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Contextually-controlled semantic false memories in the form of derived relational intrusions following training

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CONTEXTUALLY-CONTROLLED SEMANTIC FALSE MEMORIES IN THE FORM OF DERIVED RELATIONAL INTRUSIONS FOLLOWING TRAINING

BY

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DISSERTATION

Submitted in Partial Fulfillment of the
Requirements for the Degree of

Doctor of Philosophy
Psychology

The University of New Mexico
Albuquerque, New Mexico

May, 2011

DEDICATION

To my friends and family.

ACKNOWLEDGMENTS

Thanks Mike!

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ABSTRACT

Modified versions of the original Derived Relational Intrusions Following Training paradigm (DRIFT; Guinther & Dougher, 2010) were used to engineer semantic false memories and contextually-controlled semantic false memories in group data. Experiment I replicated and extended the original DRIFT paradigm by showing that interrelated conditional discrimination training (match-to-sample; MTS) could influence subsequent false recall even in the absence of tests of symmetry and transitivity. It was also found that false recall was especially likely among those participants whose self reports indicated awareness that the study list words shared a common conditionally discriminative function. Experiment II required participants to complete a contextually-controlled MTS training procedure in which study list words were assigned to participate in a functional equivalence class with one set of non-study words in one context but with a different set of non-study words in a different context. Subsequent transfer of the study list words' remembering function to non-study words (i.e., false recall) was found to be dependent upon the context in which the free recall test was administered, thus demonstrating engineered contextual control of semantic false memory.

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Introduction

Semantic false memory phenomena have typically been studied by cognitive psychologists, who use these phenomena to infer the properties of cognitive processes and structures thought to be responsible for the encoding, storage, and retrieval of information (e.g., see Brainerd & Reyna, 2005; Gallo, 2006). False memory phenomena are also of direct interest to those researchers who are interested in understanding allegations of childhood sexual abuse (e.g., Ceci & Friedman, 2000; Goodman & Clarke-Stewart, 1991; Lyon, 1995) and the credibility eyewitness testimony (e.g., Loftus, 1975; Loftus & Palmer, 1974). Such cognitive and applied investigations have been useful in the elaboration of schema theory (e.g., Brewer & Treyens, 1981; Minsky, 1975; Schank & Abelson, 1977), which in turn forms the theoretical rationale underlying a major branch of psychotherapy (i.e., cognitive therapy; Beck, 1976). In order to characterize semantic false memory phenomena in terms of the environmental variables of interest to behavior analysts, we (Guinther & Dougher, 2010) recently developed the Derived Relational Intrusions Following Training (DRIFT) paradigm.

The DRIFT paradigm was designed to produce experimentally some of the semantic behaviors exhibited during implementations of its paradigmatic predecessor, namely the Deese-Roediger-McDermott paradigm (DRM; Deese, 1959a, 1959b; Roediger & McDermott, 1995). The DRM paradigm has been enormously useful in the study of semantic false memory phenomena, showing that preexperimentally established semantic relationships are predictive of specific memory intrusions (i.e., instances of false recall). For example, given a list of preexperimentally semantically related words to remember such as *bed, rest, awake, tired, dream, snore etc.,* a person in an English-speaking community is likely to erroneously recall the semantically-related word *sleep,* even though this word was not on the original study list. Thus, the DRM paradigm allows researchers to predict the likelihood of specific intrusions from measures of semantic relations, though the semantic relations themselves were presumably established prior to experimentation.

In order to insure the semantic relatedness of DRM study words to particular non-study words, the original DRM study lists were constructed using nomothetic information gathered during free association tasks (Deese, 1959a, 1959b). Participants were asked to state the first word that came to mind following the presentation of probing root words, and their responses were recorded. Modal responses (i.e., words that would become the DRM study list items) to the root words (i.e., words presumed to be likely intrusions) were to be expected, given that the participants had extensive common natural learning histories with respect to the use of the root words. That is, all of the participants had been exposed to historical environments that promoted the speaking of coherent English, in which specific utterances were likely to have been reinforced under specific circumstances. For example, in English-speaking communities one is likely to be reinforced for emitting the words *sleep, bed, rest, awake, tired, dream, snore, etc.* in the presence of sleeping people and in the presence of beds etc., and also in the presence of these same words. With respect to the intraverbal operants frequently emitted during free association tasks, Skinner (1957) elaborates on the historical interaction between nonverbal and verbal stimuli and the reinforcement of subsequent verbal responses:

> We may assume … that, aside from intraverbal sequences specifically acquired, a verbal stimulus will be an occasion for the reinforcement of a

> verbal response of different form when, for any reason, the two forms frequently occur together. A common reason is that the nonverbal circumstances under which they are emitted occur together. … We may speak of the tendency to occur together as 'contiguous usage.' In the usual word-association experiment, [many of the observed] intraverbal operants appear to be explained by contiguous usage. There are times when it is well to have certain operants in readiness…when talking about *lakes*, it is advantageous to have the form *sea* available. In accounting for a specific intraverbal operant it is necessary to substitute an actual reinforcing event for an "advantage." In general, however, it is enough to show that the form *sea* is likely to occur in the context of *lake*; *animal* in the context of *cat*; *tears* in the context of *pain*; and so on. … Certain exceptions, in which frequency of response does not follow frequent contiguous usage, may be traced to specific reinforcements, especially where responses have a limited currency or where the history of the speaker is unusual. (Skinner, 1957, p. 75)

It then appears that one way to produce DRM-like semantic false memory phenomena would be to influence contiguous usage. That is, false memory phenomena may follow from learning histories in which the emission of a word (i.e., a word that would be considered to be an intrusion in a subsequent memory test, such as *sleep*) in the presence of some other word (i.e., a word used as a study item in a subsequent memory test, such as *bed*) had been reinforced on past occasions. More specifically, it is possible that intraverbal operants arising from contiguous usage and emitted during free association tests are also likely to be emitted during free recall tests, and such behaviors would then be labeled by researchers as false memory phenomena.

In contrast to Skinner's depiction of the contingencies involved in contiguous usage, many cognitive psychologists emphasize mere stimulus co-occurrence as the source of semantic relations (e.g., Burgess, 1998; Fodor, 1983; Foltz, 1996; Landauer & Dumais, 1997; Landauer, Foltz, & Laham, 1998; Lund & Burgess, 1996; see also Hutchison, 2003), which would imply that false memories are ultimately traceable to historical stimulus co-occurrence. That is, the functional relationship between stimuli is often ignored by cognitive psychologists, whose explanations are instead cast in terms of an information-processing metaphor. While there are a multitude of cognitive explanations of semantic relatedness, one prominent cognitive metaphor maintains that the degree semantic relatedness between stimuli is a reflection of the degree of association between mental representations of the stimuli (e.g., Anderson, 1983; Collins & Loftus, 1975; McNamara, 1992). The strength of association between representations is thought to increase following the simultaneous activation of the mental representations of the stimuli, and, in turn, the simultaneous activation of the mental representations can result from the perceived co-occurrence of stimulus referents. For example, if the word *sleep* frequently co-occurs with the words *bed, rest awake, etc.*, then the representations of these words would become strongly associated within a hypothetical mental architecture. Further supposing that a memory retrieval system relies on stimulus associations for its cognitive functioning (e.g., Roediger et a. 2001), the retrieval of the words *bed, rest, awake, etc.* could lead to the erroneous retrieval of the strongly associated word *sleep*. That is, a cognitive psychologist may say that *sleep* is intruded in the DRM paradigm because *sleep* is associated with *bed, rest, awake, etc.*, which is to say that these words have frequently co-occurred on past occasions. Of note, Skinner's contiguous usage could be reduced to stimulus co-occurrence, should the functional relations between stimuli (e.g., those relations arising from operant contingencies) prove to be inconsequential to subsequent remembering behavior.

However, it may also be the case that false memory phenomena can arise from learning histories in which the relationships between words are not the result of direct reinforcement or stimulus co-occurrence (as is the case with contiguous usage), but are instead acquired indirectly. That is, it is well established that relationships between stimuli can be derived (see Hayes, Barnes-Homes, & Roche, 2001; Sidman, 1971, 1994; Sidman & Tailby, 1982), suggesting the possibility that certain false memory phenomena may result from those environmental manipulations that promote the derivation of stimulus relations. We (Guinther & Dougher, 2010) recently tested this possibility through the DRIFT paradigm, showing that interrelated conditional discrimination training (match-to-sample, MTS) with tests of symmetry and transitivity (see Sidman 1971; Sidman 1994; Sidman & Tailby 1982) was sufficient for the derivation of novel semantic relationships, and that the training likewise resulted in corresponding semantic false memories. Specifically, a group of random English words was assigned to a common stimulus equivalence class for MTS training, stimulus equivalence was tested, and then a subset of the words from within the class was presented for memorization. On subsequent tests of free recall and recognition, words that had been assigned to the same class as the study list words were more likely to be intruded and falsely recognized than words that had been assigned to different classes. Furthermore, stimuli that frequently co-occurred with study list words during prior MTS training were not especially likely to be intruded or falsely recognized on subsequent memory tests. We interpreted these findings to reflect the differential transfer of an instructed "remembering" function from study words to same-class non-study words; the intrusions and false recognitions reflected the formation of corresponding functional equivalence classes (see Donahoe & Palmer, 2004; Dougher & Markham, 1994, 1996; Goldiamond, 1962, 1966). Importantly, there were no preexperimental semantic relationships between study list words and intruded or falsely recognized words. Instead, artificial semantic relationships were created through the experimental manipulation of environmental variables promoting the derivation of stimulus relations, and, hence, semantic false memory phenomena were likewise controlled.

It is important to keep in mind that there are several different ways of conceptualizing "semantic relations." Within the field of cognitive psychology, semantic relations are typically conceived of as being embodied in structural linkages between informational representations of linguistic terms and physical referents (e.g., Anderson, 1983; Collins & Loftus, 1975; McNamara, 1992); cognitive psychologists use public behaviors to infer the properties of these mental (i.e., hypothetical, cognitive) semantic structures. In contrast, behavior analysts make no appeal to mental structures in their accounts of semantic relations. Instead, semantic relations are considered to be manifest in particular behaviors, and these behaviors are to be understood in terms of the conditions under which they occur. According to one line of behavior analytic thinking (Barnes-Holmes et al., 2005; Hayes & Bisset, 1998; Sidman, 1994), semantic behaviors occur when the stimuli controlling these behaviors have acquired their functions indirectly through derived relationships. That is, semantic behaviors are thought to occur under the conditions that give rise to derived relational responding. For example, if a person is trained or instructed that A=B and A=C, the spontaneous (i.e., untrained and uninstructed) emission of behaviors consistent with the relation B=C would be taken as evidence that there is a semantic relation between B and C. This type of semantic behavior is often exhibited by verbally competent individuals following MTS training, as was found in the original DRIFT study when participants derived equivalence between study words and non-study words that had been assigned to a common class (Guinther & Dougher, 2010).

The two experiments in the current study were designed to replicate and extend the original DRIFT paradigm. Experiment I was intended to more closely specify the MTS training characteristics essential for the production of subsequent semantic false memories. In particular, we wished to determine if tests of symmetry and transitivity during MTS were necessary components of the paradigm, and therefore did not include them in the current DRIFT designs. That is, if stimulus equivalence and functional equivalence are both the product of a common learning history (e.g., MTS training; see McIlvane & Dube, 1990), then, following such a history, demonstrations of stimulus equivalence should not be necessary for demonstrations of functional equivalence (i.e., higher levels of intruding for words assigned to the same class as study words should be evident even in the absence of tests for stimulus equivalence).

Also differing from the original DRIFT design, the study list words' MTS sample stimulus was not displayed during study list presentation in Experiment I. When participants were ostensibly memorizing the study list words under the original DRIFT design, the presence of the sample stimulus may have influenced participants' interpretations of the meanings of the words. For example, if all of the study list words came from a class in which a red square served as the conditional sample during MTS, the presence of the red square during study list memorization could have helped some participants abstract that all of the words came from the same class. As such, the presence of the sample stimulus could have influenced performance on subsequent memory tests. As an exploratory manipulation in Experiment I, we did not present the study words' MTS sample during study list presentation and later asked participants whether they were aware that all of the study words came from the same class.

Experiment II of the current study was intended to extend the original DRIFT study through the introduction of manipulations that are known to affect derived relationships and the transfer of stimulus functions. Specifically, equivalence responding can be brought under contextual control through appropriate environmental manipulations (Wulfert & Hayes, 1988), and we therefore anticipated that comparable manipulations could lead to the contextual control of semantic false memory phenomena. In the traditional DRM paradigm, the study list words may themselves serve as contextual variables that mutually establish meaning. For example, the word *rest* is semantically related to *sleep* in the context of *pillow, awake,* and *tired*, but *rest* is semantically related to *silence* in the context of *note, measure,* and *staff*. That is, some words have more than one meaning, depending on context. Given that meaning is oftentimes context dependent, it would follow that false memory could likewise be context dependent.

Consider, for example, the hypothetical list of study words in Table 1. The meaning of the study words might align with either BUSINESS or FARM depending on the context of presentation (e.g., an office versus a barn), and one might expect subsequent intrusions to be similarly aligned. That is, the natural learning histories of English-speaking persons are such that the study words share a context-dependent conditionally discriminative function with certain other words (e.g., *stock* and *capital* are interchangeable responses in the context of BUSINESS, whereas *stock* and *lineage* are interchangeable responses in the context of FARM). Consequently, one would predict that the direct acquisition of a remembering function by the study items would be indirectly acquired by words sharing a common contextually-controlled conditionally discriminative function (see Wulfert & Hayes, 1988). Such an effect would manifest in the form of context-dependent memory intrusions.

The preceding example involving naturally-occurring semantic relationships is speculative, and does not specify a particular learning history responsible for the proposed effect. Rather than testing the speculative example, we sought to demonstrate in Experiment II the effects of contextually-controlled MTS training on subsequent false memory, using words sharing no particular preexperimental semantic relationships. That is, we employed a contextually-controlled MTS procedure to produce contextually-controlled semantic relationships, as evidenced by contextually-controlled functional equivalence responding in the form of contextually-controlled false recall. Stimulus co-occurrence of study words and non-study words was held constant across contexts during MTS training in order to highlight the important role that contingencies can play in the creation of derived functional relationships and semantic false memories.

Table 1

Hypothetical example of naturalistic contextual control of semantic false memory phenomena

CONTEXT: BUSINESS				CONTEXT: FARM
Natural Equivalences		Study Words		Natural Equivalences
capital	←	stock	→	lineage
Shop	←	store	→	supplies
upward	←	bull	→	breeder
downward	←	bear	→	predator
Sum	←	aggregate	→	soil
factory	←	plant	→	sew
criminal	←	crook	→	staff
↓				↓
Intrusions				Intrusions
capital				lineage
downward				predator
criminal				staff

Experiment I

Method

Participants. A total of 43 undergraduate psychology students were recruited through a departmental web advertisement and participated in Experiment I for course credit; 1 graduate student also participated in the study and did not receive compensation. Data are omitted for 3 participants who failed to pass the MTS training portion of the experiment and for 1 participant who failed to follow directions during the free recall task, leaving a total of 40 participants (20 males and 20 females) in the final sample. The mean age of participants in the final sample was 20.80 years (*SD* = 2.96; Range = 18-29) and their mean level of education was 13.48 years (*SD* = 1.52; Range = 12-19).

Setting, Apparatus, and Materials. Participants completed Experiment I in a quiet 2 m x 2 m laboratory in the Psychology Department at the University of New Mexico. The room contained two chairs, a desk, and a standard desktop computer equipped with a mouse for making responses and a 43.2 cm (17 inch) monitor on which stimuli were presented. The computer program for presenting stimuli and collecting responses was written by the first author and is available upon request. A total of 48 words were chosen as experimental stimuli (from Wilson, 1988) on the basis that there was no obvious theme uniting them; the list contained adjectives, adverbs, nouns, and verbs (see Figure 1). For each participant on an individual basis, 24 words were randomly assigned to be “red square words” (RSW’s) and 24 words were randomly assigned to be “blue circle words” (BCW’s). Each RSW was randomly paired with a BCW, producing 24 different word pairs that served as comparison stimuli in the MTS task described below. Finally, 12 of the RSW's were randomly assigned for each participant to be study list words on the free recall task, also described below.

	RSW's ■	BCW's ●	
T1 (Free Recall)	AIRPORT	COWBOY	T2
	AROSE	CRISES	
	BATHROOM	DANCING	
	BECAME	DEALT	
	BLONDE	DESERT	
	BLOWING	EARNINGS	
	CANDLE	EATING	
	CANNOT	ESSAY	
	CEILING	ETHICS	
	CHARMING	FLOATING	
	CLOTHING	FOREST	
	CONCERT	GRANDMA	
T3	JUDGMENT	STOLEN	T4
	LAUGHING	SWOLLEN	
	MEANING	TEETH	
	MINUTE	THERMAL	
	MOTEL	THYROID	
	OPENING	TIRED	
	PICNIC	TODAY	
	PLASTIC	TRAFFIC	
	POLITICS	UNLIKE	
	SALESMEN	VIOLIN	
	SLIDING	WHILE	
	STATED	YOUNG	
T0 (Extra-experimental Intrusions)			

Figure 1. The 48 words used in Experiment I. Although shown in alphabetical order here, the words were randomly assigned to one of four Types (T1-T4) for each participant. T1 and T3 words were red square words (RSW's), and T2 and T4 words were blue circle words (BSW's). T1 words were studied list words for the free recall portion of the experiment. Any intrusions that were not T2-T4 words were classified as T0 words.

Procedure. After meeting the experimenter and signing statements of informed consent, participants began the experiment with a computerized training procedure. This training was intended to establish two 24-member functional equivalence classes and consisted of an arbitrary, two-comparison, MTS task. Training followed a one-to-many format, with the colored shapes (i.e., a red square or a blue circle) always serving as samples and the words as comparisons. Participants read the following instructions on the computer screen and any questions were clarified by the experimenter:

> Welcome to the experiment! In this part of the experiment, you will see either a square or circle in the top third of the screen and a pair of words on the bottom third of the screen. Your job is to pick the word that "matches" the current shape. You can pick the word on the left by pressing the left mouse button, or pick the word on the right by pressing the right mouse button. If you pick the correct word you will see a happy face, and if you pick the incorrect word you will see a sad face. Once you pick the correct word from the pair twice in a row, the shape will change. Then you will have to match a word from the pair to the new shape. You will get a new pair of words once you have successfully matched twice in a row for the square and the circle. Then you will continue with this same process for a number of word pairs. There are a limited number of word pairs. Once you have gone through all of the word pairs, you will get feedback about your performance. If you get a high enough score, we will move on to the next part of the experiment. It is important for the experiment that you learn which words go with which shapes, so if your score isn't high

enough, you will go through all of the word pairs again until your memory score is high enough. Please let the experimenter know if you have any questions. Press [SPACE BAR] to start training.

As depicted in Figure 1, there were five Types of words. Type zero (T0) words were any words other than the 48 words used as stimuli in the experiment, representing extra-experimental intrusions during the free recall task. Type one (T1) words were the 12 RSW's that were randomly assigned to be study list words during the free recall task. Type two (T2) words were the 12 BCW's paired with the T1 words as comparisons during MTS training; T1 and T2 words frequently co-occurred during MTS training. Type three (T3) words were the remaining 12 RSW's that were non-study words. Type four (T4) words were the 12 BCW's paired with the T3 words as comparisons during MTS training; T3 and T4 words frequently co-occurred during MTS training.

On each training trial, a sample shape (i.e., a red square or a blue circle) appeared in the center of the top third of the computer screen and two words (i.e., a T1-T2 pair or a T3-T4 pair) appeared on either side of the bottom third of the computer screen. The left-right positions of the two words in a pair were randomly determined on each trial, and participants were required to select one of the two words using a left or right mouse-button press. Correct responses were scored if the participant selected a RSW in the presence of the red square sample or a BCW in the presence of the blue circle sample. Correct responses were followed by the presentation of a happy face and a pleasant chime sound, whereas incorrect responses were followed by the presentation of a sad face and an unpleasant buzz sound. A cash reward of $100 was promised and awarded to the participant who completed MTS training with the fewest number of errors.

Each MTS training block consisted of 24 trial sets consisting of some number of trials with each of the 24 word pairs. The number of trials required to complete a set depended on the participants' performance. The order of set presentation was randomly determined at the beginning of each block. The first time a word pair appeared in a set of trials, the sample was randomly determined and stayed the same on each trial until the participant made two consecutive correct responses. At that point the sample shape changed from square to circle or from circle to square. Once the participant made two consecutive correct responses to the second sample, the set of trials for that word pair was completed and a new word pair and sample appeared. At the end of a block of 24 trial sets, the percentage of completely correct trial sets (i.e., when no errors were made for a word pair) was calculated for the block. Training blocks continued until a 90% trial set accuracy criterion was achieved; a perfectly logical "win stay, lose switch" strategy based on a random response to the first trial of each set would produce a 50% trial set accuracy for that block. Thus, while the 90% criterion is an arbitrary cutoff, it is highly unlikely that participants could have achieved this level of performance without learning the conditional discriminations. Those participants who failed to achieve the accuracy criterion after 40 minutes were dismissed ($N = 3$), and no further data were collected from them. Unlike the original DRIFT design, there were no tests of symmetry or transitivity.

Following MTS training, participants were required to leave the laboratory and take a break for approximately 5 min. Once they returned, they were told that they were entering a new phase of the experiment, and were given the following instructions for the free recall task:

> For the next part of the experiment, we will show you some words that we want you to remember for a later memory test. The words will automatically appear one at a time on the screen. These words that you are about to see are the MEMORY TEST words. Please ask the experimenter if you have any questions. The words will begin to appear once you press the [SPACE BAR].

The 12 T1 words were then presented on the computer screen one at a time for 2 s each with a 2 s inter-stimulus interval, during which the screen was blank. Unlike the original DRIFT design, the memory test words' sample stimulus (i.e., red square) did not appear on the screen during study presentation in Experiment I. Following presentation of the T1 study list words, participants were shown a screen instructing them to "Remember the MEMORY TEST words!" and were then handed a one page article on global dimming, which they were asked to read as a distractor task. The distractor task was not timed. After reading the article, participants were given a pen and a blank sheet of paper and were instructed to write down as many of the study list (T1 free recall) words as they could remember, and to notify the experimenter when they had finished. Then the experimenter manually entered the recalled words into the computer for scoring, making corrections for misspellings, plurality, or suffix substitutions (e.g., CRISIS was recorded as CRISES; FLOAT was recorded as FLOATING).

Part way through collecting data for Experiment I, we realized that it might be of interest to record whether or not participants were aware that all of the memory test words were RSW's. From that point on, at the end of the experiment, participants were first asked "Did you notice anything in particular about the memory tests words?" If the participant answered in the negative, they were then asked "All of the memory test words had something in common. Did you notice what it was?" If this was also answered in the negative, they were asked "Did you notice that all of the memory test words were red square words?" If the participant answered in the affirmative to any of these questions, they were asked to clarify their response. If questioning indicated that the participants had noticed the RSW connection between the memory test words, they were classified as being "Aware" (n = 6), and if they did not noticed they were classified as being "Unaware" (n = 21). Given the relatively low number of Aware participants (i.e., in terms of statistical reliability), we ran separate analyses for the total sample and for those participants for whom awareness data were collected.

Results

The number of blocks participants took to complete MTS training ranged from 2 to10 (*Mean* = 5.73; *SD* = 1.85). On the free recall task, participants from the total sample recalled an average of 6.33 correct T1 words (*SD* = 2.17; Range = 3-11). Participants from the Aware sample recalled an average of 7.17 correct T1 words (*SD* = 1.33; Range = 6-9). Participants from the Unaware sample recalled an average of 6.43 correct T1 words (*SD* = 2.38; Range = 3-11). There was no significant difference between the Aware and Unaware participants in the mean number of words correctly recalled, $t(25) = 0.72$, $p = .48$. Information regarding the number of intrusions for the total sample, the Aware participants, and the Unaware participants can be found in Table 2. Individual participant data can be found in Table 3.

Table 2

Intrusion Data for the Total Sample, Aware Participants, and Unaware Participants in Experiment I

Sample	Type	N	% of Sum	Mean	SD	Min	Max
Total (*N* = 40)	T0	13	17.7	0.33	.57	0	2
	T2	14	18.9	0.35	.70	0	3
	T3	37	50.0	0.93	1.29	0	5
	T4	10	13.5	0.25	.54	0	2
	Sum	74	100	1.85	1.72	0	6
Aware (*n* = 6)	T0	1	7.7	0.17	0.41	0	1
	T2	0	0.0	0.00	0.00	0	0
	T3	10	76.9	1.67	1.63	0	4
	T4	2	15.4	0.33	0.82	0	2
	Sum	13	100	2.17	1.47	0	4
Unaware (*n* = 21)	T0	7	20.6	0.33	0.58	0	2
	T2	10	29.4	0.48	0.87	0	3
	T3	12	35.3	0.57	1.21	0	5
	T4	5	14.7	0.24	0.54	0	2
	Sum	34	100	1.62	1.86	0	6

Table 3

Individual Participant Data from Experiment I

		Training			Intrusions			
Case	Order Tested	Blocks	Aware	T1	T0	T2	T3	T4
1	1	6	.	4	0	1	0	0
2	2	6	.	6	0	1	0	0
3	3	6	.	9	0	0	0	0
4	4	4	.	3	0	0	1	1
5	5	2	.	6	0	0	1	0
6	6	4	.	7	0	0	3	0
7	7	6	.	9	1	0	0	0
8	8	4	.	8	0	0	0	0
9	9	5	.	4	0	0	2	0
10	10	4	.	6	0	1	3	0
11	11	6	.	3	0	1	2	1
12	12	5	.	4	0	0	2	0
13	13	4	.	6	2	0	1	1
14	16	5	Yes	8	1	0	4	0
15	17	6	Yes	6	1	0	3	0
16	25	4	Yes	8	1	0	2	0
17	29	9	Yes	9	0	0	0	2

Table 3 (cont.)

18	31	10	Yes	6	1	0	0	0
19	40	4	Yes	6	0	0	1	0
20	14	6	No	5	1	0	0	0
21	15	5	No	4	0	0	0	0
22	18	6	No	8	0	3	0	0
23	19	8	No	3	0	0	0	0
24	20	4	No	9	0	1	0	0
25	21	7	No	9	0	0	1	0
26	22	6	No	6	0	0	0	0
27	23	8	No	4	0	0	0	0
28	24	8	No	8	0	1	0	1
29	26	9	No	4	0	0	0	0
30	27	8	No	3	0	0	0	0
31	28	6	No	8	0	1	5	0
32	30	4	No	5	0	0	0	1
33	32	8	No	5	0	2	1	2
34	33	5	No	9	0	0	0	0
35	34	5	No	5	0	0	0	0
36	35	4	No	10	0	2	2	1
37	36	5	No	7	1	0	1	0

Table 3 (cont.)

38	37	3	No	5	0	0	0	0
39	38	5	No	7	0	0	2	0
40	39	9	No	11	0	0	0	0

We present data on the occurrence of T0 intrusions, as this phenomenon may be of some conceptual interest to readers. However, we did not include T0 intrusions in our formal analyses because these words were likely to have been recalled on the basis of uncontrolled extra-experimental learning histories. Of the experimental stimuli, we anticipated that T4 words would be the least likely to be intruded on the grounds that T4 words never co-occurred with T1 words, and because T4 words were not assigned to participate in the same class as T1 words. As such, T4 words would be the least likely to indirectly acquire the remembering function of the T1 words. We therefore conducted two comparisons using the mean number of T4 intrusions as a baseline: a) the difference between the mean number of T2 and T4 intrusions, which would reveal the effect of co-occurrence for T1 and T2 words relative to the absence of co-occurrence for T1 and T4 words, and b) the difference between the mean number of T3 and T4 intrusions, which would reveal the influence of shared class assignment by T1 and T3 words relative to the absence of co-occurrence and differential class membership for T1 and T4 words. We also examined the difference between the mean number of T2 and T3 intrusions, which would reveal the effects of shared class assignment relative to co-occurrence.

Experiment I intrusion data for the total sample can be seen in Figure 2. A one-way within-subjects ANOVA with a Greenhouse-Geisser correction for sphericity indicated a significant difference among the mean number of T2, T3, and T4 intrusions in the total sample, $F(1.42, 55.52) = 6.97$, $p = .005$, $\eta^2 = .15$. Post hoc analyses were conducted using pairwise comparisons with a Bonferroni correction. The test of the co-occurrence effect showed that the difference between the mean number of T2 intrusions and T4 intrusions was not significant ($p = .999$). However, the difference between the mean number of T3 and T4 intrusions was significant (p = .014) as was the difference between the mean number of T2 and T3 intrusions (p = .042), indicating a relatively strong effect of shared class assignment.

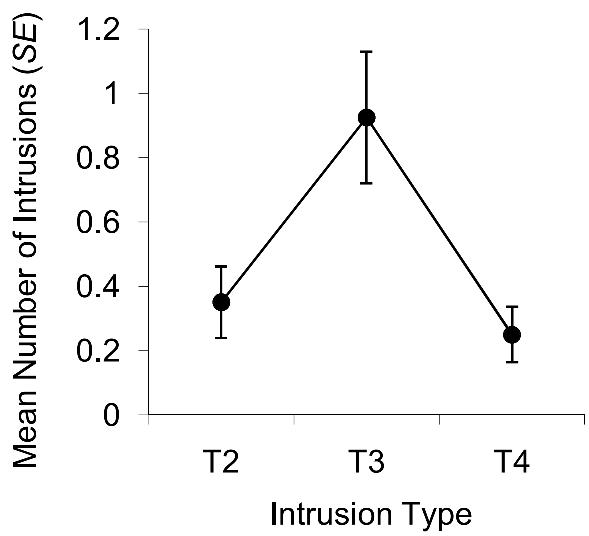

Figure 2. The mean number of intrusions by Type for the total sample in Experiment I.

Separate analyses were run for those participants who had been classified according to their awareness that all of the study words were RSW's. Data for these analyses can be seen in Figure 3. A 2 x 3 (Awareness x Intrusion Type) mixed-design ANOVA with a Greenhouse-Geisser correction for sphericity indicated a nonsignificant main effect of Awareness, (1, 25) = 0.72, p = .403, partial η^2 = .03, and a significant main effect of Intrusion Type, F(1.43, 35.81) = 5.81, p = .012, partial η^2 = .19. However, these results must be interpreted in light of a significant interaction between Awareness and Intrusion Type, (1.43, 35.81) = 3.74, p = .047, partial η^2 = .13. Analyses of the simple main effect of Intrusion Type at each level of Awareness were conducted using pairwise comparisons with Bonferroni corrections. Among the Aware participants, there was no significant difference between the mean number of T2 and T4 intrusions (p = .912), or between the mean number of T3 and T4 intrusions (p = .116). However, the difference between the mean number of T2 and T3 intrusions was significant (p = .019). Among the Unaware participants, there was no significant difference between the mean number of T2 and T4 intrusions (p = .520), between the mean number of T3 and T4 intrusions (p = .925), or between the mean number of T2 and T3 intrusions (p = .999). Thus, only the Aware participants gave any indication of elevated T3 intrusions.

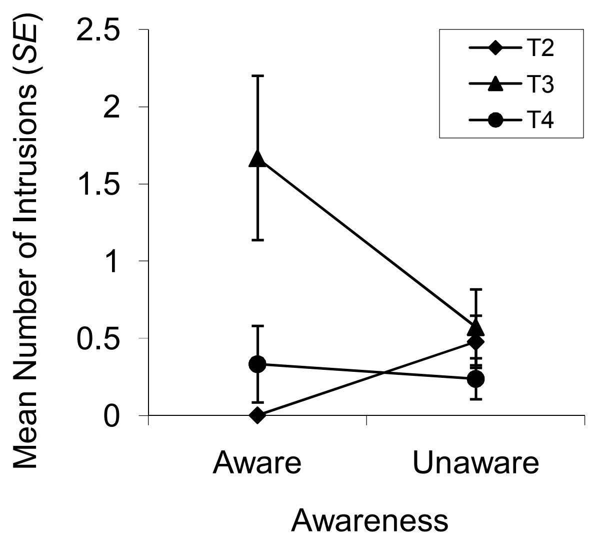

Figure 3. The interaction between Awareness and Intrusion Type in Experiment I.

Experiment I Discussion

The results of Experiment I replicate the findings of the original DRIFT design, and indicate that tests of symmetry and transitivity are not essential components of the DRIFT paradigm. Even in the absence of tests of stimulus equivalence, non-study words that had been assigned to participate in the same functional equivalence class as study list words were more likely to be intruded than non-study words that had been assigned to a different class. Furthermore, participants' self-report data suggests that the occurrence of elevated same-class intruding was largely limited to those participants who abstracted that all of the study list words came from a common class (i.e., the finding was largely limited to those participants who reported that they were aware that all of the memory test words were "red square words"). While the variables determining reports of awareness were not systematically addressed in the current study, demonstrating a correlation between awareness and intruding represents an important first step in identifying additional environmental variables, outside of MTS training, that can influence false recall.

In addition to addressing the question of whether equivalence testing is essential to the DRIFT paradigm, Experiment I also served as a pilot study for the design of Experiment II. First, although we did not measure the proposed effect, we presumed that the inclusion of the sample stimulus during study list presentation in the original DRIFT design would assist participants in abstracting the common conditionally discriminative function of the study list words, thereby boosting subsequent false recall. The Awareness findings of Experiment I were not inconsistent with this presumption, and we therefore reintroduced the presentation of the sample stimulus during study list presentation in

Experiment II in an attempt to maximize effects. Second, we did not want contextually-controlled MTS training to be overly burdensome to participants in Experiment II, so Experiment I was intended to test the plausibility of a relatively streamlined version of the original DRIFT design. Specifically, there were three classes (and equivalence testing) in the original design, but only two classes in Experiment I. Given that we were able to produce the intended false recall effects under the streamlined design of Experiment I, this design served as the foundation for the ostensibly more difficult contextually-controlled MTS training of Experiment II.

Experiment II

Method

Participants. A total of 83 undergraduate psychology students were recruited through a departmental web advertisement and participated in Experiment II for course credit; none of them had participated in Experiment I. Although all participants received comparable contextually-controlled interrelated conditional discrimination training during the first phase of the experiment, participants were randomly assigned to a Context 1 (C1) group or a Context 2 (C2) group for the memory test phase of the experiment. The data from several participants were omitted from analyses due to failures to comply with the experimental procedure (n = 5), spontaneous disclosures of neurological disorders (n = 3), the spontaneous disclosure of recent severe distress (n = 1), highly atypical responding (n = 1), or failures to pass discriminative training by completing a block of MTS training with 90% trial set accuracy within the allotted time (n = 25), leaving a total sample of 48 participants.

Setting, Apparatus, and Materials. Experiment II involved the same setting and apparatus as Experiment I. MTS training stimuli in Experiment II were similar to those employed in Experiment I, including the same red square and blue circle sample stimuli. However, only 40 of the words from Experiment I were used as comparison stimuli in Experiment II (see Figure 4). The number of words per Type was reduced in an attempt to make it easier for participants to learn the contextually-controlled conditional discriminations within the allotted time. Depending on context (C1 or C2), words were presented either on a magenta background in white, italic, 20 point, Orlando font (C1), or on a green background in black, regular, 18 point, Jokewood font (C2).

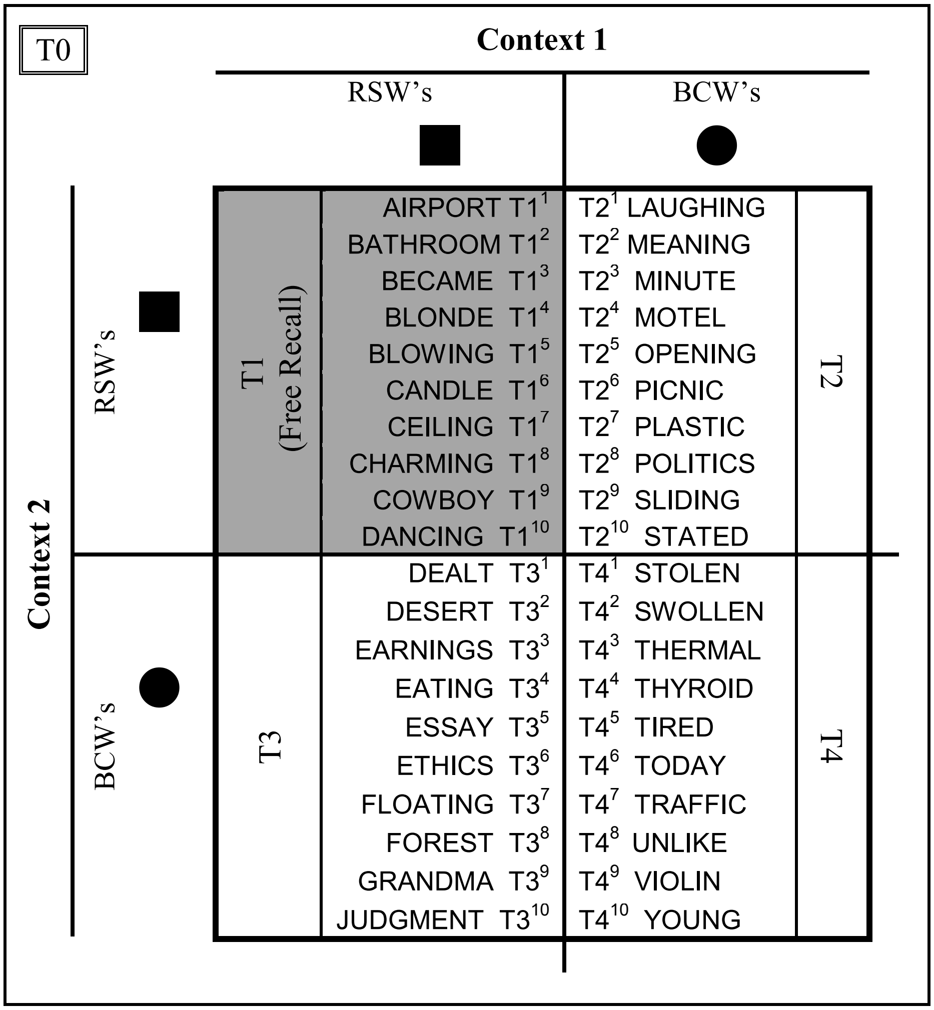

Figure 4. The 40 words used in Experiment II. Although shown in alphabetical order here, the words were randomly assigned to one of four Types (T1-T4) for each participant. T1 words were RSW's regardless of context, and were studied list words for the free recall portion of the experiment. T2 words were BCW's in C1 but RSW's in C2. T3 words were RSW's in C1 but BCW's in C2. T4 words were BCW's regardless of context. Any intrusions that were not T2-T4 words were classified as T0 words. Superscripts denote specific randomly-assigned words of a given Type, and can be cross-referenced with Table 4.

Procedure. Experiment II followed the same general progression as Experiment I. Experiment II began with a computerized MTS training procedure intended to establish four contextually-controlled, 20-member functional equivalence classes via a contextual, arbitrary, two-comparison, MTS task. Participants read the same instructions as were presented in Experiment I. The experimenter also gave the following verbal instructions to participants: “There are actually three things you will have to pay attention to: the words, the shapes, and also the background color of the screen makes a difference. So between the background color of the screen and the shape, there is enough information to tell you which of the two words you should pick. Do you have any questions?” Any questions were then clarified by the experimenter.

For each participant, the 40 stimulus words were randomly assigned to one of four Types (see Figure 4). T0 words were any words other than the 40 words used as stimuli in the experiment, representing extra-experimental intrusions during the free recall task. T1 words were always RSW’s regardless of context, and were presented as study items during the free recall memory test. T2 words were BCW’s that were consistently paired with T1 words in C1, but were same-class non-study RSW’s in C2. T3 words were same-class non-study RSW’s in C1, but were BCW’s consistently paired with T1 words in C2. T4 words were BCW’s regardless of context, and were paired with T3 words in C1 but paired with T2 words in C2.

On each training trial, a sample shape (i.e., a red square or a blue circle) appeared in the center of the top third of the computer screen and two words appeared on either side of the bottom third of the screen (i.e., a T1-T2 pair or a T3-T4 pair in C1; a T1-T3 pair or a T2-T4 pair in C2). The left-right positions of the two words in the pair were randomly determined on each trial, and participants were required to select one of the two words using a left or right mouse-button press. Correct responses were scored if the participant selected a contextually-controlled RSW in the presence of the red square sample or a contextually-controlled BCW in the presence of the blue circle sample. Correct responses were followed by the presentation of a happy face and a pleasant chime sound, whereas incorrect responses were followed by the presentation of a sad face and an unpleasant buzz sound. A cash reward of $100 was promised and awarded to the participant who completed training with the fewest number of errors.

Each training block consisted of 20 trial sets consisting of some number of trials (see Table 4). Each trial set was comprised of four problems. In illustration of the four problems in the first trial set, Problem 1 consisted of a C1 magenta background with a red square sample, $T1^1$ and $T2^1$ as comparison stimuli, with the correct response being $T1^1$. Problem 2 consisted of a C1 magenta background with a blue circle sample, $T1^1$ and $T2^1$ as comparison stimuli, with the correct response being $T2^1$. Problem 3 consisted of a C2 green background with a red square sample, $T1^1$ and $T3^1$ as comparison stimuli, with the correct response being $T1^1$. Finally, Problem 4 consisted of a C2 green background with a blue circle sample, $T1^1$ and $T3^1$ as comparison stimuli, with the correct response being $T3^1$. The order of set presentation was randomly determined at the beginning of each block. The number of trials required to complete a set depended on the participants' performance. Each set always began in either C1 or C2, counterbalanced across participants. The first time a comparison word pair appeared in a set of trials (or after a context switch), the sample was randomly determined and stayed the same on each trial until the participant made two consecutive correct responses. At that point the sample shape changed from square to circle or from circle to square, but the comparison stimuli were unchanged (with the exception that comparison position was randomly determined on each trial). Once the participant made two consecutive correct responses to the second

Table 4

The sample and comparison stimuli presented in each trial set during the contextually controlled interrelated conditional discrimination training of Experiment II

	Context 1				Context 2			
	Problem 1 Sample: Red Square		Problem 2 Sample: Blue Circle		Problem 3 Sample: Red Square		Problem 4 Sample: Blue Circle	
	Comparison Stimuli		Comparison Stimuli		Comparison Stimuli		Comparison Stimuli	
Set	RSW	BCW	RSW	BCW	RSW	BCW	RSW	BCW
Set 1	$T1^{1}$	$T2^{1}$	$T1^{1}$	$T2^{1}$	$T1^{1}$	$T3^{1}$	$T1^{1}$	$T3^{1}$
Set 2	$T1^{2}$	$T2^{2}$	$T1^{2}$	$T2^{2}$	$T1^{2}$	$T3^{2}$	$T1^{2}$	$T3^{2}$
Set 3	$T1^{3}$	$T2^{3}$	$T1^{3}$	$T2^{3}$	$T1^{3}$	$T3^{3}$	$T1^{3}$	$T3^{3}$
Set 4	$T1^{4}$	$T2^{4}$	$T1^{4}$	$T2^{4}$	$T1^{4}$	$T3^{4}$	$T1^{4}$	$T3^{4}$
Set 5	$T1^{5}$	$T2^{5}$	$T1^{5}$	$T2^{5}$	$T1^{5}$	$T3^{5}$	$T1^{5}$	$T3^{5}$
Set 6	$T1^{6}$	$T2^{6}$	$T1^{6}$	$T2^{6}$	$T1^{6}$	$T3^{6}$	$T1^{6}$	$T3^{6}$
Set 7	$T1^{7}$	$T2^{7}$	$T1^{7}$	$T2^{7}$	$T1^{7}$	$T3^{7}$	$T1^{7}$	$T3^{7}$
Set 8	$T1^{8}$	$T2^{8}$	$T1^{8}$	$T2^{8}$	$T1^{8}$	$T3^{8}$	$T1^{8}$	$T3^{8}$
Set 9	$T1^{9}$	$T2^{9}$	$T1^{9}$	$T2^{9}$	$T1^{9}$	$T3^{9}$	$T1^{9}$	$T3^{9}$
Set 10	$T1^{10}$	$T2^{10}$	$T1^{10}$	$T2^{10}$	$T1^{10}$	$T3^{10}$	$T1^{10}$	$T3^{10}$
Set 11	$T3^{1}$	$T4^{1}$	$T3^{1}$	$T4^{1}$	$T2^{1}$	$T4^{1}$	$T2^{1}$	$T4^{1}$

Table 4 (cont.)

Set 12	$T3^{2}$	$T4^{2}$	$T3^{2}$	$T4^{2}$	$T2^{2}$	$T4^{2}$	$T2^{2}$	$T4^{2}$
Set 13	$T3^{3}$	$T4^{3}$	$T3^{3}$	$T4^{3}$	$T2^{3}$	$T4^{3}$	$T2^{3}$	$T4^{3}$
Set 14	$T3^{4}$	$T4^{4}$	$T3^{4}$	$T4^{4}$	$T2^{4}$	$T4^{4}$	$T2^{4}$	$T4^{4}$
Set 15	$T3^{5}$	$T4^{5}$	$T3^{5}$	$T4^{5}$	$T2^{5}$	$T4^{5}$	$T2^{5}$	$T4^{5}$
Set 16	$T3^{6}$	$T4^{6}$	$T3^{6}$	$T4^{6}$	$T2^{6}$	$T4^{6}$	$T2^{6}$	$T4^{6}$
Set 17	$T3^{7}$	$T4^{7}$	$T3^{7}$	$T4^{7}$	$T2^{7}$	$T4^{7}$	$T2^{7}$	$T4^{7}$
Set 18	$T3^{8}$	$T4^{8}$	$T3^{8}$	$T4^{8}$	$T2^{8}$	$T4^{8}$	$T2^{8}$	$T4^{8}$
Set 19	$T3^{9}$	$T4^{9}$	$T3^{9}$	$T4^{9}$	$T2^{9}$	$T4^{9}$	$T2^{9}$	$T4^{9}$
Set 20	$T3^{10}$	$T4^{10}$	$T3^{10}$	$T4^{10}$	$T2^{10}$	$T4^{10}$	$T2^{10}$	$T4^{10}$

Note. Superscripts denote specific randomly-assigned words of a given Type, and can be cross-referenced with Figure 2.

sample shape, the context would switch. Participants would then have to make two consecutive correct responses to another RSW and two consecutive correct responses to another BCW in the second context before the set of trials was completed. At the end of a block of 20 trial sets, the percentage of completely correct trial sets (i.e., when no errors were made for either of the C1 word pair problems or either of the C2 word pair problems in the set) was calculated for the block. Training blocks continued until a 90% trial set accuracy criterion was achieved in a single training block. Those participants who failed to achieve the accuracy criterion after 100 minutes were given a break and automatically advanced to the next phase of the experiment; their data are excluded from analyses. Participants who passed MTS training (or ran out of time) were then required to leave the laboratory and take a break for approximately 5 min.

Once they returned, participants were told that they were entering a new phase of the experiment, and were given the same free recall instructions that were presented in Experiment I. After reading these instructions off of the computer screen, the experimenter also gave the following verbal instructions to participants: “Even though all of the words that you are about to see will be familiar to you, when I later ask you to remember the memory test words, they are *just the words that you are about to see*. Do you have any questions?” Any questions were then clarified by the experimenter. The 10 T1 words were then presented on the computer screen one at a time below a red square for 2 s each with a 2 s inter-stimulus interval. As in the original DRIFT design, the red square stimulus was presented during the presentation of the study list words in Experiment II, with the hopes of heightening the false memory effects that come with “awareness” of the study list words’ red-square interrelation. For participants in the C1 group, the T1 words were presented on a magenta background in the corresponding C1 font, whereas participants in the C2 group were shown the T1 words on a green background in the corresponding C2 font.

Following presentation of the study list, participants were shown a reminder screen instructing them to "Remember the MEMORY TEST words!" and were then handed a one page article on global dimming, which they were asked to read as a distractor task. The background color and font of the reminder screen was appropriate to context, and remained on the computer screen throughout the distractor task and during the recall period. After reading the article, participants were given a pen and a blank sheet of paper and were instructed to write down as many of the Memory Test (T1 free recall) words as they could remember, and to notify the experimenter when they had finished. Then the experimenter manually entered the recalled words into the computer for scoring, making corrections for misspellings, plurality, or suffix substitutions. No awareness data were collected.

Results

As can be seen in Table 5, there were no significant differences between the C1 and C2 groups in mean age, mean years of education, proportion of females (coded as 0) and males (coded as 1), mean number of blocks taken to complete discriminative training, mean number of total errors made during discriminative training, mean number of erroneously recalled T0 words, or mean number of correctly recalled T1 words. In summary, context was not related to these demographic and performance variables, as anticipated.

Table 5

T-test comparisons of the C1 and C2 groups on demographic and control variables in Experiment II

	Total ($N = 48$)		C1 ($n = 22$)		C2 ($n = 26$)			
Variable	Mean	*SD*	Mean	*SD*	Mean	*SD*	*t*	*p*
Age	19.79	2.11	19.55	2.11	20.00	2.14	-0.74	.46
Sex	.33	.48	.23	.43	.42	.50	-1.44	.16
Education	13.17	1.16	13.09	1.15	13.23	1.18	-0.41	.68
Blocks	9.19	2.77	9.00	1.98	9.35	3.32	-0.43	.67
Errors	119.31	42.93	122.73	46.60	116.42	40.27	0.53	.61
T0 Recall	0.21	.50	0.18	0.50	0.23	0.51	-0.33	.74
T1 Recall	5.96	1.93	5.55	1.95	6.31	1.89	-1.37	.18

Note. Females were coded as 0, and males were coded as 1.

Experiment II intrusion data can be seen in Figure 5. A 2 x 3 (Context Group x Intrusion Type) mixed-design ANOVA with Greenhouse-Geisser corrections for sphericity indicated a significant main effect of Context Group, (1, 46) = 6.30, $p = .016$, partial $\eta^2 = .12$. The main effect of Intrusion Type was also significant, $F(1.95, 89.83) = 8.79$, $p < .001$, partial $\eta^2 = .16$. However, the two significant main effects must be interpreted in light of a significant interaction between Context Group and Intrusion Type, $F(1.95, 89.83) = 4.32$, $p = .017$, partial $\eta^2 = .09$. Post hoc analyses were conducted by analyzing the simple main effect of Intrusion Type at each level of Context Group using pairwise comparisons and a Bonferroni correction. Within the first Context Group (C1), there was no significant difference between the mean number of T2 and T4 intrusions ($p = .424$), the difference between the mean number of T3 and T4 intrusions was significant ($p = .001$), and there was no significant difference between the mean number of T2 and T3 intrusions ($p = .122$). Within the second Context Group (C2), there was a significant difference between the mean number of T2 and T4 intrusions ($p = .004$), there was no significant difference between the mean number of T3 and T4 intrusions ($p = .308$), and there was no significant difference between the mean number of T2 and T3 intrusions ($p = .247$). Thus, elevated intruding was evidenced for those words assigned to the same class as the T1 study list words, in accordance with the contextual control of class membership.

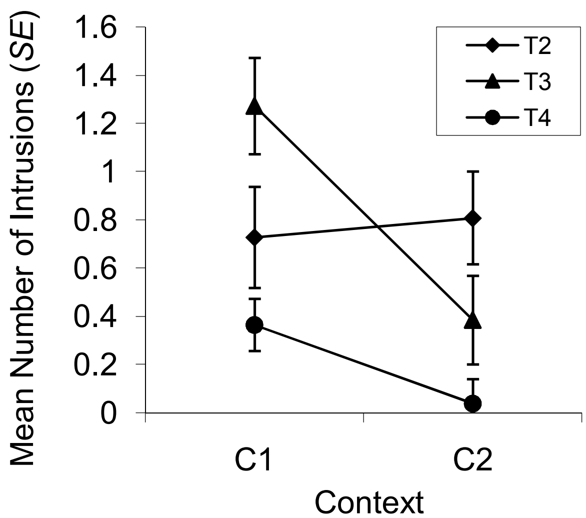

Figure 5. The interaction between memory test Context and Intrusion Type in Experiment II.

Experiment II Discussion

The results of Experiment II suggest that the remembering function of the T1 words was differentially acquired by the T2 and T3 words depending on the memory test context, thereby demonstrating the engineered contextual control of semantic false memory phenomena. As with Experiment I, these results were obtained in the absence of tests of symmetry and transitivity, indicating that equivalence testing is not a necessary component of the DRIFT paradigm.

By visual inspection, the highest levels of intruding came from non-study words assigned to the same class as study words within a given context, intermediate levels of intruding came from non-study words that were assigned to a different class but had frequently co-occurred with study words within a given context, and the lowest levels of intruding came from non-study words that were assigned to a different class and had never co-occurred with study words regardless of context. There are at least two explanations for this graded pattern of intrusions. One possibility is that the indirect acquisition of stimulus functions is especially likely among stimuli assigned to the same class within a given context, but also somewhat likely among stimuli that have frequently co-occured within a given context. That is, it is possible that stimulus co-occurrence is indeed causally related to intruding, but that functional relationships (e.g., the manipulation of contingencies that lead to derived relational responding) exhibit stronger control over intruding. Alternatively, participants may have not fully discriminated the contextual stimuli, resulting in the formation of a class consisting of T1 words along with differential numbers of T2 and T3 words. That is, given only partial discrimination of the contextual stimuli, there would still be some context-dependent differences between T2 and T3 words in their susceptibility to function acquisition, though class membership would not be completely determined by context. These two explanations are not mutually exclusive; stimulus co-occurrence and incomplete contextual control could have operated simultaneously to produce the observed effects. In all cases, the functional relationship between stimuli would appear to play an important role in accounting for the observed pattern of intrusions.

General Discussion

The present study demonstrates that false memory phenomena can be brought under contextual control: words sharing a contextually-controlled conditionally discriminative function with study words were more likely to be intruded when a memory test occurred in the corresponding context, relative to words that did not share a common conditionally discriminative function. Thus, it would appear that the behaviors constituting false memory phenomena can take the form of contextually-controlled functional equivalence responding (see Donahoe & Palmer, 2004; Dougher & Markham, 1994; Dougher & Markham, 1996; Goldiamond, 1962, 1966; Wulfert & Hayes, 1988). Furthermore, the present results were obtained without resorting to experimentally preexisting semantic relationships (c.f. Deese, 1959a, 1959b; Roediger & McDermott, 1995), and without testing for symmetry or transitivity (see Sidman & Tailby, 1982). Instead, it would appear that contextually-controlled semantic relationships were produced through contextual MTS training alone, as evidenced by higher rates of intruding for words that had been assigned to be semantically related to study words within the constraints of contextual control. The present results are consistent with other research indicating the viability of equivalence relations as a satisfactory behavior analytic account of semantic meaning (e.g., Barnes-Holmes et al., 2005; Guinther & Dougher, 2010; Hayes & Bisset, 1998), and show that the DRIFT paradigm can be usefully modified for the purposes of studying semantic false memory phenomena.

Under the original DRIFT design (Guinther & Dougher, 2010), participants were given tests of symmetry and transitivity during MTS training, permitting a demonstration of stimulus equivalence responding in a subgroup of participants. Furthermore, those participants who exhibited stimulus equivalence responding were also more likely to exhibit higher levels of intruding for T3 non-study words that had been assigned to the same class as T1 study words (i.e., they were more likely to exhibit class-specific functional equivalence responding). There are at least three reasons to suspect that testing for stimulus equivalence responding could have influenced subsequent functional equivalence responding. First, stimulus equivalence testing required that same-class words appear simultaneously, thereby introducing a source of stimulus co-occurrence for T1 and T3 words. To the extent that stimulus co-occurrence builds “associations” in cognitive networks (e.g., Anderson, 1983; Collins & Loftus, 1975; McNamara, 1992), one would expect that equivalence testing could have lead to increased levels of intruding for same-class T3 words. Second, people will sometimes exhibit stimulus equivalence responding with respect to stimuli that have historically co-occurred (Barnes et al., 1996; Leader et al., 1996; Tonneau, Arreola, & Martinez, 2006). To the extent that co-occurrence leads to stimulus equivalence responding and to the extent that the learning histories capable of producing stimulus equivalence responding are the same as the learning histories capable of producing functional equivalence responding, one would expect that co-occurrence during stimulus equivalence testing could have lead to increased levels of intruding for same-class T3 words. (These two explanations, however, do not take in to account the fact that differently-classed incorrect comparisons also co-occurred with T1 words during stimulus equivalence testing.) Third, testing for stimulus equivalence could have established the experimental context as a “context of relating” (see Hayes, Barnes-Holmes, & Roche, 2001), thereby increasing the likelihood that participants would derive stimulus equivalence relations and functional equivalence relations. Thus, establishing the experimental context as a context of relating could have lead to increased levels of intruding for same-class T3 words. However, elevated same-class intrusions (Experiment I) and elevated contextually-controlled same-class intrusions (Experiment II) were also obtained in the current DRIFT designs, which did not include tests for stimulus equivalence. Thus, while further experimentation would be required to determine whether stimulus equivalence testing influences subsequent intruding, stimulus equivalence testing does not appear to be a necessary component of the DRIFT paradigm.

As was the case in our original DRIFT study (Guinther & Dougher, 2010), we found no definitive evidence of an effect of stimulus co-occurrence on subsequent false recall in the current designs. In particular, the results of Experiment I provide no evidence of an effect of co-occurrence but do provide evidence for an effect of functional relationships (i.e., the manipulation of contingencies leading to derived relational responding would appear to account for the elevated levels of T3 intruding). In contrast, the results of Experiment II could be partially explained by an appeal to a combination of stimulus co-occurrence and functional relationships, though they could also be explained through an appeal to functional relationships alone. As was the case in the original DRIFT design, stimulus co-occurrence was confounded with class membership during MTS training, a factor that could have overridden any potential effect of stimulus co-occurrence. Thus, though co-occurrence may indeed play a role in producing false memory phenomena, an appeal to functional relationships would appear to be necessary when accounting for the present findings.

In a related vein, under the original DRIFT design we found that higher levels of MTS training achievement were associated with lower levels of intruding for words assigned to a different class from study list words. We labeled this finding a "semantic suppression" effect, and noted that some participants reported that they had considered writing down differently-classed non-study words during recall but then decided against this course of action in recognition of differential class membership (e.g., "I thought about writing down *garden*, but then I didn't because I knew it was a circle word but all of the memory test words were square words."). A semantic suppression effect may also be reflected in the performances of Aware participants in Experiment I, who intruded no T2 words despite their frequent co-occurrence with T1 words. However, it is unclear why this ostensible semantic suppression effect would be evident for T2 but not T4 words. Furthermore, the observed pattern of data may not be especially reliable, reflecting the performance of only 6 Aware participants relative to 21 Unaware participants. Thus, a determination of the relationship between Awareness, elevated levels of intruding for semantically related same-class non-study words, and the semantic suppression of differently-classed non-study words requires further replication and experimentation.

While the conditions that lead to the behaviors that constitute false memory phenomena are an important target of investigation, an understanding of false memory has broader implications for the development of a fuller understanding of interpretation and meaning. The original DRIFT design and Experiment I can be thought of as methods for generating synonyms (i.e., T1 and T3 words come to "mean the same thing" as a result of MTS training), whereas the design of Experiment II can be thought of as a method for generating homonyms (i.e., as a result of contextually-controlled MTS training, T1 words come to "mean the same thing" as T3 words in one context, but T1 words come to "mean the same thing" as T2 words in another context). Once such newlyacquired meanings are in place, they would appear to interact with peoples' interpretations of events. That is, as a general rule, people do not simply remember an event, but rather tend to remember their subjective interpretations of the meaning of the event, as manifest in a combination of "true" and "false" recollections of the event (see Brainerd & Reyna, 2005). Thus, one can alter people's recollections of an event by altering people's interpretations of the meaning of the event.

The results of Experiment II suggest that people can interpret the meaning of a single event (e.g., the presentation of a list of words) in multiple different ways, depending on learning history and contextual variables. This finding has some interesting implications that could lead to the development of more effective therapeutic technologies. For example, cognitive therapy (Beck, 1976) is explicitly concerned with cognitive biases, and has proven to be effective in the treatment of a variety of mental disorders. The memory structures (e.g., semantic networks, associative networks, prototypes, etc.) thought to underlay false memory phenomena are akin to the dysfunctional mental schema thought by cognitive therapists to underlay maladaptive behaviors (see Brainerd & Reyna, 2005). However, the theoretical rationale of cognitive therapy is largely based in prediction and relies on hypothetical mental structures that cannot be directly manipulated. Thus, the ability to influence false memory phenomena directly through the manipulation of environmental variables, as opposed to merely predicting these phenomena, may more effectively translate into an ability to influence maladaptive health behaviors.

We believe Experiment II provides a rough behavior analytic model of some of the cognitive biases that are sometimes attributed to hypothetical mental schema. For example, C1 could be representative of a depressive schema and C2 could be representative of an adaptive schema, leading to the biased recollection of depressive material (e.g., T3 words) or adaptive material (e.g., T2 words), respectively. Consistent with this contention, a recent study by Ruci, Tomes, and Zelenski (2009) suggests that one important contextual variable that can bias recollections is a person's own mood. These researchers used mood inductions to place participants in either a positive, negative, or control mood, and then gave them valenced DRM word lists consisting of either positive (e.g., *beautiful, sweet, wish*), negative (e.g., *anger, trash, smoke*), or control (e.g., *pen, chair, needle*) words. It was found that participants were more likely to intrude the DRM lists' critical root words when participants' induced mood was congruent with the valence of the study list. A clinical implication of this finding is that a person's mood could serve as a contextual variable controlling the distorted recollection of events. In turn, these distorted recollections could perpetuate the initial mood. But as was the case with the original DRM paradigm, the mood-congruent semantic associations and false memories of the Ruci et al. study were based in relationships that had been established prior to experimentation. That is, although an important phenomenon was illuminated, their procedures allowed prediction but not influence. In contrast, the DRIFT paradigm is explicitly concerned with the exploration of environmental variables that can be manipulated in the service of influencing biases in memory. It is our hope that ongoing translational research using the DRIFT paradigm can be used to develop new therapeutic technologies that help people interpret, reinterpret, and recollect their experiences in ways that promote adaptive functioning.

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