Figurative Language:
"Meaning" is often more than just a sum of the parts

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Abstract

Although the field of natural language processing has made considerable strides in the automated processing of standard language, figurative (i.e., non-literal) language still causes great difficulty. Normally, when we understand human language we combine the meaning of individual words into larger units in a compositional manner. However, understanding figurative language often involves an interpretive adjustment to individual words. A complete model of language processing needs to account for the way normal word meanings can be profoundly altered by their combination. Although figurative language is common in naturally occurring language, we know of no previous quantitative analyses of this phenomenon. Furthermore, while certain types and tokens are used more frequently than others, it is unknown whether frequency of use interacts with processing load. This paper outlines our current research program exploring the functional and neural bases of figurative language through a combination of theoretical work, corpus analysis, and experimental techniques. Previous research seems to indicate that the cerebral hemispheres may process language in parallel, each with somewhat different priorities, ultimately competing to reach an appropriate interpretation. If this is indeed the case, an optimal architecture for automated language processing may need to include similar parallel-processing circuits.

1. Introduction

When we understand language we combine the meanings of individual words into larger units in a compositional manner. For example, understanding *John ate the apple* requires combining the determiner *the* with the noun *apple* to form the noun phrase *the apple*. This noun phrase is then combined with the verb *ate* to form a verb phrase *ate the apple*, and so on. However, the process of understanding words in combination often requires contextual adjustments of word meanings, a profound example of which is metaphor:

1. All the world's a stage, And all the men and women merely players.

Metaphorical language like this involves the resolution of an apparent semantic conflict. In (1), the "world" is much larger than any possible literal stage, but the aim is to ascribe attributes of the theater to the real world Understanding metaphorical predications like (1) requires a conceptual mapping of one domain onto another, allowing us to understand an abstract concept in terms of a simpler or more common one (Lakoff & Johnson 1980).

Other familiar types of interpretive adjustment include idioms, irony, sarcasm, jokes, and puns. A more subtle but perhaps equally common interpretive effect is LEXICAL COERCION. While (2-3) below appear to have the same meaning, experimental findings suggest that (3) requires significantly more cognitive effort to process than (2) (McElree et al. 2006; Traxler, Pickering, & McElree 2002; McElree et al. 2001):

2. The pastry chef **finished** the cake.
3. The pastry chef **baked** the cake.

Sentence (2) takes longer to process because the verb *finished* requires the interpreter to shift the meaning of the noun phrase *the cake* from that of an ENTITY to that of an ACTION (*the baking of the cake* — or possibly *the eating of the cake*). Coercion, therefore, refers to a combinatory affordance in which the meanings of isolated words or phrases are profoundly altered by their combination (Michaelis 2004; Jackendoff 1997; Pustejovsky 1995).

1.1 Figurative Language

Various umbrella terms including *non-literal language* have been used in the literature to capture the wide variety of context-triggered adjustments in word meanings. We prefer the term FIGURATIVE LANGUAGE, however, because the term *non-literal* implies a two-stage interpretation process, in which the hearer initially arrives at a patently false interpretation and then infers the speaker's intended meaning through a process like Gricean quality implicature (Speaks 2008). While such an account may be plausible for previously unseen metaphorical examples like (1), it seems unreasonable to assume that coercion examples like (2) have a “false” initial meaning.

Recent studies of human figurative language using neurophysiological methods has led to a potential paradox (Coulson & Severens 2007, Coulson & Van Petten 2007, Coulson & Wu 2005, Coulson & Williams 2005, Goel & Dolan 2001),. The recruitment of the cerebral left hemisphere advantage by language tasks is one of the best-established facts about the brain. However, much of the recent research seems to indicate that the right hemisphere plays a key role in figurative language processing, posing a significant challenge to the left-hemisphere model. Consequently, examining asymmetrical brain and cognitive functions may provide a unique opportunity for understanding the neural basis of complex cognition.

Figurative language has also been a focus in the field of cognitive linguistics, which has made great strides in relating the language faculty to general cognitive processes (Talmy 1988, Langacker 1990, Lakoff & Johnson 1998, Fauconnier & Turner 2003). Cognitive linguistics recognizes that word meaning is not “fixed” but is rather a function of perspective. In this view, the linguistic faculty is similar to general-purpose knowledge representation and perception, and compositionality can only be maintained if context is taken into consideration.

Although both neurophysiological studies and cognitive linguistics have contributed to the recognition that figurative language may be processed differently than literal language, neither approach has considered the importance of conventionalization. Clearly, not all instances of figurative language are the same — individual tokens vary widely with respect to their novelty. In some cases we resolve a semantic conflict by creating an innovative meaning (e.g., *The pastry chef **dressed up** the cake),* while in other cases the adjusted interpretation has become so conventionalized that we do not even recognize it as being figurative (e.g., *The pastry chef **finished** the cake)*. In short, the processing of figurative language may be strongly shaped by frequency (either type frequency, token frequency, or both), creating a tradeoff between prediction based on previous experience and online semantic-conflict resolution.

1.2 Figurative Language and Artificial Intelligence

Figurative language is challenging not only for linguistic theory but also for artificial intelligence (AI). Although the field of natural language processing (NLP) has made considerable advances in the automated processing of standard language, figurative language still causes great difficulty. Clearly, natural language is extremely fluid — old words are often used in new ways. Although people understand these novel usages quite readily, computers are not yet able to perform the kinds of semantic-conflict resolution that humans do effortlessly. Therefore, a complete model of language processing needs to first detect and then account for both metaphorical mappings and the combinatory affordance of lexical coercion. Such a model would ideally scale up to all instances of figurative language.

This, however, is a difficult problem. Insight from the neurophysiology of language processing may prove valuable in the construction of systems that can process both literal and figurative language. Previous research seems to indicate that the cerebral hemispheres may tackle this problem by processing language in parallel. If further research can confirm and clarify this idea, automated language processing may benefit from incorporating similar parallel-processing circuits. Unfortunately, relatively little psycholinguistic or neurolinguistic research has been done in this area to date.

1.3 Background on Lexical Coercion

Each of the figurative language phenomena described above requires an adjustment in meaning due to context, often without us consciously noticing that there was any difficulty. However, coercion is somewhat different from the others because it is influenced by grammar as well as semantics. Therefore, understanding how coercion is processed may have important implications for psycholinguistic theories of how grammatical and semantic cues are coordinated during language understanding.

Coercion can be classified into different types, some of which are illustrated here (Michaelis 2003, 2004):

4. The chef finished the chicken.	Complement coercion
5. The girl jumped for hours.	Aspectual coercion
6. He had a beer.	Nominal coercion
7. Give me some blanket.	Nominal coercion
8. You have apple on your tie.	Nominal coercion

Sentence (4) is an example of COMPLEMENT COERCION. As briefly described with respect to (2) above, the verb seems to be the coercion trigger, because verbs are known to have differing selectional preferences (Langacker 1987, Michaelis 2004). For example, verbs like *finish, begin,* and *enjoy* prefer a complement that denotes an ACTIVITY (e.g., *He began to laugh; I enjoy photography*). However, verbs in this class often take complement noun phrases that do not inherently refer to an action (e.g., *book, dinner*). Rather than creating semantic incoherence, however, such mismatches trigger an interpretive adjustment in which the complement noun comes to refer to an ACTIVITY. For example, *He began the book* is understood as ‘‘He began reading (or writing) the book’’ and *I enjoyed dinner* can be interpreted as ‘‘I enjoyed eating dinner.” In short, the meaning of the complement noun seems to shift to accommodate the verb’s selectional preferences.

Coercion can also apply to the ASPECT of a linguistic expression, which reflects the temporal structure of some described event. For example, an event can be described as ongoing (e.g., *I’m running*) or as completed (e.g., *I ran*). Furthermore, certain kinds of verbs tend to be used only with a particular aspect. *Break, shoot* and *jump*, for example, are considered to be PUNCTUAL VERBS because they refer to events that are of extremely short duration. DURATIVE VERBS, on the other hand, refer to events that unfold over time (e.g., *run, swim, read*). ASPECTUAL COERCION results when the normal temporal structure of a verb is shifted. For example, in a sentence like (5) the punctual verb *jump* is coerced into a durative interpretation via the adverbial phrase *for hours*. Rather than transforming the meaning of the noun (as in complement coercion), aspectual coercion shifts the meaning of the verb.

Finally, in NOMINAL COERCION, the standard meaning of a noun can be overridden not by the selectional preferences of a verb, but simply by the article with which it is used (e.g., *a, an, the*)—or even by the lack of an article. In English, as in many other languages, nouns that refer to liquids, powders, and substances are generally considered MASS NOUNS. In other words, they represent an unbounded mass rather than a bounded entity. Nouns referring to objects or people, on the other hand, are considered COUNT NOUNS. The contexts in (6-8) override the standard interpretations of the nouns *beer, blanket,* and *apple*. In (6), the mass noun *beer* receives an individuated interpretation because it is used with the indefinite article *a*. In (7-8), the opposite occurs: the count nouns *blanket* and *apple* are coerced into mass-noun interpretations.

2. Project Goals

2.1 Cognitive and Neural Basis

Our work explores the functional and neural bases of figurative language through a combination of theoretical work, corpus analysis, and experimental techniques. We seek to shed light on a number of outstanding issues related to the time-course and neural bases of the processes that accomplish figurative language

Two-stage Model versus Conventionalization Account. As mentioned above, one central question in the study of figurative language is whether instances are computed by a two-stage process in which a literal interpretation is first attempted, then rejected, ultimately leading to a figurative interpretation. Alternatively, figurative interpretations may become entrenched, or 'lexicalized'. In the conventionalization view, a non-literal interpretation could become an established meaning of the word through repeated use, essentially "short circuiting" the inference process and resulting in direct retrieval. In support of the former account is the intuition that figurative meanings often seem to involve an "aha" moment, when the creative interpretation is constructed online. However, the latter interpretation seems consistent with the fact that many common metaphorical interpretations (e.g., *their love grew*) or coercive interpretations (e.g., *a beer*) do not seem to require significant processing effort.

These two accounts may not be mutually exclusive. Figurative language may sometimes be processed online and sometimes be lexicalized. One possible explanation is that there may be a frequency-based continuum, with two-stage processing at one end and conventionalized senses at the other. Novel or low-frequency instances may require full two-stage processes, while highly frequent interpretations may manifest a 'well-worn path' through memory and thus become automated or lexicalized. In order to establish whether or not certain interpretations have become lexicalized, we first need a reliable technique for detecting distinct senses of a word.

Polysemy and the Mental Lexicon. Determining which meanings of a word are distinct enough to warrant separate representations in a computer model of the mental lexicon is a continuing problem for language processing programs. When a single word form is associated with multiple related meanings, or senses, we refer to that word form as POLYSEMOUS. According to the process of conventionalization described above, a single word form might retain its original meaning while also gaining a new sense. Such extensions can proliferate, especially for frequently used words.

The problem of creating a language processing system that can distinguish between a word's senses begins with the question, "Which senses do we want the system to be able to distinguish?" Dictionaries encourage us to consider words as having a discrete set of senses, yet any comparison between dictionaries quickly reveals how differently a word's meaning can be divided into separate senses. Rather than having a finite list of senses, many words seem to have senses that shade from one into another.

Research that we have recently completed with human subjects suggests that word senses may fall along a continuum of relatedness (Brown 2008). Rather than storing discrete mental representations of different word senses, the brain may organize related senses via shared, overlapping mental representations. In other words, closely related senses may have a high degree of overlap, while distantly related senses have less overlap.

The results of this study suggest that some word usages considered different by the lexical resource WordNet elicit similar responses as those to same sense usages. If these usages activate the same or largely overlapping meaning representations, it seems safe to assume that little meaning loss would result from clustering these closely related senses into one more general sense for the purposes of language processing computer systems. Conversely, people reacted to distantly related senses much as they did to homonyms, suggesting that making distinctions between these usages would be useful in a language processing computer system.

Further analysis of the data from this experiment suggests that established metaphorical extensions of a word's meaning are only distantly related to the original literal sense. However, frequency of use may also affect how much overlap the senses of a polysemous word have. By including both conventionalized and novel interpretations in our ongoing experiments, we will be able to detect effects of conventionalization on semantic-distance measures.

Neurolinguistic Studies of Coercion. Previous experimental work on coercion has produced mixed results. Some recent findings suggest that even seemingly simple and highly frequent coercions incur a processing cost, suggestive of some type of two-stage model. Evidence from reading-time (Traxler et al. 2005; but see de Almeida 2004), eye-tracking (Pickering et al. 2005), speed-accuracy tradeoff (McElree et al. forthcoming), magnetoencepalography (MEG) (Pylkkänen, et al. 2004), and event-related brain potential (ERP) studies (Kuperberg et al. 2008) have shown that complement coercion is costly to process. Aspectual coercion, however, only seems to entail greater processing difficulty under more specific conditions (Traxler et al. 2002).

One possible explanation for mixed results and variation across coercion types may have to do with frequency effects. For example, aspectual coercion in general may occur more frequently (i.e., have a greater type frequency) than complement coercion. In addition, particular lexical items may be used more often (i.e., have greater token frequency) than others in coercive contexts, and consequently become conventionalized over time. For example, it may be the case that certain nouns, like *beer*, are used more frequently in coercion contexts (e.g., *a beer*) than in non-coercive phrases (e.g., *a glass of beer*).

Frequency Effects. It is becoming increasingly clear that many kinds of probabilistic knowledge play a role in sentence comprehension (Jurafsky 1996, Bybee & McClelland 2005). Furthermore, frequently used linguistic sequences tend to become even more common, more accessible, and more easily integrated online (Narayanan & Jurafsky 2005). Consequently, it seems likely that frequency of use would have a significant effect on the processing of figurative language.

Unfortunately, although coercion effects are thought to be relatively common in naturally occurring language, we know of no quantitative analyses that have been done to date. Furthermore, while it seems likely that certain instances of coercion occur much more frequently than others (e.g., *a beer* vs. *a ketchup*) and consequently may have become conventionalized into separate senses, as of yet we do not know whether frequency of use interacts with the processing load associated with coercion.

Cerebral Hemispheres. Another important theoretical and experimental issue is whether and how the left and right cerebral hemispheres may make distinct contributions to figurative language processing and language processing more generally. As mentioned above, models of language processing have historically characterized the left hemisphere as the primary brain region responsible for language function. However, findings have increasingly suggested important right hemisphere contributions to language. For instance, patients with right hemisphere brain damage are often impaired in understanding figurative language relative to patients with similar left hemisphere damage (Winner & Gardner 1977, Brownell et al. 1983, Van Lancker & Kempler 1987, Federmeier, Wlotko & Meyer 2008). Other studies have suggested that the left hemisphere exhibits greater sentitivity than the right to sentence-level cues, while the right exhibits greater sensitivity to contextual cues (REFs??)

Two hypotheses offer somewhat different explanations for these observations, although they may not be mutually exclusive. The "coarse-coding hypothesis" suggests that subtle micro-anatomical differences in the cerebral hemispheres may lead to significant functional differences (Beeman 1998; Jung-Beeman 2005). On this view, the processing of a word strongly activates small but focused semantic fields in the left hemisphere, which contain only information directly associated with the dominant meaning of the input. In the right hemisphere, on the other hand, the word activates weak, diffuse, and large semantic fields that include distant associations, and thereby provide only a coarse interpretation. These larger right hemisphere fields, however, tend to overlap and therefore summate, potentially allowing the right hemisphere to make the less obvious connections required in figurative language.

Alternatively, the "prediction/integration account" proposes that statistical information is primarily utilized by the left hemisphere, which then uses that information to make predictions about upcoming words (Federmeier et al. 2008). This predictive strategy can use semantic and grammatical regularities in the input in many normal processing situations to accurately anticipate and preprocess upcoming words. Since the vast majority of language studies have utilized literal rather than figurative language, the assumption that the left hemisphere is "the language hemisphere" may be premature. The prediction/integration account argues that the right hemisphere may process words in a more post hoc and integrative fashion, taking what has been called a "wait and see" approach (Federmeier et al. 2008). Consequently, the right hemisphere may be more active during the processing of less-predictable, figurative language, allowing for "outside the box" inferences.

It may well be that the brain is organized in such a way that both cerebral hemispheres process language in parallel, each with somewhat different priorities, and ultimately competing to reach an appropriate interpretation. In the remainder of this paper we will outline our ongoing research program that combines both corpus and neurophysiological methods in an attempt to determine how conventionalization may affect the processing of figurative language and whether it leads to significant hemispheric asymmetries.

2.2 Corpus Analysis

Analysis of natural language corpora can provide a window into the processing of figurative language phenomena. One critical feature that can emerge from such analyses is the relative frequencies of various linguistic types and tokens. This is particularly relevant because the processing cost required to achieve a figurative interpretation is likely to be modulated by the relative frequency of the particular usage. Currently, we are identifying and analyzing instances of metaphor and the three types of coercion in a variety of spoken and written English-language corpora (e.g., Gigaword, British National Corpus, American National Corpus, Switchboard, GALE

Web Text). In the case of metaphor, we are searching a sense-tagged corpus for literal and metaphoric uses of a candidate set of verbs whose meanings often vary considerably when combined with other parts of a sentence (e.g., *push, run, spill, eat, clear*). For complement coercion, we have selected another candidate set of verbs that are known to prefer action-verb complements (e.g., *begin, complete, enjoy, master, try, resist*) and are searching part-of-speech tagged and syntactically parsed corpora to identify the instances in which the verbs are used with non-eventive noun complements. In the case of aspectual coercion, we have selected a set of candidate verbs that are typically punctual (e.g., *sneeze, blink, poke, jump, pulse*) and are searching for these verbs in combination with durative phrases (e.g., *for an hour/minute/day, all day/night, for awhile*). For nominal coercion, we have selected a set of mass nouns (e.g., *beer, coffee, water, cheese, ketchup*) and a set of count nouns (e.g., *blanket, muffin, newspaper*) that can shift their type depending on their combination with various determiners or plural markers. We are using pattern matching of these combinations to find instances of nominal coercion effects.

For each verb or noun we are calculating its relative frequency of use in the appropriate type of figurative interpretation. Based on these figures, we will rank the lexical items in each set on a scale of conventionalization.

2.3 Experimental Techniques

Our work also uses experimental techniques to understand the cognitive and neural mechanisms that subserve figurative interpretations. Our experiments involve both behavioral measures of cognitive processing, as discussed above, as well as scalp-recorded event-related brain potentials (ERPs).

ERP Components. ERPs are patterned changes in scalp-recorded electrical activity that occur in response to sensory, cognitive, and motor events. ERP studies of language processing find, among other things, robustly distinct brain response to grammatical anomaly (e.g., *The cats won't* ***eating*** *their food*) and semantic anomaly (*The cats won't* ***bake*** *their food*). These two classes of stimuli modulate distinct components in the ERP (the so-called N400 and P600 effects; c.f. Osterhout, McLaughlin, Kim, Greenwald & Inoue 2005). Such functional dissociations within the ERP may be used to study the cognitive processes recruited by figurative interpretation and, to a lesser extent, the neuro-anatomical substrates of these processes. For instance, figurative-interpretation sentences like *She ordered* ***a milk*** might be perceived as semantically challenging (because *milk* must be coerced into a unit of milk) or grammatically ill-formed (because *milk* is a mass noun and should be preceded by a determiner like *some*). ERPs can be used to study how the brain responds to such sentences, and whether context, frequency-of-occurrence, or individual differences may modulate brain responses.

Source Estimation. Although the temporal resolution of ERP is excellent (on the order of milliseconds), the spatial resolution is somewhat inferior to imaging technologies like MRI and PET. However, recent advances in computing resources and algorithms have made estimation of the neural generators of scalp-recorded ERPs more accurate and computationally feasible. Source analysis techniques may allow estimation of the neuro-anatomical structures recruited by figurative language, and to do so with high temporal resolution. This approach may, for instance, allow the observation of temporally dynamic patterns of recruitment of left versus right hemispheres during figurative language processing.

Hemifield Manipulations. Another method for assessing the contributions of the left and right hemispheres to language or other cognitive processes is to manipulate the visual presentation of critical stimuli such that only one visual hemifield is exposed to a critical word during reading. This "visual-hemifield presentation" technique takes advantage of the fact that visual information presented to one half of the retina (of both eyes) is projected to the visual cortex on the contra-lateral (opposite side) cerebral hemisphere. In other words, information presented exclusively to the right of fovea (i.e., offset to the right of center) is processed, at least initially, by the left hemisphere only, and vice versa.

We are currently running a study of language processing in which we manipulate the visual hemifeld to which words are presented and examine both behavioral measures (e.g., reaction times) and ERPs, in order to explore the contribution of the different hemispheres.

3. Conclusion

Meaning is more than just a sum of the parts. Human understanding of figurative language requires more than the monotonic combination of individual word meanings. In order to process figurative language, the brain may be organized in such a way that the two cerebral hemispheres work in parallel, each with somewhat different priorities, competing to reach an appropriate interpretation. If this is indeed the case, a biologically-inspired cognitive architecture for automated language processing may need to include similar parallel-processing capabilities. Ultimately, we hope that the results of our current work will contribute to a biologically inspired solution to automated language processing.

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