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Plasticity of fear memory: a search for relapse prevention

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Retrospective revaluation effects following serial compound training and target extinction

Effting, M., Vervliet, B., & Kindt, M. (2010). Retrospective revaluation effects following serial compound training and target extinction. *Learning and Motivation*, *41*, 67-83.

Abstract

Using a conditioned suppression task, two experiments examined retrospective revaluation effects after serial compound training in a release from overshadowing design. In Experiment 1, serial $X \rightarrow A+$ training produced suppression to target A, which was enhanced when preceded by feature X, whereas X by itself elicited no suppression. Subsequent A- presentations extinguished responding to A, but had no effect on either responding to $X \rightarrow A$ or X alone. However, the addition of A- trials did enhance the ability of feature X to elicit suppression to a novel target, B, suggesting retrospective revaluation of X's properties. Experiment 2 showed that the enhanced transfer effect, observed in Experiment 1, was independent of the training history of the target (B- or $Y \rightarrow B+/B-$). Together, these results suggest that feature X did not retrospectively acquire excitatory strength or occasion setting power, but rather a generalized ability to increase responding to any other cue.

Introduction

Results from human causal judgment studies suggest that people can retrospectively alter their judgment of the causal relationship between a target cue and an outcome (Dickinson & Burke, 1996; Melchers, Lachnit, & Shanks, 2004; Shanks, 1985). One example of these so-called retrospective revaluation effects is *release from overshadowing*, which is usually demonstrated using the “food allergy task”. In a prototypical procedure, during a first learning phase, two compound cues consisting of two foods, XA and YB, are repeatedly presented and followed by the outcome (i.e., allergic reaction; XA+, YB+). During a second learning phase, cue A is presented without reinforcement (A-). Typically, on a final test, cue X is rated more likely to cause the outcome than control cue Y in spite of a similar reinforcement history (e.g., Larkin, Aitken, & Dickinson, 1998; Wasserman & Berglan, 1998). Interestingly, these findings indicate that the perceived causal status of a cue can change by virtue of training its former associate alone during a second learning phase.

Revisions of associative theories have been able to successfully account for retrospective revaluation effects such as release from overshadowing (Dickinson & Burke, 1996; Van Hamme & Wasserman, 1994; see Cheng & Holyoak, 1995; Ghirlanda, 2005; Miller & Matzel, 1988, for alternative explanations). Like standard associative theories (e.g., Rescorla & Wagner, 1972), revised theories state that nonreinforced A trials (A-) will reduce the strength of the excitatory association between cue A and the outcome. In addition, and beyond the scope of standard associative theories, they claim that the associative strength of the nonpresented cue (X) of the original XA compound will also change, thus, without a direct learning experience. A crucial tenet is that the associative change for the absent cue is in the opposite direction of the associative change for the cue that was present during subsequent learning. Accordingly, absent cue X's associative strength will increase if the associative strength of cue A decreases. To explain learning about absent cues, it is asserted that within-compound associations are formed between cues A and X during compound training (e.g., Dickinson & Burke, 1996; Melchers et al., 2004; Wasserman & Berglan, 1998). As a consequence, A- trials that follow AX+ trials will not only associatively activate the representation of the outcome in memory, but also the associated representation of cue X. The simultaneously activated representations of X and the outcome are thought to strengthen the excitatory association between them. Thus, according to revised associative

theories, an increase in excitatory strength not only occurs when two stimuli are paired, but also when stimuli are concurrently expected but absent.

In demonstrating release from overshadowing in humans, nearly all studies have made use of a simultaneous compound training procedure, in which the onsets - as well as the offsets - of the two cues coincide in time (e.g., Larkin et al., 1998; Lovibond, 2003; Wasserman & Berglan, 1998). There is, however, one study showing that retrospective revaluation effects can also be obtained after serial compound training, in which one cue *precedes* the other cue in time. Aitken, Larkin, & Dickinson (2001), using a food allergy paradigm, paired two serial compound stimuli with the outcome ($X \rightarrow A+ / Y \rightarrow B+$) in a first stage prior to training the target cues (A/B) separately in a second stage. Presenting A without the outcome (A-) increased causal ratings of X compared to Y after pairing B with the outcome (B+). In accordance with revised associative theories, Aitken et al. argued that within-compound associations enabled targets (A/B) to associatively activate a representation of their feature counterparts (X/Y) on target alone trials, thereby inducing retrospective revaluation of the feature. Aitken et al. did, however, not include a control compound stimulus without subsequent target training. Hence, they were unable to identify the retrospective revaluation effect as due to release from overshadowing (i.e., a gain in associative strength of X) or backward blocking (i.e., another form of retrospective revaluation consisting of a loss of associative strength of Y). The present study was designed to test whether target extinction after serial compound training can indeed result in a retrospective increment of the excitatory strength of a cue.

Furthermore, from the literature it is well-known that the temporal arrangement of cues in compound training can be of crucial importance for what will be learned about the individual cues. For instance, feature-positive (FP) discrimination training studies suggest that two types of learning may occur depending on the specific temporal relationship of the compound stimuli (e.g., Holland, 1986; Ross & Holland, 1981; see Schmajuk, Lamoureux, & Holland, 1998; Swartzentruber, 1995, for reviews). In these tasks, target cue A is followed by an (biologically significant) unconditioned stimulus (US) in the presence of feature cue X, but not when it is presented alone. When cues X and A are presented simultaneously during compound training trials (i.e., $XA+ / A-$), feature X normally acquires a direct excitatory association with the US (X-US). In contrast, when cue X *precedes* cue A during compound training (i.e., $X \rightarrow A+ / A-$), feature X will come to modulate responding to the target A-US association rather than becoming directly associated with the US. Stimulus X “sets the occasion” for stimulus A

being followed by the US. From this perspective, the design of Aitken et al. (2001) can actually be seen as a phased occasion setting procedure, where A is only followed by the outcome when it is preceded by X. It is currently unknown, however, whether modulatory properties can be acquired in a retrospective manner, and Aitken et al. did not test for this possibility. In the present study, we added an extra test phase to examine such modulatory properties of X.

The overall majority of studies on retrospective revaluation has been conducted in causal judgment tasks. Although they are very interesting in their own respect, little is known about retrospective revaluation of online anticipatory behaviour. The experiments of the present study were conducted in a well-established behavioural task that resembles a conditioned suppression procedure (the "Martians" computer game developed by Arcediano, Ortega, & Matute, 1996). Importantly, both direct excitatory strength and modulatory properties have been demonstrated within this behavioural procedure (Baeyens, Vansteenwegen, Hermans, Vervliet, & Eelen, 2001). This makes it an excellent tool for the objectives of this study. These objectives were: (1) to test release from overshadowing in an anticipatory behavioural task, (2) to test release from overshadowing following serial compound training, and (3) to explore the occasion setting powers of X. The design of the present experiments differed in one important way from that employed in Baeyens et al. (2001). Discrimination trials were presented phased ($X \rightarrow A+$ then $A-$) instead of intermixed ($X \rightarrow A+/A-$) in order to create a release from overshadowing design.

Experiment 1 examined release from overshadowing (to X) after serial feature-target compound training ($X \rightarrow A$) followed by target extinction ($A-$). Experiment 2 further investigated whether the retrospective revaluation effect, observed in Experiment 1, was the result of increased occasion setting power to X.

Experiment 1

The top half of Table 3.1 illustrates the design of Experiment 1. During Phase 1, all participants received serial compound training trials ($X \rightarrow A$), which were followed by the US¹ on 80% of the trials (see also Baeyens et al., 2001). Feature X and target A were neutral stimuli of different sensory modalities (auditory and visual, respectively). During Phase 2, participants in the experimental condition (EXT) received nonreinforced presentations of target cue A ($A-$). To control for

¹ The US was an instructed US, which meaning becomes significant by verbal instructions, rather than by its biological properties.

retrospective effects resulting from the posttraining extinction procedure, no extinction trials were administered to the control condition (NO-EXT).

Table 3.1 Design of Experiments 1 and 2.

Exp	Condition	Phase			
		1: Conditioning	2: Extinction	3: Transfer target training	4: Test
1	EXT	12(X→A+) 3(X→A-)	15(A-)	1(B-)	1(X→A-) 1(A-) 1(X→B-) 1(B-) 1(X-)
	NO-EXT	12(X→A+) 3(X→A-)		1(B-)	1(X→A-) 1(A-) 1(X→B-) 1(B-) 1(X-)
2	EXT-mod	12(X→A+) 3(X→A-)	15(A-)	12(Y→B+) 3(Y→B-) 15(B-)	1(X→A-) 1(A-) 1(X→B-) 1(B-) 1(X-)
	EXT-neu	12(X→A+) 3(X→A-)	15(A-)	1(B-)	1(X→A-) 1(A-) 1(X→B-) 1(B-) 1(X-)

Note. Letters X, Y, A, and B refer to feature and target stimuli consisting of sound patterns (X and Y) and background screen patterns (A and B). A ‘→’ represents a 1.5-s empty interval, ‘+’ indicates reinforcement (0.5-s white-flashing screen plus a sound pattern), and ‘-’ represents nonreinforcement. Numbers specify how many trials of each type were presented in a given phase.

A retrospective increase in the associative strength of feature X was assessed by an X alone test trial. Conditioned responding was measured in terms of suppression of ongoing bar pressing. Our prediction for this test was straightforward: If direct excitation retrospectively accrued to feature X, conditioned responding to X alone should be larger in Condition EXT than in Condition NO-EXT. In addition, we also added a compound test trial with a novel target B (X→B) to see to what extent X→A+ training would transfer to this novel compound, and to what extent A- training would possibly influence that transfer. This additional test was added for exploratory purposes; we had no specific predictions.

Method

Participants

Forty psychology students from the University of Amsterdam (12 male, 28 female) with a mean age of 22.48 years (range: 18-48) participated in return for course credits or a small payment. None of them had any prior experience with the Martians computer game. Participants were randomly assigned to Condition EXT ($n = 20$) or Condition NO-EXT ($n = 20$).

Stimuli

Stimuli X and A consisted of a presentation of sound pattern 1 (Windows TM95 “Windows 95 maximize.wav”, played backwards in continuous looping) and a full-screen presentation of a marble-green background pattern (Windows TM95 “marble.bmp”, tiled presentation), respectively.² Stimulus B was a full-screen presentation of a patchy brown-golden background pattern (Windows TM95 “gold.bmp”, tiled presentation). The US comprised a simultaneous presentation of a white flashing screen (5 flashes at a rate of 10 flashes/s; flash time = 50 ms, interflash time = 50 ms) and sound pattern 2 (Windows TM95 “In the computer program error.wav”, played backwards in continuous looping).

Apparatus and Software

The experiment was run on a Pentium IV 3 GHz PC with a 17-in. monitor. Auditory stimuli were presented through Monacor MD-4600 headphones. Responses were given on the space bar of the keyboard. A Windows 95 version of the Martians computer game (Baeyens & Clarysse, 1998) managed presentation of stimuli and recording of bar pressing. Participants were tested individually in a small room for about 17 to 20 min, depending on the specific condition.

Procedure

The procedure was similar to that of Experiment 2 (Group Neutral) in Baeyens et al. (2001), with some modifications. Unlike Baeyens et al., presentation of discrimination trials was phased (X→A+ then A-) instead of intermixed (X→A+/A-). In order to prevent interference between phases, no test for discrimination training (X→A-/A-/X-) was administered after the second phase (i.e., A-). For similar reasons, participants received no reminder trial (X→A+/A-) prior to the critical test.

The experiment consisted of six phases: two pretraining phases were followed by four phases involving the actual experimentation. Prior to the two pretraining phases and experimental Phase 1, participants received written instructions on the computer screen (see Appendix). After reading the instructions, the experimenter always repeated the critical parts.

² In contrast to Baeyens et al. (2001), assignment of the auditory stimulus and the visual stimulus as feature and target, respectively, was not counterbalanced in the present study (personal communication with F. Baeyens).

Pretraining 1: operant training. In this phase, participants learned to make a constant operant bar pressing response. Before operant training, participants were instructed that it was their task to defend the planet from invading Martians, which would land on the planet every quarter of a second. It was explained that they could destroy Martians by using their laser-gun (pressing the space bar). The instructions stressed the importance of firing just before a new Martian would appear on the screen and that there was only one shot available per Martian.

Martians (see Figure 3.1) were then presented one by one at a rate of 4/s in horizontal rows against a black background, starting at the top left corner of the screen. Each row was filled with ten Martians, and they remained on the screen while subsequent rows were filled. Once seven rows were filled, the uppermost row scrolled off the screen and new Martians appeared at the bottom row. If participants fired before the next Martian was presented, an explosion (see Figure 3.1) instead of a Martian emerged. A Martian was depicted as a green head with red eyes and mouth against a yellow background. An explosion was red and was presented against a grey background. Martians and explosions measured 15 mm × 15 mm and were displayed at a distance of 6 mm from each other. If participants fired more than one shot before the next Martian presentation, a Martian rather than an explosion appeared. The operant training phase consisted of 100 Martian presentations. Participants pressed the space bar themselves and, if necessary, the experimenter gave extra verbal instructions to speed up or to slow down responding. Afterwards, the percentage of destroyed Martians was presented to participants on the screen.



Figure 3.1 Depiction of a Martian (left) and an explosion (right).

Pretraining 2: US-only phase. Following operant training, the instructional US was introduced to participants. It was explained that the Martians had developed an anti-laser shield (US) to defend themselves. Participants were informed that firing during an active anti-laser shield would evoke an invasion of Martians, while temporarily disabling their laser-gun. After the instructions, participants were required to put on the headphones. The experimenter then gave a demonstration

of the negative consequences of continued bar pressing during an anti-laser shield (US). In this phase, four unsignalled 0.5-s USs (intermittent flashing screen plus sound) were presented with intertrial intervals (ITIs) that varied randomly between 7.5, 10 and 12.5 s with an average of 10 s. During USs and ITIs, characteristics for Martians presentation were similar to the operant training phase (i.e., a rate of 4/s). If a space bar response was detected during an US presentation (i.e., active anti-laser shield), the US was followed by a 5-s invasion. Throughout an invasion, during which firing was hindered, Martians appeared on the screen at a rate of 10/s. In addition, participants saw an intermittent white flashing screen (20 flashes at a rate of 10 flashes/s; flash time = 50 ms) and heard a sound pattern 3 (Windows 95 “Robotz~2.wav”, played backwards in continuous looping). However, if no response was detected during an US presentation, no invasion was elicited. Just before the first US (anti-laser shield) appeared, the experimenter quit bar pressing, so that no invasion was triggered. During the second US, the experimenter kept on pressing the space bar, thereby eliciting an invasion. Right before the third US, the experimenter stopped bar pressing again and showed that there was no danger caused by resuming bar pressing immediately after US presentation. At the fourth US, the experimenter refrained from pressing right after US onset, thereby demonstrating that quitting bar pressing during an US could not prevent the occurrence of an invasion.

Phase 1: Pavlovian conditioning. Following the pretraining phases, the actual experiment started and Phases 1 to 4 were presented without interruption. In the conditioning phase, participants in both conditions learned that the appearance of the US (anti-laser shield) was indicated by a serial feature X-target A compound stimulus. Prior to conditioning, participants were instructed about the emergence of indicators. It was explained that indicators would be presented to them in order to help them know when the Martians were about to activate the anti-laser shield. Participants were instructed to pay attention to the indicators as some indicators would be correct whereas others would be false. It was stressed that if they identified the correct indicators, they would always be able to refrain from firing during anti-laser shield presentations and, accordingly, prevent the occurrence of invasions. After assurance that the instructions were satisfactorily understood, the experimenter left the room and the participant started the experiment.

During conditioning, serial compound stimuli were presented at an 80% reinforcement schedule; there were 12 X→A+ and 3 X→A- trials. Trials were divided into three blocks, each of which contained three reinforced X→A trials and one nonreinforced X→A trial. Each block was followed by one reinforced

X→A+ assessment trial during which conditioned responding to target A was measured. Within each block, order of trials was random with the restriction that no more than two trials were of the same type. ITIs varied randomly between 7.5, 10 and 12.5 s with a mean of 10 s. A compound stimulus consisted of a 1.5-s presentation of feature X (sound 1) followed by a 1.5-s empty time interval, which in turn was followed by a 1.5-s presentation of target A (marble-green screen). The 0.5-s US immediately followed the offset of target A on reinforced trials. On assessment trials, in order to prevent an underestimation of suppression by learning that the US only appeared after the target, presentation of target A was increased from 1.5 to 3 s. Periods for feature X and the feature-target interval remained 1.5 s.

Phase 2: extinction. The extinction phase differed across the two conditions. Participants in the EXT condition received 15 nonreinforced target A trials (A-). Extinction trials were distributed over three blocks with each block containing four A- trials. Each block was followed by one nonreinforced A- assessment trial. An extinction trial consisted of a 1.5-s presentation of target A (marble-green screen), and its duration was prolonged to 3 s on an A- assessment trial. ITIs were identical to the conditioning phase. Participants in the NO-EXT condition did not receive any A- trials and immediately moved onto the next phase.

Phase 3: transfer target training. In order to reduce novelty effects on test, both conditions were given one nonreinforced 1.5-s presentation of transfer target B (brown-gold screen).

Phase 4: test. In the test phase, a retrospective increment in X's associative strength was examined by means of a feature X alone test. The transfer of X's properties to a novel target was explored by a transfer test, including an X→B and a B alone trial. All participants received single presentations of feature X alone (X-), of the transfer target alone (B-), of the transfer target preceded by X (X→B-), and, as a comparison, of target A alone and preceded by X (A- and X→A-). The order of the assessment trials was randomly determined with the only restriction that the X- trial always occurred at the end. Trials were separated by similar ITIs as in the conditioning phase. Target stimuli and feature alone stimuli were presented for 3 s. Feature presentation and feature-target interval in serial compound stimuli were 1.5 s. In all phases, Martians appeared on the screen during stimuli, USs, and ITIs with similar parameters as during operant training.

Scoring, Response Definition, and Statistical Analyses

Bar presses were counted throughout the whole experiment. On assessment trials, suppression of ongoing bar presses to targets alone (A, B) or preceded by feature X ($X \rightarrow A$, and $X \rightarrow B$) and to feature X alone (X) was assessed. Suppression was expressed in the ratio: $a/(a + b)$, where a represents the number of bar presses during the 3-s critical stimulus presentation and b the number of bar presses during a 3-s period prior to stimulus presentation. For instance, on an A- assessment trial a reflects the number of bar presses during the 3-s target A presentation and b reflects bar presses during a 3-s period immediately prior to target A presentation, whereas on a serial $X \rightarrow A$ - assessment trial a is the number of bar presses during the 3-s A presentation and b is the number of presses during a 3-s period immediately preceding X. A suppression ratio of 0.50 indicates *no suppression* of operant behaviour during the stimulus of interest, whereas a ratio of 0 indicates *complete suppression*.

Differences in responding on assessment trials were examined with analyses of variance (ANOVA). The presence of any suppression on trials was evaluated by comparing suppression ratios to a level of 0.50 (i.e., no suppression) using one-sample t tests. The results of most interest were further examined with planned contrasts and pairwise comparisons (using Bonferroni adjustment for multiple comparisons). Greenhouse-Geisser corrections were applied in case of violation of the sphericity assumption. An alpha level of .05 was used for all statistical analyses.

Results

Participants' mean suppression ratios for target A on assessment trials during conditioning and extinction are presented in Table 3.2. The table also includes responding to target A during the first conditioning trial as a baseline level (baseline $X \rightarrow A+$). Note that as this trial is not an assessment trial, target duration was 1.5 s. Accordingly, suppression ratios for this trial are based on bar presses during the 1.5-s critical target presentation (a) and during the 1.5-s prefeature period (b).

Conditioning

Suppression data during conditioning were subjected to a 4 (Trial: baseline, 1, 2, and 3) \times 2 (Condition: EXT vs. NO-EXT) ANOVA with repeated measures on the first variable. The analyses revealed a main effect of trial, $F(3, 114) = 63.29, p <$

.01, reflecting an increase in suppression across trials. No condition main effect or a Trial \times Condition interaction were found, $F(1, 38) = 1.30, p = .26$, and $F < 1$, respectively. Additional separate t tests on the last reinforced assessment trial showed that in both conditions suppression ratios were significantly smaller than 0.50, $t_{\text{EXT}}(19) = -14.21, p < .01$, and $t_{\text{NO-EXT}}(19) = -16.36, p < .01$. Together, these results indicate that both conditions developed comparable conditioned responding to target A preceded by feature X.

Table 3.2 Mean suppression ratios (with standard deviations in parentheses) on baseline and assessment trials during each training phase in Experiments 1 and 2.

Phase and trial	Experiment 1		Experiment 2	
	EXT	NO-EXT	EXT-mod	EXT-neu
<i>Conditioning</i>				
Baseline X \rightarrow A+	0.39 (0.12)	0.40 (0.07)	0.44 (0.06)	0.45 (0.06)
1 X \rightarrow A+	0.14 (0.13)	0.19 (0.14)	0.27 (0.14)	0.12 (0.10)
2 X \rightarrow A+	0.18 (0.12)	0.19 (0.11)	0.18 (0.11)	0.17 (0.12)
3 X \rightarrow A+	0.14 (0.11)	0.19 (0.09)	0.17 (0.09)	0.18 (0.13)
<i>Extinction</i>				
1 A-	0.43 (0.14)	-	0.43 (0.11)	0.45 (0.10)
2 A-	0.47 (0.11)	-	0.48 (0.03)	0.51 (0.07)
3 A-	0.47 (0.08)	-	0.50 (0.03)	0.50 (0.02)
<i>Transfer target training</i>				
Baseline Y \rightarrow B+			0.41 (0.16)	-
Baseline B-			0.48 (0.05)	-
1 Y \rightarrow B+			0.17 (0.10)	-
1 B-			0.47 (0.11)	-
2 Y \rightarrow B+			0.19 (0.10)	-
2 B-			0.48 (0.07)	-
3 Y \rightarrow B+			0.25 (0.10)	-
3 B-			0.48 (0.08)	-

Extinction

For the extinction condition (EXT), a one-way repeated measures ANOVA was conducted on the last assessment trial of conditioning and the three extinction assessment trials. Suppression readily decreased across trials, which was indicated by a significant main effect of trial, $F(1.86, 35.26) = 75.59, p < .01$. An additional t test confirmed that no suppression was left on the last extinction trial, $t(19) = -1.60, p = .13$.

Test: X \rightarrow A-/A-/X- discrimination

Figure 3.2 (top) displays results for the originally trained target A preceded by feature X and for A and X alone. To assess the influence of additional A- trials on

responding to the original trained compound and its individual elements, data were subjected to a 3 (Stimulus: X→A-, A-, and X-) × 2 (Condition: EXT vs. NO-EXT) mixed ANOVA with stimulus as a repeated measure. The analysis yielded a significant main effect of stimulus, $F(2, 76) = 115.25, p < .01$. Within-subjects contrasts showed that overall suppression was stronger on target A preceded by X (X→A-) compared to target A alone (A-), $F(1, 38) = 84.93, p < .01$, which in turn was stronger than feature X alone (X-), $F(1, 38) = 20.31, p < .01$. There was also a significant interaction between stimulus and condition, $F(2, 76) = 10.00, p < .01$. Pairwise comparisons, which contrast mean suppression ratios between conditions (EXT vs. NO-EXT) at each level of stimulus, revealed that conditions differed significantly only for suppression on target A alone, $F(1, 38) = 15.74, p < .01$. Suppression to target A was weaker in Condition EXT than in Condition NO-EXT. Conditions did not differ for their suppression ratios on target A preceded by feature X, $F < 1$, nor on feature X alone, $F(1, 38) = 1.82, p = .19$. Additional pairwise comparisons contrasted responding between stimuli (X→A-, A-, X-) for each condition separately. For the NO-EXT condition, suppression to A preceded by X was stronger than to A alone, $p < .01$, and X alone, $p < .01$, while suppression to A alone was stronger than to X alone, $p < .01$ (i.e., X→A > A > X). In contrast, for the EXT condition, while suppression to A preceded by X was stronger than to A alone, $p < .01$, and X alone, $p < .01$, there was no difference between suppression to A alone and X alone, $p = 1.0$ (i.e., X→A > A = X). The main effect of condition was not significant, $F(1, 38) = 2.57, p = .12$.

In addition, in both conditions, suppression ratios for X alone were not significantly different from 0.50, $t_{EXT}(19) = -1.35, p = .19$, and $t_{NO-EXT} < 1$. Together, these results indicate that target A extinction following serial XA+ training led, not surprisingly, to a decrease in conditioned suppression to target A, but left responding to A preceded by feature X and to X alone unchanged. Hence, no evidence was provided that feature X acquired direct excitation as a result of posttraining extinction of target A.

However, calculated suppression of bar pressing *during* feature X presentation may reflect an underestimation of conditioned responding evoked by X. Throughout serial X→A+ compound training, participants may have learned about the temporal relationship between feature X and the US (see also Cole, Barnet, & Miller, 1995; Miller & Barnet, 1993). That is, they possibly learned there was a 3-s delay between X offset and US onset. Accordingly, X may have elicited suppression of responding not until 3 s after its offset – the time at which the US was expected to be presented. Therefore, we also calculated suppression ratios on

X alone assessment trials using bar presses during the 1.5- to 4.5-s period *after* X offset, which includes the critical 3-s delay. Although the ANOVA revealed that mean suppression ratios were marginal significantly different from 0.50 for Condition EXT ($M = 0.48$), $t(19) = -2.05$, $p = .05$, but not for Condition NO-EXT ($M = 0.49$), $t < 1$, conditions did not differ from each other in their responses for the delay on X alone assessment trials, $F < 1$. Thus, this analysis also revealed no indication for the retrospective acquisition of a direct X-US relationship by the addition of A- trials.

Transfer Test: X→B-/B- discrimination and X→A- vs. X→B-

Figure 3.2 (bottom) depicts results for the transfer test. To explore the transfer of feature X powers to a neutral target B, a 2 (Stimulus: X→B- vs. B-) × 2 (Condition: EXT vs. NO-EXT) mixed ANOVA with stimulus as a repeated measure was conducted. The analysis revealed significant main effects of condition, $F(1, 38) = 6.36$, $p = .02$, and stimulus, $F(1, 38) = 46.89$, $p < .01$, the latter indicating overall stronger suppression to target B preceded by feature X (X→B-) relative to B alone (B-). More importantly, X→B-/B- discrimination was larger in the EXT condition than in the NO-EXT condition, as reflected by a significant Stimulus × Condition interaction, $F(1, 38) = 12.79$, $p < .01$. Pairwise comparisons showed no difference between conditions in suppression to B alone (B-), $F < 1$, while suppression to X→B- was significantly stronger in the extinction condition (EXT) than in the control condition (NO-EXT), $F(1, 38) = 11.24$, $p < .01$. The enhanced conditioned suppression to X→B- in Condition EXT suggests that presenting target A alone trials changed the influence of feature X on responding to new targets.

To establish the strength of transfer of feature X from the old (A) to the new (B) target in both conditions, suppression data were analyzed with a 2 (Target: X→A- vs. X→B-) × 2 (Condition: EXT vs. NO-EXT) mixed ANOVA with target as a repeated measure. The analysis revealed significant main effects of target, $F(1, 38) = 46.61$, $p < .01$, and condition, $F(1, 38) = 4.85$, $p = .03$. The crucial Target × Condition interaction, $F(1, 38) = 17.42$, $p < .01$, indicated a significant difference in transfer between conditions. Pairwise comparisons showed that for participants in the NO-EXT condition, suppression to B preceded by X was significantly smaller than to A preceded by X, $F(1, 38) = 60.51$, $p < .01$, whereas for participants in the EXT condition this difference was only marginally significant, $F(1, 38) = 3.52$, $p = .07$. Thus, while both conditions demonstrated

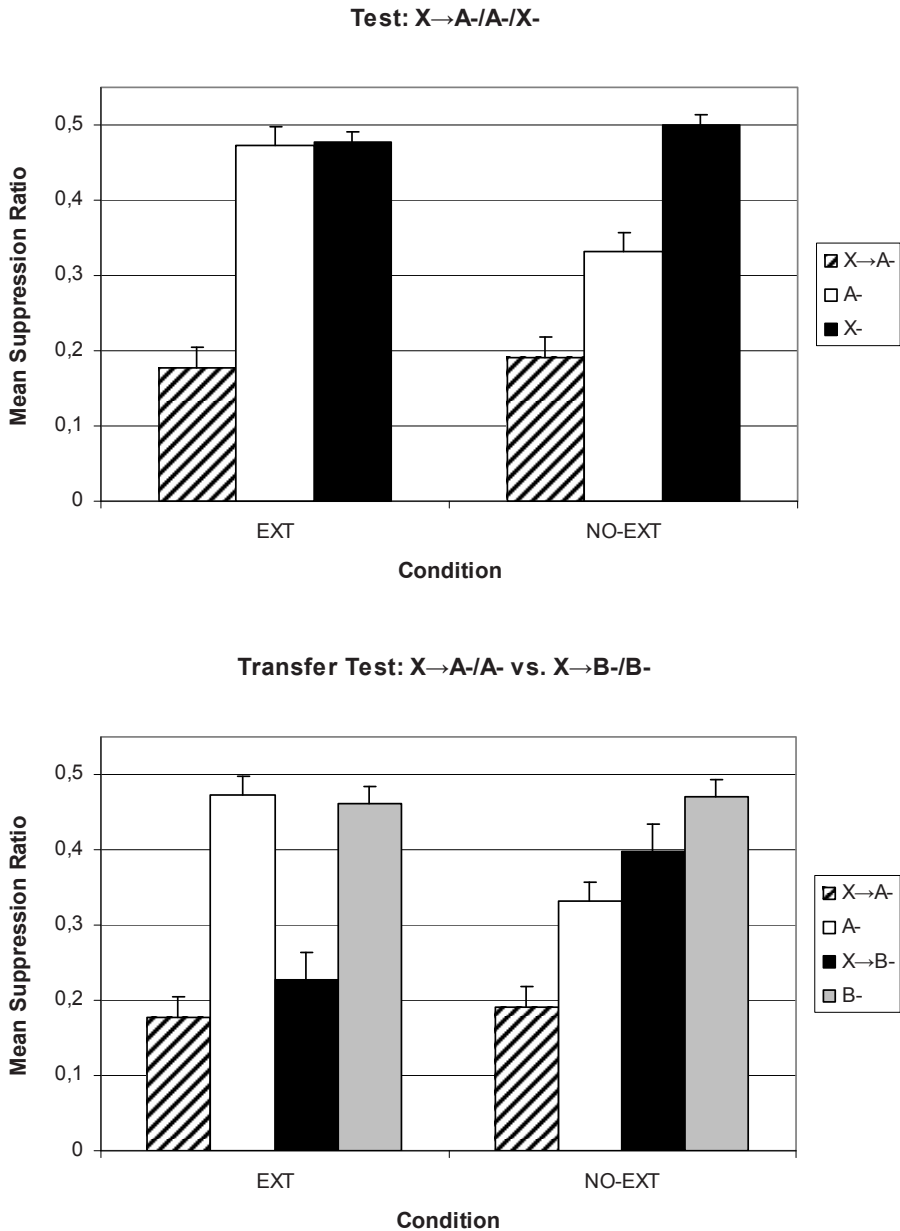


Figure 3.2 Mean suppression ratios (+ SEM) for $X \rightarrow A/A-/X-$ discrimination (top) and the transfer test (bottom) in Experiment 1.

incomplete transfer of feature X's influence for the original target A to a new target B, the loss of transfer was greater for the control condition (NO-EXT) in comparison to the extinction condition (EXT).

Discussion

Serial compound training ($X \rightarrow A+$) resulted in reliable suppression to target A, which was enhanced when preceded by feature X, while feature X elicited no suppression by itself. Subsequent nonreinforced target presentations (A-) extinguished responding to target A but left the ability of feature X to evoke conditioned suppression to A intact.

There was no support for the prediction that target extinction after serial feature-target training retrospectively increased feature X's associative strength. On the X alone test, X elicited no suppression by itself. Interestingly, and in contrast to the X alone test, the results from the transfer test did suggest a retrospective revaluation effect: Extinction of responding to target A after $X \rightarrow A+$ training augmented the transfer of feature X to a novel target B. Thus, without being presented itself during the second training phase (i.e., target A extinction), the meaning of feature X for new targets changed. However, this effect seems not to reflect a retrospective increase in the direct associative association of X with the US.

An alternative hypothesis is that target extinction retrospectively endowed feature X with occasion setting properties. This suggestion may be supported by the findings of Experiment 1. Following serial compound conditioning, target A elicited suppression, which was augmented by feature X, while X elicited no suppression by itself. Subsequent target A extinction increased discriminative $X \rightarrow A/A$ responding: Participants showed strong suppression to target A, but only when preceded by feature X, whereas A and X evoked no suppression by themselves. Such a pattern of responding is typical for occasion setting: Feature X signals whether target A will be followed by the US (e.g., Swartzentruber, 1995). These results suggest that by making target A ambiguous as a result of extinction, feature X indicated more effectively whether A was going to be reinforced.

At first glance, however, the observations of the transfer test seem not consistent with an interpretation in terms of occasion setting. Normally, if serial FP is resolved by X modulating the A-US relationship, transfer of X's properties to other targets is limited and selective (Holland, 1992; Swartzentruber, 1995). Feature X does not readily increase responding to a novel target B on $X \rightarrow B$

compound trials, unless B has also been involved in FP discrimination training ($Y \rightarrow B+/B-$) (e.g., Holland, 1986, 1989a, 1989b). Such findings indicate that the transfer of occasion setters depend on the training history of the transfer target. Hence, in contrast to what models on occasion setting predict (e.g., Lamoureux, Buhusi, & Schmajuk, 1998; Schmajuk et al., 1998), the present results show that the ability of feature X to enhance responding to target A readily transferred to an untrained target, B. Nevertheless, even though substantial transfer to B was observed in the extinction condition (EXT), it was incomplete. Feature X elicited less suppression to transfer target B than to its own target A. The fact that transfer was not complete allows for the possibility that the extent of transfer depends on the specific training history of the transfer target. That is, greater transfer may be observed to targets that are trained in other positive modulation discriminations, as in occasion setters. This was examined in Experiment 2.

Experiment 2

The bottom half of Table 3.1 represents the design of Experiment 2. Experiment 2 examined whether (some of) the retrospectively gained properties of feature X, as obtained in Experiment 1, were modulatory (i.e., occasion setting). Although models on occasion setting disagree on how occasion setters exactly operate, they agree that occasion setters differ in their transfer to other targets conditional upon the training history of these targets (Bonardi, 1998; Bouton & Nelson, 1998; Lamoureux et al., 1998; Schmajuk et al., 1998). In animal and human literature, converging evidence exists that the transfer of positive occasion setters after serial FP training ($X \rightarrow A+/A-$) is greatest to targets that have also been involved in FP discrimination training (e.g., $Y \rightarrow B+/B-$) (Baeyens et al., 2001; Holland, 1986, 1989a, 1989b). By contrast, in several studies no transfer has been obtained to neutral target cues (i.e., nonreinforced preexposed targets) (Baeyens et al., 2001; Rescorla, 1985).

In the present experiment, there were two conditions that differed for their transfer target training. Both conditions received initial training which was similar to the extinction condition (EXT) of Experiment 1: serial compound training ($X \rightarrow A+$) followed by nonreinforced target A trials ($A-$). In the subsequent transfer target training, cue B was involved in either an intermixed serial FP discrimination ($Y \rightarrow B+/B-$) (Condition EXT-mod) or remained neutral ($B-$) (Condition EXT-neu). Transfer of feature X's properties was assessed on a transfer test. If feature X retrospectively had become a positive occasion setter, X was predicted to show

more transfer to a target involved in another FP discrimination than to a neutral target.

Method

Participants

Forty students from the University of Amsterdam (13 male, 27 female) with a mean age of 22.30 years (range: 18-47) participated in return for course credits or a small payment. None of them had any prior experience with the Martians task. Assignment to the conditions was at random: EXT-mod ($n = 20$) and EXT-neu ($n = 20$).

Stimuli

The stimuli were identical to that used in Experiment 1, except for the addition of stimulus Y, which was a presentation of a sound pattern 2 (Windows TM95 “Sixties menu command.wav”, played backwards in continuous looping).

Apparatus and Software

Experiment 2 was run with the same apparatus and software as used in Experiment 1. Participants were again tested individually in a small room and completion required between 20 to 25 min, depending on the specific transfer target training.

Procedure

The procedure of Experiment 2 was similar to Experiment 1 (Condition EXT) with the only exception that the transfer target training differed between conditions. Participants in the neutral condition (EXT-neu) received one nonreinforced presentation of cue B (1 B-), while participants in the modulated condition (EXT-mod) were exposed to traditional intermixed serial FP training (Y→B+/B-). In the EXT-mod condition, the training consisted of 12 Y→B+, 3 Y→B-, and 15 B- trials, which were divided into three blocks containing 3 Y→B+, 1 Y→B-, and 4 B- trials. Each block was followed by two assessment trials: one reinforced Y→B+ trial and one nonreinforced B- trial presented in a random order. Within each block, order of trials was quasi-random with the restriction that no more than two consecutive trials were of the same type. ITIs varied randomly between 7.5, 10 and 12.5 s with a mean of 10 s. A serial compound stimulus

consisted of a 1.5-s presentation of feature Y (sound 2) followed by a 1.5-s empty time interval, which in turn was followed by a 1.5-s presentation of target B (brown-gold screen). On reinforced trials, the 0.5-s US followed immediately after target B offset. During Y→B+ assessment trials, presentation of target B was extended from 1.5 to 3 s, while the feature-target interval remained 1.5 s. A B- trial consisted of a 1.5-s presentation of target B and its duration was prolonged to 3 s on a B- assessment trial.

Scoring, Response Definition, and Statistical Analyses

Scoring of bar presses, calculation of suppression ratios and statistical analyses were identical to Experiment 1.

Results

Table 3.2 summarizes mean suppression ratios for target A on the first conditioning trial (baseline) and on assessment trials during conditioning and extinction as well as for target B during transfer target training. Table 3.2 also includes responding to B during the first trials of the transfer target training as a baseline level (baseline Y→B+ and baseline B-). Note that as these trials are not assessment trials, target duration was 1.5 s. Accordingly, suppression ratios for these trials are based on bar presses during the 1.5-s critical target presentation (*a*) and during the 1.5-s prefeature (baseline Y→B+) or 1.5-s pretarget (baseline B-) period (*b*).

Conditioning

A 4 (Trial: baseline, 1, 2, and 3) × 2 (Condition: EXT-mod vs. EXT-neu) ANOVA with repeated measures on the first variable revealed a main effect of trial, $F(3, 114) = 81.74, p < .01$, indicating a gradual development of suppression. No main effect of condition was obtained, $F(1, 38) = 3.04, p = .09$, but there was a significant interaction between trial and condition, $F(3, 114) = 6.57, p < .01$. Pairwise comparisons per trial showed only a difference between conditions on the first assessment trial, $F(1, 38) = 15.62, p < .01$, but not for baseline or the other assessment trials, $F_s < 1$. Additional separate *t* tests on the last reinforced assessment trial showed that in both conditions suppression ratios were significantly smaller than 0.50, $t_{\text{EXT-mod}}(19) = -16.86, p < .01$, and $t_{\text{EXT-neu}}(19) = -10.85, p < .01$. Thus, although the development of suppression differed between

conditions, there were no initial differences. At the end of conditioning, participants in both conditions had mastered comparable conditioned suppression to target A.

Extinction

A 4 (Trial) \times 2 (Condition: EXT-mod vs. EXT-neu) mixed ANOVA on the last assessment trial of conditioning and the three extinction assessment trials yielded no main effect of condition, $F < 1$, but a main effect of trial, $F(1.98, 75.30) = 163.72, p < .01$, indicating a gradual decrease in suppression during extinction. This pattern of extinction did not differ between conditions, as reflected by a nonsignificant Trial \times Condition interaction, $F < 1$. In addition, t tests on the last extinction assessment trial showed no reliable suppression in both conditions, $t_s < 1$. Hence, conditioned suppression to target A was successfully extinguished in the extinction phase.

Transfer Target Training

For the modulated condition (EXT-mod), a 2 (Stimulus: Y \rightarrow B+ vs. B-) \times 4 (Trial: baseline, 1, 2, and 3) repeated measures ANOVA was performed. A main effect of stimulus was found, $F(1, 19) = 88.63, p < .01$, indicating stronger suppression to target B preceded by Y compared to B alone. Moreover, there was a main effect of trial, $F(1.55, 29.35) = 18.44, p < .01$, which suggests an overall decline in suppression across training trials. Most importantly, the interaction between stimulus and trial was significant, $F(3, 57) = 14.35, p < .01$, indicating a gradual increase in Y \rightarrow B+/B- discrimination across trials. Pairwise comparisons per trial revealed reliable Y \rightarrow B+/B- discrimination at each trial except baseline, $F_{\text{baseline}}(1, 19) = 2.85, p = .11$, $F_1(1, 19) = 71.71, p < .01$, $F_2(1, 19) = 114.44, p < .01$, and $F_3(1, 19) = 37.40, p < .01$, respectively. Together, these results indicate that participants acquired discriminative Y \rightarrow B+/B- responding. As participants in the neutral condition (EXT-neu) did not receive assessment trials, no suppression ratios were calculated.

Test: X \rightarrow A-/A-/X- discrimination

Suppression data for the originally trained target A preceded by feature X and for A and X alone are depicted in Figure 3.3 (top). A 3 (Stimulus: X \rightarrow A-, A-, and X-) \times 2 (Condition: EXT-mod vs. EXT-neu) mixed ANOVA with stimulus as a repeated measure yielded, as expected, no main effect of condition, $F < 1$, but a

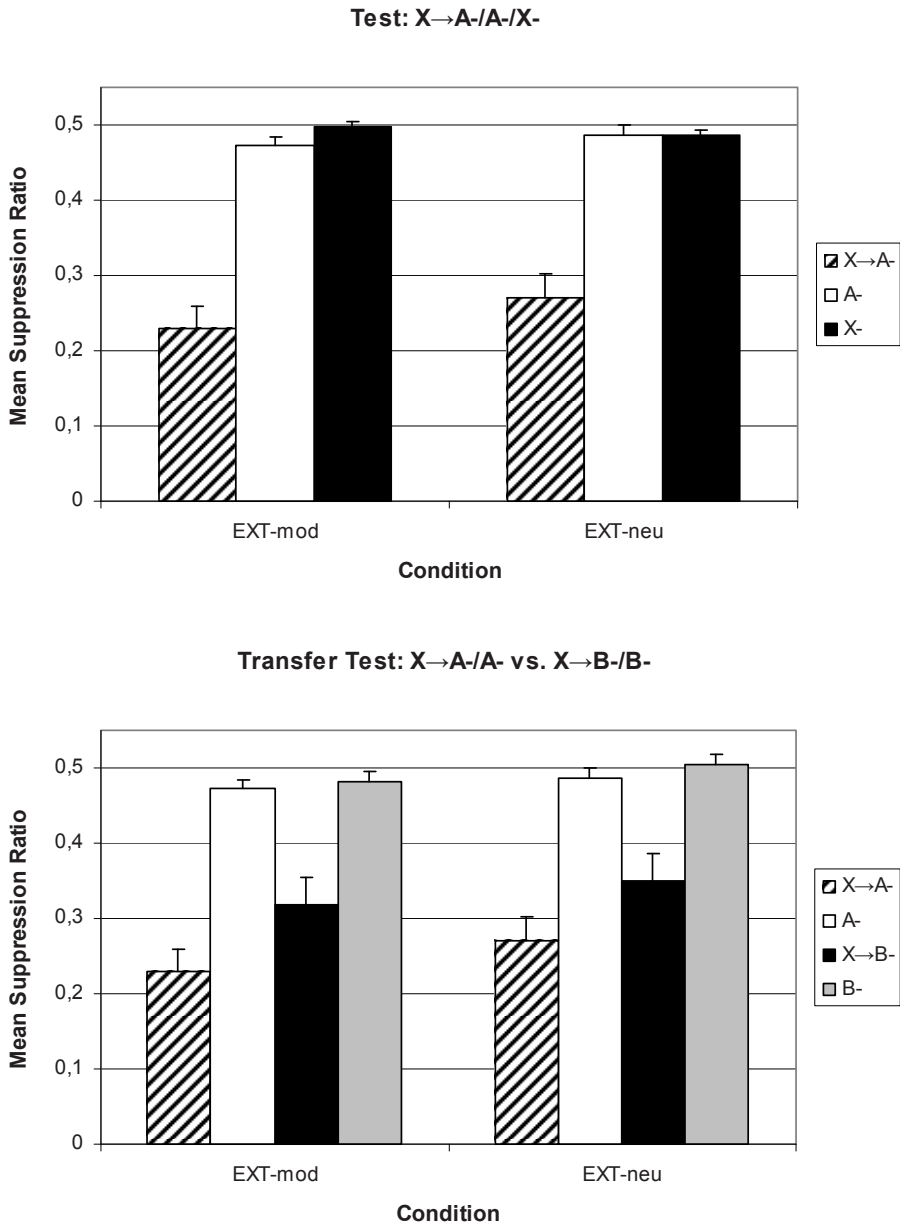


Figure 3.3 Mean suppression ratios (+ SEM) for $X \rightarrow A-/A-/X-$ discrimination (top) and the transfer test (bottom) in Experiment 2.

significant main effect of stimulus, $F(1.38, 52.56) = 105.90, p < .01$. Within-subject contrasts indicated that overall suppression ratios on target A preceded by feature X were stronger than on target A alone, $F(1, 38) = 107.66, p < .01$, while suppression to A alone did not differ from X alone, $F(1, 38) = 1.37, p = .25$. This pattern of responding to the three stimuli did not differ between conditions, as reflected by a nonsignificant Stimulus \times Condition interaction, $F(1.38, 52.56) = 1.00, p = .35$. Separate t tests indicated no reliable suppression to X alone in each of the conditions, $t_{\text{EXT-mod}} < 1$, and $t_{\text{EXT-neu}}(19) = -1.28, p = .22$. In addition, suppression ratios on X alone assessment trials were calculated for the 1.5- to 4.5-s period following feature X's offset (see also Experiment 1). A one-way ANOVA revealed no significant difference between conditions in delayed suppression ratios ($M_{\text{EXT-mod}} = 0.50, M_{\text{EXT-neu}} = 0.48$), $F(1, 38) = 1.69, p = .20$. Moreover, in both conditions delayed suppression ratios were not significantly different from 0.50, $t_{\text{EXT-mod}} < 1$, and $t_{\text{EXT-neu}}(19) = -1.49, p = .15$. Hence, like in Experiment 1, there was no evidence that a serial compound training followed by extinction trials turned X retrospectively into a simple excitator.

Transfer Test: X→B-/B- discrimination and X→A- vs. X→B-

Figure 3.3 (bottom) displays the results for the transfer test. A 2 (Stimulus: X→B- vs. B-) \times 2 (Condition: EXT-mod vs. EXT-neu) mixed ANOVA produced a main effect of stimulus, $F(1, 38) = 40.41, p < .01$, indicating that suppression to X→B- was stronger relative to B-. Most pertinent to our hypotheses, the X→B-/B- discrimination did not differ between conditions as reflected by a nonsignificant Stimulus \times Condition interaction, $F < 1$. Thus, a similar pattern as in Experiment 1 was revealed: Feature X had become an indicator that a novel target was going to be reinforced. However, the extent to which feature X provoked larger suppression to a neutral target relative to the neutral target alone was independent of the specific training of that transfer target.

To assess the degree of transfer of feature X from the old (A) to the new (B) target for the two conditions, a 2 (Target: X→A- vs. X→B-) \times 2 (Condition: EXT-mod vs. EXT-neu) mixed ANOVA was performed with target as a within-subjects variable. The target main effect, $F(1, 38) = 10.79, p < .01$, showed that suppression to X→B- was weaker than suppression to X→A-. No main effect of condition or an interaction between target and condition was found, $F_s < 1$. Hence, the demonstrated incomplete transfer was comparable for the two conditions.

Discussion

In accordance with the results of Experiment 1, feature X was still able to evoke suppression to target A despite the presentation of nonreinforced A trials after serial $X \rightarrow A+$ compound training. Moreover, as in Experiment 1, the ability of feature X to elicit conditioned responding transferred to another target, B. Participants showed suppression to B, but only when preceded by X. The novel finding was that the extent of transfer was independent of the specific training history of B. Specifically, no differences in $X \rightarrow B-/B-$ discrimination were observed between participants that received an intermixed serial FP training with B (EXT-mod) and participants that received only one exposure to B (EXT-neu). The absence of a selective transfer effect suggests that feature X did not retrospectively acquire occasion setting power.

General Discussion

The present study examined retrospective reevaluation effects following serial compound training in a behavioural task using a release from overshadowing design. In Experiment 1, a serial feature-target compound training procedure ($X \rightarrow A+$) resulted in suppression to target A, which was enhanced when preceded by X, whereas feature X by itself elicited no suppression. Subsequent presentation of nonreinforced A trials ($A-$) extinguished suppression to A, but had no effect on either X's potential to evoke suppression to A or responding to X alone. By contrast, nonreinforced target A presentations did affect the significance of feature X for a novel target, B. They enhanced the ability of feature X to elicit suppression when presented in serial compound with a novel target B. Hence, without being presented itself during the critical training phase ($A-$), the meaning of X for other cues changed, suggesting retrospective learning about feature X. Experiment 2 revealed that the enhanced transfer effect, observed in Experiment 1, was independent of the specific training history of the transfer target. Similar transfer was obtained to untrained targets as to targets that were trained in a serial feature positive discrimination.

The results of Experiment 1 seem not to sustain the prediction that target extinction retrospectively increased the associative strength of feature X: Extinction of responding to target A did not augment suppression to X alone. The absence of an increase in conditioned responding to X was not attributable to a temporal encoding effect (Cole et al., 1995; Miller & Barnet, 1993). That is, during serial $X \rightarrow A+$ training participants may have learned to expect the US 3 s following

X offset. Accordingly, feature X may not have elicited conditioned responding until 3 s after its offset. However, an analysis of delayed X alone responses also showed no reliable increase in suppression by the addition of A- extinction trials. The pattern of responding after target extinction rather implies that participants learned a conditional discrimination comparable to occasion setting: They showed strong suppression to A when preceded by X, but not to A alone or X alone.

The results of Experiment 2, however, failed to observe evidence of occasion setting properties that accrued to feature X by posttraining target extinction. In contrast to the prevailing view of occasion setting (Holland, 1992; Schmajuk et al., 1998; Swartzentruber, 1995), no selectivity of transfer of feature X was observed. The ability of X to enhance responding to a novel target B was independent of whether B was involved in FP training or received no training.

Before further discussing the nature of the observed retrospective revaluation effect, it must be mentioned that the present findings pose a problem for both simple associative theories (e.g., Ghirlanda, 2005; Rescorla & Wagner, 1972) and revised associative theories (e.g., Dickinson & Burke, 1996; Van Hamme & Wasserman, 1994). Although the latter theories are silent about the possibility that cues may retrospectively acquire a hierarchical structure (e.g., occasion setting power), they assume retrospective increases in the direct associative strength of cues. To recap, according to revised associative theories, nonreinforced target presentations will activate a representation of the feature in memory by virtue of a within-compound association, which was formed during feature-target compound training. Also, serial compound training is assumed to produce within-compound associations (Aitken et al., 2001). The associative strength of the activated, but absent, feature will change in the opposite direction of the target that is present. By implication, this account predicts an increase in excitatory strength of feature X by presentation of target A extinction trials. The absence of any suppression to feature X alone following posttraining target extinction in the present study, therefore, contradicts predictions of revised associative theories.

Turning to the interpretation of the results, several explanations may account for the transfer data obtained in the present study. At face value, the increased ability of feature X to enhance suppression to a novel target B due to target A extinction might simply reflect generalization on the basis of sensory modality. Because feature X was a sound and target A was a visual pattern, participants may have deduced by target extinction after feature-target training that sounds predict reinforcement, while visual patterns alone mean nonreinforcement. This would explain the enhanced transfer on X→B trials for participants in the

EXT condition compared to the NO-EXT condition (Experiment 1). Such sensory modality generalization may also account for the finding that responding on $X \rightarrow B$ trials was independent of the training history of target B (Experiment 2). However, it can neither explain the finding that sound X did not evoke any suppression when presented alone (Experiments 1 and 2) nor the finding that sound feature Y did not enhance suppression to visual target B at the start of transfer training (Experiment 2).

Alternatively, the present findings may suggest that nonreinforced target presentations retrospectively changed the causal status of compounds in general. Compared to serial compound training alone, suppression on compounds was less specific to the trained feature-target combination when serial compound training was followed by target extinction. The originally trained feature now showed an enhanced prediction of reinforcement when presented in compound with a novel target. This may suggest that target extinction encouraged subjects to apply the rule that compounds, but not elements, signal reinforcement. This account relates to findings of rule-based generalization (Shanks & Darby, 1998). Shanks and Darby exposed subjects to A+, B+, AB-, C-, D-, and CD+ trials together with I+, J+, M-, and N- trials. On a subsequent test, subjects rated the outcome on novel compound IJ less likely than on novel compound MN, suggesting that performance was based on an abstract rule (i.e., rule-based generalization: reinforcement on a compound and its elements is reversed) rather than on similarity of the elements (i.e., feature-based generalization). However, in the study of Shanks and Darby, subjects inferred this rule by intermixed presentation of the trials, thereby allowing for a confirmation of rules. By contrast, if rule learning plays a role in the current study, it should be based on deductive reasoning instead of direct experience. By additional nonreinforced target presentations, subjects may have deduced that compound stimuli predict reinforcement but not elements alone. Such deductive reasoning is unlikely to be induced by mere presentation of $X \rightarrow A+$ trials.

In accordance with a rule-based generalization account, suppression to $X \rightarrow B$ was enhanced after $X \rightarrow A+$ training and subsequent A- trials relative to $X \rightarrow A+$ alone training (Experiment 1). Note, however, that transfer to B was not complete, suggesting to some extent specificity of the $X \rightarrow A$ compound. An explanation in terms of rule-based generalization also predicts the absence of suppression to elements A, B, and X (Experiments 1 and 2). Moreover, it can clarify why the training history of B had no influence on the amount of transfer (Experiment 2). The one outcome that cannot be explained is the lack of enhanced

suppression to compound $Y \rightarrow B$ compared to element B alone at baseline (Experiment 2).

One potential limitation in the current study may account for the failure to observe an increment in suppression to X after target extinction. X alone trials were always presented at the end of the test phase. Although there were only four nonreinforced test trials, participants may have inferred that trials were not longer reinforced by the end of the test phase.

In summary, the data of the present experiments suggest that retrospective revaluation effects can be observed after serial feature-target compound training followed by nonreinforced target presentations. Without being presented itself during the critical learning phase, the meaning of the feature cue for other target cues changed. Target extinction seems to enhance transfer of the originally trained feature. This may point to a paradoxical effect of extinction learning. Extinction of responding to a target cue, which was previously conditioned in attendance of another feature cue, may enhance the ability of the original feature to evoke conditioned responses when combined with cues that are perceptually similar to the extinguished cue.

Appendix

Instructions prior to phases (translated from Dutch)

Pretraining 1: Operant Training

In this task you are asked to defend the planet from invading Martians. Every quarter of a second one Martian will try to land. You will see that the Martians appear one by one in rows on the screen.

In order to destroy them, you must shoot them with your laser-gun (by pressing the space bar) before they can see you. That is, just before a new Martian will appear on the screen. But do not shoot too early, because you only have one shot per Martian. You do not have to aim your laser-gun. The only thing that matters is to fire at the right moment (pressing the space bar). If you destroyed a Martian, you will see an explosion appearing on the screen, at the place where a Martian would have appeared otherwise. At the end of this phase, we will tell you the percentage of Martians that you have killed.

As soon as you press the OK-button, the Martians immediately start landing, and you must start firing. THE PLANET DEPENDS ON YOU!! DO NOT ALLOW THEM TO LAND!!

Pretraining 2: US-only Phase

The Martians have now developed a powerful anti-laser shield. You must continue to use your laser gun to prevent their landing. BUT BE CAREFUL, because if you shoot when the anti-laser shield is active, your shot will be rebounded, which temporarily disables your laser-gun. Immediately, thousands of Martians will land safely and you will not be able to stop that invasion. You will recognize that the anti-laser shield is activated when you see a WHITE INTERMITTENT FLASHING on the computer screen. Also, you hear clearly that the anti-laser shield is activated, due to the fact that activating the shield produces a METALLIC WIND.

So remember well: just a single shot as soon as the anti-laser shield is activated (WHITE FLASHING SCREEN & METALLIC WIND), and the Martians will make a successful invasion!! The experimenter will now illustrate all this....

Phase 1: Pavlovian Conditioning

Some INDICATORS will help you to predict when the Martians are about to activate the anti-laser shield. There are, however, correct and false indicators. If you learn to distinguish between correct and false indicators, you will always be able to avoid firing while the anti-laser shield is on. Otherwise, every time that the Martians activate the anti-laser shield, you will be firing, and an inevitable invasion will follow...