INVESTIGATING THE EFFECTS OF TRANSPARENCY AND AMBIGUITY ON IDIOM LEARNING

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Mehrgol Tiv

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This thesis was presented

by

Mehrgol Tiv

It was defended on

April 15, 2016

and approved by

Dr. Natasha Tokowicz, PhD., Department of Psychology

Dr. Michael Dickey, PhD., Department of Communication Science and Disorders

Dr. Debra Titone, PhD., Department of Psychology, McGill University

Thesis Advisor: Dr. Tessa Warren, PhD., Department of Psychology

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Mehrgol Tiv, B.Phil.

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The purpose of this thesis was to learn how transparency and ambiguity affect idiom learning. Experiment 1 was a norming study to measure the transparency, ambiguity, and familiarity levels of translated French idioms into English. Experiment 2 was a training study where 25 native English speakers learned 32 of the normed idioms from Experiment 1. The procedure was distributed over three days and included two learning sessions and one testing session. In addition, each participant completed individual difference tasks for working memory, creativity, and figurative language proficiency. We ran Linear Mixed Effects Regression models which rendered a significant effect of transparency on performance. Given the ceiling effects from Experiment 2, we conducted Experiment 3 which differed from Experiment 2 in that it reduced the amount of time subjects spent learning and practicing the idioms and also included a semantic relatedness test. Experiment 3 showed a significant main effect of transparency and an interaction between transparency and the type of test such that performance was better for high transparency idioms on a recall test but worse on a semantic relatedness test. Across the two training experiments, we found neither an effect of ambiguity nor any significant relation between individual difference tasks and performance.

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1.0   INTRODUCTION

A majority of research on idiomatic language (also referred to as "nonliteral" or "figurative" language) has focused on how idioms are mentally represented and processed. There has been much less investigation of how idioms are learned, despite the practical ramifications it bears for second language learning applications (Howarth, 1998; Yorio, 1989). The current study was designed to investigate the way that the idiomatic properties of transparency and ambiguity affect learning.

Idioms are highly conventional expressions in which the overall meaning of the expression often transcends the literal meanings of the individual constituents (Nunberg, Sag, & Wasow, 1994). For example, it is very difficult to arrive at the correct idiomatic meaning of "naïve or inexperienced" from a literal analysis of the words within the phrase *wet behind the ears*. Additionally, idioms frequently have both literal and figurative overall meanings ("naïve or inexperienced" vs. "literally wet behind the ears"); the chosen interpretation depends on the comprehender's familiarity with the idioms (Nordmann, Cleland, & Bull, 2014) as well as the context in which the idiom is embedded (Ortony, Schallert, Reynolds, & Antos, 1978).

Several key characteristics of idiomatic language arise from the tension between literal word meaning and idiomatic phrase meaning, two of which—transparency and ambiguity—will be considered in the current work. Both characteristics involve the relationship between an idiom's two overall meanings: literal and figurative.

Transparency refers to the ease with which the comprehender can make a connection between the idiom's literal and figurative meanings (Nunberg et al., 1994). The idiom *spill the beans* is highly transparent because the connection between "divulging a secret" and "releasing beans from a container" is very clear. In contrast, the idiom *wet behind the ears* is less transparent because the relationship between the literal and figurative meaning is less obvious.

Ambiguity refers to whether an idiom has both literal and figurative meanings, or only a figurative meaning. For example, the idiom *kick the bucket* is ambiguous because it has both a literal meaning (striking a pail with a foot) and a figurative meaning (dying), but the idiom *under the weather* is unambiguous because it only has a figurative meaning (Titone & Connine, 1994).

Although there is a small pool of literature on idiom learning, considerably more work has been conducted on single word learning. We will begin with a brief review of significant findings for how single words are learned, because they are broad in scope and provide a secure foundation from which to draw predictions, before transitioning to specific work on idioms. In the context of single word processing and learning, the term "transparency" is not often used. A potentially parallel trait could be semantic similarity, which can take the form of *polysemes* or *homonyms.* According to Eddington and Tokowicz (2015), *polysemous* words are very close in meaning and only indicate a different sense (e.g., research/wrapping paper) whereas *homonyms* have multiple unrelated meanings (e.g., bank). Thus, the two forms of semantic similarity measure how closely two words are related, which is what transparency aims to measure as well. In their review article of several unresolved theories of how semantic similarity influences ambiguous word processing, they cite many studies that have found a processing advantage for polysemous, or semantically close, words as opposed to homonymous, or more semantically distant words (Klepousniotou & Baum, 2007; Rodd, Gaskell, & Marslen-Wilson, 2002).

Additionally, several works found that semantic similarity aides in word recognition, suggesting that it has some underlying ties to learning.

A study by Rodd et al. (2012), which was also analyzed in the review article by Eddington and Tokowicz (2015), corroborated previous findings that stronger semantic similarity between a novel vs. pre-existing meaning facilitate performance. In Experiment 1, participants first read a series of paragraphs and rated them on novelty, plausibility, and clarity. Following a test of general vocabulary, participants completed a cued-recall test in which they had to recall the paragraphs with as much detail as they could remember. The results showed that semantic similarity significantly affected the proportion of correct responses, with more semantically similar words recalled with greater accuracy. To extend the findings of Experiment 1 to long-term learning, they conducted Experiment 2, which differed not only by increasing the learning phase and introducing a test delay, but also introduced lexical decision tests. Experiment 2 lent support to the conclusion that semantic similarity facilitates recall accuracy. Experiment 3, which served as an extension of Experiment 2, aimed to increase novel word learning. By implementing a modified training procedure, the overall mean recall was increased, and the same semantic similarity effects on performance emerged.

Moving beyond the single word level, transparency also plays a critical role in the form-meaning mapping of L2 grammar structures (DeKeyser, 2005). In learning grammatical structures in a novel language, the ease of learning depends on transparency of the form-meaning mapping, such that a very clear mapping (high transparency) will only require minimal exposure to learn but a less clear mapping (low transparency) will demand more exposure (DeKeyser, 2005).

Ambiguity at the single word level occurs in a variety of forms. These can include the polysemes and homonyms alluded to in reference to semantic similarity within a language, where one orthographic form has multiple senses or meanings (Eddington & Tokowicz, 2015). Additionally, ambiguity can occur cross-linguistically such that a word in one language can map to multiple words in a second language (Degani & Tokowicz, 2010; Eddington, 2015). Degani and Tokowicz investigated the effect of translation ambiguity on word learning between Dutch-English word pairs (2010). In this experimental design, participants saw 48 English words with their Dutch translations, which were normed in a previous study (Tokowicz, Kroll, De Groot, & Van Hell, 2002). Half of the English words had one Dutch translation wheras the other half had two translations. The multiple-translation words were further split in half on form-ambiguity and meaning-ambiguity. The experiment consisted of three sessions where session two occurred two days and session three occurred two and a half weeks after session one. The results across all sessions indicated that in a language production task, where participants were shown a Dutch word and asked to produce its English translation, ambiguous items were produced with less accuracy. This finding reinforces the conclusion that ambiguity hurts word learning.

From here, we can proceed to review the few studies that have explored idiom learning. Despite the vast literature that supports a helpful role of transparency/semantic similarity on word learning, the evidence of transparency's effect on idiom learning is mixed. For example, Steinel, Hulstijn, and Steinel (2007) investigated the effects of transparency on L2 idiom learning by presenting English-Dutch idiom pairs and instructing participants to learn them to the best of their ability. The study measured learning through tests of recognition and production. Although the results showed minimal effects of transparency only on recognition, imageability (capacity to evoke a mental image) was a predictor of performance. This indicates the individual

properties of idioms can significantly influence learning. However, this study presented only 20 idioms to the participants and classified the independent variables of transparency and imageability into three classifications: high, intermediate, and low. This means that only a few idioms represented each category (e.g. High Imageability x High Transparency, Intermediate Imageability x High Transparency, etc.) or that the number of idioms in each category was unbalanced. For example, there were no idioms in the Low Imageability x High Transparency and High Imageability x Low Trasnparency groups, but five idioms in the Low Imageability x Low Transparency group. Thus, one could argue that the study did not have adequate power to conclude that transparency plays little to no role in learning.

Boers, Eyckmans, and Stengers (2007) conducted a study on the motivation behind idioms, drawing on work that challenged the earlier notion that idioms are arbitrary expressions (Gibbs, 1994; Lakoff, 1987). They were primarily interested in whether an understanding of the etymology of the idiom would aid in identifying the meaning. Participants were separated into a control group and an experimental group. Both groups, consisting of Dutch-speaking students majoring in English, were taught 25-30 English idioms. All participants completed the same learning tasks (identifying the meaning and source of the idiom), but the order of activities differed for each group. The control group identified the meaning first, whereas the experimental group identified the source first. The results showed that first understanding the source of an idiom aids in learning the meaning later on. This process of establishing a connection between an idiom and its origin can certainly be a measure of transparency, because one is learning from where the connection between the idiom and its definition originate. For example, one of the idioms *jump the gun* was explained as originating from the domain of athletics where "a contender who *jumps the gun* sets off before the starting pistol has been fired" (Boers et al.,

2007). This elaborated story brings the idiom and its definition closer, thus increasing the level of transparency.

Ambiguity of idiomatic expressions has received even less attention. Cieślicka (2006), investigated whether there was a literal or figurative priority for idioms. Cieślicka presented 43 fourth-grade native Polish students, who were all proficient in English, 40 idioms in a lexical decision task. All idioms were taken from a previous norming study by Titone and Connine (1994). Each idiom was presented in a neutral context (e.g. "Peter was planning to *tie the knot* later that month"), followed by a pair of target words that corresponded to the literal and figurative definitions (e.g. MARRY and ROPE). The response to literal target words was significantly faster than to an idiomatic target word, suggesting that people are more likely to associate an idiom with its literal definition. Cieślicka proposes a literal salience model for L2 idiom comprehension, which explains that for L2 speakers there is a literal processing priority as a result of the more salient, or familiar, literal understanding of a set of words (Kecskes, 2000). In short, due to a preference for a literal interpretation, arriving at an idiomatic understanding of an idiom may be more difficult.

Given the large body of work on predictors of word learning and the dearth of literature on idiom learning, we were interested in whether transparency and ambiguity influence how successfully individuals will learn the meanings of idioms. As mentioned, most previous idiom learning studies have focused on learning idioms in a second language (Steinhel et al., 2007; Cieślicka, 2006) and on the way that context affects learning (Verbrugge & McCarrell, 1977; Zyzik, 2011; Blake & Freeland, 2014). The present study is novel because it investigates idiom learning in the participants' native language and controls for familiarity, which is critical because there is evidence that comprehenders find more familiar idioms more transparent (Nunberg et al.,

1994; Keysar & Bly, 1995). In addition, there have been multiple calls in the literature to do a better job controlling for familiarity, which this study does (Cronk, Lima, & Schweigert, 1993; Whyte, Nelson, & Scherf, 2014). It was therefore important to ensure that all the idioms learned in the present study were equally unfamiliar, thereby avoiding any learning advantage from exposure to higher familiarity idioms. We did this by presenting participants with unfamiliar phrases that had no English idiomatic meaning, allowing us to examine how unfamiliar idiomatic meanings are learned. This also parallels natural idiom acquisition, in which the comprehender must learn to assign idiomatic meanings to unfamiliar strings of words.

Drawing from the aforementioned literature, we predict that figurative meanings of more transparent idioms will be learned better than figurative meanings of less transparent idioms. This is because participants will be able to more easily draw connections between the idioms' literal and figurative meanings, thereby boosting recall. We also predict that figurative meanings of less ambiguous idioms will be learned better than figurative meanings of more ambiguous idioms. This is because the literal meanings of ambiguous idioms may interfere with learning of figurative meanings.

We investigated three individual difference factors that we expect might interact with the learning process and influence performance (Grolnick & Ryan, 1987). The first was performance on the Operation-Span (O-Span) task, a measure of working memory (Atkinson & Shiffrin, 1971; Baddeley, 1992; Turner & Engle, 1989). Because working memory is important for learning, we predict that individuals who score higher on an O-Span task will outperform individuals that score lower on the O-Span task. Additionally, we predict that more creative individuals will be able to create more or stronger connections between the literal and figurative meanings of the idioms so that the low transparency idioms seem more transparent. Thus, we

expect that participants that score higher on the Abbreviated Torrance Test for Adults (ATTA) will perform better overall on the learning test and show less of a difference between performance on high and low transparency idioms (Goff, 2002). Finally, we expected that better performance on an Author Recognition Test, a proxy for language experience and thus figurative language proficiency, would also be predictive of idiomatic learning (Stanovich & West, 1989).

2.0   EXPERIMENT ONE: NORMING IDIOM PROPERTIES

To inform the choice of stimuli for the training study, we conducted multiple norming questionnaires.

2.1   METHODS

2.1.1   Participants

85 undergraduate students enrolled in Introduction to Psychology at the University of Pittsburgh participated for course credit. All participants were over 18 years old, native speakers of American English, and had no prior experience with French.

2.1.2   Materials

305 French idioms were translated word-for-word (literally) and as an idiomatic phrase (nonliterally) using online and print resources (Bonin, Meot, & Bugaiska, 2013; "Idioms," 2006; Lamiroy & Klein, 2010; "Proverbes en français," 2006; "Traduction en contexte," 2006; "Word Reference"). All translated idioms are listed in Appendix A. For example, the French idiom *avoir un cheveu sur la langue* was translated literally as *to have a hair on your tongue* and

nonliterally as *to have a lisp.* French idioms that were extremely similar to English idioms were excluded, leaving 157 translated idioms in the set that was normed.

2.1.3   Procedures

We designed online Qualtrics questionnaires to evaluate familiarity, transparency, and ambiguity. Each participant was randomly assigned to one questionnaire, and each questionnaire was distributed to at least thirteen participants. Each questionnaire contained several catch trials to confirm that participants were on task and attentive. All participants completed a brief language history questionnaire.

To verify that the translated idioms were not familiar, fifteen participants were shown each idiom and asked to "determine if there is an English phrase that is similar to and means the same thing as the following expression" by answering "Yes" or "No." Any idiom that received more than one "Yes" response was excluded from the set of stimuli.

To measure the level of transparency for each idiom, we presented the literal translation of each idiom (e.g. *to have a hair on your* tongue) with its figurative translation (e.g. *to have a lisp*) and asked participants to rate how likely from 1 (*Very unlikely*) to 5 (*Very likely*) they were to have the same meaning. Each opportunity for rating was followed by a free-response question: "why did you select that meaning?" Piloting trials indicated that the questionnaire could take over an hour to complete, so, in order to avoid fatigue, each participant received half of the questionnaire. Fourteen participants completed the first half, and thirteen completed the second half.

To index ambiguity, we evaluated the salience of the literal interpretation of the idiom by asking participants to "decide which [interpretation] you think is the more likely interpretation

by assigning each option with a percentage (0-100). A higher percentage indicates the more likely interpretation." For example, for the idiom *to have a hair on your tongue* participants would have to assign a percentage to each of the two options (1) *to have a hair resting on your tongue* and (2) *to have a lisp*. The more likely the literal meaning was judged to be (option 1 in this example) the higher the ambiguity of the idiom, because increasing the likelihood of the literal meaning increases the chance that it will compete with the figurative meaning. An additional question asked participants to "indicate how likely (from *very unlikely* to *very likely*) you would be to encounter these expressions when reading a novel or talking with someone." The ambiguity scores reported below are the averages of the first question; the second was used to make a final decision if the assigned percentages were very close. This questionnaire was also time-consuming so it was similarly split in half. Fifteen participants completed each half.

2.2   RESULTS

Average ambiguity and transparency scores for each idiom were calculated and plotted (Figure 1). These results are also reported in Appendix A. We aimed to test idioms from all four quadrants: High Transparency x High Ambiguity, High Transparency x Low Ambiguity, Low Transparency x High Ambiguity, and Low Transparency x Low Ambiguity. The most representative eight idioms in each quadrant—those that were furthest from the origin—were selected for use in the training study for a total of 32 idioms (The idioms used as stimuli in the training study are listed in Appendix B.).

Norming scores for transparency were measured on a five-point scale, on which a score closer to five indicated a more transparent idiom. Reported ambiguity scores reflect the

percentage assigned to the question: how likely is this expression to be used literally? A higher

literality score (closer to 100) suggests higher ambiguity. The wide distribution of idioms in

Figure 1, across the full spans of both transparency and ambiguity justified using them as

continuous factors in later analysis.

Transparency and Ambiguity Scores
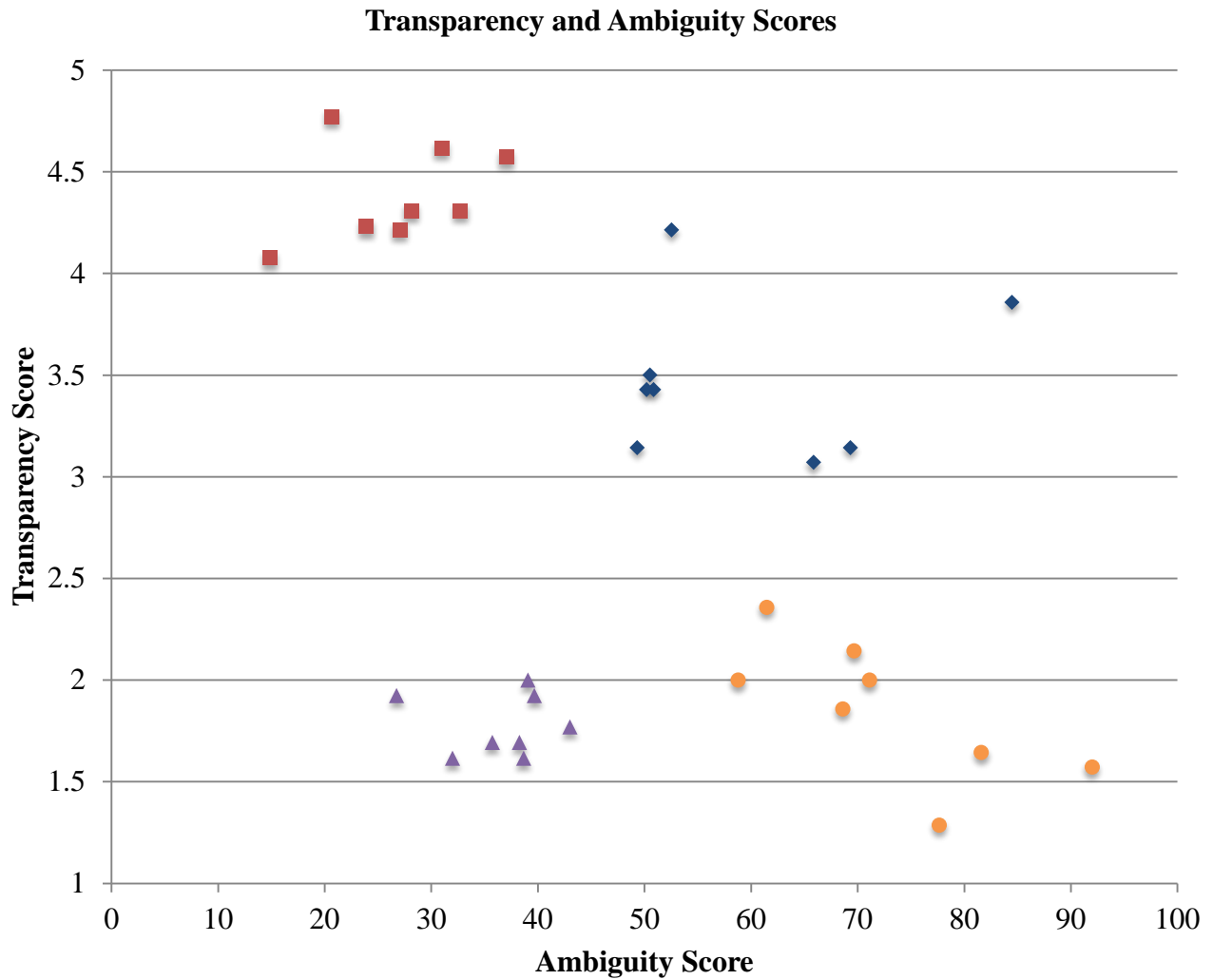
Figure 1: Transparency and Ambiguity Distribution for Final 32 Idioms Used in Training Study

3.0   EXPERIMENT TWO: LEARNING OF UNFAMILIAR IDIOMS

3.1   METHODS

3.1.1 Participants

Participants were 26 undergraduate students from the same population as Experiment 1 who participated for course credit. Participants who completed Experiment 1 were ineligible to participate in Experiment 2.

3.1.2 Materials

The 32 idioms used for the training study were selected from the previous norming study (listed in Appendix B).

3.1.3 Procedures

The training study and Operation Span test were presented electronically using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA); the ATTA, Author Recognition test, and language history questionnaire were administered on paper.

Participants signed up for three separate sessions about 2-3 days apart. For each session, presentation of all items was randomized. During the first session (approximately 30-45 minutes), participants viewed an idiom and typed what they thought it meant. After they typed their answer, the true meaning of the idiom appeared on the next screen, and participants were asked to indicate whether their answer was correct or not. Finally, on a third screen, participants were asked to generate a novel sentence that included the idiom. This procedure was repeated for each idiom.

The second session (approximately 20-30 minutes) consisted of three parts. The first part started with a presentation of each idiom and its definition on one screen for twelve seconds in total. After this initial presentation, the set of idioms repeated but this time included a metacognitive question for the participant to rate how confident they are that they would be able to remember the definition for the idiom if asked. Then, the idiom and its definition reappeared on the screen for another twelve seconds. This metacognitive question served both to ensure that participants were paying attention and as an aid in learning (Kang, McDermott, & Roediger, 2007). During the second part, participants verbalized each idiom and its meaning to add a physical and auditory memory trace. After this was completed for all idioms, participants concluded the session by again generating a novel sentence that included the idiom. This time, the participants simply saw the idiom and had to type the sentence without a reminder of the definition.

In the third session, the participants were tested via a simple cued-recall test. Participants were instructed to "type the learned definition of the expression to the best of your ability." Emphasis was put on recalling the correct definition, instead of recalling verbatim. On each screen, the participant saw an idiom and typed their answer below. Next, participants completed

an Operation Span task (Turner & Engle, 1989), Abbreviated Torrance Test for Adults (Goff, 2012), and Author Recognition Test (Stanovich & West, 1989). Finally all participants completed a brief language history questionnaire.

Recall accuracy was coded by the author based on a tight coding criteria (see results). A second coder was consulted when it was difficult to code the response as correct and incorrect. In the case of disagreement, the two coder discussed the response until a consensus could be reached.

In the Operation Span task (O-Span), participants viewed variably sized sets of simple mathematical computations followed by single words. The participants were instructed to quickly judge whether the answer to the math problem was correct or incorrect (by pressing a key on the keyboard) and then remember the word that flashed on the screen immediately after each computation. At the end of each set, the participants were asked to recall as many words as they could remember from that set. Set size ranged from 3-6 words.

In the Abbreviated Torrance Test, participants had three minutes to complete each of three activities. They had to answer thought questions and create images or pictures with incomplete figures. Participants only worked on one activity at a time.

In the Author Recognition test, participants were given a piece of paper that contained eighty names. They were instructed to "read the names and put a check mark next to the names of the individuals you know to be writers."

3.2   RESULTS

Analyses were done in R (R Development Core Team, 2015; ver 3.2.3) with the lme4 package using linear mixed effect logit models with participants and items as crossed random factors (Baayen, 2008; Bates, Maechler, Bolker, & Walker, 2015). Fixed factors (e.g. ambiguity, transparency) were treated as continuous variables to better capture variability, and were centered in all analyses. When maximal models failed to converge, the random slopes that captured the least variance were dropped until the model converged (Barr, Levy, Scheepers, & Tily, 2013).

Participant responses were coded for accuracy according to the following criteria: a verbatim or slightly reworded response of the learned definition was counted as correct. For example, for the idiom *to jump from the rooster to the donkey* which means "to switch from one subject to another", the response "to switch sides" was marked as incorrect. However, the answer "to switch from one thing to another" was marked as correct. This coding scheme was used in analysis because the criteria are strict enough to represent learning over guessing and flexible enough to measure competence over rote-memorization. Means and standard deviations for accuracy by condition are shown in Table 1.

Individual difference measures were evaluated according to standardized procedures. For the Operation Span Task, set size was used instead of total words recalled because it is more representative of an individual's maximal working memory potential. The range of scores across subjects for each test was as follows: Operation Span Task Set Size (3-6), Abbreviated Torrance Test for Adults Creativity Index (26-90), and Author Recognition Test hits (4-26). The ATTA Creativity Index was scaled down (by dividing scores by a factor of 10) to make the scales more similar to allow the model to converge.

An initial model was designed to investigate main effects of and an interaction between transparency and ambiguity across all of the data. This model, which included random slopes by subjects for transparency and ambiguity, rendered a significant effect of transparency (β= 0.59, SE= 0.28, p= 0.04), but no effect of ambiguity (β= 0.01, SE= 0.01, p= 0.63) and no interaction (β= 0.01, SE= 0.01, p= 0.32).

However, ceiling effects in learning reduced the amount of variability in the data. Participants performed with perfect accuracy on approximately half the items, and approximately half of participants made no errors across all items (Table 1 illustrates the limited variability in accuracy means across the four categories).

Table 1: Descriptive Statistics for Exp.2 Accuracy

Transparency	Ambiguity	N	Mean	SD
High	High	200	0.94	0.24
High	Low	200	0.93	0.26
Low	High	200	0.85	0.36
Low	Low	200	0.85	0.36

Due to the limited variability in the data, we performed subset analyses on the participants and items that had some variability. Initial models that included ambiguity as a fixed effect failed to converge. Ambiguity showed almost no contributions and was dropped to allow the model to converge. The full model investigated the main effects and interaction between transparency and the individual difference test scores. We found a significant effect of transparency and a significant interaction between transparency and operation span score, but no significant effect of O-Span (transparency: β= -2.08, SE= 0.95, p= 0.03; O-Span: β= 0.01, SE= 0.34, p= 0.98; interaction: β= 0.42, SE= 0.18, p= 0.02). There was no significant effect or

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interaction with the ATTA (transparency: β= 0.32, SE= 0.64, p= 0.70; ATTA: β= 0.12, SE= 0.18, p= 0.49; interaction: β= -0.04, SE= 0.10, p= 0.70). There was no significant effect or interaction with the author recognition test (transparency: β= -0.08, SE= 0.35, p= 0.83; Author: β= 0.04, SE= 0.06, p= 0.49; interaction: β= 0.02, SE= 0.03, p= 0.57). These analyses are merely suggestive due to the small and quite unbalanced data set.

4.0   EXPERIMENT THREE: FOLLOW UP TRAINING

Experiment 3 was conducted to reduce the amount of training in Experiment 2, which had led to ceiling effects. In addition, a semantic relatedness test was included as a measure of deeper learning.

4.1   METHODS

4.1.1   Semantic Relatedness Norm

Experiment 3 included a semantic relatedness test in which participants were asked to indicate whether the definition of a learned idiom was related or unrelated to a single target word that was presented on the screen. Appendix C displays each idiom and the related/unrelated key word with which it was paired.

To create this test, a single word that was semantically related to the definition of the idiom was generated. Next, the key words were scrambled and matched to an unrelated idiom. Two lists were prepared, each of which consisted of half related idiom-word pairs and half unrelated idiom-word pairs. Each idiom appeared only once in each list, and the number of "related" and "unrelated" key words was balanced across the two lists. To confirm that the related idiom-word pairs and unrelated idiom-word pairs were in fact related or unrelated,

respectively, we conducted a brief norming questionnaire. Participants were 33 undergraduate students from the same population as Experiment 2 who participated for course credit. Participants who completed either Experiment 1 or Experiment 2 were ineligible from participating in the questionnaire.

In the questionnaire, participants were given the definition of each idiom, but not the idiom itself, and asked to rate how related (from *Very Unrelated* to *Very Related*), the key word was to the definition. For related idiom-word pairs, only key words that received responses of *Related* or *Very Related* were used. For unrelated idiom-word pairs, only key words that received responses of *Unrelated* or *Very Unrelated* were used.

4.1.2 Participants

Participants were 21 undergraduate students from the same population as Experiment 2 who participated for course credit. Participants who completed Experiment 1, Experiment 2, or the semantic relatedness norming questionnaire were ineligible from participating in Experiment 3. Four participants were unable to complete the second session due to technology problems, so 17 datasets were analyzed.

4.1.3 Materials

The same 32 idioms used in Experiment 2 were used in Experiment 3.

4.1.4 Procedures

Experiment 3 consisted of two sessions: a learning session and, two days later, a testing session. Because Experiment 2 suggested there might be a significant interaction between transparency and the Operation Span test, this task was also administered in Experiment 3. The ATTA and Author Recognition test, which did not have significant effects or interactions in the previous experiment, were not included in this experiment. All subjects completed the language history questionnaire.

All of the learning activities in Session One were present in Experiment 2, but not all activities from Experiment 2 were used in Experiment 3. Similar to Experiment 2, presentation of all items in Experiment 3 was randomized. Session One in Experiment 3 consisted of three distinct parts (approximately 30-60 minutes in total). Part One began the same way as Experiment 2: Participants viewed an idiom and typed what they thought it meant. After they typed their answer, the true meaning of the idiom appeared on the next screen, and participants were asked to indicate whether their answer was correct or not. This was repeated for all idioms. In Part Two, participants went through the same flashcard activity as Experiment 2, however the duration of each flashcard was reduced from twelve seconds to six seconds. In Part Three, participants were asked to generate a novel sentence that included the idiom. This procedure was also repeated for each idiom.

In Session Two, participants were tested via the same simple cued-recall test as Experiment 2. Once the participant typed the definitions to all idioms, they completed a semantic relatedness test. Nine participants received List 1 and eight participants received List 2. In this test, participants were instructed to indicate whether the learned expression and the presented

word were related or not by pressing keys on the keyboard. Finally, participants completed the Operation Span test and language history questionnaire.

4.2 RESULTS

All analyses were done in R with the same procedures as Experiment 2. Recall accuracy was coded according to the same criteria as Experiment 2; Means and standard deviations for accuracy by condition are shown in Table 2.

Table 2: Descriptive Statistics for Exp.3 Recall Accuracy

Transparency	Ambiguity	N	Mean	SD
High	High	136	0.84	0.37
High	Low	136	0.88	0.33
Low	High	136	0.68	0.47
Low	Low	136	0.65	0.48

4.2.1 Transparency and Ambiguity

The same model was used to investigate the interaction between transparency and ambiguity on recall accuracy. The model, which included random slopes by subject for transparency and ambiguity rendered a significant effect of transparency ($\beta= 0.61$, SE= 0.26, p= 0.02), but no effect of ambiguity ($\beta< 0.01$, SE= 0.01, p= 0.95) and no interaction ($\beta< 0.01$, SE= 0.01, p= 0.79).

A similar model was designed to investigate the interaction between transparency and ambiguity on semantic relatedness accuracy. Means and standard deviations for accuracy by condition on the semantic relatedness test are shown in Table 3. The model, which also included random slopes by subject for transparency and ambiguity showed a significant effect of transparency (β= -0.52, SE= 0.22, p= 0.02), but no effect of ambiguity (β= -0.01, SE= 0.01, p= 0.25) and no interaction (β< 0.01, SE= 0.01, p= 0.64). Both models indicate main effects of transparency, but interestingly in opposite directions.

Table 3: Descriptive Statistics for Exp. 3 Relatedness Accuracy

Transparency	Ambiguity	N	Mean	SD
High	High	136	0.79	0.41
High	Low	136	0.79	0.41
Low	High	136	0.90	0.30
Low	Low	136	0.92	0.27

4.2.2 Mode of Testing: Recall vs. Relatedness Accuracy

The mean accuracies for high and low transparency idioms as measured by the recall and relatedness tests for all 17 subjects are shown in Figure 2.
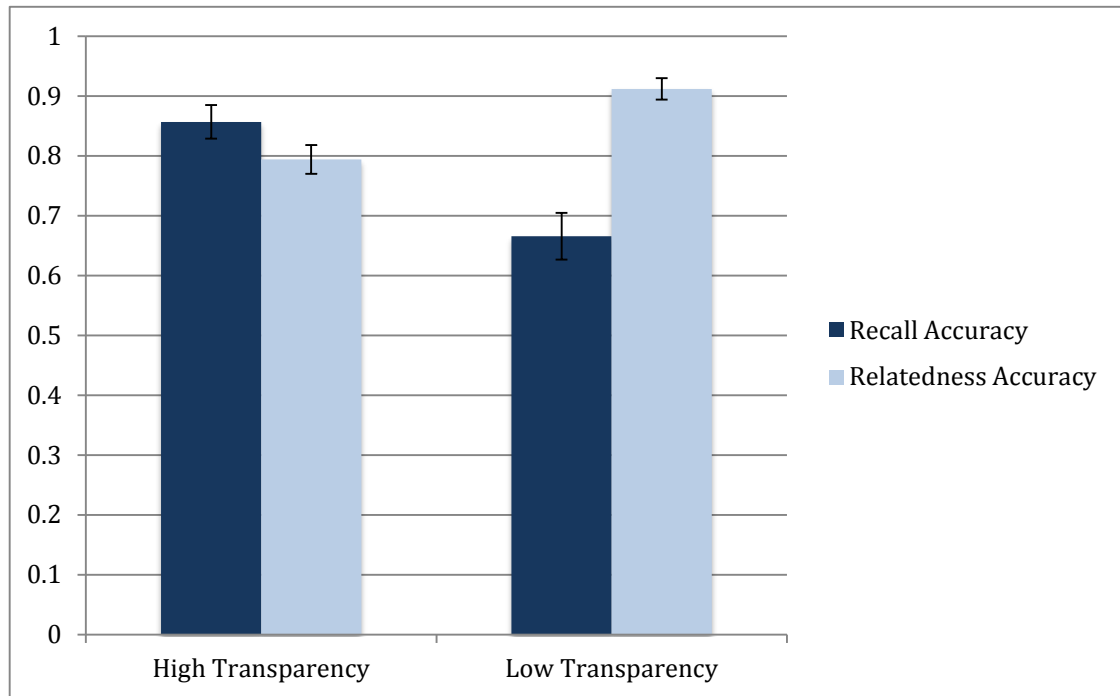
Figure 2: Average Accuracy by Transparency and Mode of Test

To determine whether the mean accuracies for high and low transparency idioms varied significantly by test type, a repeated measures ANOVA was conducted. The results are shown in Table 4. These results show a significant main effect of test mode ($F(1, 16) = 18.54$; $p < 0.05$) and a significant interaction between test mode and transparency ($F(1, 16) = 41.78$; $p < 0.05$). The main effect of transparency approached, but did not reach, significance ($F(1, 16) = 3.54$; $p = 0.08$).

Table 4: ANOVA Based on Estimated Marginal Means

Test Mode	High Transparency		Low Transparency		
	Mean	Std. Error	Mean	Std. Error	Sig.
Recall	0.86	0.028	0.67	0.039	$p < 0.05$
Relatedness	0.79	0.024	0.91	0.018	$p < 0.05$

The pairwise comparisons indicate that people are significantly more accurate in recalling the definitions for high transparency idioms versus low transparency idioms. However, when asked to judge whether the learned definition is semantically related to another word, accuracy of low transparency idioms is significantly higher than accuracy of high transparency idioms.

4.2.3 Subset Analysis

To establish a better baseline in measuring the effects of learning, we conducted a subset analysis across all data from Experiments 2 and 3 by excluding the recall data for each idiom that a subject correctly guessed before the training from Experiments 2 and 3. The responses of three subjects were excluded from analysis due to computer malfunction or lack of following directions, leaving 44 datasets. Analyses did not display any new effects or interactions that hadn't emerged in the full dataset for either transparency and ambiguity on recall or for transparency, ambiguity, and operation span score on recall. Transparency continued to have a robustly significant main effect on recall ($\beta = 0.62$, SE$= 0.24$, p$= 0.01$). Because the semantic relatedness test was only administered in Experiment 3, subset analyses were not conducted due to the already small sample size.

4.2.4   Operation Span Test

The distribution of Operation Span scores for Experiment 3 was spread out more evenly than Experiment 2 and is illustrated in Appendix D. The final model from Experiment 2, which had found a significant interaction between transparency and Operation Span score and a significant main effect of transparency in that study, showed no reliable effects in Experiment 3 (β= 0.80, SE= 0.60, p= 0.18) nor an interaction (β= -0.04, SE= 0.12, p= 0.70). A second model designed to capture main effects of ambiguity, transparency, and Operation Span score with random slopes by subject for transparency and ambiguity, indicated a significant effect of transparency (β= 5.84 e -1, SE= 2.48 e-1, p= 0.02).

5.0   DISCUSSION

5.1   SUMMARY OF FINDINGS

In this experiment, we were interested in learning more about how transparency and ambiguity affect learning of unfamiliar idioms. The results show that when only these two properties are used to predict accuracy, transparency has a robustly significant effect on learning. The direction of this effect, however, seems to depend on the test used to measure accuracy—more transparent idioms are recalled with higher accuracy on a simple cued-recall test, but accuracy on a semantic relatedness test increases for less transparent idioms. We did not find any significant effects of ambiguity nor any interactions between transparency and ambiguity on learning. In addition, there was no significant effect of O-span, ATTC, or Author Recognition score on recall, and the interaction that emerged in Experiment 2 between O-span score and transparency was not found in Experiment 3. We attribute that interaction to the low variability in recall accuracy and small dataset for participants in Experiment 2.

5.2   TRANSPARENCY

As predicted, we found that transparency contributes significantly to the idiom learning process, as it does with other learning processes. One plausible explanation is that transparency measures a very common and simple memorization strategy: finding connections and links between items.

5.2.1   Transparency on Cued Recall

Although our study design did not ask participants how they encoded the meaning of the idioms, we can consider two mechanisms through which high transparency may have aided learning: at the word and phrasal levels.

At the word level, spreading activation from a single word in the phrase could aid in recall, such as the learned expression *there is an eel under the rock:* the word *eel* could activate the broader associative network of a fish which then prompts the adjective *fishy* to emerge at the time of recall. At the phrasal level, the relationship may be more illustrative or story-like. The idiom itself could have a handful of plausible meanings, but once one of them has been selected (by means of the training program) most people can easily elaborate and reinforce the pairing through some sort of mental imagery or storytelling (e.g. the concept of *to hold to the panes* suggests a lack of movement. Participants learn that this means *to stick to the rules* and might apply the imagery of not moving to one's firm rule-following). However, for lower-transparency expressions, several more steps may be required to connect the idiom to its meaning. The distance between the meanings introduces more opportunities for other cues to intervene and might lead to lower accuracy.

5.2.2   Transparency on Semantic Relatedness

The influence of transparency on idiom learning accuracy was found to depend on the way we measured accuracy. In the semantic relatedness test, less transparent idioms were learned with higher accuracy than more transparent idioms. The aim of implementing the semantic relatedness test was to measure "deeper learning" of the idioms, through abstraction and application of the meaning onto a single word (Anderson & Redder, 1979). Previous work has indicated that different processes are at work in learning a meaning only to recall it later (memorization) versus applying it to a new context (deep learning) (Hyde & Jenkins, 1973; Fry, Kitteridge, & Marshall, 2009).

At their core, the cued recall test and semantic relatedness test ask the participants to do two very different things. For cued recall, the participant must pay attention to the idiom and its definition as they are displayed on the screen.   The person must implement strategies to remember this meaning and then, at test, reproduce it to the best of their ability. The semantic relatedness test demands a little more. Because there is only one learning phase for both tests, the encoding process for both tasks will not differ. However, at test, the participant is now being asked to evaluate the definition that they learned and see if it relates in any way to another word. This task is much more semantically engaging than a cued recall test, requiring the participant to undergo additional steps to produce a correct answer. Thus, it is reasonable that two different patterns emerged for the two tests.

In addition, we were curious to learn more about the distribution of errors across the recall and relatedness tests. We compared individual performance across the two test modes for high and low transparency idioms and came up with four categories that any response from an individual on any given idiom could fall into: (1) correct for both the recall and semantic

relatedness tests, (2) correct for the recall test but incorrect for the semantic relatedness test, (3) incorrect for the recall test but correct for the semantic relatedness test, and (4) incorrect for both recall and semantic relatedness tests (Table 5).

Table 5: Comparing Count of Correct Responses Between Test Mode

	High Transparency		Low Transparency	
	High Ambiguity	Low Ambiguity	High Ambiguity	Low Ambiguity
Recall & Relate Correct	89	97	86	82
Recall Correct / Relate Incorrect	25	22	7[a]	6[a]
Recall Incorrect / Relate Correct	19	11	37[b]	43[b]
Recall & Relate Incorrect	3	6	6	5

Note: [a] and [b] indicate the disparity of errors in low transparency idioms for recall/relatedness

First, the bottom row of the table shows that inaccurate performance on both the recall and relatedness tests is mostly the same for all categories. Returning to the dataset to see which idioms were essentially unlearned did not provide substantial insight—in particular, we checked if any resembled another idiom in the set of stimuli, but did not find that to be the case. Next, the table provides another visualization of the transparency and test mode interaction, but uniquely highlights one pattern: for high transparency idioms, subjects are relatively similarly likely to make an error in *either* the recall or the relatedness tests; however, it is much more common in low transparency idioms to make an error in the recall test while performing accurately on the relatedness test than the other way around. This suggests that if a participant didn't fully learn an idiom—enough to perform accurately on every type of test that would measure learning—what they are able to do with the information they did acquire depends on the transparency level: a

more transparent idiom will be recalled with higher accuracy on a surface level test while a less transparent idiom will be recalled with higher accuracy on a deep level test.

A plausible mechanism to explain this unanticipated pattern could stem from work by Keenan, Baillet, and Brown (1984) and Myers, Shinjo, and Duffy (1987) on degrees of causal relatedness. In the original study by Keenan et al. and the replication with slight modification of stimuli by Myers et al., the central question was how do varying degrees of causality, ranging from close to unrelated, aid in memory? In their experimental designs, a second sentence was generated (e.g. "the next day his body was covered with bruises") along with the following four levels of first sentences that would be paired with it:

> Level 1: "Joey's big brother punched him again and again."
>
> Level 2: "Racing down the hill, Joey fell off his bike."
>
> Level 3: "Joey's crazy mother became furiously angry with him."
>
> Level 4: "Joey went to a neighbor's house to play."

The dependent variables of these studies were reading time and recall probability, which provided one of the sentence pairs and the participant was instructed to produce the other sentence. Contrary to their expectation of finding a positive, linear relationship between causal relatedness and recall probability, the data took the form of an inverted U-shape. In other words, moderately related sentence pairs displayed the highest recall probability while the lowest and highest levels of relatedness displayed the lowest recall probability. In addition, the data did display a positive, linear relationship between causal relatedness and reading time.

Keenan et al. posit that the inverted U-shape of recall probability is a product of the number of different relations that one makes between concepts. Relations are made through elaboration, a process through which an individual not only encodes the information they see and

hear, but also incorporate their own evaluations and thoughts in creating a more holistic picture. Through this process, one expands and increases the "nodes and pathways" that make up a representation (Myers et al., 1987). Here is how that played out in the causal relatedness study: Highly related pairs, which have a very clear relationship between sentence pairs, are processed too quickly to receive any elaboration. With unrelated pairs, a reader cannot elaborate on what does not exist. Thus, recall accuracy is equally low because the sentences are only minimally connected. The moderately related pairs are a different story. Recall accuracy is improving for some people from the more distant pairs as it becomes easier to infer a link between the sentences. Simultaneously, the moderately related sentences are activating more "retrieval routes among concepts" which means that there is spreading activation in how these concepts and sentences are represented.

We suggest that a similar mechanism may be occurring in the learning of high and low transparency idioms. High transparency idioms, which have very close relationships between the idiom and the definition, are processed shallowly. The tight link between the two concepts does not permit elaboration and thus does not activate additional nodes in the periphery of the idiom-definition representation. This means that on a task such as cued recall, which does not demand deep processing, high transparency idioms are responded with high accuracy. However, when the test (e.g. semantic relatedness) demands a deeper understanding of the concepts, the participant hasn't formed as many elaborations or activated as many nodes relating their conceptual representation of the idiom, so they have lower accuracy.

Conversely, low transparency idioms, which have more distant relationships between the idiom and the definition, experience the opposite effects. It is possible that at the point of encoding, the participant expended more energy to find a link between the idiom and its

seemingly unconnected definition. Idiomatically speaking, they cast a wider net of "retrieval routes" between the two concepts, even if these routes didn't necessarily get them to the correct definition of the idiom. As such, low transparency idioms are not always recalled with accuracy, but may score more accurately on the semantic relatedness test as a result of the wider activation that was made during encoding.

To further investigate this mechanism, future efforts should track reading time, within this experimental paradigm. A positive, linear relationship between reading time and level of transparency, like the one found between reading time and causal relatedness in the Myers et al. (1987) study, could lend additional support to the hypothesis that the mechanisms hypothesized there could explain the differing effects of transparency on idiom learning across shallower and deeper tasks.

5.2.3   Qualitative Post-Hoc Analysis of Familiarity

To begin to investigate whether there are relationships between familiarity, transparency, and the guessing of an idiom's meaning, a qualitative post-hoc analysis of the pre-training guesses from Experiments 2 and 3 was conducted. Of the 1536 total pre-training guesses to the question "what do you think this expression means?" 137 responses matched the idiom's correct definition. Table 5 illustrates the distribution of correct guesses across idioms, divided across high/low transparency and ambiguity levels. We were curious whether the most correctly guessed idioms scored higher in the familiarity norm than the idioms that were not correctly guessed as readily. In revisiting the norming data from Experiment 1, the mean familiarity scores for idioms often guessed correctly versus not were quite close: On a scale of 1 to 2, the average familiarity score for correctly guessed idioms was 1.64 and 1.70 for not correctly guessed idioms. This qualitative

analysis suggests that it's possible to separate knowing a meaning from being familiar with a meaning. Even though the majority of correct guesses before the training occurred in idioms for which the meaning was more semantically related, those idioms were equally unfamiliar to idioms where the definition was not as close. Transparency could possibly be the mechanism in dissociating knowing and being familiar with an expression.

Table 6: Count of Pre-Training Correct Guesses & Familiarity Norm Scores

	Correct Guesses	Familiarity Norm
High Transparency	**123**	**1.6**
High Ambiguity	**40**	**1.6**
To turn the jacket inside out	14	1.7
To turn on the night light	0	1.1
To have a little pit	3	1.7
To water down your wine	11	1.6
To have a resistant heart	10	1.7
To be able to put your fingers in your nose	2	1.5
To have a dirty head	0	1.6
To have a hair on your tongue	0	1.9
Low Ambiguity	**83**	**1.6**
To live like a rooster with delicacies	20	1.6
To jump from the rooster to the donkey	2	1.6
To fall like apples	0	1.7
To stick something in the wheels	23	1.6
To move with both hands and feet	8	1.6
To hold to the panes	0	1.7
To discover the pot in the roses	3	1.6
There is an eel under the rock	27	1.7
Low Transparency	**14**	**1.7**
High Ambiguity	**7**	**1.8**
To do your hair	2	1.6
To make the goat cheese	0	1.9
To make smoked sausage	2	1.8
To take a walk on your feet	1	1.6
There is some to drink and some to eat	1	1.7
To turn your eye	0	2
To be next to one's shoes	0	1.9
To not be able to smell someone	1	1.7
Low Ambiguity	**7**	**1.7**
To be a beautiful leg to someone	0	1.8
To breathe like an ox	1	1.7
To mow the lawn under the feet of someone	3	1.9
To make the head	0	1.7
To have blood of ink	0	1.7
To not miss the air	1	1.7
To make all the cheese	1	1.6
To be hard of paper	1	1.7
Grand Total	**137**	**1.7**

5.3   AMBIGUITY

There was no effect of ambiguity on recall of the idiomatic meanings and so it is not surprising that transparency and ambiguity did not interact. Although we expected ambiguity to influence idiom learning, it did not seem to be as important as transparency. Unlike previous studies where ambiguity arises from either one or more highly salient meanings, the expressions in our study were all unfamiliar For the most part, ambiguity served as a measure for the *potential* of an expression to be taken for its literal interpretation, as opposed to the frequency with which it is used in everyday speech; this has also been referred to as *literal plausibility* (Titone, Columbus, Whitford, Mercier, & Libben, 2015). Effectively, we taught two meanings simultaneously: the literal and idiomatic. The literal meaning came about from the collocation itself. Because these collocations were novel, the first interpretation to activate should have been the literal, which is what occurs in bilingual idiom learning tasks (Cieślicka, 2006; Kecskes, 2000). If the expression was not introduced in a context where participants were instructed that they would be learning the meaning of certain expressions, there would conceivably be no reason for them to assume that there is a second layer of meaning at the figurative level. So perhaps at the point of encoding, there was slight competition between the literal and idiomatic meanings. But, due to the nature of the training, both meanings were salient at test and suffered from similar competition.

If this study is to be replicated in the future, the manipulation of high versus low ambiguity idioms could be strengthened. Though we aimed to distinguish idioms of high and low ambiguity in designing the stimuli, the idioms in the current study are arguably of very similar ambiguity levels. This could be a result of their novelty—in the norming process, we eliminated all idioms that represented English expressions, and thus we reduced the salient literal competitor

that is key in raising ambiguity. In creating a new set of stimuli that are high in ambiguity, future methods could involve reassigning new meanings to preexisting, familiar English idioms. This paradigm has been presented a multitude of times at the level of single words or verb phrases (Rodd et al., 2012; Clark & Gerrig, 1983), but rarely used for longer phrases, such as idioms. With this method, there would certainly be competition between the original meaning of the idiom and the new meaning that is assigned to it (high ambiguity). The same methods as the current study would be sufficient in creating a set of low ambiguity idioms. In short, although controlling for familiarity did give our study certain strengths over previous research, it also could have impeded our ability to measure effects of ambiguity.

5.4   INDIVIDUAL DIFFERENCE

The individual difference tests were not independently predictive of recall accuracy in this experiment, nor did they interact significantly with transparency and/or ambiguity in either Experiments 2 or 3. As previously mentioned, Experiment 2 did show a significant interaction of O-span score with transparency, but this did not emerge in Experiment 3, which displayed much greater variability in both O-span score distribution and recall accuracy across conditions. This suggests that the interaction found in Experiment 2 may have been a result of low variability of the data. Because the effect of individual differences on learning was not the main focus of this study, no analyses beyond the ones described above were pursued. Future research could hone in on more subtle influences of individual difference measurements on learning, as past research has indicated may exist.

APPENDIX A

154 FRENCH IDIOMS, TRANSLATIONS, AND NORMS

French	English (Literal)	English (Figurative)	Transparency Score	Ambiguity Score
A tout bout de champ	At every end of the field	At every opportunity	--	--
Accuser le coup	To blame the knock	To be affected	--	--
Avoir une dent contre quelqu'un	To have a tooth against someone	To hold a grudge against someone	3.50	19.33
Avoir bon dos	To have a good back	To take the blame	--	--
Avoir des doigts de fée	To have the fingers of a fairy	To be dexterous	3.43	12.60
Avoir du cœur	To have some heart	To be understanding	--	--
Avoir du pain sur la planche	To have bread on the board	To have a lot to do	2.36	36.13
Avoir l'estomac dans les talons	To have your stomach in your heels	To be famished	3.64	13.33
Avoir la haute main sur quelque chose	To have the high hand	To have absolute control	--	--
Avoir la langue bien pendue	To have a loose tongue	To talk a lot	--	--
Avoir la main heureuse	To have a happy hand	To be lucky	--	--

French	English (Literal)	English (Figurative)	Transparency Score	Ambiguity Score
Avoir le bras long	To have a long arm	To have influence	--	--
Avoir le cœur bien accroché	To have a resistant heart	To not be squeamish	3.07	65.87
Avoir le cul entre deux chaises	To have you ass stuck between two chairs	To be in the middle of two things	--	--
Avoir le fin mot de l'histoire	To have the last word of the story	To find out the cause of something	2.36	57.80
Avoir les foies	To have the livers	To be very scared	2.00	33.00
Avoir les oreilles en feuilles de chou	To have ears like leaves of cabbage	To have big, flappy ears	--	--
Avoir mal au cœur	To have pain in your heart	To feel nauseous	--	--
Avoir quelqu'un dans le nez	To have someone in your nose	To have someone get on your nerves	--	--
Avoir un blanc	To have a white	To forget something	2.93	47.00
Avoir un cheveu sur la langue	To have a hair on your tongue	To have a lisp	3.43	50.87
Avoir un coup de foudre	To have a strike of lightening	To fall madly in love	--	--
Avoir un petit creux	To have a little pit	To be a little hungry	3.14	49.33
Avoir un poil dans la main	To have a hair in your hand	To be very idle	3.15	23.27
Avoir une mémoire d'éléphant	To have the memory of an elephant	To never forget anything	--	--
Avoir une peur bleue	To have a blue fear	To be very scared	3.69	30.00
Avoir une sale tête	To have a dirty head	To look awful	3.43	50.20
Avoir une taille de guêpe	To have the shape of a wasp	To have an hourglass figure	3.31	27.93
Boire en Suisse	To drink in Switzerland	To drink alone	2.71	63.33
Bouffer du lion	To eat some lion	To have a lot of energy	2.85	35.00
Brasser du vent	To knead the wind	To talk nonsense	2.85	11.93
C'est la fin des haricots	It's the end of the beans	Game Over	--	--
C'est un navet!	It's a turnip	It's a bad film	2.93	72.67
C'est un serpent de mer	It's a sea serpent	It's a silly made up story	--	--
C'est une feuille de chou	It's a cabbage leaf	The newspaper article is worthless	3.46	56.60

French	English (Literal)	English (Figurative)	Transparency Score	Ambiguity Score
Changer son fusil d'épaule	To switch your gun to your other shoulder	To change how you feel	3.07	44.27
Chercher la petite bête	To look for the little beast	To make trivial distinctions	2.14	32.80
Chercher midi à quatorze heures	To look for noon at 2 pm	To complicate things	3.38	19.07
Cirer les pompes à quelqu'un	To polish someone's shoes	To be obedient and attentive to someone	--	--
Couper l'herbe sous les pieds de quelqu'un	To mow the lawn under the feet of someone	To suddenly stop helping someone	1.69	38.27
Couper la poire en deux	To cut the pear in two	To meet halfway	--	--
Découvrir le pot aux roses	To discover the pot in the roses	To discover the truth	4.31	32.73
Donner carte blanche à quelqu'un	To give someone the white card	To give somebody free reign	--	--
Donner sa langue au chat	To give your tongue to the cat	To give up on guessing	--	--
Dormir à poings fermés	To sleep with closed fists	To sleep soundly	--	--
En avoir plein le dos	To have a full back	To be fed up with	2.92	34.67
En faire tout en fromage	To make all the cheese	To make a big fuss out of something	2.00	39.07
Etre à côté de ses pompes	To be next to one's shoes	To be unfocused	2.00	58.80
Etre bonne poire	To be a good pear	To be too good-natured	--	--
Etre comme un coq en pâte	To live like a rooster with delicacies	To enjoy a life of money and comfort	4.08	14.87
Etre dans le pétrin	To be in the dough trough	To be in trouble	3.31	15.33
Etre dans les choux	To be in the cabbages	To be in a mess	2.92	37.87
Etre dans ses petits souliers	To wear the little slippers	To feel very small	3.36	44.00
Etre dur de la feuille	To be hard of paper	To have difficulty hearing	1.62	38.67
Etre en cheville avec quelqu'un	To work with the ankle of someone	To be in cahoots with someone	3.54	25.60
Etre hors de soi	To be without oneself	To be really angry	--	--
Etre le pigeon	To be the pigeon	To be the victim of a con	3.15	27.60
Etre marron	To be brown	To be duped	--	--
Etre mis à pied	To be put on foot	To be laid off	2.50	29.80

French	English (Literal)	English (Figurative)	Transparency Score	Ambiguity Score
Etre sur les genoux	To be on your knees	To be exhausted	--	--
Etre tiré à quatre épingles	To be pulled to four pins	To be dressed very properly	3.08	20.93
Etre tiré par les cheveux	To be pulled by the hairs	To be unlikely to happen	2.23	46.13
Etre un chaud lapin	To be a hot rabbit	To be horny	--	--
Etre un maquereau	To be a mackerel	To be a pimp	2.31	19.53
Etre un requin	To be a shark	To be untrustworthy	--	--
Etre une tête de Turc	To be a head of a Turk	To be a scapegoat	2.31	37.07
Etre vache	To be a cow	To be a mean person	--	--
Exécuter un travail de fourmi	To perform the work of ants	To do a pain-staking job	--	--
Faire avaler une couleuvre	To swallow a gardensnake	To be gullible	--	--
Faire des pieds et des mains	To move with both hands and feet	To exert the utmost effort	4.21	27.07
Faire des ronds de jambe	To make circles of one's leg	To do something to please someone	1.86	48.67
Faire du foin	To make some hay	To make a big fuss	--	--
Faire du vilain	To make the villain	To make trouble	--	--
Faire l'andouille	To make smoked sausage	To goof off	1.29	77.67
Faire la chèvre	To make the goat cheese	To act disorderly	1.64	81.60
Faire la pluie et le beau temps	To make it be rainy and sunny	To make all the decisions	3.29	27.67
Faire la tête	To make the head	To sulk and pout	1.77	43.00
Faire le poing dans sa poche	To make a fist in your pocket	To try to have self-control	--	--
Faire porter le chapeau à quelqu'un	To make someone else wear the hat	To put the blame on someone else	--	--
Faire quelque chose pour des prunes	To do something for the plums	To do something for nothing	2.62	30.67
Faire tapisserie	To do needlepoint	To be left out	2.57	80.00
Faire un temps de chien	To have the weather of dogs	To have foul weather	3.85	23.07
Faire une belle jambe à quelqu'un	To be a beautiful leg to someone	To not be useful to anyone	1.62	32.00
Filer à l'anglaise	To fly by to the English	To leave without saying goodbye	2.23	37.40

French	English (Literal)	English (Figurative)	Transparency Score	Ambiguity Score
Foutre le camp	To do camping	To be told to go away	2.71	67.80
Il n'y a que le premier pas qui coûte	It is only the first step that costs	The first step is the hardest	--	--
Il y a à boire et à manger	There is some to drink and some to eat	There are good and bad parts	2.36	61.47
Il y a anguille sous roche	There is an eel under the rock	There is something fishy going on	4.23	23.93
Il y a de l'eau dans le gaz	There is water in the gas	There is trouble brewing	2.93	33.33
Il y a deux poids deux mesures	To have two weights by two measures	To have double standards	--	--
Jeter des fleurs à quelqu'un	To throw flowers at someone	To compliment someone	--	--
La mettre en veilleuse	To turn on the night light	To quiet down	3.86	84.47
Lancer le bouchon un peu trop loin	To throw the cork a little too far	To exaggerate	--	--
Manger de la vache enragée	To eat the rabid cow	To have trouble managing one's finances	2.08	40.87
Marcher sur les plates-bandes de quelqu'un	To walk on someone's flowerbeds	To involve yourself with someone else's business	--	--
Mettre de l'eau dans son vin	To water down your wine	To back off	3.50	50.53
Mettre des gants pour dire quelque chose à quelqu'un	To put on gloves before speaking	To speak carefully	--	--
Mettre du beurre dans les épinards	To add butter to your spinach	To earn a little more money	3.77	46.00
Mettre la main à la pâte	To put your hands in paste	To join in	2.50	62.13
Mettre la puce à l'oreille	To put a fly in someone's head	To plant an idea in someone's head	--	--
Mettre les bâtons dans les roues	To stick something in the wheels	To impede someone's progress	4.57	37.07
N'en faire qu'à sa tête	To only reach your own head	To do exactly as one pleases	2.50	34.60
Ne pas arriver à la cheville de quelqu'un	To not reach someone's ankles	To be inferior to someone	4.23	22.93
Ne pas avoir froid aux yeux	To not have cold eyes	To not be faint-hearted	2.36	31.13

French	English (Literal)	English (Figurative)	Transparency Score	Ambiguity Score
Ne pas avoir gardé les cochons ensemble	To not have kept the pigs together	Not to be of the same background	2.85	46.00
Ne pas avoir les yeux en face des trous	To have holes in your face as eyes	To be hungover	3.08	20.40
Ne pas être dans son assiette	To not be in one's plate	To be a little sick	2.54	29.20
Ne pas être tombé de la dernière pluie	To not have fallen from the last rain	To not be as naïve as one looks	3.23	29.40
Ne pas manquer d'air	To not miss the air	To be bold	1.92	39.67
Ne pas mettre les deux pieds dans le même soulier	To not put two feet in the same slipper	To not make quick and rash decisions	--	--
Ne pas pouvoir sentir quelqu'un	To not be able to smell someone	To not like someone	2.14	69.67
Ne pas savoir si c'est du lard ou du cochon	To not know if it is the fat or bacon	Not be able to tell if something is true or false	4.00	28.73
Ne pas se faire de bile	To not have bile	Not to worry	3.46	39.73
Ne pas se fouler la rate	To not twist your spleen	To be lazy	--	--
Parler le français comme une vache espagnole	To speak French like a Spanish cow	To speak French very badly	--	--
Partir comme des petits pains	To leave like dinner rolls	To be very popular	3.77	33.93
Partir les pieds devant	To leave your feet behind	To die	3.00	49.79
Passer sur le billard	To go on the pool table	To have an operation	2.14	47.00
Passer un savon à quelqu'un	To pass soap to someone	To scold someone	2.57	64.27
Perdre les pédales	To lose the pedals	To lose your grip	--	--
Prendre quelqu'un la main dans le sac	To find someone's hand in the bag	To catch someone in the course of wrongdoing	--	--
Prendre ses jambes à son cou	To stretch your legs to your neck	To run for one's life	--	--
Recevoir une châtaigne	To receive a chestnut	To receive a punch	2.38	47.00
Regarder quelqu'un de travers	To look through someone	To give someone a dirty look	--	--
Regarder voler les mouches	To watch the flies fly	To stare into space	--	--
Remplacer quelqu'un au pied levé	To replace someone when your foot is already raised	To replace someone at the last minute	3.62	31.20

French	English (Literal)	English (Figurative)	Transparency Score	Ambiguity Score
Renvoyer deux personnes dos à dos	To send two people back to back	To refuse to get involved in an argument	2.62	40.13
Repousser aux calendes grecques	To postpone to the Greek calendar	To put something off indefinitely	4.00	26.00
Retourner sa veste	To turn the jacket inside out	To change sides	4.21	52.53
Réussir les doigts dans le nez	To be able to put your fingers in your nose	To do something that is easy	3.14	69.33
Rouler les mécaniques	To roll the mechanics	To play the tough guy	3.23	29.00
S'en mettre plein la lampe	To make yourself full of light	To overeat	--	--
Sauter aux yeux	Jump to the eyes	To be very obvious	--	--
Sauter du coq à l'âne	To jump from the rooster to the donkey	To switch from one subject to another	4.77	20.67
Se faire des cheveux	To do your hair	To worry yourself a lot	1.57	92.00
Se faire marcher sur les pieds	To take a walk on your feet	To be taken advantage of	1.86	68.60
Se faire tirer l'oreille	To require a pulling of your ears	To need a lot of persuading	--	--
Se faire un sang d'encre	To have blood of ink	To worry yourself a lot	1.92	26.73
Se mêler de ses oignons	To meddle with someone's onions	To be nosy	3.93	24.13
Se mettre en quatre	To be folded into fourths	To go through a lot of trouble	3.57	29.13
Se mettre le doigt dans l'œil	To put your finger in your eye	To be entirely mistaken	2.43	45.00
Se mettre sur son trente-et-un	To put on one's 31st	To dress very properly	3.00	23.93
Se tenir à carreau	To hold to the panes	To stick to the rules	4.31	28.13
Se tenir les pouces	To hold your thumbs	To be nervous for something	--	--
Souffler comme un bœuf	To breathe like an ox	To make empty threats	1.69	35.73
Taper le carton	To hit the cardboard	To play cards	2.62	42.60
Tenir la jambe à quelqu'un	To hold someone's legs	To talk a lot	--	--
Tirer les marrons du feu	To pull the chestnuts from the fire	To reap the benefits	3.92	34.00
Tomber dans les pommes	To fall like apples	To faint	4.62	31.00
Tomber de haut	To fall from high up	To not see something coming	--	--
Tourner de l'œil	To turn your eye	To faint	2.00	71.13

French	English (Literal)	English (Figurative)	Transparency Score	Ambiguity Score
Tous les trente-six du mois	All 36 of the months	Very rarely	3.23	29.93
Trouver chaussure à son pied	To find a shoe on your feet	To find the right person	--	--
Vivre à la colle	To live in glue	To live in sin	3.00	19.13

Note: "--" indicates that an idiom was removed from analysis due to high familiarity scores

TRANSPARENCY AND AMBIGUITY LEVELS OF IDIOMS IN TRAINING TASK

Idiom	Meaning	Transparency	Ambiguity
To turn the jacket inside out	To change sides	High	High
To turn on the night light	To quiet down	High	High
To have a little pit	To be a little hungry	High	High
To water down your wine	To back off	High	High
To have a resistant heart	To not be squeamish	High	High
To be able to put your fingers in your nose	To do something that is easy	High	High
To have a dirty head	To look awful	High	High
To have a hair on your tongue	To have a lisp	High	High
To live like a rooster with delicacies	To enjoy a life of money and comfort	High	Low
To jump from the rooster to the donkey	To switch from one subject to another	High	Low
To fall like apples	To faint	High	Low
To stick something in the wheels	To impede someone's progress	High	Low
To move with both hands and feet	To exert the utmost effort	High	Low
To hold to the panes	To stick to the rules	High	Low
To discover the pot in the roses	To discover the truth	High	Low

Idiom	Meaning	Transparency	Ambiguity
There is an eel under the rock	There is something fishy going on	High	Low
To do your hair	To worry yourself a lot	Low	High
To make the goat cheese	To act disorderly	Low	High
To make smoked sausage	To goof off	Low	High
To take a walk on your feet	To be taken advantage of	Low	High
There is some to drink and some to eat	There are good and bad parts	Low	High
To turn your eye	To faint	Low	High
To be next to one's shoes	To be unfocused	Low	High
To not be able to smell someone	Not to like someone	Low	High
To be a beautiful leg to someone	To not be useful to anyone	Low	Low
To breathe like an ox	To make empty threats	Low	Low
To mow the lawn under the feet of someone	To suddenly stop helping someone	Low	Low
To make the head	To sulk / To pout	Low	Low
To have blood of ink	To worry yourself a lot	Low	Low
To not miss the air	To be bold	Low	Low
To make all the cheese	To make a big fuss out of something	Low	Low
To be hard of paper	To have difficulty hearing	Low	Low

APPENDIX C

SEMANTIC RELATEDNESS NORMS

C.1   LIST 1

Idiom	Definition	Key Word	R/U/C
Catch Trial	To laugh	Laughter	CR
Catch Trial	To sing	Song	CR
Catch Trial	To do laundry	Ball	CU
Catch Trial	To play a computer game	Computer	CR
Catch Trial	To wait for the bus	Swim	CU
There is an eel under the rock	There is something fishy going on	Silence	U
There is some to drink and some to eat	There are good and bad parts	Bittersweet	R
To be a beautiful leg to someone	To not be useful to anyone	Inaudible	U
To be able to put your fingers in your nose	To do something that is easy	Effortless	R
To be hard of paper	To have difficulty hearing	Collapse	U
To be next to one's shoes	To be unfocused	Inattentive	R

Idiom	Definition	Key Word	R/U/C
To breathe like an ox	To make empty threats	Snack	U
To discover the pot in the roses	To discover the truth	Courageous	U
To do your hair	To worry yourself a lot	Withdraw [a]	U
To fall like apples	To faint	Unconscious	R
To have a dirty head	To look awful	Exploited	U
To have a hair on your tongue	To have a lisp	Intensify	U
To have a little pit	To be a little hungry	Obstruction	U
To have a resistant heart	To not be squeamish	Strong	R
To have blood of ink	To worry yourself a lot	Anxiety	R
To hold to the panes	To stick to the rules	Investigate	U
To jump from the rooster to the donkey	To switch from one subject to another	Digress	R
To live like a rooster with delicacies	To enjoy a life of money and comfort	Wealth	R
To make all the cheese	To make a big fuss out of something	Honest	U
To make smoked sausage	To goof off	Idle	R
To make the goat cheese	To act disorderly	Ugly	U
To make the head	To sulk and pout	Frown	R
To move with both hands and feet	To exert the utmost effort	Dedicated	R
To mow the lawn under the feet of someone	To suddenly stop helping someone	Withdraw [a]	R
To not be able to smell someone	To not like someone	Stress	U
To not miss the air	To be bold	Pointless	U
To stick something in the wheels	To impede someone's progress	Stutter	U
To take a walk on your feet	To be taken advantage of	Exaggerate	U
To turn on the night light	To quiet down	Suspicious	U
To turn the jacket inside out	To change sides	Indecisive	R
To turn your eye	To faint	Hatred	U
To water down your wine	To back off	Retreat	R

Note. R/U/C refers to 'Related,' 'Unrelated,' or 'Catch Trial.'
[a] List 1 contained two instances of the key word 'Withdraw'

Idiom	Definition	Key Word	R/U/C
Catch Trial	To go swimming	Swim	CR
Catch Trial	To throw a basketball	Ball	CR
Catch Trial	To knit a sweater	Computer	CU
Catch Trial	To take an exam	Laughter	CU
Catch Trial	To eat dinner	Song	CU
There is an eel under the rock	There is something fishy going on	Suspicious	R
There is some to drink and some to eat	There are good and bad parts	Inattentive	U
To be a beautiful leg to someone	To not be useful to anyone	Pointless	R
To be able to put your fingers in your nose	To do something that is easy	Retreat	U
To be hard of paper	To have difficulty hearing	Inaudible	R
To be next to one's shoes	To be unfocused	Frown	U
To breathe like an ox	To make empty threats	Exaggerate	R
To discover the pot in the roses	To discover the truth	Investigate	R
To do your hair	To worry yourself a lot	Stress	R
To fall like apples	To faint	Wealth	U
To have a dirty head	To look awful	Ugly	R
To have a hair on your tongue	To have a lisp	Stutter	R
To have a little pit	To be a little hungry	Snack	R
To have a resistant heart	To not be squeamish	Effortless	U
To have blood of ink	To worry yourself a lot	Unorganized [b]	U
To hold to the panes	To stick to the rules	Honest	R
To jump from the rooster to the donkey	To switch from one subject to another	Anxiety	U
To live like a rooster with delicacies	To enjoy a life of money and comfort	Dedicated	U
To make all the cheese	To make a big fuss out of something	Intensify	R
To make smoked sausage	To goof off	Unconscious	U
To make the goat cheese	To act disorderly	Unorganized [b]	R

Idiom	Definition	Key Word	R/U/C
To make the head	To sulk and pout	Digress	U
To move with both hands and feet	To exert the utmost effort	Bittersweet	U
To mow the lawn under the feet of someone	To suddenly stop helping someone	Idle	U
To not be able to smell someone	To not like someone	Hatred	R
To not miss the air	To be bold	Courageous	R
To stick something in the wheels	To impede someone's progress	Obstruction	R
To take a walk on your feet	To be taken advantage of	Exploited	R
To turn on the night light	To quiet down	Silence	R
To turn the jacket inside out	To change sides	Strong	U
To turn your eye	To faint	Collapse	R
To water down your wine	To back off	Indecisive	U

Note. R/U/C refers to 'Related,' 'Unrelated,' or 'Catch Trial.'

[b] List 2 contained two instances of the key word 'Unorganized'

APPENDIX D

OPERATION SPAN SCORE DISTRIBUTIONS FOR EXPERIMENT 2 & 3

Set Size	Experiment 2	Experiment 3
3	1	1
4	3	5
5	12	6
6	9	5
Total Participants	25	17

Note. The numbers under Experiment 2 and Experiment 3 indicate the number of participants who received the specified score.

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