An Experimental Investigation of Semantic and Syntactic Effects on Idiom Recognition

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1. Introduction

The process of interpreting a syntactic representation is guided by the principle of compositionality: the notion that the meaning of a complex expression is equivalent to the meaning of its parts and the way in which those parts are combined (Frege, 1884). Compositionality is largely responsible for explaining how the rich, productive system of human language can exist given finite vocabulary and experience. However, there are limits to compositionality. Sentences such as *John kicked the bucket* or *Mary hit the hay* are ambiguous between a literal interpretation and an idiomatic interpretation. In the former case the meaning of the sentence can be compositionally determined in the normal way and is predictable from the component pieces (e.g. *John impacted the bucket with his foot*). In the latter case the meaning is neither predictable nor compositional, and the principle of compositionality breaks down (e.g. *John died*).

  Such non-compositional expressions are far from exceptional. They are pervasive in a given language (Jackendoff, 1995) and frequent in naturally-occurring language use (Pawley & Snyder, 1983). Thus, complete models of lexical representation should be capable of accounting for these expressions. Despite a long history of idiom research, however, there are still many questions about how these expressions are represented and accessed. Additionally, the relationship between an idiomatic expression and its literal counterpart is still poorly understood. In what follows we will examine attempts in the literature to integrate idiomatic expressions into models of the mental lexicon. We will then present the results of an experiment designed to examine the relationship between the literal and idiomatic interpretations of these strings, and the interplay between syntactic computation and idiom access.

1.1. Previous research

Early proposals treated idioms as word-like units. In a simple lexical view, words are linguistic representations with arbitrary direct mappings to particular syntactic, semantic and conceptual information. Early research into idioms argued that idioms are word-like, in the sense that they occupy the same level of representation, being directly associated with semantic and conceptual information without a need for compositional interpretation (Bobrow & Bell, 1973; Swinney & Cutler, 1979; Katz & Postal, 1963). For example, Bobrow & Bell (1973) argued that idioms are stored in a separate system accessed via a special, non-compositional processing mode. Evidence for this comes from literalness priming effects: Participants are more likely to interpret an ambiguous string as idiomatic after recent exposure to several idiomatic strings, and as literal after exposure to literal strings (Bobrow & Bell, 1973).

Further evidence for the word-like nature of idioms was provided by Swinney & Cutler (1979)'s finding that idiomatic expressions are recognized as valid expressions faster than literal phrases (see also Gibbs & Gonzales, 1985; Gibbs 1980; Gibbs & Nayak, 1989). According to Swinney & Cutler, idioms are stored in the lexicon like words. During processing, accessing the idiom and computing the literal meaning of the expression proceeds in parallel, with the apparent speed advantage of idiomatic expressions emerging because idioms can be accessed directly in the mental lexicon without need for additional computational steps. They termed this model the *Lexical Representation Hypothesis* (LRH). In addition to offering an intuitively appealing explanation for the rapid recognition of idioms, the LRH also allows us to delegate the resolution of the pervasive literal/non-literal ambiguity to the same sort of systems which handle other kinds of lexical ambiguity.

While the LRH predicts no relationship between the idiomatic and literal versions of an ambiguous string, later research shed doubt upon this prediction. Gibbs & Nayak (1989) noted that idioms occupy a continuum of structural flexibility, and their research provided evidence for a correlation between this flexibility and the degree to which they can be semantically decomposed. In more recent work, Konopka & Bock (2009) found evidence for syntactic priming with phrasal verbs regardless of their level of idiomaticity, strongly arguing for a structural representation of idiomatic strings (see also Peterson et al, 2001).

More fine-grained information regarding the processing and representation of idioms comes from Cacciari & Tabossi (1988), who used cross-modal lexical decision to probe whether idiomatic and literal interpretations were activated during the processing of Italian idioms (e.g. *in seventh heaven*).They found that participants showed evidence of activation of the idiomatic interpretation but not the literal interpretation when probed on the final word of the idiom when the idiomatic nature of the phrase was predictable. When the idiom was not predictable, as measured by an idiom completion pretest, participants showed activation of the literal meaning at the final word, but did not exhibit signs of

idiomatic activation until 300ms later. These results argue against the idea, inherent in the architecture of the LRH, that the literal and idiomatic interpretations of a given ambiguous string are processed in parallel. (See also Cacciari et al, 2007; Titone & Connie 1994, 1999; Fanari et al 2006). This work lead to the Configuration Hypothesis (CH) in which idioms have a distributed representation in the lexicon (Cacciari & Glucksberg, 1991).

In line with this approach, recent work into idiom production also suggests a distributed representation and a primacy of the literal components. On the basis of speech error data, Cutting & Bock (1997) suggest that the production of idioms is sensitive not only to the idiomatic meaning of the phrase at hand, but also to its syntactic internal structure and literal meaning. The finding that, during idiom *production*, the literal meaning and associated syntactic structure are nevertheless activated is quite striking, given that the speaker presumably knows that she is producing an idiomatic expression -- hence one might expect that sensitivity to the structural properties and literal interpretation of an idiom would be unnecessary. Thus, Cutting & Bock's data is strong evidence in favor of a *hybrid representation of idioms*. In their model, idiomatic expressions are represented as phrasal frames in a lexical-conceptual layer of the lexicon. Like words, idioms are connected directly to their idiomatic conceptual meaning, like structures, access is mediated via the literal components of the expression. This model predicts that structural and literal information will be recruited both during idiom production and comprehension. The model also predicts tight integration between the idiomatic representation of an ambiguous string and the literal meaning of its component parts. Activation of an expression such as *kick the bucket*, for example should result in activation of literal *bucket* which in turn should result in activation of semantic and phonologically related lemmas (e.g. *pail* and *bucket*).

Sprenger, Levelt & Kempen (2006) examined these predictions explicitly and provided a refined model of idiom production. Their experiments showed that identity priming of a word in an idiom (e.g. showing people *bucket* for *kick the bucket*) facilitated cued recall of the idiom. Additionally, this priming effect was found to be *greater* for idioms than for related literal strings (e.g *clean the road*) as predicted by the architecture of Cutting & Bock's hybrid model. They also found that sentence completion of an incomplete idiomatic string was facilitated by priming words related phonologically and semantically to the target word, further suggesting that the content of the literal lemmas that comprise the idiomatic string are activated during production. They propose a slightly revised model in which idiomatic representations are instantiated as *super-lemmas*, which occupy a level of representation between structures and words. Like words, these *super-lemmas* are directly associated with a conceptual representation, but unlike words they contain a great deal of structural information and access to them is mediated via the literal lemmas which

comprise the idiom. As such they are able to enter into competition during language production with other literal and idiomatic phrases.

1.2 Aims

The hybrid model of idiom representation goes a long way in articulating the representation of idioms in the mental lexicon and the relationship between idioms and their literal components. Applying the hybrid model to idiom comprehension, however, is not trivial, and a number of questions remain open. First, it is somewhat unclear what the contents of this *super-lemma* representation are. One possibility is that it encodes detailed structural information. For example, an idiom such as *kick the bucket* may be specified at this level as a verb-phrase. This would differ from the representation of a typical VP in that access to the *super-lemma* is (i) directly mediated by access to the lemmas *kick* and *bucket* (ii) structurally specified rather than compositionally composed and (iii) directly associated with a conceptual meaning.

Given point (i) and what we already know about the structure of the lexicon, we might assume that idiomatic activation may proceed to some degree even if one or more of the comprising lemmas is not fully active. Thus parsing a string such as *kick the pail* may partially activate the idiomatic representation by virtue of partial activation of the trigger lemma *bucket* via spreading activation from the conceptually related *pail*. Point (ii) is interesting, as it provides us a potential way of explaining why idiomatic expressions vary with respect to their syntactic flexibility. The degree to which this structural representation is 'hard-coded' could correlate with the flexibility of the idiom. Thus a particularly frozen idiom, like *kick the bucket*, may be fully specified as an active VP, thus prohibiting its syntactic productivity and explaining why, for example, it cannot passivize. If this is the case, however, we would expect that consideration of idiomatic meaning would be inhibited in cases in which the component lemmas occupy a syntactic structure incompatible with this *super-lemma* representation. Furthermore we would predict that this effect will vary depending on the idiom in question. Idioms may differ along some continuum of flexibility, as mentioned earlier, or simply be individually specified for which structural features they permit.

In this paper we focus on these two points. To investigate point (i), we presented sentences such as *John kicked the bucket last Sunday* and *John kicked the pail last Sunday* to participants and used real-time eye-tracking in a text-based visual-world paradigm to investigate the time-course of consideration of the idiomatic and literal interpretations of these sentences over time. If our view is correct we predict competition between the idiomatic and literal interpretations upon hearing *kick the bucket*, and similar effects when hearing *kick the pail*.

To investigate point (ii) without making any assumptions about the underlying representation of the feature of 'flexibility,' it was essential to choose a syntactic structural feature which completely rules out an idiomatic interpretation regardless of the flexibility of our stimuli. To accomplish this, we presented participants with sentences in which the idiomatic string was broken up across a sentential boundary. If our view is correct, the syntactic structure should rule out the idiomatic interpretation, resulting in no consideration of the idiomatic interpretation in either …*kick. The bucket*… or …*kick. The pail*… cases.

2. Method

2.1 Participants

12 undergraduate students at the University of Southern California participated in this study. All participants were native speakers of American English.

2.2 Materials

2.2.1 Lexcial availability
12 idioms were selected out of a pool of 21 based on the results of an off-line norming study. All idioms (including those not selected for the main experiment) were of the form *verb x noun* (e.g. *kick the bucket, find her feet, smell a rat, pull his leg*) where *x* was either an article (*a* or *the*) or a possessive pronoun (*his* or *her*). The 12 selected idioms were chosen based upon their familiarity to the majority of participants in the norming study, and the ease of their use in stimuli for the main experiment. These items comprised our **Lexically Available** condition. 12 semantic-associates were then created by changing the final noun of each idiom to a semantically-related word (e.g. *kick the pail, find her toes, smell a mouse, pull his arm*). These items comprised our **Lexically Unavailable** condition.

2.2.2 Syntactic availability
Syntactic availability was manipulated by placing each idiom and semantic-associate into one of two sentential frames. In the **Syntactically Available** conditions, the relevant string was inserted into a simple sentence containing only a proper name and a time phrase so as to not contextually bias individuals to interpret the string one way or the other. In the **Syntactically Unavailable** conditions, the string was divided between two sentences with the *verb* occurring as the final word of the first sentence and *x noun* occurring as the beginning of the following sentence. An example is given in Table 1.

Syntax	Lexical	Sentence
Available	Available	John *kicked the bucket* last Thursday.
Available	Unavailable	John *kicked the pail* last Thursday.
Unavailable	Available	It was surprising to see someone as skilled as John completely miss when he *kicked. The bucket* full of orange slices was completely destroyed when he accidentally missed the ball.
Unavailable	Unavailable	It was surprising to see someone as skilled as John completely miss when he *kicked. The pail* full of orange slices was completely destroyed when he accidentally missed the ball.

Table 1. Example items for the idiom *kick the bucket* in each of our four conditions.

2.2.3 Stimuli

The test sentences (recorded by a native speaker of American English, no splicing to ensure naturalness) were presented over headphones. In addition to the 48 target audio sentences, 60 filler sentences were also recorded. To better mask the target stimuli, half of all fillers were short simple sentences and half were longer multi-sentence stories.

The visual stimuli consisted of a set of four words presented on the screen. For target items, these were an **Idiom Associate**, **Literal Associate** and two **Distractors**. **Idiom Associates** were selected based upon the results of an off-line norming study which asked people to list the first three words that came to mind when reading the given idiom. **Literal Associates** were semantic associates of one of the nouns (e.g. *Bucket*; 7 items) or the verb (5 items). To help mask the targets, half the filler displays also contained a word semantically related to one of the words in the sentence (see Meyer, 2005; Heuttig & McQueen, 2007, McQueen & Viebahn, 2007). In addition, three-fourths of fillers contained a word that matched a word in the auditory sentence.
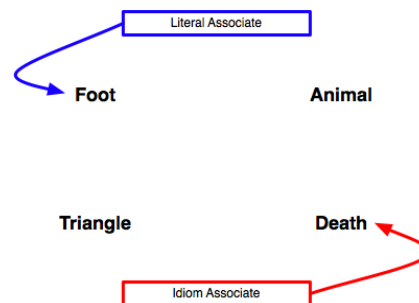

Figure 1. A sample display with Literal and Idiom associates marked.

Visual stimuli were presented on the screen with one word in each corner as shown in the sample display in Figure 1. Position of the associates and distractors was balanced both within the target items and overall (pooling targets and fillers).

2.3 Procedure

Participants' eye movements were recorded using an Eyelink II eye-tracker (SR Research). For each trial participants first saw the four visual stimuli appear on the screen and were given 5 seconds to preview the words. After 5 seconds the audio stimuli was presented. Participants were instructed to read each word silently to themselves during the preview phase and to maintain their attention on the screen during the audio phase. Stimuli were presented to participants using a modified latin-square design. Each participant saw two versions of each target, but never saw any target in the same condition more than once. Presentation order was pseudo-randomized: The first version of a particular target item occurred in the first half of the list, and the second occurred in the second half. Half of the participants saw lists with reverse order to control for possible learning effects.

3. Results

We were primarily interested in qualitative differences in looking behavior in our different conditions, and on the timing of changes in looking behavior over the course of a trial. Thus for each condition we examined whether looks to either the Idiomatic Target or Literal Target deviated significantly from the distractors and from each other. To prepare our data we computed average fixation proportions (by subject and by item) over a time interval extending from 200ms after the onset of the critical noun (e.g. *Bucket* or *Pail*) to 1000ms post onset. As we were also interested in changes in looking behavior over this time window, the full time window was partitioned into eight 100ms windows, and further analyses were performed on each of those windows. Analyses were performed using a series of ANOVA over the full time window and each individual partition.

  In the interest of clarity, results are presented graphically as *literal advantage scores*. These scores are computed by subtracting the proportion of looks to the idiomatic target from the proportion of looks to the literal target. Thus, a positive value represents more looks to the literal target (literal advantage), a negative value represents more looks to the idiomatic target and a value close to 0 represents equal looks to both the literal and idiomatic targets. (Statistical analyses were conducted on the proportions of looks, rather than on the difference scores of proportions of looks.)

3.1 Syntactically Unavailable Trials

Figure 2 shows the literal advantage scores for each time window in the *Syntactically Unavailable condition*. Generally we can see that participants seem

to be largely focused upon the literal interpretation. Our statistical analysis confirms these trends. First examining the full time window from 200ms to 1000ms, looks differ significantly in the Lexically Unavailable condition by both subjects and items [$F_{1(2,11)}$ = 3.94, $p < .05$; $F_{2(2,11)}$ = 8.85, $p < .01$] and marginally for the Lexically Available condition [$F_{1(2,11)}$ = 2.75, $p = .08$; $F_{2(2,11)}$ = 3.11, $p = .06$]. Pairwise analyses reveal that these differences are driven by the looks to the Literal target which is significantly different from the Distractors and Idiomatic Target in the Lexically Unavailable Condition [all p's < .05] and marginally different in the Lexically Available Condition [all p's < .1]

   Examining individual time windows, the results largely confirm what we can observe visually. For the Lexically Available targets, looks to the Literal target are significantly greater than looks to the Idiom target [p's < .05] – i.e., bars are significantly greater than 0 -- until the 600ms-700ms interval, when the difference scores indicate some competition between the idiomatic and literal interpretations [p's > .1] – bars get 'shorter', closer to 0. In the Lexically Unavailable condition, looks to the Literal target begin to deviate significantly from looks to the Idiomatic target in the 400ms-500ms interval [$p < .05$] and continue to differ significantly or marginally for the entire window [significant by items, marginal by subjects].
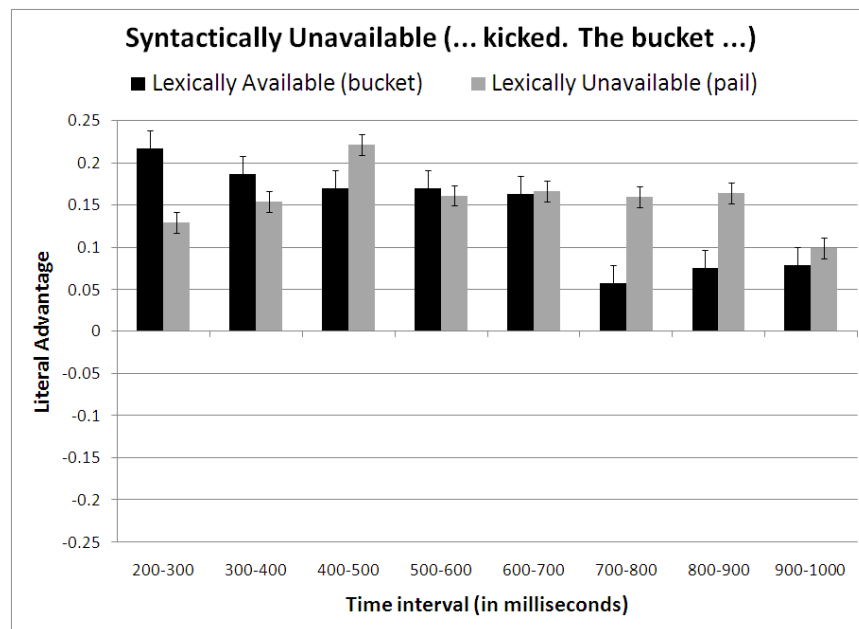

Figure 2. Literal advantage scores for the syntactically unavailable conditions (e.g. … *kicked. The bucket* …). Bars represent the difference between looks to the literal target and looks to the

idiomatic target for each 100ms time window, with 0ms corresponding to the onset of the critical noun (e.g. *bucket* or *pail* for lexically available and lexically unavailable conditions respectively).

Generally, these results confirm our hypothesis regarding the syntactic manipulation. Recall that we predicted that placing an idiomatic expression into a completely incompatible syntactic frame would cause the lexical access system to completely rule out the idiomatic possibility. This does appear to be what is happening in the Lexically Unavailable condition. In the Lexically Available condition we also see this general effect, however we also some late consideration of the idiomatic interpretation. We suggest that this may represent a sort of post-processing reconsideration effect, however further experimentation is require to confirm or deny this possibility.

3.2 Syntactically Available Trials

Figure 3 shows the literal advantage scores for each time window in the *Syntactically Available condition.* At first glance we can see that these results are qualitatively very different from the results obtained in the syntactically unavailable conditions. For the Lexically Available condition, it appears that we have long-lasting competition between the Idiomatic and Literal targets, while for the Lexically Unavailable condition we see an early preference for the Idiomatic Target shifting over time to a preference for the Literal Target.
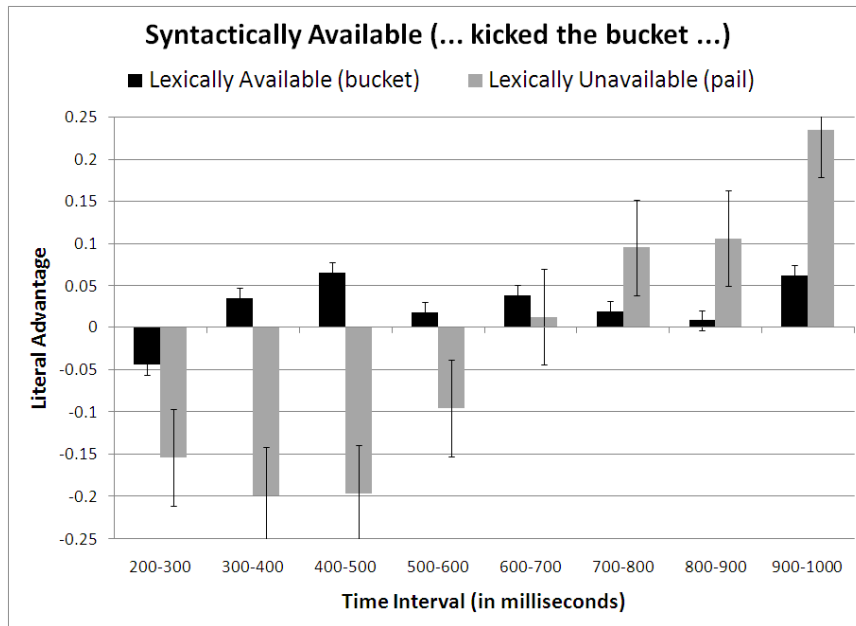
Figure 3. Literal advantage scores for the syntactically available conditions (e.g. … *kicked the bucket* ...). Bars represent the difference between looks to the literal target and looks to the idiomatic target for each 100ms time window, with 0ms cooresponding to the onset of the critical noun (e.g. *bucket* or *pail* for lexically available and lexically unavailable conditions respectively).

Statistical analyses reveal no significant difference in looks over the full time window for the Lexically Available condition [$F1(2,11) = .79$ $p = .46$; $F2(2,11)=.56$, $p = .57$] and significant differences by item only in the Lexically Unavailable condition [$F1(2,11) = .41$, $p = .66$; $F2(2,11) = 3.7$, $p < .05$]. This is somewhat expected as changes in behavior over the large window will affect the proportion calculation, potentially washing out effects.

Examining individual time windows, we can see that there is no significant difference between looks to the Literal and Idiomatic targets in the Lexically Available condition [p's > .6] (black bars are close to 0), confirming the visual suggestion that these two interpretations are in competition for the duration of the trial. Further analyses reveal that looks to either the Literal or Idiomatic target deviate significantly from the distractors starting in the 600ms-700ms time window [$p < .05$].

Turning our attention to the Lexically Unavailable condition, we see significantly more looks to the Idiomatic Target in the time windows ranging from 400ms to 600ms [p's < .05] (bars are strongly negative), followed by competition, and then more looks to the Literal Target than the Idiomatic Target in the final 900ms-1000ms window [$p < .05$] (bars become positive).

The Lexically Available results suggest that individuals do indeed consider both the idiomatic and literal meaning of potentially idiomatic strings (e.g. *kick the bucket*) during on-line processing, as exhibited by long-lasting competition between the two interpretations in our results. We also hypothesized the same sort of competition would occur in semantically-related non-idiomatic strings (e.g. *kick the pail*), and our results also partially support this conclusion but suggest a more complicated behavior when parsing these strings. Particularly we see early attention on the *incorrect* idiomatic interpretation, and full consideration of the *correct* literal interpretation only much later.

4. Conclusions & Discussion

Hybrid models of idiom representation suggest that idioms are (i) represented as structural chunks and (ii) accessed via their component lemmas. With respect to the former point, we hypothesized that syntactic contexts which are incongruent with this pre-specified structure would quickly rule out the idiomatic possibility and prevent consideration of the idiomatic interpretation. Indeed, our results demonstrate that syntactic structure, at least large global properties such as the presence/absence of a sentential boundary, are used rapidly during one-line processing of a potentially ambiguous idiom string.

Interestingly, in the Syntactically Unavailable conditions, we also found some late hints of participants considering the idiomatic interpretation when the idiom was lexically available (e.g. *..kick. The bucket…*). This was unexpected, but could perhaps be due to a post-processing recognition of the idiomatic string. As an example of post-processing recognition, consider figurative phrases like *His bucket was thoroughly kicked*. These phrases represent playful use of language in which the idiomatic interpretation is clearly intended, though the structural requirements on idiom itself have been intentionally violated. Under this view, recognition of the idiomatic interpretation in such phrases would be delayed due to structural violations, yet the phrase is clearly (eventually) interpreted idiomatically. For our data, we believe something similar may be at work.

Overall, our findings regarding the effects of a syntactic boundary have potentially interesting implications for our understanding of sentence processing. We mentioned earlier that one of the characteristics of idiomatic expressions is their profile of rapid access as compared to literal controls. These results suggest that this rapidity is, in part, due to lexical storage of specified structural information. If this is the correct explanation, this means that idiomatic expressions, perhaps out of necessity, are stored lexically as structural units. However, the property of rapid access is not limited to idioms. Recent work has demonstrated similar results obtain with clichés (e.g. *handle with care*, Tabossi et al, 2009) and frequent expressions (e.g. *all over the place*, Arnon & Snider, 2010). One possible way to account for this is to ascribe the same sort of 'structural chunk' representation to these expressions as we have for idioms. Under this view the lexicon may also contain chunks of pre-compiled structure not only for non-compositional expressions, but also for compositional ones.

Again, for idioms this may be out of necessity, as compositional computation would result in an incorrect meaning. Extended to clichés and frequent expressions, however, this view would mean that even some compositional structures may be directly stored rather than computed in the normal course of sentence comprehension. In the case of frequent expressions, this could be beneficial to the parser, as it allows frequently repeated structures to be accessed and retrieved rapidly. Of course, further investigation is required to establish that the sort of representation our data suggests for idioms applies to certain compositional structures, however the implications for sentence processing and lexical access are interesting.

In addition to the presence vs. absence of a syntactic boundary, we also manipulated the lexical nature of the critical string (*kick the bucket* vs. *kick the pail*). The results of the lexical manipulation suggest that when syntactic requirements are met, there is competition between the idiomatic and literal interpretation regardless of whether the given string is actually ambiguous (e.g. *kick the bucket*) or just semantically related (e.g. *kick the pail*). In the Lexically Available condition we saw early-onset, long-lasting competition between the two interpretations. In the Lexically Unavailable condition we saw similar

competition until relatively late, when the correct literal interpretation won out over the incorrect idiomatic interpretation. We also saw that in the Lexically Unavailable condition, participants showed an early preference for the incorrect idiomatic interpretation. Further investigation is required to determine the source of this behavior. It may be related to a sort of 'Double Take Effect' as found by Gibbs (1980). The idea is that the unconventionality of the expression *kick the pail* coupled with its close semantic association with *kick the bucket* may temporarily boost consideration of the latter expression.

Broadly, our results support the hypothesis that idioms are represented as structural units which are accessed via the literal lemmas which compose them.

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