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Idiom comprehension in aphasia: Literal interference and abstract representation

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Abstract

We investigate three potential mechanisms underlying the deficit in idiom comprehension seen in aphasia: difficulty inhibiting literal meanings, inability to recognize that a figurative interpretation is required, and difficulty processing abstract words and concepts. Unimpaired adults and PWA read high and moderate familiarity idioms either preceded or followed by a figuratively biasing context sentence. They then completed a string-to-word probe selection task, choosing between a figurative target, a literal lure, and unrelated concrete and abstract lures. PWA chose the figurative target more often for more familiar idioms and after figuratively biasing contexts, suggesting that difficulty accessing figurative meanings may be a key contributor to idiom impairment in aphasia. Importantly, PWA chose abstract lures at the same rate as they chose literal lures, suggesting that abstract lures may be considered equally good matches for weak idiomatic representations in PWA, and therefore that idiomatic figurative meanings may be represented similarly to abstract concepts for PWA. These results have implications for models of idiom comprehension in aphasia, as well as the design of future studies of idiom comprehension in PWA.

Keywords

Idioms; aphasia; figurative language; abstract representation; concreteness

INTRODUCTION

Idioms are multiword structures that are understood quickly and easily by unimpaired comprehenders despite the fact that their figurative meanings cannot be computed on the basis of the literal meanings of their individual words (Bonin, Meot, & Bugaiska, 2013; Glucksberg, 1991; Nunberg, Sag, & Wasow, 1994; D. A. Titone & Connine, 1994). Many idioms possess both literal and figurative meanings—for example, *sail close to the wind* can mean both *sailing close to the direction from which the wind is blowing* and *behaving recklessly or dangerously*. These different interpretations may be more or less easily

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accessible during comprehension depending on characteristics of the idiom and the context in which it appears. Although idioms are frequent in everyday language and easily understood by unimpaired comprehenders, idiom comprehension is often impaired in people with aphasia (Cacciari et al., 2006; C. Papagno, Tabossi, Colombo, & Zampetti, 2004). The present study manipulates two factors that affect comprehension in neurotypical comprehenders—idiom familiarity and the context in which the idiom appears—and investigates their effects on idiom comprehension in people with aphasia (PWA). The findings have implications for three possible mechanisms contributing to idiom comprehension deficits in PWA: interference from literal meanings, difficulty recognizing that a figurative interpretation is appropriate, and difficulty processing abstract concepts.

Research using online measures of comprehension in unimpaired comprehenders has found that higher familiarity idioms are easier to process than lower familiarity idioms. This is because more familiar idioms are likely to have stronger associations between the idiom and its figurative meaning, facilitating retrieval of that meaning. Consistent with this, Cronk, Lima, and Schweigert (1993) found that higher-familiarity idioms in figurative contexts were read faster than lower-familiarity idioms in figurative contexts, especially if the words within the idiom were high-frequency. Similarly, across multiple experiments Libben and Titone (2008) found that increased familiarity facilitated idiom comprehension. Finally, D. Titone and Libben (2014) found a positive correlation between idiom familiarity and priming magnitude 1000 ms post idiom offset. These results, across multiple comprehension measures, all indicate that familiarity facilitates idiom comprehension.

However, the context in which the idiom is embedded also plays an important role in idiom comprehension. Comprehension of lower-familiarity idioms tends to be boosted when these idioms are preceded by a supportive context. Qualls and colleagues (2003) found that in isolation, only high and moderate, but not low familiarity idioms were well comprehended. But presenting an explanatory story before the idiom resulted in equally high comprehension of high, moderate, and low familiarity idioms. This pattern appears to generalize to other forms of figurative language: Blasko and Brihl (1997) found that low-familiarity metaphors were read faster when preceded by a related metaphorical context than by an unrelated literal context. This body of work suggests that familiarity and context, both independently and interactively, can bolster activation of the figurative meaning of an idiom in unimpaired language comprehension.

Idiom comprehension is often impaired in aphasia: PWA frequently appear to interpret idioms literally even when instructed to focus on figurative interpretations (Cacciari et al., 2006; Cie licka, Ratal, & Jawroska, 2011; Nenonen, Niemi, & Laine, 2002; C. Papagno et al., 2004). Cacciari et al. (2006) found high rates of literal errors when PWA were tasked with choosing the meanings of idioms from sets including a literal meaning, a figurative meaning, and an unrelated distractor. For example, PWA were given the idiom “he has raised the elbow”, an Italian idiom roughly meaning “he has been drinking too much”, and then were asked to select between a figurative target (wine), a literal lure (leg), an unrelated foil that could plausibly be an object of the verb (box), and a foil that matched the concreteness of the figurative target (tree). They found that the most common error was the literal lure. On the basis of these results, they proposed two potential loci of aphasic idiom impairment. The

first potential locus of impairment is in recognizing that a figurative meaning is required. Under this account, interpretation of an idiom proceeds literally until the comprehender encounters a cue that a figurative interpretation is required (for example, opacity or syntactic ill-formedness) and activates the figurative meaning while suppressing the literal meaning. PWA may be relatively insensitive to such cues. Indeed, there is independent evidence that PWA put less weight on syntactic or form-based cues than controls (e.g., Gibson, Sandberg, Fedorenko, Bergen, & Kiran, 2016; Warren, Dickey, & Liburd, 2017). Another potential locus of impairment is in suppressing literal meanings once they are activated (see also Cieslicka et al., 2011). High rates of literal errors may reflect impairment in PWA's ability to suppress literal meanings. These two potential loci of impairment are not mutually exclusive; it is possible that both mechanisms may play a role in idiom comprehension impairment in PWA.

Both of these proposed mechanisms of aphasic idiom impairment—difficulty recognizing the need for a figurative interpretation and inability to suppress literal meanings—are consistent with the assumption that idiomatic representations are intact in aphasia. However, another possibility is that the impairment may be rooted in the representations of the figurative meanings of idioms themselves. One potential reason to think this is that figurative meanings are often abstract. In a norming study of more than 600 German idioms, Citron and colleagues (2016) quantified idiom abstractness, finding that highly figurative idioms were also considered to be more abstract. Visual examination of 271 English idioms tested in large-scale norming studies (Nordmann et al., 2014; Titone & Connine, 1994) also indicates that the majority are associated with abstract concepts (i.e. death, debt, danger, drunkenness). If PWA have particular difficulty with abstract concepts, it could contribute to impairment during idiom comprehension.

Even in unimpaired comprehenders, concreteness, or the degree to which a word's referent can be perceived with the senses (James, 1975), affects comprehension (Paivio, 1971). Processing is usually slower and less accurate for abstract words (e.g. *patience*) compared to concrete words (e.g. *medal*). However, PWA usually show larger concreteness effects than unimpaired comprehenders (Barry & Gerhand, 2003; Berndt, Haendiges, Burton, & Mitchum, 2002; Kiran, Sandberg, & Abbott, 2009), suggesting they have particular difficulty accessing and representing abstract concepts. Kiran and colleagues (2009) found that training abstract words promoted learning of associated concrete words in PWA. However, the reverse was not true: training concrete words only promoted learning of associated concrete words. They proposed that this pattern of results reflects differences in the ways that abstract and concrete concepts are represented: abstract concepts are represented based on their relationships with other concepts, both abstract and concrete. In contrast, concrete concepts are represented based on the sensory experiences they evoke (Bird, Howard, & Franklin, 2003), and have less widely distributed meanings. Under this account, PWA may show greater concreteness effects because the more distributed and relational structure of abstract concept representations might make them more likely to be affected by circumscribed neural damage to perisylvian language regions than concrete concept representations.

Cacciari et al (2006) found hints that concreteness may play a role in PWA's idiom comprehension, even when idioms are highly familiar. They found high rates of literal errors in their study of idiom comprehension in PWA using string-to-word matching. Critically, on trials in which the figurative target was abstract, accuracy was lower than on trials in which the target was concrete. However, this analysis was conducted post-hoc and the abstract/concrete nature of the target was not systematically manipulated. This finding can therefore be taken as only suggesting that concreteness may be an important factor to consider in PWA's idiom comprehension.

In contrast, Papagno and Cacciari's case study of a person with aphasia (MC) with a reversed concreteness effect on nouns (2010) suggests that mechanisms other than concreteness can contribute to idiom impairments in PWA. MC had preserved abstract word comprehension, but difficulty generating figurative idiom meanings despite the fact that these meanings were also abstract. The factor accounting for much of MC's impairment in idiom comprehension was ambiguity: MC showed greatest impairment for unambiguous idioms, which are idioms with only figurative meanings, and less impairment for ambiguous idioms, which have both literal and figurative interpretations. Critically, both ambiguous and unambiguous idioms were equally likely to refer to abstract mental states, suggesting that factors independent of concreteness or abstractness may contribute importantly to PWAs' idiom-comprehension impairments. These results, taken together with Cacciari and colleagues' (2006) results described above, point to the need for greater investigation of concreteness effects on idiom comprehension in PWA, particularly in order to separate the effects of concreteness/abstractness from those of other potential loci of impairment.

Task effects must also be taken into account when assessing the degree of idiom impairment in PWA. Studies of idiom comprehension in aphasia frequently use matching tasks, in which an idiom is presented and the participant is asked to choose an item representing the idiom's meaning from an array of distractors. Such arrays usually include distractors related to the idiom's literal meaning, and interference from these literal distractors could contribute to the bias towards literal interpretations often observed in aphasia. Indeed, Papagno and colleagues (2004) found that PWA produced fewer literal errors when their task was to verbally explain the meaning of idioms than when their task was to match idioms to pictures presented in sets that included a literal distractor picture, although they still made more errors than did unimpaired controls. This finding is more consistent with an account under which the high rate of literal errors observed in matching tasks may be partially due to difficulty inhibiting literal meanings when they are explicitly presented, rather than insensitivity to cues indicating a figurative interpretation.

The current study was designed to: (1) investigate PWA's sensitivity to factors that modulate figurative meaning activation (i.e. familiarity, context) and (2) test the predictions of two possible mechanisms underlying idiom comprehension deficits in PWA: insensitivity to cues indicating a figurative interpretation and interference from literal meanings. Additionally, the study design allows us to explore a third possible mechanism: difficulty processing abstract words and concepts. PWA and neurotypical controls read sentences that contained highly familiar idioms, moderately familiar idioms (with a very similar figurative meaning), or literal paraphrases of the figurative meaning of the idioms. These sentences were either

preceded or followed by a context sentence that supported the figurative meaning of the idioms. After reading these sentences, participants had to choose a target word associated with the critical figurative meaning from a set that also included a literal lure and unrelated abstract and concrete lures. We measured reading times on a neutral region following the idiom, as well as reaction time and accuracy on the probe selection task. If PWA are sensitive to factors that modulate figurative meaning activation, then higher-familiarity idioms and supportive contexts should facilitate and boost comprehension in PWA, just as they do in unimpaired comprehenders.

Error patterns will be informative about potential mechanisms of idiom impairment in aphasia. If aphasic impairment is related to an inability to suppress literal meanings, we would expect to see high rates of literal errors regardless of idiom familiarity or context. This is because the literal interpretation will always be activated during the matching task on account of reading the literal lure. If aphasic impairment is caused by insensitivity to cues indicating a figurative interpretation, this should also result in high rates of literal errors and few errors of other kinds. This is because PWA should consistently choose the literal lure if their initial interpretations are always literal and they fail to transition away from them. Depending on what counts as a cue, this account could also predict effects of idiom familiarity and context. For cues that depend only on the literal string, like encountering an anomaly in a literal interpretation, no such effects would be predicted. But if cues can be related to the figurative interpretation, for example if a cue could be entering a processing state in which the upcoming words are highly predictable under a figurative interpretation (see Brothers, Swaab, & Traxler, 2016, for evidence that local predictability can be a learning cue), then sensitivity to such cues would depend on the accessibility of the figurative interpretation. In this case, high rates of literal errors would be expected, but those rates might be even higher for lower-familiarity idioms and idioms in less supportive contexts.

Critically, all of these accounts predict that PWA should make mostly literal errors. However, the rate at which participants choose the abstract lure may also be informative regarding their idiom representations. High rates of literal lure choices may reflect activation of the literal interpretation of the idiom. In contrast, the choice of an unrelated abstract word would suggest a different locus of deficit—one more likely rooted in the representation of the figurative meaning of the idiom.

METHODS

PARTICIPANTS

Two groups of participants took part in this study: 16 individuals with diagnosed aphasia due to left hemisphere stroke, and 31 unimpaired control adults in a similar age range to the people with aphasia. All participants were paid \$10/hour for their participation.

Unimpaired adults were native, monolingual, speakers of English with self-reported normal or corrected-to-normal vision and normal hearing. Ages ranged from 47 to 73 years ($M=61.3$; $SD=7.5$; two participants did not report age). Older, unimpaired participants were

recruited through the Research Participant Registry, a registry of community-dwelling adults with ages across the life span.

People with aphasia (PWA) were native speakers of English who were diagnosed with aphasia following a unilateral left hemisphere stroke. PWA were recruited through the Western Pennsylvania Patient Registry, a registry of community-dwelling stroke survivors. Ages ranged from 50 to 82 years ($M = 68.1$; $SD = 8.49$). Testing took place from 17 to 151 months after the onset of aphasia (see Table 1 for full participant demographics, including lesion volumes for gross left hemisphere frontal, subcortical, and posterior regions; lesion volume data were available for seven participants).

Participants were administered the Comprehensive Aphasia Test (CAT; Swinburn, Porter, & Howard, 2004) in order to characterize their pattern of language impairments. The CAT provides a measure of overall aphasia severity, the Modality Mean T-Score, as well as subtests that measure performance at multiple linguistic levels (word, sentence, and connected discourse) in both spoken and written modalities. Both the Modality Mean and the subtest scores are T-Scores, scaled scores with a mean of 50 and a standard deviation of 10. A T-Score of 50 thus indicates that an individual's performance is in the middle of the distribution for the CAT's normative sample of 113 PWA, whereas a T-Score of 60 would be one standard deviation from this mean. A Modality Mean T-score of 68.2 is considered the cutoff for the presence of aphasia on the CAT (Swinburn et al., 2004). Modality-Mean T-Scores for study participants as well as T-Scores on several CAT subtests are provided in Table 2.

The participants had mild to moderate overall language impairments, with Modality Mean T-Scores ranging from 45.8 to 66.1 (mean: 57.6). The CAT also contains a cognitive screening battery, to identify the presence of frank non-language cognitive impairments (such as visuo-perceptual impairments, or impairment in object recognition and recall). The participants did not show evidence of significant non-language cognitive impairments on this battery, with a mean cognitive battery raw score of 34.7 out of 38, with no participant scoring lower than 30 out of 38.

Medical records and self-report of the participants with LH damage indicated no premorbid history of head injury with cognitive sequelae, progressive neurodegenerative disorder, or other speech-language or neuropsychological disorders. PWA were significantly older than the unimpaired control adults ($t(43) = -2.80$; $p < .05$).

MATERIALS

Participants completed a probe selection task. First, participants read sentence pairs using a self-paced presentation paradigm. The 3×2 design crossed idiom type (highly-familiar vs. less-familiar vs. a literal paraphrase of the idioms' figurative meaning) with the position of a figuratively-biased context sentence (before vs. after the idiom sentence; 1a-f). Participants then chose which of four probe words (figurative target, literal lure, unrelated concrete lure, unrelated abstract lure) went best with the sentence pair. There were 34 items with six conditions each, as shown below (see Appendix A for full list of stimuli; idioms are italicized):

- (1a) The party was a disaster. Carey was *tearing his hair out* in the kitchen. (highly-familiar idiom; context before)
- (1b) The party was a disaster. Carey was *having kittens* in the kitchen. (less familiar idiom; context before)
- (1c) The party was a disaster. Carey was *worried and angry* in the kitchen. (literal paraphrase; context before)
- (1d) Carey was *tearing his hair out* in the kitchen. The party was a disaster. (highly-familiar idiom; context after)
- (1e) Carey was *having kittens* in the kitchen. The party was a disaster. (less familiar idiom; context after)
- (1f) Carey was *worried and angry* in the kitchen. The party was a disaster. (literal paraphrase; context after)

Each sentence pair contained an idiom sentence and a context sentence. The context sentence strongly biased a figurative interpretation of the idiom and appeared either before or after the idiom sentence. The idiom sentence consisted of a neutral precritical region (“Carey was”), a critical region containing either an idiom or a literal paraphrase (“tearing his hair out/having kittens/worried and angry”), and a neutral postcritical region (“in the kitchen”). Only the critical idiom region varied across conditions.

After reading each pair of sentences, participants chose the most appropriate probe word from an array of four: a figurative target (“tantrum”), a literal lure that differed depending on the idiom (“brush” or “puppies”), an unrelated concrete lure (“blanket”) or an unrelated abstract lure (“trust”). In the case of the literal paraphrase, a second unrelated concrete lure (“tomato”) was used instead of a literal lure.

Additionally, 30 filler items were included. These items were pairs of sentences that did not contain idioms (for example, “The sun shone over the mountains. Rain was predicted for next week.”). For filler sentences, the array of probe words included a target (“cloud”), a concrete unrelated lure (“stone”), and two abstract unrelated lures (“tense”, “wish”).

NORMING

To verify the familiarity of the idioms, we conducted a norming study. A community sample of 11 unimpaired older adults participated. All were native speakers of English, and were between 53 and 68 years of age ($M = 62$; $SD = 5.4$). Participants rated each idiom on a scale of 1 to 7 (1 = *very familiar*, 7 = *very unfamiliar*). Idioms in the lower-familiarity condition ($M = 2.57$; $SD = 1.29$) were rated as less familiar than idioms in the higher-familiarity condition ($M = 1.41$; $SD = .53$; $t(33) = -5.29$; $p < .05$).

Additionally, we asked participants to generate a definition for each idiom. This test was intended to verify that the figurative meaning supported by the context sentence was similar to participants’ natural intuition regarding the idiom’s meaning. Written responses were coded based on whether they matched the exact meaning of the idiom as generated by the researchers (1 = match, 0 = no match). Participants provided the correct definition for lower-

familiarity idioms ($M = .69$; $SD = .34$) less often than for higher- familiarity idioms ($M = .86$; $SD = .14$; $t(33) = 3.06$; $p < .05$).

Finally, we measured the semantic distance between each probe word and the final content word of each idiom using *snaut* (Mandera, Keuleers, & Brysbaert, 2017). In *snaut*, the semantic distance between two items is calculated based on co-occurrences in large text corpora. We found a significant effect of probe type ($F(3,99) = 76.66$; $p < .05$). In particular, the semantic distance between the final content word of each idiom and the literal lure was significantly less than the semantic distance between the final content word and any of the other probe words ($p < .05$). Additionally, the semantic distance between the final content word and probe was greater for abstract lures than for the figurative target or literal lure ($p < .05$). We will return to this point in the Discussion.

PROCEDURE

Unimpaired participants were tested in a lab at the University of Pittsburgh in a single session lasting approximately 1-2 hours. PWA were tested either in the lab or in their homes, according to their preferences and mobility requirements. PWA completed two sessions of testing lasting approximately 3 hours each. In the first session, PWA completed several tasks intended to assess their cognitive, linguistic, and semantic-memory functioning. The first of these tests, the CAT, characterizes language impairment on several dimensions, including overall severity (Mean Modality T-Score) and comprehension and production of language at word, sentence, and discourse levels, both written and oral. PWA primarily completed the present experiment during the first testing session, although to avoid fatigue the present experiment was occasionally conducted during the second session.

During the experiment, both groups of participants viewed items on a personal laptop computer using the E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA), and responded using the laptop's number pad. All participants in the study provided informed consent before participating. All participants were then given questionnaires collecting demographic information such as age, educational and language background, and medical history. The spouses or caregivers of PWA sometimes completed these forms on the participant's behalf. Following consenting and collection of demographic information, participants completed the self-paced reading task. Instructions were displayed on the screen and read aloud to participants, followed by five practice items. One practice item contained an idiom, although participants were not explicitly instructed to interpret sentences idiomatically. The experimenter verified that participants understood the study procedures before starting the main experiment, as well as gave feedback on the answers provided during the practice session. Participants read 34 sentences like (1) above, as well as 30 filler sentences. The experimental sentences appeared in one of the six conditions above using a Latin Square design, such that participants only saw each experimental item in one condition and an equal number of items in each condition. There were either 5 or 6 observations per cell, with most participant/condition combinations having 6 observations.

Sentences were presented in a phrase-by-phrase moving window format using the E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). An underline preview preceded

each item. Participants pressed the “0” key on the laptop’s number pad to reveal each segment of the item. After each item, participants saw a screen divided into four quadrants, each containing one of the probe words described above. Participants used keys 1–4 on the number pad to indicate which word was the most appropriate match for the sentences they had just read. Locations of the probe words were counterbalanced such that each word was equally likely to appear in each of the quadrants. Participants were encouraged to take breaks during the study if needed.

RESULTS

Data were analyzed using linear mixed effects models (reaction time) and generalized linear mixed effects models (accuracy; Baayen, 2008) in the R statistical computing package (R Development Core Team, 2013; ver. 3.0.1) and using the lme4 package (Bates, Maechler, Bolker, & Walker, 2015; ver. 1.1–7). P-values were obtained using the lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2016; ver. 2.0–20). Models were fit using the fullest random effects structure that would support convergence (Barr, Levy, Scheepers, & Tily, 2013). Models contained fixed effects of sentence order and familiarity and random intercepts of participant and item, as well as by-participant and by-item random slopes for sentence order and familiarity. In cases of non-convergence, random effects were removed sequentially until convergence was achieved. Outcome variables for the probe selection task were reaction time to select the probe word and accuracy of probe selection. We also analyzed reading time. Because the words in the critical idiom region necessarily varied across conditions, we analyzed reading time data only on the neutral postcritical region, which was identical across conditions within each item. Focusing analysis on this region means that the between-condition comparison is not confounded by any lexical differences.

We created three comparisons of interest using contrast coding. The first comparison, hereafter referred to as the literality comparison, compared responses in the literal control condition to responses in the two idiom conditions regardless of familiarity. This comparison allowed us to determine whether comprehension is facilitated for idiomatic sentences compared to literal paraphrases. The second comparison compared responses to the lower familiarity idiom to responses to the higher familiarity idiom, allowing us to determine whether higher familiarity idioms confer processing advantages (Cronk et al, 1993; Libben & Titone, 2008; Titone & Libben, 2014). We will refer to this comparison as the familiarity comparison. Finally, the last comparison tested the effect of sentence order, looking for facilitative processing when context precedes the critical region, regardless of literality (Holsinger, 2013; Ortony, Schallert, Reynolds, & Antos, 1978). Interaction terms for these comparisons were also included in the models.

READING TIME

Reading time data from all regions can be seen in Table 3; however, as noted above, only the postcritical region was analyzed. We constructed a linear mixed effects model containing fixed effects of sentence order, familiarity, and population, random effects of participant and item, and random slopes of familiarity and sentence order within participants and items. An effect of population showed that PWA were significantly slower to read the postcritical

region than were older unimpaired adults ($\hat{\beta} = 1176.65$; $SE=153.11$; $t=7.69$; $p<.05$). Based on this significant difference between populations, we proceeded with analyses separately for each group.

OLDER UNIMPAIRED ADULTS

The model contained fixed effects of sentence order and familiarity, random effects of participant and item, the random slope of familiarity within participants and items, and the random slope of sentence order within participants. Participants were faster to read the postcritical region when the context sentence appeared after the idiom than when it appeared before ($\hat{\beta} = -104.8$; $SE=38.47$; $t=-2.73$; $p<.05$). There were no effects of familiarity or literality, and no interactions.

PEOPLE WITH APHASIA

The model contained fixed effects of sentence order and familiarity, random effects of participant and item, and the random slopes of familiarity and sentence order within participants. Participants were faster to read the postcritical region when the context sentence appeared after the idiom ($\hat{\beta} = 402.69$; $SE=160.15$; $t=2.51$; $p<.05$). Participants were likewise faster to read the postcritical region when they had just read a literal paraphrase compared to an idiom ($\hat{\beta} = 530.44$; $SE=169.24$; $t=3.13$; $p<.05$). Finally, participants were faster when they had just read a higher-familiarity idiom compared to a lower-familiarity idiom ($\hat{\beta} = -526.23$; $SE=155.31$; $t=-3.39$; $p<.05$).

PROBE SELECTION ACCURACY

Probe-selection accuracy for both populations across conditions is reported in Table 4.

OLDER UNIMPAIRED ADULTS

Because accuracy data were binomial, generalized linear mixed effects models were used to analyze responses. The model contained fixed effects of sentence order and familiarity and random effects of participant and item; models containing random slopes of sentence order and familiarity within participants and items did not converge. Figurative target responses were coded as hits and all other responses were coded as misses. There was a significant effect of familiarity such that seeing a higher familiarity idiom increased the odds of choosing the target by 4.22 times ($\hat{\beta} = 1.44$; $SE=0.32$; $z=4.58$; $p<.05$). However, there were no effects of literality ($\hat{\beta} = -0.52$; $SE=0.37$; $z=-1.42$; $p=.16$) or sentence order ($\hat{\beta} = -0.26$; $SE=0.25$; $z=-1.01$; $p=.31$), and no interactions.

PWA

The same model was used for PWA as for older unimpaired adults, because again models containing random slopes of familiarity and sentence order within participants and items did not converge. There was a significant effect of literality: seeing a figurative sentence decreased the odds of a correct response by .24 times ($\hat{\beta} = -1.43$; $SE=0.31$; $z=-4.67$; $p<.05$). But seeing a higher familiarity idiom increased the odds of a correct response by 1.69 times ($\hat{\beta} = 0.51$; $SE=0.24$; $z=2.17$; $p<.05$). Finally, seeing the context sentence after the

idiom decreased the odds of choosing the correct probe by .58 times ($\hat{\beta} = -0.55$; $SE=0.20$; $z=-2.70$; $p<.05$).

PROBE SELECTION REACTION TIME

OLDER UNIMPAIRED ADULTS—Probe-selection reaction time for both populations across conditions is reported in Table 4 (correct responses) and Table 5 (errors). The model contained fixed effects of sentence order and familiarity, random effects of participant and item, and random slopes of familiarity and sentence order within participants and items. Only correct responses were analyzed. An effect of literality showed that older unimpaired adults were faster to respond to literal control sentences compared to sentences containing idioms, ($\hat{\beta} = 379.8$; $SE=167.7$; $t=2.27$; $p<.05$). Unimpaired adults were also faster to respond to more familiar idioms than to less familiar idioms ($\hat{\beta} = -536.9$; $SE=208.1$; $t=-2.58$; $p<.05$). There was no effect of sentence order and no interactions.

PEOPLE WITH APHASIA—The same model was used for PWA as for older unimpaired adults. Again, only correct responses were analyzed. There were no effects of literality ($\hat{\beta} = 290.6$; $SE=651.63$; $t=.45$; $p=0.66$), idiom familiarity ($\hat{\beta} = 896.6$; $SE=944.7$; $t=.95$; $p=0.36$), or sentence order ($\hat{\beta} = 493.6$; $SE=621.6$; $t=.79$; $p=0.44$), and no interactions.

ERROR ANALYSES

The distribution of errors across conditions is presented in Table 6.

To examine the pattern of literal errors and abstract errors in PWA and unimpaired controls, we created a linear mixed effects model comparing rates of choosing the literal lure to rates of choosing the abstract lure. The concrete lure was not included in analyses because it was hardly ever chosen. Because unimpaired adults made very few errors, we transformed the data with the empirical logit, grouped over items, to better allow models to converge. The model contained fixed effects of sentence order, familiarity, and population and the random effect of participant. Literal errors were coded as “hits” and abstract errors were coded as “misses”. There was a significant interaction between sentence order and population ($\hat{\beta} = 0.026$; $SE=0.012$; $t=2.07$; $p<.05$). Unimpaired adults made almost entirely literal errors and no abstract errors when context appeared before the idiom. When context appeared after the idioms, unimpaired adults made slightly fewer literal errors and slightly more abstract errors than when context appeared before the idioms. However, PWA made literal and abstract errors at the same rate regardless of sentence order.

To explore this interaction in more detail, we created a generalized linear mixed effects model comparing rates of literal errors to rates of abstract errors in PWA. We included fixed effects of sentence order and familiarity, random intercepts of participant and item number, and random slopes of sentence order within participants and items; models containing the random slopes of familiarity within participants and items did not converge. There were no reliable effects of sentence order ($\hat{\beta} = 0.14$; $SE=0.53$; $z=0.26$; $p=.79$) or familiarity ($\hat{\beta} = 0.15$; $SE=0.40$; $z=0.37$; $p=.71$), and there was no interaction.

To determine whether PWA made more abstract errors than did unimpaired controls, we used a generalized linear mixed effects model comparing rates of abstract errors in both populations. The model included the fixed effect of population and random intercepts of participant and item number. We found a significant effect of population such that having aphasia increased the odds of making an abstract error by 5.31 times ($\hat{\beta} = 1.67$; $SE=0.42$; $z=3.95$; $p<.05$).

GENERAL DISCUSSION

The current study found that PWA were impaired in idiom comprehension compared to neurotypical adults, consistent with previous findings (e.g., Cacciari et al., 2006; Cieslicka et al., 2011; Nenonen, Niemi, & Laine, 2011; Papagno et al., 2004). However, in situations in which figurative meanings were easier to access, their accuracy improved: PWA were more accurate in choosing a figurative target after reading higher-familiarity idioms and when idioms were preceded by a figuratively-biased context (cf. Cronk et al., 1993; Libben & Titone, 2008; Titone & Libben, 2014; Qualls et al., 2003). The separate effects of idiom familiarity and sentence order suggest that difficulty activating figurative meanings likely plays a significant role in idiom comprehension impairment in aphasia. In contrast, neurotypical controls showed no differences in comprehension between idiomatic sentences and literal paraphrases, and only the familiarity manipulation affected their accuracy. This pattern in neurotypical controls is congruent with data in younger participants showing that familiarity is an extremely strong predictor of idiom comprehension (Nordmann et al., 2014), and suggests that idiom comprehension mechanisms in older neurotypical adults are largely intact and unaffected by cognitive aging.

The error patterns in the current study constrain previous hypotheses regarding the locus of idiom comprehension impairment in PWA. As noted above, PWA were more accurate on more familiar idioms and in figurative-supporting contexts, which is consistent with Cacciari and colleagues' account under which PWA have difficulty accessing figurative meanings. However, if an inability to suppress literal meanings had been the sole driver of idiom impairment in PWA, we would have expected to see similarly high rates of literal errors across conditions. This is because the literal probe should have activated the literal meaning during the matching task in every condition. Similarly, if the sole driver of idiom impairment in PWA were insensitivity to figurative interpretation cues that were properties of only the literal string (e.g., syntactic ill-formedness), we would have expected to see similarly high rates of literal errors across conditions. To be clear, the current findings do not rule out the possibility that these mechanisms could be at play, but they suggest that they are not the whole story. Instead, these findings indicate that there must be additional or alternative mechanisms in which the accessibility of figurative meanings plays an important role.

It is also the case that none of the previously hypothesized mechanisms behind idiom impairment in PWA straightforwardly predict the finding that PWA's rates of abstract and literal errors were similarly high. One possible account of the high rate of abstract errors in the current study is that if abstract words are loosely associated with many concepts (Kiran et al., 2009), and additionally are weakly represented in aphasia (Barry & Gerhand, 2003; Berndt et al., 2002; Kiran et al., 2009), then they may appear to be better matches for

similarly weakly represented idioms than better-represented concrete words. These loose associations between abstract words and idioms may be difficult to suppress especially when idiom representations are degraded, resulting in similarly high error rates for both abstract and literal lures. This is consistent with the pattern across conditions in the current study: PWA chose literal and abstract lures at the same rates after reading idiomatic sentences, but largely ignored the abstract lure in the literal paraphrase conditions. This suggests that the abstract lure is as appealing as the literal lure for PWA only for idiomatic conditions, and that there is nothing unusual about the abstract lure when it is not associated with an idiom. This pattern is notably different from that shown by neurotypical controls, who made almost exclusively literal errors. Furthermore, error patterns in the present study cannot be easily explained by an overall reduction in accuracy for PWA: the concrete lure was almost never selected, suggesting that the high literal and abstract error rates truly reflect distinct mechanisms at play during idiom comprehension in aphasia.

PWA's high rate of abstract errors could be driven by properties of abstract word representations. One possibility, noted above, is that abstract words might be weakly represented and loosely associated with many concepts, making them appear to be better matches to weakly represented idiom meanings than concrete words. A potential mechanism for this comes from recent work on abstract concept representation, which questions traditional accounts under which abstract and concrete concepts are represented in separate semantic systems (e.g., Shallice & Cooper, 2013). Instead, concrete and abstract representations are hypothesized to overlap to some degree, but concrete concepts may additionally be grounded in sensorimotor representations, whereas abstract concepts may additionally be grounded in affective/emotional systems (Vigliocco et al., 2014). If this is the case, then given that idioms refer to abstract concepts and largely describe affective states or events with high emotional valence (Citron et al., 2016), the idiom meanings and abstract lures of the current study may both have been grounded in affective representations and thus have had some representational overlap. This may have made these lures especially tempting alternatives when the true figurative meaning was inaccessible or degraded. Although this explanation is highly speculative, it suggests that investigation of the representational status of both idioms and ambiguous concepts can improve our understanding of patterns of impairment in aphasia, as well as language comprehension in general.

An alternative, though less likely, explanation for the observed pattern of errors is that they reflect spreading activation from the individual words in the idioms to associated words. This is particularly the case for the literal probe words, which were closer in semantic distance to the last content word in each idiom than were any of the other probes, raising the possibility that the high rates of literal errors seen in the present study could be due to spreading activation rather than literal misinterpretation of the idioms. Although this is indeed a possibility, the presence of a multiword post-critical region between the idiom and probe array makes it less likely for associations activated by the individual words in the idiom to carry over into the probe selection task. Additionally, if spreading activation between idiom content words and literal probe words had affected probe choice, we might have expected to see more literal errors when the context sentence appeared before the idiom, thereby reducing the distance between idiom and probe array. However, this was not the case. Finally, the high rate of abstract errors in PWA argues against a spreading

activation account: the semantic distance between content words and probes was significantly smaller for literal lures than for abstract lures, yet PWA chose literal and abstract lures at the same rate, contrary to what we would expect if spreading activation alone was driving lure choice.

It is worth considering whether the degree or nature of PWA's idiom-comprehension impairments depend on their lesion location and volume. For instance, individuals with right versus left hemisphere lesions, or anterior versus posterior left hemisphere lesions, might differ in their ability to access figurative meanings. We had lesion volume data for 7 participants, all of whom had unilateral left hemisphere lesions. This fact means that we cannot address the potential contribution of right-hemisphere lesions to idiom comprehension impairments with the current sample. However, these participants' left-hemisphere lesions varied in location and size (see Table 1 for gross lesion volume data). Visual inspection of individual participants' lesion data, as well as individual accuracy and abstract error rates, showed no clear relationship between lesion site and performance, for either accuracy or abstract errors. It's possible that different lesion patterns result in different mechanisms of impairment playing stronger or weaker roles in idiom comprehension in PWA. However, the results of the present study do not allow us to draw any firm conclusions about this relationship, and the lesion correlates of impaired figurative language comprehension thus remain elusive.

The current study explored the mechanisms underlying idiom comprehension in PWA, focusing on interference from literal meanings, recognition of a figurative interpretation, and difficulty processing abstract words and concepts. The findings suggest that difficulty accessing figurative meanings may be a key contributor to idiom impairment in aphasia. Furthermore, they suggest that idiomatic figurative meanings may be represented similarly to abstract concepts for PWA. These findings thus importantly open the door to future work exploring the contribution that abstractness might have on idiom processing, and on idiom-comprehension impairments among PWA.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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APPENDIX A

Context Location	Idiom Familiarity		Target		
before idiom	more familiar	John was sick in bed all week.	Finally he	<i>kicked the bucket</i>	cemetery
	less familiar			<i>bought the farm</i>	cemetery
	literal paraphrase			<i>died</i>	cemetery
after idiom	more familiar	John finally		<i>kicked the bucket</i>	cemetery
	less familiar			<i>bought the farm</i>	cemetery
	literal paraphrase			<i>died</i>	cemetery
before idiom	more familiar	The new project promised to be interesting	Molly was	<i>straining at the leash</i>	eager
	less familiar			<i>first out of the gate</i>	eager
	literal paraphrase			<i>excited to start</i>	eager
after idiom	more familiar	Molly was		<i>straining at the leash</i>	eager
	less familiar			<i>first out of the gate</i>	eager
	literal paraphrase			<i>excited to start</i>	eager
before idiom	more familiar	The controversial decision upset many people.	Addie	<i>didn't have a horse in the race</i>	investment
	less familiar			<i>didn't have a dog in the fight</i>	investment
	literal paraphrase			<i>wasn't interested</i>	investment
after idiom	more familiar	Addie		<i>didn't have a horse in the race</i>	investment
	less familiar			<i>didn't have a dog in the fight</i>	investment
	literal paraphrase			<i>wasn't interested</i>	investment
before idiom	more familiar	Dan and Dave's store had been busy all day.	Dan	<i>was dead on his feet</i>	exhaustion
	less familiar			<i>was out of gas</i>	exhaustion
	literal paraphrase			<i>was incredibly tired</i>	exhaustion
after idiom	more familiar	Dan		<i>was dead on his feet</i>	exhaustion
	less familiar			<i>was out of gas</i>	exhaustion
	literal paraphrase			<i>was incredibly tired</i>	exhaustion
before idiom	more familiar	All the workers had gathered for a discussion	Gloria was	<i>in a tight spot</i>	trouble
	less familiar			<i>in a jam</i>	trouble
	literal paraphrase			<i>having problems</i>	trouble
after idiom	more familiar	Gloria was		<i>in a tight spot</i>	trouble
	less familiar			<i>in a jam</i>	trouble
	literal paraphrase			<i>having problems</i>	trouble
before idiom	more familiar	The party was a disaster.	Carey	<i>was tearing his hair out</i>	tantrum
	less familiar			<i>was having kittens</i>	tantrum
	literal paraphrase			<i>was worried and angry</i>	tantrum
after idiom	more familiar	Carey		<i>was tearing his hair out</i>	tantrum

Context Location	Idiom Familiarity		Target	
	less familiar	<i>was having kittens</i>	tantrum	
	literal paraphrase	<i>was worried and angry</i>	tantrum	
before idiom	more familiar	Everyone was sad that vacation was over.	<i>back to the grind</i>	toil
	less familiar		<i>back to the salt mines</i>	toil
	literal paraphrase		<i>back to work</i>	toil
after idiom	more familiar	It was time to go	<i>back to the grind</i>	toil
	less familiar		<i>back to the salt mines</i>	toil
	literal paraphrase		<i>back to work</i>	toil
before idiom	more familiar	The painting turned out to be a forgery.	<i>been taken for a ride</i>	fraud
	less familiar		<i>bought a pig in a poke</i>	fraud
	literal paraphrase		<i>been fooled</i>	fraud
after idiom	more familiar	Jay had	<i>been taken for a ride</i>	fraud
	less familiar		<i>bought a pig in a poke</i>	fraud
	literal paraphrase		<i>been fooled</i>	fraud
before idiom	more familiar	Finally the novel was ready to be published.	<i>had broken her back</i>	labor
	less familiar		<i>had kept her shoulder to the wheel</i>	labor
	literal paraphrase		<i>had worked very hard</i>	labor
after idiom	more familiar	Jordan	<i>had broken her back</i>	labor
	less familiar		<i>had kept her shoulder to the wheel</i>	labor
	literal paraphrase		<i>had worked very hard</i>	labor
before idiom	more familiar	Marco was very politically active.	<i>chose his battles wisely</i>	planned
	less familiar		<i>picked the hill he wanted to die on</i>	planned
	literal paraphrase		<i>decided what he cared about</i>	planned
after idiom	more familiar	Marco	<i>chose his battles wisely</i>	planned
	less familiar		<i>picked the hill he wanted to die on</i>	planned
	literal paraphrase		<i>decided what he cared about</i>	planned
before idiom	more familiar	Jean was dissatisfied with her neighborhood.	<i>to hit the road</i>	travel
	less familiar		<i>to pull up stakes</i>	travel
	literal paraphrase		<i>to get in her car</i>	travel
after idiom	more familiar	It was time	<i>to hit the road</i>	travel
	less familiar		<i>to pull up stakes</i>	travel
	literal paraphrase		<i>to get in her car</i>	travel
before idiom	more familiar	Everyone had asked Anne for help.	<i>run out of steam</i>	exhausted
	less familiar		<i>at the end of her rope</i>	exhausted

Context Location	Idiom Familiarity		Target		
	literal paraphrase		<i>drained of energy</i>		exhausted
after idiom	more familiar	Anne had (was)	<i>run out of steam</i>	and wanted to leave	Everyone had asked her for help.
	less familiar		<i>at the end of her rope</i>		exhausted
	literal paraphrase		<i>drained of energy</i>		exhausted
before idiom	more familiar	The family was struggling to survive.	Joe	<i>kept his head in the sand</i>	and did nothing
	less familiar			<i>turned his back on them</i>	dismiss
	literal paraphrase			<i>ignored their problems</i>	dismiss
after idiom	more familiar	Joe	and did nothing	<i>kept his head in the sand</i>	The family was struggling to survive.
	less familiar			<i>turned his back on them</i>	dismiss
	literal paraphrase			<i>ignored their problems</i>	dismiss
before idiom	more familiar	Andy's client refused to sign the contract.	He	<i>had his back to the wall</i>	and was getting nervous
	less familiar			<i>was in a pickle</i>	stuck
	literal paraphrase			<i>had no way out</i>	stuck
after idiom	more familiar	Andy	and was getting nervous	<i>had his back to the wall</i>	His client refused to sign the contract.
	less familiar			<i>was in a pickle</i>	stuck
	literal paraphrase			<i>had no way out</i>	stuck
before idiom	more familiar	The bank manager got fired yesterday.	He	<i>had sticky fingers</i>	and finally got caught
	less familiar			<i>had his hand in the till</i>	thief
	literal paraphrase			<i>was stealing from the company</i>	thief
after idiom	more familiar	The bank manager	and finally got caught	<i>had sticky fingers</i>	He got fired yesterday.
	less familiar			<i>had his hand in the till</i>	thief
	literal paraphrase			<i>was stealing from the company</i>	thief
before idiom	more familiar	Karen just got a new job.	She was	<i>out of her league</i>	for the first week
	less familiar			<i>out of her depth</i>	struggle
	literal paraphrase			<i>trouble keeping up</i>	struggle
after idiom	more familiar	Karen was	for the first week	<i>out of her league</i>	She just got a new job.
	less familiar			<i>out of her depth</i>	struggle
	literal paraphrase			<i>trouble keeping up</i>	struggle
before idiom	more familiar	The lecture was hard to listen to.	Eleanor	<i>had her head in the clouds</i>	all afternoon
	less familiar			<i>was on the moon</i>	daydream
	literal paraphrase			<i>didn't pay attention</i>	daydream
after idiom	more familiar	Eleanor	all afternoon	<i>had her head in the clouds</i>	The lecture was hard to listen to.
	less familiar			<i>was on the moon</i>	daydream
	literal paraphrase			<i>didn't pay attention</i>	daydream

Context Location	Idiom Familiarity					Target
before idiom	more familiar	Avery's grandfather was very old.	He	<i>went to meet his maker</i>	last night	funeral
	less familiar			<i>cashed in his chips</i>		funeral
	literal paraphrase			<i>died in his sleep</i>		funeral
after idiom	more familiar	Avery's grandfather	He was very old.	<i>went to meet his maker</i>	last night	funeral
	less familiar			<i>cashed in his chips</i>		funeral
	literal paraphrase			<i>died in his sleep</i>		funeral
before idiom	more familiar	Adrian hasn't worked in six months.	He was	<i>left up a creek</i>	and was very upset	stranded
	less familiar			<i>left up a blind alley</i>		stranded
	literal paraphrase			<i>left with no options</i>		stranded
after idiom	more familiar	Adrian was	He hasn't worked in six months.	<i>left up a creek</i>	and was very upset	stranded
	less familiar			<i>left up a blind alley</i>		stranded
	literal paraphrase			<i>left with no options</i>		stranded
before idiom	more familiar	Stephanie loved skydiving.	She	<i>lived on the edge</i>	and loved her life	danger
	less familiar			<i>sailed close to the wind</i>		danger
	literal paraphrase			<i>enjoyed risky activities</i>		danger
after idiom	more familiar	Stephanie	She loved skydiving	<i>lived on the edge</i>	and loved her life	danger
	less familiar			<i>sailed close to the wind</i>		danger
	literal paraphrase			<i>enjoyed risky activities</i>		danger
before idiom	more familiar	Molly discovered Brad's mistake.	He had to	<i>eat his words</i>	yesterday	apology
	less familiar			<i>eat humble pie</i>		apology
	literal paraphrase			<i>admit he was wrong</i>		apology
after idiom	more familiar	Brad had to	Molly had discovered his mistake.	<i>eat his words</i>	yesterday	apology
	less familiar			<i>eat humble pie</i>		apology
	literal paraphrase			<i>admit he was wrong</i>		apology
before idiom	more familiar	The new gossip shocked the friends.	Michael	<i>had upset the apple cart</i>	and everyone was unhappy	mischievous
	less familiar			<i>had stirred the pot</i>		mischievous
	literal paraphrase			<i>liked to cause trouble</i>		mischievous
after idiom	more familiar	Michael	The new gossip shocked the friends.	<i>had upset the apple cart</i>	and everyone was unhappy	mischievous
	less familiar			<i>had stirred the pot</i>		mischievous
	literal paraphrase			<i>liked to cause trouble</i>		mischievous
before idiom	more familiar	The wrong horse won the race.	The lost bet had left Mel	<i>in the red</i>	and very worried	debt
	less familiar			<i>in the hole</i>		debt
	literal paraphrase			<i>owing money</i>		debt
after idiom	more familiar	The lost bet had left Mel	The wrong horse won the race.	<i>in the red</i>	and very worried	debt
	less familiar			<i>in the hole</i>		debt
	literal paraphrase			<i>owing money</i>		debt

Context Location	Idiom Familiarity					Target
before idiom	more familiar	The interview took all day.	Ben	<i>didn't make the cut</i>	and went home	failure
	less familiar			<i>fell at the first hurdle</i>		failure
	literal paraphrase			<i>performed very badly</i>		failure
after idiom	more familiar	Ben		<i>didn't make the cut</i>	The interview took all day.	failure
	less familiar			<i>fell at the first hurdle</i>		failure
	literal paraphrase			<i>performed very badly</i>		failure
before idiom	more familiar	The party lasted all night.	Shane	<i>was feeling no pain</i>	after the first hour	drunk
	less familiar			<i>was far gone</i>		drunk
	literal paraphrase			<i>had a lot of beer</i>		drunk
after idiom	more familiar	Shane		<i>was feeling no pain</i>	The party lasted all night.	drunk
	less familiar			<i>was far gone</i>		drunk
	literal paraphrase			<i>had a lot of beer</i>		drunk
before idiom	more familiar	Bill came to work very late.	He was	<i>under the influence</i>	last night	beer
	less familiar			<i>out of his tree</i>		beer
	literal paraphrase			<i>very drunk</i>		beer
after idiom	more familiar	Bill was		<i>under the influence</i>	He came to work very late.	beer
	less familiar			<i>out of his tree</i>		beer
	literal paraphrase			<i>very drunk</i>		beer
before idiom	more familiar	Amanda was depressed by the sad news.	She	<i>had a few</i>	last night	wine
	less familiar			<i>fell off the wagon</i>		wine
	literal paraphrase			<i>drank heavily</i>		wine
after idiom	more familiar	Amanda		<i>had a few</i>	She was depressed by the sad news.	wine
	less familiar			<i>fell off the wagon</i>		wine
	literal paraphrase			<i>drank heavily</i>		wine
before idiom	more familiar	No one knew Cory and Sam had bought the company.	Finally they	<i>showed their hand</i>	last night	reveal
	less familiar			<i>put their cards on the table</i>		reveal
	literal paraphrase			<i>made an announcement</i>		reveal
after idiom	more familiar	Finally Cory and Sam		<i>showed their hand</i>	No one knew they had bought the company.	reveal
	less familiar			<i>put their cards on the table</i>		reveal
	literal paraphrase			<i>made an announcement</i>		reveal
before idiom	more familiar	Joe got into a car accident last week.	He's	<i>pushing up daisies</i>	now	gravestone
	less familiar			<i>going home in a box</i>		gravestone
	literal paraphrase			<i>dead and buried</i>		gravestone
after idiom	more familiar	Joe		<i>is pushing up daisies</i>	He got into a car accident last week.	gravestone
	less familiar			<i>is going home in a box</i>		gravestone
	literal paraphrase			<i>is dead and buried</i>		gravestone
before idiom	more familiar	No one made the deadline.	Mark and Kelsey had	<i>gotten their wires crossed</i>	last week	confusion

Context Location	Idiom Familiarity					Target
	less familiar			<i>muddied the waters</i>		confusion
	literal paraphrase			<i>given the wrong instructions</i>		confusion
after idiom	more familiar	Mark and Kelsey had	<i>muddied the waters</i>	last week	No one made the deadline.	confusion
	less familiar					confusion
	literal paraphrase					confusion
before idiom	more familiar	Bobby worked a dangerous job.	We learned that he	<i>bit the dust</i>	the other day	coffin
	less familiar					coffin
	literal paraphrase					coffin
after idiom	more familiar	We learned that Bobby	<i>bit the dust</i>	the other day	He worked a dangerous job.	coffin
	less familiar					coffin
	literal paraphrase					coffin
before idiom	more familiar	Frankie's manager was an unpleasant person.	He put Frankie	<i>through the wringer</i>	all last year	stress
	less familiar					stress
	literal paraphrase					stress
after idiom	more familiar	Frankie's manager put (gave) her	<i>through the wringer</i>	all last year	He was an unpleasant person.	stress
	less familiar					stress
	literal paraphrase					stress
before idiom	more familiar	Maddie left the table abruptly.	She had to	<i>take a leak</i>	in the middle of dinner	toilet
	less familiar					toilet
	literal paraphrase					toilet
after idiom	more familiar	Maddie had to	<i>take a leak</i>	in the middle of dinner	She left the table abruptly.	toilet
	less familiar					toilet
	literal paraphrase					toilet
before idiom	more familiar	Terry is a respectable doctor now.	When he was young	<i>he painted the town red</i>	and had a great time	wild
	less familiar					wild
	literal paraphrase					wild
after idiom	more familiar	When Terry was young	<i>he painted the town red</i>	and had a great time	He's a respectable doctor now.	wild
	less familiar					wild
	literal paraphrase					wild

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Highlights

Three potential mechanisms of idiom impairment in aphasia were explored

Difficulty accessing figurative meanings may underlie idiom impairment in aphasia

Idiomatic figurative meanings may be represented similarly to abstract concepts for PWA

Table 1

Demographics of Participants With Aphasia

Partic.	Sex	Age at Testing	Months post-onset	Occupation	Education	LH Frontal Lesion %	LH Subcortical lesion %	LH Posterior Lesion %
201	F	71	39	Manufacturing worker	High school	10.9	10.2	5.9
202	F	70	63	Manager - grocery store	High school	NA	NA	NA
203	M	62	68	Electronic engineer / computer programmer	BS in Computer Science	NA	NA	NA
204	F	68	69	Medical assistant	Associate's degree	NA	NA	NA
205	F	54	71	Teacher	Masters of Education	30.9	8.1	0.0
206	F	50	94	Case worker	Bachelor's degree	NA	NA	NA
207	F	64	30	Housewife	High School GED	1.5	1.8	2.2
209	M	65	70	Realtor	20 years	8.2	0.0	26.2
211	M	74	19	Institutional researcher	PhD	5.0	0.3	3.2
212	M	78	120	Professor	PhD in English	2.3	2.6	37.0
214	M	80	136	Retired	PhD	0.2	0.0	5.2
216	M	67	52	Engineer	BS	1.0	2.9	0.0
217	M	67	151	Sheet metal worker	14 years	NA	NA	NA
219	M	82	23	Metallurgical engineer	College plus some graduate work	NA	NA	NA
220	M	67	35	Engineer	High school	NA	NA	NA
221	M	71	17	Private contractor	Bachelor's degree, plus some graduate work	NA	NA	NA

Table 2

Selected Results From the Comprehensive Aphasia Test

Partic.	CAT Modality-Mean	CAT Written Sentence Comp.	CAT Written Complex Sentence Comp.	Object Naming T score	Action Naming T Score	Word Fluency	Spoken Picture Desc. T Score	Sentence Rep.
	T score	T score	raw score					
201	45.8	51	18	49	39	43	34	48
202	56.9	57	23	61	56	59	52	56
203	56.6	51	18	64	63	60	73	60
204	59.6	64	28	62	69	61	70	63
205	63.6	67	30	64	59	61	68	63
206	50.1	64	28	51	54	48	36	48
207	66.1	72	32	66	69	71	75	63
209	62	64	28	64	69	60	60	63
211	45.6	41	6	47	52	45	39	45
212	62.1	61	26	64	56	60	75	53
214	62.4	60	25	70	63	68	75	53
216	47.9	46	12	54	59	47	39	53
217	53.1	51	18	59	63	56	50	48
219	60.1	68	31	62	54	51	58	63
220	41.8	51	18	37	39	43	N/A	39
221	61.7	55	21	74	63	66	N/A	63

Table 3

Unimpaired Adults/PWA Reading Times By Region (ms)

Pop.	Sentence Order	Familiarity	Precritical Region		Critical Region		Postcritical Region	
			Mean	SD	Mean	SD	Mean	SD
UA	Context First	Control	706	392	1001	498	1111	656
		High Fam.	708	330	1141	576	1108	604
		Low Fam.	719	409	1326	792	1212	688
	Idiom First	Control	780	528	1096	708	1027	544
		High Fam.	828	689	1176	673	1022	619
		Low Fam.	754	439	1351	766	1022	655
PWA	Context First	Control	1460	1201	2320	1562	2198	1283
		High Fam.	1296	745	2460	1722	2398	1606
		Low Fam.	1424	903	2896	1752	2590	1829
	Idiom First	Control	1610	1067	2626	1634	2071	1113
		High Fam.	1976	1679	2766	1467	2188	1244
		Low Fam.	1829	1440	3362	2145	2115	1275

Table 4

Unimpaired Adults/PWA RT Means (correct trials only)

Population	Sentence Order	Familiarity	Mean (ms)	Standard Deviation
Unimpaired Adults	Context First	Control	3436	1867
		High Fam.	3611	1884
		Low Fam.	3950	2094
	Idiom First	Control	3686	2106
		High Fam.	3556	1599
		Low Fam.	4197	2525
PWA	Context First	Control	7612	4161
		High Fam.	8175	6595
		Low Fam.	7855	3994
	Idiom First	Control	8590	4830
		High Fam.	8003	4205
		Low Fam.	7852	4069

Table 5

Unimpaired Adults/PWA Error RT (ms)

Population	Sentence Order	Familiarity	Error Type	Mean	SD
UA	Context First	Control	*Literal	7521	5059
			Abstract	6581	3305
			Concrete	7716	NA
	High Fam.	Control	Literat	9265	5821
			Abstract	**NA	NA
			Concrete	NA	NA
	Low Fam.	Control	Literat	6456	4220
			Abstract	4715	2238
			Concrete	NA	NA
	Idiom First	Control	Literat	7114	5672
			Abstract	8655	3426
			Concrete	NA	NA
PWA	Context First	Control	Literat	4561	1991
			Abstract	6650	765
			Concrete	10621	9420
	High Fam.	Control	Literat	6589	3399
			Abstract	6588	2417
			Concrete	NA	NA
	Low Fam.	Control	Literat	13551	7866
			Abstract	12605	5800
			Concrete	15070	3413
	Idiom First	Control	Literat	12645	7432
			Abstract	10735	4944
			Concrete	9952	6603
PWA	Context First	Control	Literat	11942	7220
			Abstract	14433	7284

Population	Sentence Order	Familiarity	Error Type	Mean	SD
	Idiom First		Concrete	6280	NA
		Control	Literal	14403	9373
			Abstract	10296	3837
			Concrete	104975	9094
		High Fam.	Literal	11262	4893
			Abstract	12445	7226
			Concrete	15197	13832
		Low Fam.	Literal	12427	6283
			Abstract	12518	6610
			Concrete	13777	4006

* „Literal“ errors in control conditions reflect selection of a second concrete distractor
** „NA“ values indicate that probe was not selected

Table 6

Unimpaired Adults/PWA Probe Selection

Population	Sentence Order	Familiarity	Fig. Target		Lit. Lure		Conc. Lure		Abs. Lure	
			M	SD	M	SD	M	SD	M	SD
UA	Context First	Control	.91	.27	.03	.18	.01	.08	.05	.21
		High Fam.	.95	.22	.05	.22	0	0	0	0
		Low Fam.	.85	.36	.13	.34	0	0	.02	.15
	Idiom First	Control	.91	.28	.04	.19	0	0	.05	.21
		High Fam.	.93	.25	.03	.18	.01	.11	.02	.15
		Low Fam.	.82	.38	.15	.36	0	0	.03	.17
PWA	Context First	Control	.83	.37	.05	.22	.02	.14	.09	.29
		High Fam.	.69	.46	.11	.32	.03	.17	.16	.36
		Low Fam.	.52	.50	.23	.42	.01	.10	.24	.43
	Idiom First	Control	.68	.47	.09	.29	.06	.24	.16	.37
		High Fam.	.56	.49	.24	.43	.03	.17	.18	.38
		Low Fam.	.55	.50	.21	.41	.04	.19	.21	.41