The memory conjunction error paradigm: Normative data for conjunction triplets

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In the typical memory conjunction experiment, participants are presented with two “parent” stimulus items (e.g., *blackmail* and *jailbird*) that are later recombined to form a “conjunction lure” (e.g., *blackbird*). This paradigm is an efficient way to test false memories because participants frequently show false recognition for the recombined features of the previously studied stimuli. Two experiments are reported in which normative data for 96 memory conjunction triplets are presented. The first experiment provides descriptive statistics for how often the conjunction triplets show true and false recognition. Due to the variance in the rates of false recognition for the conjunction lure, the second experiment was conducted to help build an understanding of the factors that affect the rate of false recognition of the conjunction lures. Conceptual overlap of the first parent word and the conjunction item predicted false recognition. Digital files containing norms for 96 memory conjunction triplets may be downloaded from www.psychonomic.org/archive.

A memory conjunction error is a false memory that involves recombining features from actually presented items. For example, a participant who studies the words *blackmail* and *jailbird* may falsely remember the word *blackbird* (Reinitz & Demb, 1994). Feature errors reflect false memories for nonpresented items that contain some old features and some new features (e.g., *blackboard*). Memory conjunction errors have been demonstrated with a variety of materials including words (Jones, 2005; Jones & Atchley, 2002, 2006; Jones & Jacoby, 2001; Jones, Jacoby, & Gellis, 2001; Lampinen, Odegard, & Neuschatz, 2004; Reinitz & Demb, 1994; Underwood, Kapelak, & Malmi, 1976; Underwood & Zimmerman, 1973), pseudo-words made from nonsense syllables (Reinitz, Lammers, & Cochran, 1992), faces (Hannigan & Reinitz, 2000; Reinitz & Hannigan, 2001; Reinitz et al., 1992), sentences (Reinitz et al., 1992), and autobiographical events (Odegard & Lampinen, 2004).

In the present article we present norms for memory conjunction materials. In a typical memory conjunction experiment, researchers create materials based on sets of *memory conjunction triplets*. A triplet is made up of two parents (e.g., *blackmail*, *jailbird*) and one combined item (e.g., *blackbird*). Elements of the parents (i.e., *black* from *blackmail* and *bird* from *jailbird*) are recombined to form the memory combined item. Typically, the recognition memory test is made up entirely of combined items from the triplets. The role the combined item plays in the exper-

iment varies depending on which members of the triplet are presented at study. For some triplets, the conjunction item itself is studied, making the memory conjunction item a target. For other triplets, both parents are studied, making the memory conjunction item a conjunction lure. For other triplets, either the first or the second parent is studied, making the conjunction item a feature lure. For still other triplets, no items from the triplet are studied, making the conjunction item on the test an unrelated foil. Typically, participants are more likely to respond “old” to targets than to conjunction lures, conjunction lures than to feature lures, and feature lures than to unrelated foils (see, e.g., Lampinen et al., 2004).

Theoretical accounts of the memory conjunction effect fall into three broad categories. Some researchers have proposed single process accounts of the memory conjunction effect. According to these accounts, false recognition of conjunction and feature lures occurs because of conceptual and/or perceptual overlap between the studied items and the lures, leading to a graded feeling of familiarity (Ghatala, Levin, Bell, Truman, & Lodico, 1978; Underwood et al., 1976). Other researchers have proposed dual process accounts in which familiarity can lead to the false recognition of conjunction and feature lures, and in which recollection of one or both parents can result in rejection of the conjunction and feature lures (Jones & Jacoby, 2001; Lampinen et al., 2004; Odegard, Lampinen, & Toggia, 2005). Finally, configural accounts argue

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that features from presented items can at times become mistakenly bound together, either at study or test, leading to an illusory conscious recollection of conjunction lures (Kroll, Knight, Metcalfe, Wolf, & Tulving, 1996; Reinitz & Demb, 1994).

Recently there has been evidence that the degree of conceptual overlap between study and test items influences the memory conjunction effect. In particular, it has been noted that memory conjunction triplets vary in terms of the degree to which the parents overlap in meaning with the combined item (Ghatala et al., 1978; Jones & Jacoby, 2001). For instance, in the triplet *blackmail*, *jailbird*, *blackbird*, the conceptual overlap between the targets and the conjunction item is relatively weak. Blackbirds are both black and birds. But blackmail is not really black and jailbirds are not really birds. For other triplets, the conceptual overlap between the parents and the conjunction lure is stronger. For instance, for the triplet *handball*, *shotgun*, *handgun*, the overlap in meaning is strong. Handball is a game played with the hand, and handguns are held in the hand. Shotguns are a type of gun, and handguns are a type of gun. Recently, Odegard et al. (2005) demonstrated that triplets with strong conceptual overlap produce stronger memory conjunction effects than triplets with weaker conceptual overlap (see also Ghatala et al., 1978). In Experiment 2 of the present article, we present an exploratory regression analysis of memory conjunction triplets in which we examine whether memory conjunction errors are more common when conceptual overlap is stronger. This experiment extends the results of Odegard et al. in two important ways. First, the conjunction triplets used in Odegard et al. were constructed specifically for the purpose of having high and low degrees of semantic overlap. The conjunction triplets used in the present experiments, however, are materials that have been used in prior memory conjunction research (Jones, 2005; Lampinen et al., 2004) and have not been designed to have a specific degree of semantic overlap. Furthermore, this experiment adds to the research conducted by Odegard et al. in the fact that 96 conjunction triplets with varying degrees of conceptual overlap are tested in this study, whereas Odegard et al. used only 40 triplets.

Given the recent interest in memory conjunction errors, and because compound words have been some of the most commonly used stimuli to test the theoretical assumptions of the paradigm, Experiment 1 was devoted to developing a set of normed compound word triplets that could be used to study the memory conjunction effect. Normed false memory materials have proven invaluable in other domains (see, e.g., Stadler, Roediger, & McDermott, 1999), and we believed they would also be useful in helping to explicate the memory conjunction effect. In particular, we believed that developing a reliable set of norms for true and false recognition for memory conjunction triplets would aid other researchers in developing materials for their own experiments, as well as opening up an investigation into those item factors likely to affect the production of memory conjunction errors. Therefore, in Experiment 2, we report an initial regression analysis

of item variables that influence the production of memory conjunction errors.

EXPERIMENT 1

Method

Participants. Participants were 432 undergraduate students at the University of Arkansas who completed the experiment in exchange for partial course credit.

Materials. Ninety-six conjunction triplets were gathered from previous memory conjunction experiments (Jones, 2005; Lampinen et al., 2004). Each triplet consisted of the two parent words (e.g., *blackmail* and *jailbird*; Parent A and Parent B, respectively) that could be recombined to form a conjunction (e.g., *blackbird*).¹ The words were presented on a computer screen in 16 pt. bold System font. The words were presented in the center of the screen in capital letters. There were eight main counterbalancing orders with each test word serving as a target in two of the orders (e.g., the participant studied *blackbird* and was tested with *blackbird*), a conjunction lure in two of the orders (e.g., the participant studied *blackmail* and *jailbird* and was then tested with *blackbird*), a feature lure in two of the orders (e.g., the participant studied *blackmail* or *jailbird* and was then tested with *blackbird*), and a foil in two of the orders (e.g., the participant did not study any components from the *blackbird* triplet but was tested with *blackbird*). For those triplets being tested as feature lures, half of the time the study item was the first parent (e.g., the participant studied *blackmail* and was tested with *blackbird*), and half of the time the study item was the second parent (e.g., the participant studied *jailbird* and was tested with *blackbird*).

The 96 studied words were divided into 3 groups of 32 so that parent words for the conjunction lures were never presented more than 31 items apart. Within the groups of 32 words, the studied items were presented in a random order for each of the participants. In addition, each of the eight main counterbalanced conditions was further broken down into three counterbalanced conditions to control for order effects. The recognition memory test was composed of 96 words with 24 words each serving as targets, conjunction lures, feature lures, and foils. On each test, half of the feature lures were from triplets where the first parent had been studied and half were from triplets where the second parent had been studied.

Procedure. Participants entered the lab in groups of no more than four. Each participant sat at a computer and was told that he or she would be presented a list of words. The experimenter told participants to pay attention to the words, as they would be tested on their memory for the words later. At that time, participants pressed the space bar on the computer to begin the presentation of the words. The participants viewed 96 words at a rate of 3 sec per word. The 96 words were divided into three blocks of 32. Within each block of 32, eight of the conjunction words were presented (to serve as targets during the test phase), eight pairs of parent words were presented (e.g., *blackmail* and *jailbird* were presented to create the conjunction lure *blackbird* during the test phase), four Parent A words were presented, and four Parent B words were presented (to serve as Feature 1 lures and Feature 2 lures, respectively). Within the three blocks, the words were randomly presented. After viewing all of the words, the participants were given a 2 min distractor task. After the 2 min, the experimenter read the instructions for the memory task. The experimenter told the participants that they would be presented words on the computer screen, and for each of those words there would be two questions. The first question would be, "Did you see the word _____?" The second question would be, "How confident are you in your answer about the word _____?" The participants were told to press the keys marked "yes" and "no" for the first question and to respond on a scale of 1 to 4 for the second question, with 1 being "not at all confident," 2 being "somewhat not confident," 3 being "somewhat confident," and 4 being "very confident." The order of test items was randomly determined by the computer for

each participant. Participants were able to move through the recognition memory test at their own pace. When all participants were finished, the experimenter debriefed the participants.

Results

The intention of Experiment 1 was to develop a set of norms for the production of memory conjunction errors for a large set of memory conjunction triplets. In addition to measuring the rate at which the conjunction lures were falsely recognized, we also measured how often the words were recognized as targets, feature lures, and unrelated lures. Furthermore, we report both uncorrected recognition rates and corrected recognition rates which are based on subtracting the rate at which unrelated foils were recognized. The archived table of norms is sorted by descending order of corrected recognition of conjunction lures. Thus, triplets toward the top of the table are those that produced the most robust memory conjunction effects.

Corrected recognition of targets ranged from .30 to .82 with a mean corrected recognition rate of .49 ($s = .11$). Corrected false recognition for conjunctions ranged from $-.07$ to .47, with a mean corrected recognition rate of 0.18 ($s = .11$). As the archived table of norms shows, the triplet leading to the greatest rate of corrected false recognition for conjunction lures was the *witchcraft* triplet. The triplet producing the lowest rate of corrected false recognition was the *footstool* triplet. Corrected false recognition of feature lures ranged from $-.09$ to .33 with a mean corrected recognition rate of .09 ($s = .08$). The triplet leading to the greatest rate of corrected false recognition of feature lures was the *riptide* triplet. The triplet leading to the lowest rate of corrected false recognition of feature lures was the *needlepoint* triplet.

We examined the effect of item type (i.e., target, conjunction lure, feature lure, foil) on uncorrected recognition rates by doing an item analysis, whereby we treated each item as a participant in the analysis. A repeated measures ANOVA on uncorrected recognition produced a significant main effect [$F(3,285) = 726.25$, $MS_e = .006$, $p < .001$]. Pairwise comparisons using a Bonferroni correction showed that targets were endorsed at a significantly higher rate than conjunction lures [$t(95) = 23.77$, $p < .001$], feature lures [$t(95) = 30.92$, $p < .001$], and foils [$t(95) = 40.83$, $p < .001$]. Conjunction lures were endorsed more often than both feature lures [$t(95) = 11.62$, $p < .001$] and foils [$t(95) = 16.36$, $p < .001$], and feature lures were endorsed significantly more often than foils [$t(95) = 11.00$, $p < .001$].

A repeated measures ANOVA on corrected recognition of targets, conjunction lures, and feature lures produced similar results with a significant main effect [$F(2,190) = 632.81$, $MS_e = .007$, $p < .001$]. Pairwise comparisons using a Bonferroni correction showed that targets were endorsed at a significantly higher rate than were conjunction lures [$t(95) = 23.12$, $p < .001$] and feature lures [$t(95) = 30.44$, $p < .001$]. Conjunction lures were endorsed more often than were feature lures [$t(95) = 11.37$, $p < .001$]. These findings thus replicate the typical finding of targets being recognized more than conjunction lures, conjunc-

tion lures being recognized more than feature lures, and feature lures being recognized more than unrelated foils.

EXPERIMENT 2

The purpose of Experiment 1 was to develop a reliable set of norms for memory conjunction triplets and to examine whether they conform to the general pattern, where targets are recognized more often than conjunction lures, conjunction lures are recognized more often than feature lures, and feature lures are recognized more often than foils. Examination of the results from Experiment 1 conformed to these predictions; however, it is also noteworthy that there was substantial variation in the degree to which different triplets produced the memory conjunction effect. Thus, our purpose in Experiment 2 was to initiate an exploratory analysis into some of the possible item characteristics that might moderate the memory conjunction effect. In particular, past research has suggested that the degree to which memory conjunction lures share conceptual similarity with their parents moderates the memory conjunction effect (Odegard et al., 2005). In addition, research suggests that the expected memorability of an item abates false memory effects (Ghetti & Alexander, 2004; Ghetti & Castelli, 2006; Ghetti, Papini, & Angelini, 2006). This idea of memorability is similar to Dodson's idea of distinctiveness (Dodson & Schacter, 2001; Israel & Schacter, 1997). In particular, when participants expect an item to be memorable, they require a more vivid and distinctive memorial experience before they will endorse an item. Finally, familiarity has been a factor that has been studied in eliciting false memories (e.g., Stadler et al., 1999). Therefore, in the present experiment we collected additional norms on each of the memory conjunction triplets by asking a new set of norming participants to rate the triplets in terms of each item's familiarity, expected memorability, and the degree of conceptual overlap between the parents and the conjunction. We then used these ratings in a regression analysis to examine the degree to which they predict memory conjunction effects.

Method

Participants. Participants were 186 undergraduate students at the University of Arkansas who completed the experiment in exchange for partial course credit.

Materials. Three different types of questionnaires were created to get normative data on familiarity, memorability, and meaning overlap of the parent words and conjunction words. For the familiarity questionnaire, participants were presented 96 different words and asked to rate how familiar each of the items was to them on a scale of 1 to 7, with 1 being *very unfamiliar* and 7 being *very familiar*. There were three different familiarity scales created: one with all of the Parent 1 words from the 96 conjunction triplets, one with all of the Parent 2 words, and the other with all of the conjunction words. As with the familiarity questionnaire, there were three different versions of the memorability questionnaire: one with the Parent 1 words, one with the Parent 2 words, and one with the conjunction words. For this questionnaire, participants were asked to rate how memorable each of the 96 words would be to them. That is, they were asked to imagine that, had they been shown the word on a memory test, how easy or difficult would it be for them to remember the word. The memorability of each of the items was rated on a scale

of 1 to 7, with 1 being *very easy* and 7 being *very difficult*. For the meaning overlap questionnaire, participants were given word pairs (either the Parent 1 word and the corresponding conjunction, or the Parent 2 word and the corresponding conjunction) with the overlapping components of each of the words underlined (e.g., *toothpick*, *toothache* or *heartache*, *toothache*). The participants were asked to rate how similar the meanings of the overlapping portions of the words were. They were given the following instructions.

For each of the word pairs below, please indicate on a scale of 1 to 7 to what extent the underlined portions mean the same thing. For example, the underlined portions of some of the pairs of words might be very similar, such as *football* and *footstool*. However, the underlined portions of some of the pairs of words might be very different, such as *eggplant* and *physical plant*. For each of the pairs of words you rate, please use the scale below when indicating how different or similar you think the meaning of the underlined words are.

Participants were asked to rate the 96 word pairs on a scale of 1 to 7, with 1 being *very different* and 7 being *very similar*.

Procedure. Participants completed only one of the questionnaires listed above. They were given a copy of the questionnaire, and the experimenter read the instructions. The participants then completed the questionnaires at their own pace. Of the 186 participants who participated in this experiment, 70 completed the familiarity questionnaires, 72 completed the memorability questionnaires, and 44 completed the meaning overlap questionnaires.

Results

The purpose of Experiment 2 was to begin an exploration of the factors that could have an effect on the variability in which the conjunction triplets are accepted as targets and conjunction lures. We therefore present regression analyses for corrected recognition of targets, conjunction lures, and feature lures. We used corrected recognition in these analyses so we could remove the variability due to response bias. In particular, we predicted that the rated familiarity and memorability of the conjunction and feature lures would be inversely related to corrected recognition of conjunction and feature lures, and that the conceptual overlap between the conjunction and feature lures and their parents would be positively associated with corrected recognition of conjunction and feature lures.

We first examined factors that might influence corrected recognition of targets. Note that for targets, neither of the parents was presented at study. As a consequence, neither the rated familiarity of the parents, the rated memorability of the parents, nor the conceptual overlap between the parents and the target should have any effect on target recognition. We thus entered a regression equation in which rated memorability of the target and the rated familiarity of the target were used as predictors of corrected target recognition. The regression equation was significant [$F(2,93) = 14.17$, $MS_e = .01$] and accounted for more than a fifth of the variance in the corrected recognition of the targets (adjusted $R^2 = .22$). Both the rated familiarity of the targets ($\beta = -.10$, $p < .001$) and the rated memorability of the targets ($\beta = -.08$, $p < .001$) were significant. These findings are consistent with the predictions of the distinctiveness heuristic. Items that are judged to be familiar and memorable must pass a higher hurdle before they are endorsed, and thus lower the corrected recognition rates of these items.

We next turned to variables that might influence corrected recognition of memory conjunction lures. Note that for memory conjunction lures, the distinctiveness account would predict that the rated familiarity and memorability of the conjunction lure itself should be negatively related to the occurrence of conjunction errors, and that the average degree of conceptual overlap between the memory conjunction lures and their two parents should be positively associated with memory conjunction errors. We thus entered a regression on corrected recognition of conjunction lures, in which the rated familiarity of the conjunction lures, the rated memorability of the conjunction lures, and the average rated conceptual overlap between the parents and the conjunction lure were included as predictors. The regression equation was significant [$F(3,92) = 3.12$, $MS_e = .01$] and accounted for approximately 6% of the variance in the corrected recognition of the conjunction lures (adjusted $R^2 = .063$). Neither the average rated familiarity nor the average rated memorability of the conjunction lures significantly predicted corrected recognition of memory conjunction lures. However, the average conceptual overlap between the parents and the memory conjunction lures did significantly predict corrected recognition of the conjunction lures ($\beta = .03$, $p = .009$). These results are consistent with the prediction that conceptual overlap between parents and conjunctions can increase the familiarity of those conjunctions leading to greater levels of false memories.

We next examined the role of the rated familiarity of the feature lures, the rated memorability of the feature lures, and the degree of conceptual overlap between the feature lure and its parent on corrected recognition of feature lures. Because feature lures are based on only one parent, the effect of conceptual overlap should be limited to the parent that shares a morpheme with that feature lure. Therefore, we conducted two separate regressions, one examining feature lures in which the parent and feature lure shared the first morpheme and one in which the parent and feature lure shared the second morpheme. For feature lures which shared the first morpheme with their parent, the overall regression was significant [$F(3,92) = 4.66$, $MS_e = .01$] and accounted for approximately 10% of the variance in the corrected recognition of these feature lures (adjusted $R^2 = .104$). Both the rated familiarity of the feature lure ($\beta = -.043$, $p = .039$) and the conceptual overlap between the feature lure and its parent ($\beta = .028$, $p = .002$) were significant predictors of corrected recognition for these feature lures. Feature lures that had high rated familiarity produced lower rates of corrected recognition. Feature lures that had high levels of conceptual overlap with their respective parents tended to produce higher rates of corrected recognition. Surprisingly, for feature lures that shared the second morpheme with their respective parents, the regression equation was not significant ($F < 1$). That the regression equation was significant for feature lures that share the first morpheme but not for feature lures that share the second morpheme could be due to some sort of attentional advantage to the first morpheme in the compound word due to its position.

GENERAL DISCUSSION

The goal of the present study was to develop a large corpus of materials for the production of memory conjunction errors and to begin the process of identifying factors that predict their occurrence. To this end we compiled and normed a set of 96 memory conjunction triplets in an initial experiment. Motivated by the variability observed in the rate at which the different triplets produced a memory conjunction effect, we performed an additional exploratory study in an attempt to identify factors that predict the occurrence of memory conjunction errors. In the second study, participants provided subjective ratings about various qualities of the compound words making up the memory conjunction triplets. These data were then entered into a series of regression equations and used to predict the memory performance observed in the first experiment. Of all the ratings obtained, the average amount of conceptual overlap shared between a conjunction lure and its parent words was the best predictor of memory conjunction errors, replicating previous findings that have demonstrated the importance of conceptual overlap in the memory conjunction paradigm (Ghatala et al., 1978; Odegard et al., 2005).

Moreover, these norms also provide a promising tool for researchers interested in investigating the single process versus dual process account of recognition memory utilizing the memory conjunction paradigm. According to the dual process account, there are two factors at play: *familiarity*, which leads to the false acceptance of conjunction and feature lures, and *recollection*, which leads to the successful rejection of conjunction and feature lures. In some instances, individuals self-report that the reason they rejected a lure is due to the fact that they recalled the presentation of a parent word (e.g., "I studied shotgun and not handgun"; Lampinen et al., 2004; Odegard et al., 2005). The use of recollection of a conjunction or feature lure's instantiating parent word or words to avoid a false alarm provides a potential explanation for why the conceptual overlap between the second parent word and conjunction and feature lures failed to predict false alarms. Although conceptual overlap can function to increase perceptual familiarity, it can also serve as an effective cue for the retrieval of a previously studied parent word (or words), allowing for a feature or conjunction lure to be successfully rejected.

In addition to the observation that increased conceptual overlap elevated conjunction and feature errors, Odegard et al. (2005) also observed more self-reported occurrences of recall-to-reject for those items that were semantically related to their parent words. In fact, the occurrence of recall-to-reject was almost nonexistent for conjunction and feature lures that shared only minimal semantic overlap with their parent words. Odegard et al. did not test whether the first or second parent word was recollected more often when participants self-reported recall-to-reject, but such a finding would help to explain why conceptual overlap between the second parent word and conjunction and feature lures does not predict false alarms to these lures. If the second parent is heavily involved in recall-to-reject, then recollection and familiarity would be pushing in op-

posite directions. That is, when recollection occurred, an item would be rejected, but if recollection failed to occur, the item would feel extremely familiar and would likely be falsely accepted.

The present results provide a lot of information about the effectiveness of individual memory conjunction triplets in eliciting true and false recognition. Because compound word stimuli are commonly used in memory research to help develop some understanding of memory accuracy and errors, and because the triplets analyzed in this paper have all been previously used in conjunction experiments using compound words, the norms should be helpful for future researchers in designing studies. In addition, the exploratory analysis of Experiment 2 can be used as a initial step toward understanding the factors that go into the effectiveness or ineffectiveness of certain stimuli in eliciting memory errors.

AUTHOR NOTE

This project was supported by the Marie Wilson Howells Fund at the University of Arkansas, Fayetteville. We thank Jon Sallings, Callie Shaw, and Christina Kuykendall and the other members of the false memory lab at the University of Arkansas for their help with this project (comp.uark.edu/~lampinen/lab.html). Correspondence concerning this article should be addressed to J. K. Leding, University of North Florida, Department of Psychology, 4567 St. Johns Bluff Road S, Jacksonville, FL 32224 (e-mail: j.leding@unf.edu).

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NOTE

1. Twenty-two of the 96 conjunction triplets used in this study consisted of at least one compound word that was a two-word compound (e.g., the Parent 1 conjunction *witch hunt* in the conjunction triplet *witch hunt, spacecraft, and witchcraft*). It is important to note that there were no differences in false recognition of the conjunction lure if any of the component compound words were made up of two words—for uncorrected false recognition [$t(94) = 1.48, p < .15$] and for corrected false recognition [$t(94) = -2.06, p < .05$].

ARCHIVED MATERIALS

The following materials associated with this article may be accessed through the Psychonomic Society's Norms, Stimuli, and Data archive, www.psychonomic.org/archive.

To access these files, search the archive for this article using the journal name (*Behavior Research Methods*), the first author's name (Leding), and the publication year (2007).

FILE: Leding-BRM-2007.zip

DESCRIPTION: The compressed archive file contains two files:

LedingEtAl(2007).txt, containing norms for 96 memory conjunction triplets

LedingEtAl(2007).xls, containing the above information in Excel spreadsheet format.

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(Manuscript received August 23, 2006;
revision accepted for publication October 2, 2006.)