water.

Neutral: She soon knew it would be easy.

Target: trouble

43. Max was driving down the road.

Idiom: He hit a sharp curve and kicked the bucket.

Neutral: He hit a sharp curve and came to a stop.

Target: die

44. Hank's family had come to his party.

Idiom: They told him he was over the hill.

Neutral: They told him he was a great person.

Target: aged

45. Ralph told his friend that he made his own decisions.

Idiom: But his friends knew his wife really wore the pants.

Neutral: But his friends knew his wife made her own, too.

Target: dominate

46. Sam and Dave had been working on a difficult project.

Idiom: Eventually, they pulled the plug on it.

Neutral: Eventually, they went to get some lunch.

Target: end

47. Caleb was playing poker with his friends.

Idiom: His friend said he was on thin ice.

Neutral: His friend said he was a good player.

Target: risky

48. Isaac seemed exhausted at the end of a long day on the job.

Idiom: A co-worker told him that this was just the tip of the iceberg.

Neutral: A co-worker told him that this was an unusually hard day.

Target: beginning

Experiment 2: Idiom Transparency Items

Low Transparency Condition

1. John asked Jake how he knew the woman from the post office.

Idiom: Jake said that they'd once had a fling.

Neutral: Jake said that they went to the same church.

Target: dating

2. Sally was sitting next to a stranger on the bus.

Idiom: So she decided to break the ice.

Neutral: So she decided to read a book.

Target: social

3. Dave wanted have some fun after work.

Idiom: He went home and hit the sauce.

Neutral: He went home and went to sleep.

Target: drink

4. Sally's boss seemed reluctant to give her a raise.

Idiom: Sally decided it was time to take the bull by the horns.

Neutral: Sally decided that she'd better wait until tomorrow.

Target: determined

5. Pam told her assistant that she would have to let him go.

Idiom: She didn't make any bones about it.

Neutral: She told him there were insufficient funds.

Target: direct

6. Alan saw his classmate Vince at the store.

Idiom: Alan got his attention, and they spent some time chewing the fat.

Neutral: Alan tried his best to make sure that Vince didn't notice him.

Target: friendly

7. Shaun told Karen that his brother wasn't very smart.

Idiom: Karen said Shaun just had an axe to grind.

Neutral: Karen said Shaun was very perceptive.

Target: jealous

8. Jane told Jim that she was moving to Seattle.

Idiom: She told him about her decision right out of the blue.

Neutral: She told him about her decision right after dinner.

Target: surprise

9. Frances told her boyfriend that she was pregnant.

Idiom: He thought she was pulling his leg.

Neutral: He thought they were ready for children.

Target: joke

10. Ty and Brooke had been best friends for years.

Idiom: Ty secretly carried a torch for her.

Neutral: Ty secretly thought she was slightly weird.

Target: love

11. Jim came home early from work.

Idiom: He'd been feeling under the weather.

Neutral: He'd been wanting to watch the ball game.

Target: sick

12. Max was driving very fast down the road.

Idiom: He hit a sharp curve and kicked the bucket.

Neutral: He hit a sharp curve and skidded to a stop.

Target: die

13. Pam saw Jenny walking in the park.

Idiom: When Jenny saw Pam, they stopped and shot the breeze.

Neutral: When Jenny saw Pam, she tried to ignore her.

Target: talk

14. Kenny had missed an important deadline.

Idiom: His supervisor raked him over the coals.

Neutral: His supervisor didn't seem to notice.

Target: yell

15. Alice turned around and saw Johnny.

Idiom: He had appeared out of thin air.

Neutral: He had bought her a sandwich.

Target: sudden

16. Yolanda did not want to come in early for work.

Idiom: But she knew she had to bite the bullet.

Neutral: So she called work and told them she was sick.

Target: endure

17. Peter was at the music store because he wanted some new CDs.

Idiom: He looked at one shelf and realized he'd hit the jackpot.

Neutral: He looked at his watch and realized that he was late.

Target: find

18. Frank had been fired from his job.

Idiom: He'd made a pass at his secretary.

Neutral: He'd stolen a lot of office supplies.

Target: flirt

19. At the casino, Billy bet his money on black.

Idiom: When the wheel stopped turning, he knew his goose was cooked.

Neutral: When the wheel stopped turning, he smiled and took his money.

Target: lost

20. Sally completed her assignment early.

Idiom: Her professor had put the screws on her.

Neutral: Her professor said it was a great job.

Target: pressure

21. Butch was about to go on a date with Jane.

Idiom: By the end of the evening, he was on cloud nine.

Neutral: By the end of the evening, he wished he hadn't.

Target: happy

22. There were many interesting projects at the science fair.

Idiom: But Dylan’s presentation took the cake.

Neutral: But Dylan's project was disqualified.

Target: win

23. The sheriff saw the bank robber running down the alley.

Idiom: He made the robber bite the dust.

Neutral: But he was too fat to run fast.

Target: killed

24. Lilian and Travis were visiting New York.

Idiom: They wanted to paint the town.

Neutral: They wanted to read some books.

Target: fun

High Transparency Condition

25 Sally had started managing a troubled company.

Idiom: But soon, she had greased the wheels.

Neutral: But soon, she had left the job.

Target: improve

26 The professor asked Beth what she thought of the test.

Idiom: He told her she should speak her mind.

Neutral: He hoped it wasn't too easy.

Target: honest

27. It had been a busy day at the office.

Idiom: But Carl had kept a level head.

Neutral: But Carl could not be found anywhere.

Target: calm

28. The police chief suspended the officer.

Idiom: The chief said the officer's actions had forced his hand.

Neutral: The chief said the officer would be paid during suspension.

Target: unwilling

29. The scientist had been mixing chemicals all day.

Idiom: That evening, the lab was blown to kingdom come.

Neutral: That evening, he went home satisfied with his work.

Target: destroy

30. Murray was a devoted father.

Idiom: But when his son didn’t clean his room, Murray lost his cool.

Neutral: But when his son didn't clean his room, Murray didn't notice.

Target: angry

31. Mary had been a professor for thirty years.

Idiom: She was afraid she was losing her touch.

Neutral: She was excited to teach online classes.

Target: worse

32. Andrew was about to go on a date with a girl he’d met at the bar.

Idiom: His roommate told Andrew he was playing with fire.

Neutral: His roommate told Andrew he thought she was very nice.

Target: dangerous

33. The robber knew the police were chasing him.

Idiom: But he knew how to cover his tracks.

Neutral: But he decided to surrender.

Target: hide

34. Rodney checked the brakes on his car.

Idiom: The brakes were fit as a fiddle.

Neutral: He needed to replace the pads.

Target: safe

35. Bill was afraid he'd lose his job.

Idiom: But he had an ace up his sleeve.

Neutral: But he got promoted instead.

Target: plan

36. Matt saw a picture of his friend Doug's father.

Idiom: Matt said to Doug, "Wow, you're his spitting image!"

Neutral: Matt said to Doug, "Wow, this picture is old!"

Target: alike

37. Kim didn't like watching movies with John.

Idiom: He would always talk a mile a minute.

Neutral: He would always buy disgusting candy.

Target: fast

38. Harrison loved working at the busy office.

Idiom: But it was starting to make him lose his grip.

Neutral: But he was looking forward to his vacation.

Target: crazy

39. Roscoe needed to make money quickly.

Idiom: So he started playing the market.

Neutral: So he stole from his job.

Target: invest

40. The young boy was very excited, and ran down the street.

Idiom: His mother told him to hold his horses.

Neutral: His mother told him to buy some sugar.

Target: wait

41. Nathan rushed to the flower shop to buy a bouquet of roses.

Idiom: When he got there, the clerk told him he'd missed the boat.

Neutral: When he got there, the clerk told him he had one more left.

Target: late

42. The commune tried to be democratic.

Idiom: But in reality Billy called all the shots.

Neutral: But in reality, they just ate lots of ice cream.

Target: boss

43. Everyone liked Tommy's performance in the play.

Idiom: But they agreed that Sybil had stolen the show.

Neutral: But they agreed that his voice could have been deeper.

Target: best

44. Hiram had been working at his company for twenty years.

Idiom: He decided this year he would cash in his chips.

Neutral: He loved his career more than anything else.

Target: retire

45. The reporter had written a great story.

Idiom: But another paper had beaten him to the punch.

Neutral: But his editor said nobody would like it.

Target: first

46. Beatrice had been talking to Jill at a party.

Idiom: Jill told her she should shut her trap.

Neutral: Jill told her that she thought Brad was cute.

Target: quiet

47. Mark had been elected chair of the party planning committee.

Idiom: He ruled with an iron fist.

Neutral: He bought some nice balloons.

Target: harsh

48. Daniel read the letter from the college.

Idiom: The letter sealed his fate.

Neutral: The letter had blue ink.

Target: decide

Experiment 3: Idiom Familiarity Items

Less Familiar Condition

1. Alistair was about to go out with a girl he'd met at the bar.

Idiom: His roommate told him he was playing with fire.

Neutral: His roommate told him he thought she was very nice.

Target: danger

2. Jim came home early from work.

Idiom: He'd been feeling under the weather.

Neutral: He'd been wanting to watch the ball game.

Target: sick

3.The young boy was very excited, and ran down the street.

Idiom: His mother told him to hold his horses.

Neutral: His mother told him to buy some sugar.

Target: wait

4. Victor would marry his girlfriend in a week.

Idiom: He was starting to have cold feet.

Neutral: He was having dinner with his friends.

Target: nervous

5. Maria saw her ex boyfriend at the party.

Idiom: She gave him the cold shoulder.

Neutral: She gave him her phone number.

Target: ignore

6. Karen told her son to clean up his messy room.

Idiom: She felt like she was wasting her breath.

Neutral: She felt like it needed a good sweeping.

Target: refuse

7. Brandon knew that Kelly had a crush on her boss.

Idiom: At the party, he ended up spilling the beans about it.

Neutral: At the party, he ended up spilling his drink on her.

Target: tell

8. Terrence and Jane had been dating for a couple of years.

Idiom: Finally, Terrence popped the question.

Neutral: Finally, Terrence wanted to leave.

Target: propose

9. Matt saw a picture of his friend Doug's father.

Idiom: Matt said to Doug, "Wow, you're his spitting image!"

Neutral: Matt said to Doug, "Wow, this picture is old!"

Target: alike

10. Jack filed for taxes, but forgot how much he'd spent on donations.

Idiom: So he used a rule of thumb.

Neutral: So he looked for his receipts.

Target: estimate

11. Margaret did not know what she should make for dinner.

Idiom: She decided to play it by ear.

Neutral: She decided to look at her cookbook.

Target: impulse

12. Jimmy was riding down the street on his bicycle.

Idiom: It had cost him an arm and a leg.

Neutral: It had a plastic water bottle.

Target: expensive

13. The people behind Tom in the theater wouldn't stop talking.

Idiom: So Tom turned around and laid down the law.

Neutral: So Tom got up and moved to a new seat.

Target: confront

14. Colin forgot to pick up the milk.

Idiom: When he got home, his mom bit his head off.

Neutral: When he got home, he drank some tea instead.

Target: yell

15. Jane told Jim she was moving to Seattle.

Idiom: She told him about her decision right out of the blue.

Neutral: She told him about her decision a long time ago.

Target: surprise

16. Al was working on a difficult math problem.

Idiom: But then he saw something that sent him back to square one.

Neutral: But then he saw the time and decided to eat something.

Target: error

17. Peter was at the music store because he wanted some new CDs.

Idiom: He looked at one shelf and realized he'd hit the jackpot.

Neutral: He looked at his watch and realized that he was late.

Target: find

18. Every time Simon asked Gina out, she had an excuse.

Idiom: It was hard for him to get the picture.

Neutral: It was hard for him to get to sleep.

Target: realize

19. John asked Jake how he knew the woman from the post office.

Idiom: Jake said that they'd once had a fling.

Neutral: Jake said that they went to the same church.

Target: date

20. The policeman listened to the robbery suspect's testimony.

Idiom: The policeman knew how to read between the lines.

Neutral: The policeman knew that he didn't have a case.

Target: hidden

21. The candidate said that he was committed to family values.

Idiom: Some people thought he was just paying lip service.

Neutral: Some people thought he was not such a great speaker.

Target: lying

22. Sally was sitting next to a stranger on the bus.

Idiom: So she decided to break the ice.

Neutral: So she decided to read a book.

Target: friendly

23. Wade told Sam about his life philosophy.

Idiom: Sam said Wade blew his mind.

Neutral: Sam said Wade was very wrong.

Target: amaze

24. Frances told her boyfriend that she was pregnant.

Idiom: He thought she was pulling his leg.

Neutral: He thought they were ready for children.

Target: joke

Familiar Condition

25.Chris had just started working at a new company.

Idiom: It took him a while to get his eye in.

Neutral: It took him a while to get to sleep at night.

Target: adjust

26. Rodney checked the brakes on his car.

Idiom: The brakes were fit as a fiddle.

Neutral: He needed to replace the pads.

Target: safe

27. Caroline had recently moved to Chicago.

Idiom: Soon, she had really feathered her nest.

Neutral: Within a few months, she had started to hate the Cubs.

Target: rich

28. Dave wanted have fun after work.

Idiom: He went home and hit the sauce.

Neutral: He went home and watched a movie.

Target: drinking

29. Phil gave his wife some advice about cooking.

Idiom: She told him to button his lip.

Neutral: She told him thanks for the advice.

Target: quiet

30. Brenda and Eddie were going through a divorce.

Idiom: She was taking him to the cleaners.

Neutral: She was taking a trip to see her mom.

Target: money

31. Jake saw Mary, and asked how she was doing.

Idiom: She said everything was coming up roses.

Neutral: She said she was shopping for a heater.

Target: perfect

32. Paul changed the channel to check the football game.

Idiom: Once he saw the score, he beat his breast.

Neutral: Once he saw the score, he got a beer.

Target: excite

33. Bill had a meeting with his manager.

Idiom: He had to handle the manager with kid gloves.

Neutral: He had to make sure that he wore his best suit.

Target: gentle

34. Anthony had been listening to a physics lecture.

Idiom: Near the end, he lost the thread.

Neutral: Near the end, he lost his pencil.

Target: boring

35. Nate listened carefully to the election results.

Idiom: The whole time, he was sitting on thorns.

Neutral: The whole time, he was sitting on the couch.

Target: anxious

36. Sally had started managing a troubled company.

Idiom: But soon, she had greased the wheels.

Neutral: But soon, she had left the job.

Target: improve

37. Allison had no intention of getting married.

Idiom: Her boyfriend Frank had to put the screws on her.

Neutral: Her boyfriend Frank had no intention to, either.

Target: pressure

38. Ty and Brooke had been best friends for years.

Idiom: Ty secretly carried a torch for her.

Neutral: Ty secretly thought she was slightly weird.

Target: love

39. Alan saw his classmate Vince at the store.

Idiom: Alan got his attention, and they spent some time chewing the fat.

Neutral: Alan tried his best to make sure that Vince didn't notice him.

Target: talking

40. Pete was reading a new novel.

Idiom: He got a section that made him bust a gut.

Neutral: He got to a section that made him feel very sleepy.

Target: funny

41. Julie had a great idea for how to save her company some money.

Idiom: But the boss didn't want to upset the apple cart.

Neutral: But the boss wasn't back from his vacation yet.

Target: change

42. Roscoe started volunteering at the hospital.

Idiom: Three months later, the hospital gave him the sack.

Neutral: Three months later, the hospital gave him a plaque.

Target: fired

43. Shaun told Karen that his brother wasn't very smart.

Idiom: Karen said Shaun just had an axe to grind.

Neutral: Karen said Shaun was very perceptive.

Target: jealous

44. Laura tried to convince her husband that they needed a dog.

Idiom: She soon realized that she was going up a blind alley.

Neutral: She soon realized that he wanted a chocolate Labrador.

Target: useless

45. Pablo told his friend Jimmy that real men drive pickup trucks.

Idiom: Jimmy drove a car, so he rose to the bait.

Neutral: Jimmy drove a car, but he wasn't listening.

Target: react

46. Byron's girlfriend said something about one of their friends.

Idiom: The remark really got his goat.

Neutral: The remark made him laugh loudly.

Target: annoying

47. Ronnie was setting up Christmas decorations.

Idiom: He had gone the whole hog.

Neutral: He had used all-white lights.

Target: excess

48. The children went to visit their grandmother.

Idiom: They sat on the floor while she spun a yarn.

Neutral: They sat on the floor while she baked cookies.

Target: story

FILLER ITEMS

49. Rocco enjoys studying history.

Next semester he plans on traveling to Europe.

Target: rongt

50. Detective McNulty was on a stakeout.

He wanted to get to the bottom of the case.

Target: crese

51. Charles wanted to go to the ice cream shop.

He was craving something sweet and cold.

Target: talret

52. Josh was playing soccer in the street.

When a car would come by, he had to move back to the sidewalk.

Target: moosemit

53. Maddie bought a new lunch box for school.

All of her friends were jealous of it.

Target: gearcoune

54. Kaitlyn went to Paris for a class trip.

When she returned she was very tired.

Target: visenetex

55. Anne plays the violin often.

She takes lessons on Saturday mornings.

Target: druwpa

56. Sarah went grocery shopping.

She had many items to buy this week.

Target: codunemta

57. Perry loved his Apple computer.

It was the best thing since sliced bread.

Target: thomu

58. Peggy loved bulldogs.

When she got older, she bought one for herself.

Target: teurrn

59. Jerry likes drinking soda pop with his lunch.

Unfortunately his doctor thinks he should stop this habit.

Target: darp

60. Lizzie wanted to go to Spain.

She asked her father if he would pay for a plane ticket.

Target: peka

61. Billy had to give a history presentation.

But instead he ditched class.

Target: yeka

62. Belinda was afraid that she was going to be fired.

Her sister said that she was making a mountain out of a molehill.

Target: thedar

63. Maximilian went to the business retreat.

He spent the whole time schmoozing.

Target: ullacatec

64. Cait likes to sew her own clothing.

When she makes an outfit, she knows no one else will have it.

Target: raeng

65. James wanted to go see a new movie at the theatre.

While he was there he bought some popcorn.

Target: bodony

66. Jeremy is a painter.

He uses watercolors and oil paints.

Target: leddimim

67. Nobody would take responsibility for the problem.

But the chief said that the buck stops here.

Target: retob

68. Jason played baseball last night.

During the game, he had to be careful not to hurt his shoulder.

Target: drothi

69. Daniel is learning to drive.

His mother makes him very nervous when she teaches him.

Target: sylte

70. Megan got a new internship last month.

She really enjoys her new co-workers.

Target: slos

71. Tim went to a birthday party last weekend.

He had a lot of fun with his friends.

Target: lepicprin

72. Justin is tired of school and studying.

He cannot wait for summer to come.

Target: thinre

73. Janice bought a new dog last month.

When she takes her dog for walks, he always chases squirrels.

Target: foverig

74.JoAnne didn't feel like going to work today.

She was exhausted from the party last night.

Target: wiev

75. Max enjoyed the book he read for his class.

He decided to buy a copy to keep.

Target: luateave

76. Elise's favorite singer was Nick Cave.

She knew his lyrics backward and forward.

Target: konerck

77. Samuel baked a cake for his mother's birthday.

Her favorite was chocolate, so that's what he made.

Target: duons

78. Lawrence bought a new outfit for the family party this weekend.

He wanted to impress his father.

Target: zielaer

79. Ryan likes to play rugby.

Unfortunately, he usually injures himself.

Target: paerd

80. Claire is going to have a baby.

She is frantically getting the nursery ready by painting the walls.

Target: kalcs

81. Marie decided to start a new exercise program.

She was eager to become a healthier person.

Target: neeq

82. Phil had been studying all night for his final exam.

When he got there, he realized it was much easier than he expected.

Target: tudy

83. Meghan always looked uncomfortable when Tosh was around.

He rubbed her the wrong way.

Target: raeyl

84. Jillian rarely does her homework.

Her teacher often gets angry with her.

Target: ferrepeen

85. Dana is very sick.

Her family thinks she needs to go to the hospital.

Target: tisucej

86. Phil had been studying all night for his final exam.

When he got there, he realized it was much easier than he expected.

Target: cet

87. John moved into a new apartment last night.

He felt relieved when all of the boxes were put away.

Target: velelu

88. Sarah moved into a new apartment with her boyfriend.

Last weekend they had a house warming party.

Target: tisnucommy

89. Jon wanted to take a class in Spanish.

Later he realized how difficult this was.

Target: diputsa

90. Laura bought a new cat yesterday.

She named him Ozzie.

Target: porrecude

91. Silas had forgotten to attend an important meeting.

He'd simply lost track of time.

Target: delap

92. Marge wanted to go to the library to get homework done.

When she got there she realized it was too crowded.

Target: tounaram

93. Ted got accepted into graduate school.

He was eager to become a veterinarian.

Target: yal

94. Jacob was driving to work.

He got into a fender bender.

Target: deurteaf

95. Marty went to have a drink with his friends.

By the end of the night he was three sheets to the wind.

Target: fusrefi

96. Anne plays the violin often.

She takes lessons on Saturday mornings.

Target: lerev