Creativity in Language

In the comedy film *Office Space*, a depressed software technician named Peter shambles into his place of work and is greeted with the phrase, “Looks like someone has a case of the Mondays.” Although readily understood by native speakers, creative language such as this has received scant attention from researchers in the cognitive neuroscience of language. Under the assumption that the essential feature of language is its compositionality (e.g., Dowty, Wall, & Peters, 1981), linguists have attempted to explain how the meanings of sentences can be derived from their syntactic structure and the meanings of their constituent words. Accordingly, researchers in psychology and neuropsychology have targeted knowledge of grammar and of word meaning, investigating their development in children, their breakdown in brain damage, and the way they operate in healthy adults.

However, there are a number of reasons for researchers in cognitive neuroscience to shift their focus from the most straightforward cases of literal meaning to more creative instances of language use such as the one cited above. First, while many people think of creative language as being confined to artistic venues, it is in fact far more common than many people realize (Gibbs, Wilson, & Bryant, in press). Second, the diversity of creative language highlights the range of different cognitive processes people bring to bear on language production and comprehension. Finally, the study of figurative language has led to an important locus of generativity in language, namely the human ability to interpret linguistic expressions in light of real-world knowledge and contextual factors (Coulson, 2001).
The line of dialogue above highlights not only Peter’s melancholy, but also two constructs from cognitive linguistics that help account both for creative uses of language, and for more straightforward instances of literal meaning (Fauconnier & Turner, 2002). The first such construct is frames, hierarchically structured representations of background knowledge activated by elements in a discourse (Fillmore, 1976). For example, this snippet of movie dialogue calls upon at least two frames. The phrase “a case of” activates a frame concerned with sickness and ailments. The mention of “Monday” activates cultural knowledge about the seven-day week and Monday’s importance as the first obligatory day of work. In fact, without background knowledge about the work week, the statement is not readily interpretable. For example, an Israeli whose work week begins on Sunday might find the statement anomalous, in spite of knowing where Monday falls in the sequence of days.

In order to reach the desired interpretation, a second theoretical device is needed, namely an ability to activate mappings, or correspondences, between the appropriate elements in each of these conceptual domains. Features of the work-week frame pertaining to Monday are mapped onto features of the sickness frame that have compatible conceptual structure. Thus an illness, which is frequently unpleasant and beyond one’s control, can be readily identified with Monday. In the integrated interpretation, Monday is the very ailment from which Peter suffers.

This chapter focuses on two well-defined examples of creative language that utilize frames and mappings: jokes and metaphors. We begin each section with a review of cognitive neuroscience research used to test and develop models of the comprehension of these phenomena, and follow with a review of evidence for the importance of the right hemisphere (RH) in each. We conclude with some speculations about the potential relevance of such research to general issues relevant to meaning in language.

### Joke Comprehension

The study of joke comprehension addresses the importance of frames for language comprehension, since many jokes are funny because they invite the listener to use one frame to help interpret the information presented in the initial part of the joke, only to reveal frame-incompatible information at the punchline. For example, consider, “I let my accountant do my taxes because it saves time: last spring it saved me ten years.” Initially, the listener activates a busy-professional frame. However, at the punchline “saved me ten years” it becomes apparent that a crooked-businessman frame is more appropriate. While lexical reinterpretation is important, to truly appreciate this joke it is necessary to recruit background knowledge about the particular sorts of relationships that can obtain between business people and their accountants so that the initial busy-professional interpretation can be mapped into the crooked-businessman frame. The semantic and pragmatic reanalysis necessary to understand narrative jokes such as this is known as frame-shifting, and the
humor of a narrative joke is related in part to the contrast between the two frames (Coulson, 2001).

Patient studies of joke comprehension

Researchers in neuropsychology have long noted that joke comprehension is compromised in patients with RH lesions, especially when there is damage to the anterior portion of the frontal lobe (Brownell, Michel, Powelson, & Gardner, 1983; Shammi & Stuss, 1999). In one classic study, RH damaged (RHD) patients were given the set-up for a number of jokes and asked to pick the punchline from an array of three choices: straightforward endings, non sequitur endings, and the correct punchline. While age-matched controls had no trouble choosing the punchlines, RHD patients tended to choose the non sequitur endings, suggesting they understood that jokes involve a surprise ending, but were impaired on the frame-shifting process required to re-establish coherence.

Remarkably, the performance of RHD patients on joke comprehension tasks is slightly worse than that of left hemisphere damaged (LHD) patients whose communicative difficulties are seemingly more severe. To compare these groups, Bihrle and colleagues used nonverbal materials (cartoons) that required frame-shifting. Patients were shown the first 2 frames of the cartoon and asked to pick an ending that made it funny. On each trial, they were given two alternatives: the correct ending, and either a straightforward ending, a neutral non sequitur, or a humorous non sequitur. Though both patient groups were impaired on this task, the LHD patients were more likely to err by choosing straightforward endings, while RHD patients showed a consistent preference for non sequitur endings, especially the humorous non sequiturs, which tended to involve slapstick humor (Bihrle, Brownell & Gardner, 1986).

The latter finding suggests the deficits RHD patients experience in the comprehension and production of humor is not attributable to the emotional problems associated with some kinds of RHD, but rather from deficits in inferential processing. Moreover, subsequent research has demonstrated that RHD patients also have difficulty interpreting nonjoke materials that require semantic reanalysis (Brownell, Potter, Bihrle, & Gardner, 1986). Taken together, these observations indicate that the difficulty RHD patients experience understanding humorous materials is cognitive rather than emotional, and involves the inferential reanalysis in frame-shifting.

Cognitive electrophysiology of joke comprehension

The neurophysiology of joke comprehension has also been studied in healthy adults via the noninvasive recording of event-related brain potentials (ERPs). One virtue of this technique is that it allows the researcher to take advantage of reasonably
well-understood ERP components associated with processing different sorts of linguistic information, such as the link between the N400 and semantic integration processes (for further details, see Kutas, Kiang, and Sweeney, Volume 2, Chapter 26). The N400 component of the ERPs was first noted in experiments contrasting sentences that ended sensibly and predictably with others that ended with an incongruous word. Congruous words elicited a late positive wave, while incongruous endings elicited a negative wave beginning about 200 ms after word onset and peaking at 400 ms (Kutas & Hillyard, 1980). Subsequent experiments have demonstrated a strong inverse correlation with the predictability of the eliciting word within a given sentence context (DeLong, Urbach, & Kutas, 2005; Kutas, Lindamood, & Hillyard, 1984). In general, experimental manipulations that make semantic integration more difficult result in larger amplitude N400, while those that facilitate it reduce N400 amplitude (van Berkum, Hagoort, & Brown, 1999).

Given the impact of frame-shifting on language interpretation, one might expect the underlying processes to be reflected in the brain’s real-time response to jokes. Accordingly, Coulson and Kutas (2001) compared ERPs elicited by sentences that ended as jokes requiring frame-shifting with nonfunny “straight” endings consistent with the contextually evoked frame. Two types of jokes were tested, high constraint jokes such as (1) which elicited at least one response on a sentence completion task with a cloze probability of greater than 40%, and low constraint jokes such as (2) which elicited responses with cloze probabilities lower than 40%. Cloze probability is a measure of a word’s predictability in a sentence context obtained via a sentence completion task. For example, when given the sentence fragment in (1), 81% of participants produced the word “face”; thus, the cloze probability of “face” in this context is 81%. For both (1) and (2) the word in parentheses was the most popular response on the cloze task.

1. I asked the woman at the party if she remembered me from last year and she said she never forgets a (face 81%).
2. My husband took all the money we were saving to buy a new car and blew it all at the (casino 18%).

To control for the fact that joke endings are (by definition) unexpected, the straight controls were chosen so that they matched the joke endings for cloze probability, but were consistent with the frame evoked by context. For example, the straight ending for (1) was “name” (the joke ending was “dress”), while the straight ending for (2) was “tables” (the joke ending was “movies”). The cloze probability of all four ending types (high and low constraint joke and straight endings) was equal, and ranged from 0–5%.

Coulson and Kutas (2001) found that ERPs to joke endings differed in several respects from those to the straight endings, depending on contextual constraint as well as participants’ ability to get the jokes. In good joke comprehenders, high but not low constraint joke endings elicited a larger N400 than the straight endings, presumably because the activation of the relevant frame facilitated lexical
integration of the high constraint straight endings relative to the jokes. Similar effects may have been absent from the low constraint stimuli, because those sentences led to the activation of a diverse set of frames that were less likely to be consistent with the straight endings.

However, both sorts of jokes (high and low constraint) elicited a late positivity in the ERP (500–900 ms post-onset), as well as a slow sustained negativity 300–900 ms post-onset, evident over left frontal sites. The sustained negativity at left frontal sites has been suggested to reflect the manipulation of information in working memory (Coulson & Kutas, 2001; Coulson & Lovett, 2004). The late positivity is an ERP effect often associated with the activation of information in memory (i.e., retrieval), consistent with the suggestion that joke comprehension requires the activation of a novel frame.

In poor joke comprehenders, jokes elicited a negativity between 300 and 700 ms after the onset of the sentence final word. The absence of the late positivity and the left frontal negativity in the poor joke comprehenders’ ERPs suggests that these effects index cognitive operations important for actually getting the joke. The poor joke comprehenders apparently searched for a coherent interpretation of the joke endings, but because they were unable to retrieve the frame necessary to get the joke, they did not generate the ERP effects observed in good joke comprehenders.

These demonstrations of the brain’s relatively early sensitivity to discourse level manipulations are consistent with the dynamic inferencing mechanisms assumed in many frame-based models of comprehension. For example, based on computational considerations, Shastri (1999) proposed that frame-based inferences necessary for language comprehension occur in a time-frame on the order of hundreds of milliseconds, in keeping with the observation that joke comprehension modulates the ERPs 300 ms after the onset of a critical word (Coulson & Kutas, 2001; Coulson & Lovett, 2004). In such models, comprehension is achieved by binding elements of the discourse representation to frames in long-term memory (Coulson, 2001; Lange, 1989). Such models help explain how speakers are able to rapidly and routinely compute predictions, explanations, and speaker intentions (Shastri & Ajjanagadde, 1993; van Berkum, 2008).

Hemispheric asymmetry and joke comprehension

Studies reviewed above have revealed a number of laterally asymmetric ERP effects suggestive of hemispheric asymmetry in joke comprehension, but do not directly speak to RH involvement due to limitations on the spatial resolution of the EEG signal. However, studies in neurologically intact individuals using the hemi-field priming paradigm also suggest differences in the contribution of the two cerebral hemispheres for the comprehension of creative language use such as that in jokes. The priming part of the hemi-field priming paradigm refers to a core phenomenon in psycholinguistics, the finding that people respond faster and more accurately to
a word (e.g., “dog”) when it is preceded by a semantically related (or otherwise associated) word (e.g., “cat”), than if it has been preceded by an unrelated word (e.g., “umbrella”). The hemi-field part of hemi-field priming refers to the fact that in this paradigm stimuli are presented to either the left or the right visual hemi-field (LVF/RVF).

Because stimuli presented outside the center of gaze are initially processed only by the opposite hemisphere, hemi-field presentation is thought to shift the balance of word processing, thus allowing the experimenter to probe each hemisphere’s sensitivity to various semantic manipulations (Hellige, 1983; Zaidel, 1983). Although information presented in this way is rapidly transmitted to both hemispheres, the hemi-field technique is thought to reveal initial hemisphere-specific computations (Chiarello, 1991). Consequently, left visual field presentation is typically abbreviated as LVF/RH, while right visual field presentation is abbreviated RVF/LH.

Indeed, researchers who use the hemi-field priming paradigm report a number of results that suggest the two cerebral hemispheres differ in the way they establish the meaning of linguistic stimuli. Though these studies consistently find that RVF/LH presentation leads to shorter reaction times on priming tasks, presentation to the RVF/LH does not necessarily yield more robust priming effects, viz. the difference in reaction times between words preceded by lexical associates and words preceded by unrelated words (Chiarello, 1988). For example, though most single word priming studies using strongly associated words (such as “cat” and “dog”) report equivalent priming with RVF/LH and LVF/RH presentation, nonassociated category members such as “goat” and “dog” yield greater priming effects with LVF/RH presentation (Chiarello, Burgess, Richards, & Pollock, 1990).

These observations have led some theorists to speculate that hemispheric differences in semantic activation might explain the disparate effect of LHD and RHD on the comprehension of language. One suggestion is that semantic activations in the LH are more specific than those in the RH, described as “fine” versus “coarse” semantic coding (Beeman et al., 1994; Chiarello et al., 1990; see also Mirous & Beeman, Volume 1, Chapter 16). Words in the RH are represented by means of wide semantic fields, while words in the LH are represented via a narrow range of features relevant to the immediate discourse context. Although coarse RH semantic activations would predictably include contextually irrelevant information, diffuse RH activation might provide additional information that makes joke processing easier. Similarly, reduced access to these semantic activations in RHD patients could result in joke comprehension deficits.

One chief source of evidence for the coarse coding hypothesis comes from an experiment in which centrally presented trios of words served as “summation primes” for a weakly related lateralized target (Beeman et al., 1994). For example, “cry, foot, glass” served as summation primes for the target “cut,” and as direct primes for the target “laugh” which was semantically related to one of the prime words. Accuracies on a naming task indicated that, relative to unrelated items, both hemispheres benefited from both sorts of primes. However, there was an RVF/LH advantage for the direct primes and an LVF/RH advantage for summation primes. Beeman
and colleagues argue that these findings suggest the RH benefits from the summed activation of shared features within a set of semantic fields.

Coulson and Wu (2005), however, note that the features of “foot” and “glass” do not, in fact, intersect. They suggest that summation priming results because these elements can be linked in a cognitive model in which glass can be construed as an instrument that induces a change of state in a patient, such as a foot. Rather than the sheer breadth of activation, hemispheric differences might thus be related to the type of semantic activations in each hemisphere. For example, the RH may preferentially activate stored knowledge about typical situations when glass, feet, and crying might co-occur, while the LH is more sensitive to linguistic cues that overtly specify the same types of complex relations.

Coulson and Wu (2005) argue that such hemispheric differences reflect RH coding of thematic and relational information. RHD patients have greater difficulty than those with LHD at recalling the theme of stories they have read (Hough, 1990). Further, neuroimaging research with healthy adults also suggests the importance of RH temporal lobe activity in processing thematic information. In a story comprehension task using materials modeled after the classic Bransford and Johnson study (1972), St George and colleagues report greater RH temporal lobe activation when thematic information was not provided for ambiguous paragraphs than when thematic information was provided by the inclusion of titles for the paragraphs (St George, Kutas, Martinez, & Sereno, 1999).

**Hemispheric differences in semantic activation**

Hemispheric differences in semantic activation might explain why RHD is associated with a detrimental effect on the comprehension of narrative jokes that require frame-shifting. Like Beeman’s summation triads, jokes require the listener to access nonovertly encoded information to understand the connection between one’s initial interpretation and the construal implied by the joke’s punchline. For example, in the joke “The replacement player hit a home run with my girl,” the reader must reinterpret information about a baseball game by accessing background information about romance. **Understanding one-line jokes** Several hemi-field presentation studies in our laboratory have addressed whether hemispheric differences in semantic activation in healthy adults are relevant for joke comprehension. To do so, we used a variant of the hemi-field priming paradigm in which the measure of priming is the amplitude of the N400 component of the ERP. The use of an ERP measure of priming has a number of advantages over traditional behavioral measures, including the possibility of assessing the degree to which hemi-field presentation actually shifts the contribution of each hemisphere to stimulus processing. Further, whereas the response latencies in behavioral measures of priming are determined by a number of cognitive processes, including stimulus evaluation, response selection, and
response execution, ERPs provide an ongoing record of the brain response from the onset of the stimulus until the execution of a response. Finally, ERPs can provide measures of the stimulus evaluation process in the absence of an overt response.

To assess whether hemispheric differences in semantic activation affect the difficulty of joke comprehension, we recorded ERPs as healthy adults read laterally presented “punch-words” to one-line jokes (Coulson & Williams, 2005). As noted above, the critical word in a joke often elicits a larger N400 than a similarly unexpected “straight” ending for the same sentence: the N400 joke effect (Coulson & Kutas, 2001). We reasoned that if hemispheric differences in semantic activation are relevant for joke comprehension, lateral presentation of joke (“girl”) versus straight (“ball”) endings for sentences such as “A replacement player hit a home run with my” would result in different N400 joke effects as a function of visual field of presentation. In this sentence comprehension paradigm, the difficulty of joke comprehension is indexed by the size of the N400 joke effect with larger effects pointing to relatively more processing difficulty. In fact, N400 joke effects were smaller when the critical words were presented to the LVF/RH than the RVF/LH, suggesting joke comprehension was easier with LVF/RH presentation (Coulson & Williams, 2005).

In a similarly motivated study, we measured ERPs elicited by laterally presented probe words that were preceded either by a joke, or by a nonfunny control (Coulson & Wu, 2005). Since all jokes turned on the last word of the sentence, control sentences were formed by replacing the sentence final word with a “straight” ending. For example, to construct a control for the following joke “Everyone has so much fun diving from the tree into the swimming pool, we decided to put in a little water,” the word “water” was replaced by “platform”. Probes (such as “crazy”) were designed to be related to the meaning of the joke, but unrelated to the meaning of the straight control. In this sentence prime paradigm, the activation of information relevant to joke comprehension was signaled by differences in the size of the N400 elicited by related versus unrelated probes. The more active joke-related information was, the larger the N400 relatedness effect could be expected to be. Consistent with the hypothesis that the RH activates thematic and relational information important for joke comprehension, Coulson and Wu (2005) found larger N400 relatedness effects with LVF/RH presentation (see also Hull, Chen, Vaid, & Martinez, 2005, for comparable evidence using behavioral measures).

Understanding puns. It is, however, important not to construe jokes as a monolithic language phenomenon. The word play in puns, for example, is different from that in more semantically based jokes discussed above. While semantic jokes begin by suggesting one interpretation of the discourse situation only to replace it with another at the punchline, the point of puns is to promote multiple meanings. For example, in “Old programmers never die, they just lose their memory,” the word “memory” can refer either to a human ability or to an electronic device, and both meanings are contextually appropriate. Indeed, the humorous nature of a pun
derives from the listener’s ability to simultaneously maintain two, possibly conflicting, meanings for the same word or phrase. In contrast to jokes that rely on frame-shifting, puns might be expected to rely more on LH mechanisms for the activation of conventional meanings.

Coulson and Severens (2007) addressed hemispheric sensitivity to the different meanings of a pun using a sentence priming paradigm with puns and pun-related probe words. ERPs were recorded as healthy adults listened to puns and read probe words presented in either participants’ left or right visual hemi-fields. Probe words were either highly related to the pun that preceded them, moderately related to the pun that preceded them, or unrelated. For example, the highly related probe for “During branding cowboys have sore calves,” was “cow” and the moderately related probe was “leg”.

The activation of pun-related information was assessed by the presence of relatedness effects on the N400 component of the ERP and on positive waveforms that frequently follow the N400 such as the late positive complex (LPC). Results suggested that initially both meanings of a pun were equally active in the LH while only the highly related probes were active in the RH; by 500 ms after the offset of the pun, however, both meanings were available in both hemispheres (Coulson & Severens, 2007).

Studies with puns thus differ from research reviewed above that suggest a RH advantage in understanding the critical word in a joke (Coulson & Williams, 2005), and in the activation of joke-related information (Coulson & Wu, 2005). While pun-related information is eventually available to both hemispheres, the LH showed an initial advantage that may reflect the importance of this hemisphere (especially the left frontal lobe) in coding the association between a word’s phonological form and its conventional meaning. Consistent with this interpretation, a neuroimaging study that compared brain activity during the comprehension of semantic jokes with nonfunny controls revealed bilateral temporal lobe activations, while an analogous comparison using puns revealed left frontal activations (Goel & Dolan, 2001). Whereas the RH and LH temporal lobe activation presumably reflects memory processes necessary for the inferential demands of jokes, the LH frontal activations to puns were consistent with the need to retrieve word meanings.

Neural substrate of joke comprehension

The involvement of the RH in humorous materials that involve frame-shifting is supported by an fMRI study in which neurologically intact participants viewed pairs of funny and nonfunny cartoons (Bartolo, Benuzzi, Nocetti, Baraldi, & Nichelli, 2006). As in the linguistic stimuli employed by Coulson and colleagues, the funny cartoon pairs employed by Bartolo et al. achieved their humorous effect by creating an expectation and confounding it. A key feature of Bartolo et al.’s stimuli, however, was that the expectation being manipulated depended on the intentions of the
character depicted in the cartoon. Participants showed increased activation in right inferior frontal gyrus, as well as left middle and superior temporal gyri, while viewing the funny cartoon pairs.

Interestingly, the activations described by Bartolo et al. (2006) are markedly similar to those activated in a study of the attribution of intention (Brunet, Sarfati, Hardy-Baylé, & Decety, 2000). This result suggests that theory of mind may be crucial to understanding jokes, a connection also made by Winner, Brownell, Happé, Blum, and Pincus (1998) in a study of RHD patients’ ability to distinguish between lies and jokes. Winner et al (1998) designed stories such that in order to distinguish lies from jokes, participants had to attribute a second-order belief (i.e., a belief about someone else’s belief) to a character in the story. The RHD patients were significantly less adept at distinguishing lies from jokes than the neurologically intact controls. The difficulty RHD patients experienced distinguishing lies from jokes was thus argued to be derived from an inability to correctly attribute beliefs and intentions to others.

More generally, the recruitment of brain regions for understanding various sorts of creative language is best understood by relating these regions to the underlying cognitive processes. Because there are many different ways that linguistic utterances can diverge from literalness, we should expect to observe a similar diversity in networks of brain areas recruited to comprehend them. Just as the brain areas activated in the comprehension of literal language differ as a function of the degree to which visual imagery or emotions are evoked (Ferstl, Rinck, & Cramon, 2005; Just, Newman, Keller, McEleny, & Carpenter, 2003), so too should we expect the comprehension of various kinds of nonliteral language to differ as a function of the cognitive processes they engender. In the following section, we provide a selective review of the literature on the cognitive neuroscience of metaphoric language, a creative use of language that differs from that in jokes in a number of important ways.

**Metaphor**

Relative to other sorts of figurative language (e.g., sarcasm, jokes, and so forth), metaphor has received the vast majority of the attention of researchers in cognitive neuroscience (see, e.g., the special issue of *Brain and Language* devoted to the neural correlates of nonliteral language; Giora, 2007). A speaker uses a metaphor whenever she refers to one domain with vocabulary more generally associated with another. For example, in “I made some good arguments, but in the end he crushed me with statistics,” the speaker uses “crushed,” a verb of physical action, to discuss the outcome of a verbal argument. In contrast to the traditional view of metaphor as a departure from normal language use, cognitive linguists have argued that metaphor is a pervasive phenomenon in everyday language (Lakoff & Johnson, 1980; Lakoff & Turner, 1989; Turner, 1991), and often explains the way that word meanings change over time (Sweetser, 1990).
Electrophysiological studies

Much research on the neural basis of metaphor has been motivated by classical accounts of metaphor comprehension that posit a two-stage model in which literal processing is followed by metaphorical processing (Grice, 1975; Searle, 1979). Although this model has been undermined by behavioral data (see Gibbs, 1994; Glucksberg, 1998, for review), the idea of a qualitatively distinct mode of metaphor processing is supported by influential work in the patient literature, which suggested RHD is particularly detrimental to the comprehension of metaphors (Winner & Gardner, 1977). Because the two-stage model involves predictions about the time course of processing, a number of investigators have exploited the temporal resolution available in the ERP signal to test when metaphoric meanings become available (e.g., Pynte, Besson, Robichon, & Poli, 1996).

For example, Kazmerski, Blasko, and Dessalegn (2003) and colleagues used an ERP study of the metaphor interference effect (MIE) to demonstrate that metaphorical meanings are activated early in the processing stream. This effect is elicited when participants are asked to evaluate the literal truth of sentences which are either literally true, literally false, or metaphorically true (but literally false). The MIE refers to the increased response times to reject metaphorically true sentences such as “The divorce is a nightmare,” compared to literally false sentences such as “The divorce is a table” (Glucksberg, Gildea, & Bookin, 1982). Because the task demands that the participant attend only to the literal meaning of these sentences, the MIE is interpreted as reflecting the automatic activation of metaphoric meanings.

Kazmerski and colleagues observed an MIE in participants’ reaction times, as it took participants longer to respond “no” to the metaphorical sentences than their literal counterparts (Kazmerski et al., 2003). Interestingly, the MIE was only 11 ms in participants with low IQ (<100), but was 35 ms in participants with high IQ (>115). The ERP correlates of the MIE included a smaller N400 for the metaphorically true sentences than the literally false sentences, suggesting participants found metaphorical words easier to process than the anomalous endings, as well as a larger late positivity for the metaphors, perhaps reflecting the greater difficulty in responding “no” to these items. Moreover, these ERP effects were marked and robust in the high IQ group, but largely absent in the low IQ group whose behavioral MIE was also negligible.

Research to date thus suggests that, contrary to the standard model of metaphor comprehension, metaphoric meanings are available quite early in processing, affecting the ERPs beginning 250–300 ms after the onset of a metaphorical word (Kazmerski et al., 2003; Pynte et al., 1996). Decontextualized metaphors such as “Those fighters are lions,” elicit slightly larger N400s than plausible literal controls such as “Those animals are lions” (Pynte et al., 1996), suggesting they place more demands on semantic integration processes. However, metaphors elicit smaller N400s than implausible literal controls such as “The rumor is a lumberjack.”
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(Kazmerski et al., 2003), suggesting they are easier to process than incongruous sentence completions. This latter finding casts doubt on the suggestion that the enhanced N400 relative to plausible literal endings indexes their literal incongruity.

Coulson and van Petten (2002) have suggested that N400 amplitude to metaphors is driven by the complexity of mapping and blending operations involved in the comprehension of metaphors, but also in the comprehension of literal language. In our model, metaphor comprehension involves coordinating various conceptual domains in a blend, a hybrid model that consists of structure from multiple conceptual domains, and that often develops emergent structure of its own. Metaphor comprehension involves the temporary construction of simple cognitive models along with the establishment of mappings, or, systematic correspondences among objects and relationships represented in various models. Mappings are based on relationships such as identity, similarity, or analogy. Consequently, metaphoric meanings – that use analogy to link objects in different conceptual domains – do not fundamentally differ from meanings that employ other sorts of mappings.

For instance, understanding the metaphor in “All the nurses at the hospital say that surgeon is a butcher,” requires coordinating conceptual structure associated with surgery, butchery, and a blend of the two. To understand this metaphor, it is necessary to apprehend mappings between surgeon and butcher, patient and dead animal (e.g., cow), as well as scalpel and cleaver. However, it also involves construction of a blended model that integrates some information from each of the two domains. In this example, the blend inherits the goals of the surgeon, and the means and manner of the butcher. The inference that the surgeon is incompetent arises when these structures are integrated to create a hypothetical agent with both characteristics.

Similar conceptual operations are involved in understanding literal language. For example, understanding butcher in “During the war, that surgeon had to work as a butcher,” also requires the comprehender to establish mappings and integrate information about a surgeon’s training and skill with general information about butchers, and other aspects of the context (Coulson & Matlock, 2001). One might, for instance, infer that the surgeon in question was overqualified for his job, or that he was forced to work as a butcher in a labor camp. Differences in the comprehensibility of these butcher sentences, then, might be less a matter of their figurativity than the extent to which they require the comprehender to activate additional information to establish mappings and elaborate the blend.

To test these ideas, Coulson and van Petten (2002) compared ERPs elicited by words in three different contexts on a continuum from literal to figurative, as suggested by conceptual integration theory (Fauconnier & Turner, 1998). For the literal end of the continuum, they used sentences that prompted a literal reading of the last term, as in “He knows that whiskey is a strong intoxicant.” At the metaphoric end of the continuum, they used sentences such as “He knows that power is a strong intoxicant.” The literal mapping condition, hypothesized to
fall somewhere between the literal and the metaphorical uses, involved sentences such as, “He has used cough syrup as an intoxicant.” Literal mapping stimuli employed fully literal uses of words in ways that were hypothesized to include some of the same conceptual operations as in metaphor comprehension. These sentences described cases where one object was substituted for another, one object was mistaken for another, or one object was used to represent another – all contexts that require the comprehender to set up a mapping, that is, understand a correspondence, between the two objects in question and the domains in which they typically occur.

In the time window in which the N400 is observed (300–500 ms post-onset), ERPs in all three conditions were qualitatively similar, displaying similar wave shape and scalp topography, suggesting that processing was similar for all three sorts of contexts. Moreover, as predicted, N400 amplitude differed as a function of mapping complexity, with literals eliciting the least N400, literal mappings the next-most, and metaphors the most N400, suggesting a concomitant gradient of processing difficulty. The graded N400 difference argues against the literal/figurative dichotomy inherent in the standard model, and suggests processing difficulty associated with figurative language is related to the complexity of mapping and conceptual integration.

A similar result was obtained by Lai, Curran, and Menn (2009), who observed ERPs elicited by literal sentences (“Every soldier in the frontline was attacked”), metaphors employing conventional conceptual mappings (“Every point in my argument was attacked”), metaphors employing novel mappings (“Every second of our time was attacked”), and sentences employing anomalous, nonsensical mappings (“Every drop of rain was attacked”). They observed enlarged amplitudes early in the N400 window for all conditions except the literal. Later, beyond 440 ms post-stimulus, the novel metaphor and anomalous mapping conditions elicited continuing negativities while the literal and conventional metaphor conditions elicited more positive waveforms. Lai and colleagues interpreted the early N400 effect as evidence that both conventional and novel metaphors require real-time processing of conceptual mappings. The later effect was taken to show that the novel conceptual mapping required more time and/or processing resources, once again underscoring the importance of conceptual mapping complexity, rather than the literal/figurative distinction, per se.

Although the comprehension of metaphorical meanings poses a challenge that is greater than that associated with literal language of comparable syntactic complexity, there does not seem to be much evidence to support a view of metaphor comprehension as involving a qualitatively distinct processing mode. ERP studies of metaphor comprehension suggest metaphorical meanings are active during the same temporal interval as literal meanings (Kazmerski et al., 2003). As in the case of literal language, semantic integration difficulty of metaphoric language is largely a function of contextual support (Pynte et al., 1996), and may also be attributable to demands of conceptual mapping and blending operations (Coulson & van Petten, 2002; Lai et al., 2009).
Hemispheric asymmetry in metaphor comprehension

Results reviewed above thus suggest that qualitatively similar processing mechanisms underlie the comprehension of literal and metaphorical meanings. By contrast, the study of patients with brain damage has suggested that the LH is the province of literal language, while the RH is the preferred substrate of metaphorical meanings (e.g., Winner & Gardner, 1977). However, the early theory that the comprehension abilities of the RH were especially suited for metaphor was based on sparse data, and may have suffered from the assumption that all forms of “non-standard” language use – metaphor, jokes, sarcasm, and so forth – had the same neural bases. Indeed, the ability to understand figurative language is compromised not only by unilateral lesions in the RH, but also by lesions to the LH (Gagnon, Goulet, Giroux, & Joanette, 2003; Giora, 2000; Papagno, Tabossi, Colombo, & Zampetti, 2004; see also Cacciari & Papagno, Volume 1, Chapter 18), and by neurological conditions that compromise executive functions, such as Down’s syndrome (Papagno & Vallar, 2001), and Alzheimer’s disease (Papagno, 2001).

Similarly, whereas an early neuroimaging study of metaphor comprehension in neurologically intact adults revealed greater blood flow increase in the RH when participants read blocks of sentences containing metaphors than when they read literal control sentences (Bottini et al., 1994), more recent work has argued against the RH as the preferred substrate of metaphor comprehension (see Coulson, 2008, for a review; cf. Faust, Volume 1, Chapter 21). For example, an fMRI study in which task difficulty was well matched for literal and metaphorical sentences revealed additional LH activation for metaphors (Rapp, Leube, Erb, Grodd, & Kircher, 2004; see also Rapp, Volume 1, Chapter 20). Other studies in which investigators have made significant efforts to control for task difficulty have revealed LH activations in comparisons of literal versus metaphorical meanings (Lee & Dapretto, 2006; Rapp, Leube, Erb, Grodd, & Kircher, 2007). RH recruitment may thus depend on overall task difficulty, rather than the figurativity of the meanings (Coulson & van Petten, 2002).

In general, RH activation is associated with complex sentences and discourse level processing (Bookheimer, 2002; Kircher, Brammer, Andreu, Williams, & McGuire, 2001; St George et al., 1999; Rehak, Kaplan, & Gardner, 1992), suggesting that it is semantic complexity that triggers the recruitment of RH areas. Functional MRI studies of literal language comprehension indicate that when sentence comprehension places increased demands on lexical and syntactic processes, increased activation both in classic LH language areas and in their RH homologues is observed (Keller, Carpenter, & Just, 2001). Finally, a systematic review of frontal hemodynamic activity revealed that additional RH activation was observed as a wide variety of tasks became more difficult (Duncan & Owen, 2000).

The bulk of the evidence from the hemi-field priming paradigm also argues against the portrait of the RH as the preferred substrate of metaphor comprehension. An early report by Anaki and colleagues suggested that while metaphoric
meanings are initially activated in both hemispheres, they are only sustained in the RH (Anaki, Faust, & Kravets, 1998). However, subsequent attempts to replicate results reported by Anaki and colleagues have failed (Kacinik, 2003). Further, hemi-field priming studies using sentential stimuli have revealed priming for both literal and metaphorical meanings with presentation to both visual fields (Kacinik & Chiarello, 2007), and even shown more pronounced metaphor priming with presentation to the RVF/LH (Faust & Weisper, 2000).

Similarly, Coulson and van Petten (2007) recorded ERPs as participants read sentence contexts that promoted either a literal or a metaphorical meaning of the sentence-final word presented in either the RVF/LH or the LVF/RH. Although the hemi-field presentation paradigm had measurable effects both on participants’ behavior and their ERPs, it did not modulate the size of the N400 metaphoricity effect. These data suggest that both hemispheres are sensitive to the processing difficulty engendered by metaphorically used nouns in sentence contexts.

Results reviewed above are in keeping with the claim that the brain does not treat literal and metaphoric language as qualitatively distinct categories. Neural resources recruited for metaphor comprehension have been found to vary as a function of factors such as the novelty and complexity of the mapping that also impact the comprehension of literal language. Indeed, recent work in the hemi-field priming paradigm suggests both hemispheres have the capacity to comprehend metaphorical meanings. Given that metaphoric mapping is a basic mechanism of meaning extension, perhaps it is not surprising that both hemispheres are similarly sensitive to metaphoric meaning.

**Conclusion**

Language researchers have historically assumed that literal meanings were basic, and creative language phenomena such as metaphor involved fundamentally different processing mechanisms with a RH substrate. In an effort to concentrate on tractable problems, many researchers have focused on literal meanings, thereby avoiding the more difficult problem of figurative language. However, studies exploring the use of context in both literal and figurative language processing have pointed to common mechanisms which may underlie both. In brief, these proposed mechanisms include frames, the memory structures activated during language use (Fillmore, 1976), along with a means to activate correspondences between and within frames, permitting the conceptual mapping and integration that underlies much of linguistic creativity (Coulson, 2001).

The neural mechanisms supporting these abilities may be distributed unevenly between the two cerebral hemispheres. Specifically, human lesion studies have suggested important roles for RH in comprehending two kinds of creative language, jokes (Birhle et al., 1986; Brownell et al., 1983) and metaphors (Winner & Gardner, 1977). Electrophysiological and imaging data largely support this contention in the case of jokes, showing a RH advantage for joke processing (e.g., Bartolo
et al., 2006; Coulson & Wu, 2005). For metaphor, on the other hand, the data have argued against the hypothesized RH advantage (e.g., Rapp et al., 2004; Coulson & van Petten, 2007). Although both metaphors and jokes rely extensively on the activation and integration of background knowledge, jokes also require the suppression of some aspects of the initial interpretation and the reintegration of others. As such, the study of creative language provides a valuable window into the real-time activation of semantic knowledge and its use in language processing.

References


