THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY
2011, 64 (9), 1788–1796

Psychology Press
Taylor & Francis Group

Similarity on the rebound: Inhibition of similarity assessment leads to an ironic postsuppressional rebound

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A widely held but rarely tested assumption among cognitive scientists is that different cognitive tasks may rely upon a single basic cognitive process. Using an established methodology to examine the suppression and subsequent rebound of mental operations, the present research indicates that suppressing use of similarity in one domain results in the subsequent rebound of similarity assessment in a different domain, suggesting that both domains rely on the same underlying cognitive process. In two studies, we demonstrate that leading people to suppress natural similarity assessment in one task produces increased reliance on similarity in subsequent, different, and apparently unrelated tasks. In Experiment 1, participants led to suppress similarity in a concentration task subsequently made more errors in a false-memory paradigm than did control participants. In Experiment 2, participants suppressing similarity in a categorization task made more false-memory errors and perceived more similarity between word pairs than participants who did not suppress. The findings suggest that the cognitive process of similarity assessment may be a domain-general process, such that it is widespread across a number of different mental tasks.

Keywords: Similarity; Categorization; False memory; Rebound.

Similarity assessment is ubiquitous to cognition (Gentner & Markman, 1997; Medin, Goldstone, & Gentner, 1993; Tversky, 1977) and plays a significant role in many cognitive processes. This could imply that one single similarity process may play a central role in a number of seemingly unrelated cognitive tasks (Fodor, 1983). Building on research into postsuppressional rebound (Geeraert, Yzerbyt, Corneille, & Wigboldus, 2004; Wenzlaff & Wegner, 2000), we propose that suppression of similarity in one task will lead to rebound of similarity in a subsequent task, provided that both (unrelated) tasks draw upon the same basic cognitive process.

Our studies build on previous research on mental control indicating that suppressing thoughts or experiences in one context produces heightened activation of those thoughts or experiences in subsequent, different contexts (Wenzlaff & Wegner, 2000). In accordance with research on negative

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This research was supported by a Research Promotion Fund research grant from the University of Essex to the first author. The authors wish to thank Chris Barry, Geoff Ward, William Matthews, Steve Tipper, and two anonymous reviewers for their thoughtful comments on this paper. We also wish to thank Narelle Ong, Sarah Chapman, and Marya Saidi for their contributions to this project.

http://www.psypress.com/qjep
DOI:10.1080/17470218.2011.557737

priming (Tipper, 1985, 2001), participants obviously have the ability to temporarily inhibit mental constructs. Interestingly, however, when the intention to suppress is relaxed, a postsuppressional rebound occurs.

For instance, participants instructed to avoid thinking of a white bear temporarily had fewer such thoughts than a control group (Wegner, Schneider, Carter, & White, 1987). However, participants in the suppression condition later showed a heightened activation of the forbidden thought. These findings are typically explained in terms of cognitive demand or as result of unintended priming of the forbidden thought (Macrae, Bodenhausen, Milne, & Jetten, 1994; Wegner, 1994). Suppression and rebound effects have also been observed for emotional experience (Richards & Gross, 1999; Wegner & Gold, 1995), for stereotypic social judgements (Macrae et al., 1994; Wyer, Sherman, & Stroessner, 2000), and during dream episodes (Wegner, Wenzlaff, & Kozak, 2004).

Recent research on attribution theory also implies that suppressing mental processes in one context can result in procedural rebound of the suppressed process in a subsequent context (Geeraert & Yzerbyt, 2007; Geeraert et al., 2004; Yzerbyt, Corneille, Dumont, & Hahn, 2001). A robust phenomenon in the attribution literature is that observers tend to explain others' behaviour as being caused by their traits and personality characteristics rather than by situational constraints even when the latter should in fact be considered as providing an adequate account. Several studies have shown that participants initially led to suppress dispositional inferences in a typical attribution paradigm indeed made less strong dispositional judgements than control participants (Geeraert et al., 2004). Subsequently, however, suppressors made stronger dispositional attributions (Yzerbyt et al., 2001) or relied more on abstract, dispositional language to describe others' behaviour in an unrelated task (Geeraert & Yzerbyt, 2007; Geeraert et al., 2004). Thus far, postsuppressional rebound has been demonstrated mainly within the social cognition literature. Interestingly, however, the notion of procedural rebound provides us with a powerful paradigm to investigate whether ostensibly unrelated cognitive tasks actually rely upon the same cognitive process.

Similarity assessment is one likely candidate process that is thought to shape or influence a number of seemingly dissimilar tasks. Similarity is a relatively basic mental operation, a "natural assessment" (Kahneman, 2003), hypothesized to underlie many cognitive processes (Gentner & Markman, 1997; Medin et al., 1993), including perceptual organization (Köhler, 1947), categorization (Kruschke, 1992; Nosofsky, 1992; Rosch & Mervis, 1975), mental representation (Shepard, 1962), memory (Brown, Neath, & Chater, 2007; Roediger & McDermott, 1995; Schacter, 1999), inductive reasoning (Sloman, 1993; Sloutsky & Fisher, 2004), language production (Pothos & Bailey, 2000), and judgement under uncertainty (Tversky & Kahneman, 1974). Similarity assessment also guides social cognition underlying interpersonal attraction (Sprecher, 1998) and social comparison (Dunning & Cohen, 1992). In short, similarity is pervasive in cognitive functioning (Gentner & Markman, 1997; Tversky, 1977) and is thought to play an important role in a great many cognitive tasks.

If two cognitive tasks both rely on similarity, then the natural question arising is whether a single similarity process underlies both tasks or whether there are separate similarity processes for each task. The notion of procedural rebound may help provide an answer. If two cognitive tasks make use of the same similarity process, then suppression of similarity in one task should produce increased similarity assessment in a subsequent task. In other words, a procedural rebound of similarity assessment should occur if two superficially distinct mental tasks rely upon the same domain-general mechanism of similarity assessment.

In the present studies, we use this logic to investigate whether two tasks rely upon the same similarity process. As discussed above, similarity assessment is thought to influence different mental processes such as categorization (Rosch & Mervis, 1975) and false memory (Roediger & McDermott, 1995). To the extent that these seemingly disparate tasks rely on the same similarity assessment, then suppressing similarity use in a

categorization task, for example, should increase similarity use in a subsequent false-memory task. Alternatively, if categorization and false memory rely on functionally different similarity processes, then those processes should operate independently and should not influence each other.

EXPERIMENT 1

Participants engaged in two seemingly unrelated tasks. They first were shown a series of objects from two different categories, birds and fruits, and were instructed to mentally visualize either the category to which the object belonged (control condition) or the category to which the object did not belong (suppression condition). We assumed that visualizing a category to which the exemplar of a natural category did not belong would simultaneously activate the opposite category and require similarity suppression. As a means to check that the suppression instruction selected was effective, we asked participants in a pilot study not only to think aloud during the realization of the task but also to provide a verbal account of the strategies that they had used once they had finished the task. In line with expectations, these "pilot" suppression participants clearly reported suppressing the forbidden category.

Subsequently, participants engaged in a memory task involving potential false recognition of synonyms of actually presented words. Given that false memory has also been linked with similarity (Schacter, 1999), we predicted that participants in the suppression condition would subsequently rely more on similarity (during post-suppressional rebound), which should be evident from an increase in false memory of synonyms compared to that of participants in the control condition.

Method

One hundred students participated in exchange for course credit or on a volunteer basis. An experimenter told them they would complete several unrelated studies, the first of which was a "concentration task." Participants were told they would see labelled pictures of exemplars of the natural categories *birds* (e.g., robin) and *fruits* (e.g., apple). These 12 pictures (see Appendix) were presented randomly one at a time on a computer screen.

Participants were randomly assigned to one of two conditions. Participants in the *control* condition were instructed to visualize the category to which the exemplar belonged: "If you see a picture of a strawberry, you should concentrate and think of the category fruits, try to mentally visualize this category." In contrast, participants in the *similarity suppression* condition were asked to visualize the category to which the exemplar did not belong: "If you see a picture of a strawberry, you should concentrate and think of the category birds; try to mentally visualize this category."

Following the experimentally manipulated concentration task, participants were told that the first experiment was finished. They were then introduced to an ostensibly second experiment. Participants were asked to read carefully 30 words presented on a computer screen. Following the presentation of the words, participants spent approximately two minutes computing simple sums, after which they were given an unexpected word recognition memory task. Participants were asked to indicate whether or not each of 50 words was on the list of words they had read. Of the words in the recognition task, 10 words had been previously presented, 10 words were synonyms (e.g., ill) for words that had been presented (e.g., sick), and the 30 remaining words were lures (see Appendix). This procedure allows us to examine false recognition (Roediger & McDermott, 1995) for synonyms. After the recognition task, participants were probed for suspicion (none were) about the connection between the tasks, debriefed, and thanked.

Results and discussion

As predicted, similarity suppressors had a higher false-alarm rate to synonyms (24.8%) than did control participants (16.7%), $d = 0.45$, $t(98) = 2.23$, $p = .028$ (see Table 1). The conditions did

Table 1. Main results for Experiment 1: Percentage of positive responses

	Concentration task	
Target	*Control (n = 48)*	*Similarity suppression (n = 52)*
Synonyms	16.7 (15.7)	24.8 (20.2)
Nonsynonym lures	9.2 (10.2)	10.9 (9.9)
Seen words	61.3 (21.0)	66.9 (22.6)

Note: Percentages are provided for positive responses to synonyms (false memory), nonsynonym lures, and actually presented words, contingent on whether participants had first visualized images consistent with (control) or inconsistent with (similarity suppression) displayed exemplars (standard deviations in parentheses).

not differ in correct recognition of actually seen words, $d = 0.26$, $t(98) = 1.30$, $p = .20$, or false alarms of nonseen words, $d = 0.17$, $t(98) < 1$. These differences meant that similarity suppressors more readily (albeit falsely) discriminated synonyms from lures, as measured by d' ($M_{d'} = 0.65$, $SD = 0.58$), than did controls ($M_{d'} = 0.45$, $SD = 0.53$), although this difference did not reach conventional levels of two-tailed significance, $t(98) = 1.72$, $p < .09$. These findings provide initial support that suppressing similarity assessment produces subsequent rebound of similarity in an unrelated cognitive task.

EXPERIMENT 2

We next sought a conceptual replication of Experiment 1, but with a more direct similarity suppression manipulation and with an additional measure of similarity assessment rebound. Participants were trained to classify pictures and words of birds and fruit. In the *similarity expression* condition, participants were trained to sort pictures and words into their proper semantic category (similarity-based categorization)—for example, *pictures and words of birds* versus *pictures and words of fruit*. In the *similarity suppressor* condition, participants had to sort pictures from one category together with words from the other category (dissimilarity-based categorization)—for example, *bird pictures with fruit words* versus *fruit pictures with bird words*. The categorization task was designed such that relying on similarity of natural kinds would facilitate similarity-based categorization but would have to be ignored or suppressed during dissimilarity-based categorization. The categorization task was followed by a series of word similarity judgements, a lexical decision task (LDT), and a false-memory measure (for the words presented in the LDT). We predicted that participants suppressing similarity in the categorization task would, in the subsequent tasks, make stronger similarity judgements and exhibit more false memory to synonyms than would control participants. Importantly, the analysis of the LDT reaction times also allowed us to test whether the observed procedural rebound can be attributed to mental fatigue.

Method

Fifty undergraduates volunteered to participate in what they were told were two separate experiments. Participants were first given a categorization task in which they were presented with the same exemplars (see Appendix), displayed as either pictures or words, of the same natural categories (birds and fruits) as those from Experiment 1. Exemplars were presented in random order in the centre of a 1,024 × 768-pixel computer screen and remained on the screen until participants indicated a response. Participants were asked to categorize each object as rapidly as possible by pressing a left or right key on a response box. The categories corresponding to each key (e.g., "Bird Words") were displayed on the screen and remained visible throughout the task. In two 36-trial practice blocks—one block with words, the other pictures—participants categorized objects into their natural groups. For instance, in the first practice block a word (e.g., robin) was presented, upon which participants were to decide whether the stimulus was a "bird word" or a "fruit word". In the second practice block, participants were shown a picture (e.g., a pear) and were asked to categorize the object as a "bird picture" or a "fruit picture". Following

incorrect answers, a red "X" appeared on the screen until the correct answer was provided.

This was followed by the experimental manipulation phase, consisting of 16 practice trials with feedback and 36 trials without feedback. In the experimental phase, participants were presented with stimuli from the entire stimulus set containing both words and pictures. Participants were asked to categorize the objects in one of two ways. Participants randomly assigned to the similarity expression condition categorized pictures and words into their natural categories: pressing one key for bird pictures or bird words and another key for fruit pictures or fruit words. Participants randomly assigned to the similarity suppression condition categorized pictures from one category with words from the other category, pressing one key for bird pictures or fruit words and another key for bird words or fruit pictures. This categorization rule requires participants to categorize together pictures and words of different natural kinds, which we assumed would require suppression of participants' spontaneous assessment of similarity.

Following the experimental manipulation, participants were told that the first experiment was finished and were escorted to a different cubicle. A second experimenter then introduced participants to the ostensibly second experiment. First, participants were presented with 30 word pairs such as *cabbage–lettuce* (see Appendix) and were asked to rate how similar the two words were (1 = not at all similar, 7 = totally similar).

Next, participants completed a false-memory task similar to Experiment 1. First, participants completed a lexical decision task consisting of 30 words and 30 nonwords. A computer recorded participants' responses and latencies. Following a 2-min distractor task consisting of easy sums, participants were given a surprise recognition test for words seen during the LDT. The recognition task consisted of 50 words (see Appendix): 10 words previously presented, 10 synonyms for presented words, and 30 words not presented (lures). Participants were then probed for suspicion (none were) about the connection between the tasks, debriefed, and thanked.

Results and discussion

We first analysed the error rates and latencies of the categorization task (see Table 2). Not surprisingly, participants in the similarity suppression condition made more errors in the categorization task than did those in the similarity expression condition, $t(48) = 2.26$, $p = .029$. Suppressors were also slower than expressers, $t(48) = 6.17$, $p < .001$. These results simply suggest that the similarity suppression categorization was more difficult than the categorization based on semantic similarity.

More importantly, similarity suppressors' subsequent judgements and memories were more strongly influenced by similarity than were those of similarity expressers (see Table 2). In line with predictions, similarity suppressors rated word pairs as more similar ($M = 4.71$, $SD = 0.73$), averaged across each participant's 30 ratings, than did similarity expressers ($M = 4.33$, $SD = 0.75$), but this difference did not reach conventional levels of two-tailed significance, $t(48) = 1.85$, $p = .070$. Suppressing natural tendencies to categorize objects based on similarity thus increased the perceived similarity of word pairs in a subsequent and seemingly unrelated task.

With respect to performance on the false-memory recognition, similarity suppressors had a higher false-alarm rate to synonyms (24.8%) than did expressers (13.2%), $t(48) = 2.58$, $p = .013$. In contrast, suppressors were not less accurate in recognizing presented words (65.6%) than were expressers (66.8%), $t(48) < 1$. Nor did suppressors exhibit more false alarms to nonsynonym lures (13.7%) than did expressers (12.7%), $t(48) < 1$. Using d' as a measure of discrimination, similarity suppressors exhibited higher (false) discrimination of synonyms versus lures ($M_{d'} = 0.50$, $SD = 0.73$) than did similarity expressers ($M_{d'} = 0.12$, $SD = 0.42$), $t(48) = 2.29$, $p = .026$. Participants who were led to suppress their natural tendency to categorize objects based on similarity thus exhibited selectively more false memory to synonyms.

Additional analyses also cast doubt on the possibility that these findings are attributable to mental fatigue rather than procedural rebound of

Table 2. Main results for Experiment 2: Task performance

		Categorization task	
Measure		*Similarity expressed (n = 25)*	*Similarity suppressed (n = 25)*
Categorization task	Correct categorizations (%)	92.9 (7.0)	89.0 (5.4)
	Categorization latency (ms)	544 (65)	787 (186)
Word pair task	Similarity rating	4.33 (0.75)	4.71 (0.73)
Lexical decision task	Word latency (ms)	624 (95)	563 (67)
	Nonword latency (ms)	716 (136)	700 (67)
Memory task	Synonyms (%)	13.2 (14.1)	24.8 (16.4)
	Nonsynonym words (%)	12.7 (10.6)	13.7 (12.3)
	Seen words (%)	66.8 (24.3)	65.6 (19.4)

Note: Means (standard deviations in parentheses) are provided for participants' performance on the categorization task, ratings of word pair similarity, latency on the lexical decision task, and their (false) memory of having seen synonyms, lures, and actually seen words, contingent on whether participants had classified objects into categories consistent with (similarity expressed) or inconsistent with (similarity suppressed) their natural kind.

similarity assessment. If participants in the similarity suppression condition were more mentally fatigued than those in the similarity expression condition, then suppression participants should have taken more time and been less accurate in the LDT. They were not (see Table 2). A 2 (word vs. nonword) × 2 (similarity expression vs. suppression) analysis of variance of lexical decision latencies with repeated measures on the first factor revealed only a main effect indicating that participants responded faster to words ($M = 594$, $SD = 87$) than to nonwords ($M = 708$, $SD = 130$), $\eta_p^2 = .534$, $F(1, 48) = 55.07$, $MSE = 5{,}933$, $p < .001$. There was neither a main effect of suppression, $\eta_p^2 = .042$, $F(1, 48) = 2.11$, $MSE = 17{,}918$, $p = .15$, nor an interaction, $\eta_p^2 = .041$, $F(1, 48) = 2.03$, $MSE = 5{,}933$, $p = .16$. By the measure of lexical decision speed, then, participants who had suppressed similarity assessment did not appear to be more fatigued than those who had expressed similarity.

GENERAL DISCUSSION

Building on procedural rebound research (Geeraert et al., 2004), we proposed that suppression of similarity assessment in one task would lead to postsuppressional rebound of similarity assessment in a subsequent task, provided that both (unrelated) tasks draw upon the same basic process. In two experiments, participants were led to suppress similarity in a concentration task (Experiment 1) and a categorization task (Experiment 2). Suppressor participants subsequently perceived more similarity between word pairs (Experiment 2) and exhibited relatively more false-memory errors to synonyms (Experiments 1 and 2).

Rebound mechanism

According to Wegner (1994), thoughts are regulated by a dual-process model. An automatic *monitoring process* scans consciousness for forbidden thoughts; if detected, a controlled *operating process* replaces the unwanted thought with a distractor thought. Relying on this model, postsuppressional rebound has been explained in terms of cognitive demand of the operating process (Wegner, 1994) or as a result of the monitoring process actually priming the forbidden thought (Macrae et al., 1994). Although the theory of mental control may seem somewhat at odds with inhibition effects observed in selective attention (Tipper, 2001), this is not necessarily the case. Postsuppressional rebound and negative priming have a different temporal window, with rebound occurring some time after suppression. Obviously,

future research should compare these two effects to determine their precise relationship.

The dual-process model provides a good account of conceptual rebound, but it is unclear to what extent the model can explain the findings of procedural rebound. At this point we can only speculate, but one alternative explanation is in terms of contrast. Similarity judgements are context dependent; for example, sequentially presented stimuli may cause either assimilation or contrast effects (e.g., Stewart & Brown, 2004). Although a previous account of procedural rebound has argued against such perceptual contrast (Geeraert et al., 2004), suppressor participants may have perceived more similarity in the false-memory paradigm in contrast with lower levels of similarity in the categorization task.

Future research

These results naturally raise the question of whether other similarity-based mental operations might similarly influence each other. Indeed, many cognitive activities have been linked with similarity, ranging from perceptual organization, reasoning, and language production to judgements under uncertainty and social cognition. If similarity indeed plays a role in these differential cognitive processes, then we should be able to determine whether functional similarity assessment is the generalized process it has been argued to be (Fodor, 1983). For instance, might the suppression of similarity during categorization produce subsequent increases in inductive reasoning (Sloman, 1993), perceived likelihood (Tversky & Kahneman, 1974), or interpersonal similarity and liking (Monin, 2003)? Whether such operations are connected through their reliance on similarity is an empirical question. The methodology described here provides a novel and unique means to pursue such questions empirically.

In conclusion, the results presented here are consistent with the notion that seemingly distinct cognitive processes such as categorization, memory, and similarity ratings are driven, at least partially, by the same cognitive process. Clearly, other scholars have argued for the central role of similarity of both categorization and memory processes. According to some of the dominant models in categorization, object classification is either based on similarity between the new object and a central prototype (Rosch & Mervis, 1975), or based on the similarity between the new object and known exemplars (Kruschke, 1992; Nosofsky, 1992). Likewise, in a recent theoretical account of memory, similarity has been identified as one of the primary underlying principles (Brown et al., 2007). Unsurprisingly then, false memory (Roediger & McDermott, 1995) has also been linked to similarity processes (Schacter, 1999). While both accounts of categorization and memory have claimed the significance of functional similarity, the current findings demonstrate the link between processes of categorization, memory, and unconcealed similarity ratings, effectively linking these processes. In sum, these findings suggest that similarity assessment is a general process that may be called upon from different cognitive domains.

Original manuscript received 21 May 2010
Accepted revision received 10 January 2011
First published online 25 April 2011

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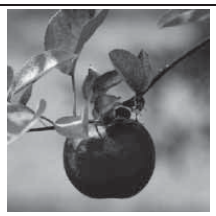
APPENDIX
Items for concentration task (Experiment 1) and categorization task (Experiment 2).

	Fruit exemplars					
Picture						
Word	apple	plum	lemon	raspberry	orange	peach
	Bird exemplars					
Picture						
Word	sparrow	finch	swallow	robin	magpie	crow

Items for false-memory paradigm Presentation words were presented randomly on a computer screen (Experiment 1) or embedded in a lexical decision task (Experiment 2).

	Presentation items
Synonym words	clever, expand, loud, neat, nice, rage, sick, small, thin, tired
Repeated words	control, empty, fright, light, near, old, pretty, promise, quick, strange
Filler words	big, grief, luck, shout, start, startle, stranger, taste, tricky, stop
	Recognition items
Synonym words	smart, enlarge, noisy, tidy, kind, fury, ill, tiny, slim, sleepy
Repeated words	control, empty, fright, light, near, old, pretty, promise, quick, strange
Filler words	accept, age, alone, cheap, destiny, eager, escape, escort, forbid, forgive,naughty, growth, help, help, hide, irony, lazy, omit, order, peace,persevere, pleasure, protect, see, soft, sort, steal, throw, tight, time

Items for word pair judgements (Experiment 2).

Word pairs	
acorn	peanut
bag	suitcase
bees	flies
boot	slipper
bottle	beaker
bricks	Lego
cabbage	lettuce
chopsticks	knife and fork
fence	gate
flower	weed

Word pairs	
hammer	mallet
horse	zebra
hospital	police station
kettle	boiler
lake	ocean
leaf	petal
letter	e-mail
map	globe
moon	star
mouse	Mickey Mouse

Word pairs	
oboe	trumpet
pyramid	desert
rose	lily
shell	pebble
snake	lizard
spider	ant
stairs	ladder
streetlight	candle
tiger	cheetah
tights	socks