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RESURGENCE OF TWO-RESPONSE SEQUENCES PUNISHED BY POINT-LOSS RESPONSE COST IN HUMANS

RESURGIMIENTO DE SECUENCIAS DE DOS RESPUESTAS CASTIGADAS POR COSTO DE LA RESPUESTA MEDIANTE LA PÉRDIDA DE PUNTOS EN HUMANOS

HIROTO OKOUCHI
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Abstract

The present experiment examined in humans whether two–response sequences resurged after they had been eliminated by response–cost punishment. Undergraduates' touches to two of eight squares (target response sequence) presented on a computer touch screen produced points exchangeable for money arranged according to a variable–interval (VI) 10–s schedule. The response sequence then lost points while another two–response sequence (alternative response sequence) was reinforced under a VI 2–s schedule. When reinforcement of the alternative sequence was discontinued (resurgence test phase), the target sequence recurred. Rates of the target sequence during the resurgence test phase for these participants were comparable to those for participants whose reinforced target sequence had been extinguished without punishment, and higher than those for participants whose target sequence had not been reinforced. Previous experiments examined resurgence of single responses punished by electric shock in rats, and the results were mixed. The present results demonstrate resurgence of two–response sequences punished by point–loss response cost in humans.

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Keywords: resurgence, punishment, response cost, variable–interval schedules, response sequence, screen touch, humans

Resumen

En el presente experimento se examinó si las secuencias de dos respuestas en humanos resurgían después de que se habían eliminado mediante el castigo por costo de la respuesta. Las respuestas de estudiantes de tocar dos de ocho cuadrados (secuencia blanco de respuestas) presentados en la pantalla táctil de una computadora produjeron puntos intercambiables por dinero conforme a un programa de intervalo variable (IV) 10 s. La secuencia de respuestas posteriormente resultaba en la pérdida de puntos, mientras que otra secuencia de dos respuestas (secuencia alternativa de respuestas) se reforzó conforme a un programa de IV 2 s. Cuando el reforzamiento de la secuencia alternativa se descontinuó (fase de prueba de resurgimiento), la secuencia blanco recurrió. Las tasas de la secuencia blanco durante la fase de prueba de resurgimiento para estos participantes fueron comparables con las tasas observadas de los participantes para quienes la secuencia blanco reforzada se extinguió sin el castigo y fue mayor que las tasas observadas para los participantes para quienes no se reforzó la secuencia blanco. En experimentos previos se examinó el resurgimiento de respuestas simples castigadas mediante choques eléctricos en ratas y los resultados fueron mixtos. Los resultados del presente estudio muestran el resurgimiento de secuencias de dos respuestas castigadas por costo de la respuesta mediante la pérdida de puntos en humanos.

Palabras clave: resurgimiento, castigo, costo de la respuesta, programas de intervalo variable, secuencia de respuestas, pantalla táctil, humanos

Resurgence is the recurrence of a previously reinforced response when an alternative, more recently reinforced, response is no longer reinforced (Epstein, 1985; Lattal, St. Peter, & Escobar, 2013). Resurgence typically is demonstrated using a three–phase experimental design. In the first (reinforcement) phase, a response (target response) is reinforced. In the second (elimination) phase, the target response is extinguished, and an alternative response is reinforced. In the third (resurgence test) phase, extinction is arranged for both responses (da Silva, Maxwell, & Lattal, 2008). The recurrence of the target response during the resurgence test phase is labeled as resurgence (Lattal & St. Peter Pipkin, 2009).

Resurgence has received attention from researchers with basic (e.g., Shahan & Sweeney, 2011) and applied (e.g., Prichard, Hoerger, Mace, Penney, & Harris, 2014) interests. Considerable research has demonstrated that resurgence is a reliable effect that occurs across a variety of species (e.g., Epstein & Skinner, 1980; Leitenberg, Rawson, & Bath, 1970; Wilson & Hayes, 1996) and response topographies (e.g.,

Leitenberg et al., 1970; Sanchez–Carrasco & Nieto, 2005). In addition to such generality, a number of experiments have isolated variables that affect resurgence (e.g., Sweeney & Shahan, 2013). The present experiment, as one such attempt, examined effects of punishment on resurgence.

To date, two studies have examined resurgence after the target responses were punished, and the results are mixed (Kestner, Redner, Watkins, & Poling, 2015; Rawson & Leitenberg, 1973). Rawson and Leitenberg (1973) used a two–component multiple schedule, consisting of a control component in which an identical variable–interval (VI) schedule was in effect throughout the experiment and an experimental component in which the contingencies changed across phases. Presses to a lever (target responses) by rats, which had been reinforced under a VI schedule during a reinforcement phase, did not produce food but rather a 0.5–s 0.25–mA electric shock, and presses to another lever (alternative responses) produced food during the experimental component of an elimination phase. Thereafter, presses to neither lever produced consequences (i.e., produced neither food nor shock) during the experimental component in 15 sessions of a resurgence test phase. The number of target responses during the experimental component of the resurgence test phase for these rats was not different from that for rats that had not been presented shocks during the elimination phase, demonstrating that punished responses resurged as unpunished, typically treated, responses did.

Unlike Rawson and Leitenberg (1973), Kestner et al. (2015) did not find resurgence of a punished response. In Kestner et al.'s experiment, presses to a lever (target responses) by rats, which had been reinforced under a VI schedule during a reinforcement phase, did not produce food but rather a 0.5–s 0.6–mA electric shock, and nose–poke responses (alternative responses) produced food during an elimination phase. Thereafter, neither response produced consequences during a five–session resurgence test phase. The number of the target responses per min during the resurgence test sessions was larger than that during the final elimination sessions for only one of five rats. Of the other five rats that had not been presented shocks during the elimination phase, by contrast, four emitted the target response more frequently during the test sessions than during the final elimination sessions.

The present experiment was different from those by Rawson and Leitenberg (1973) and Kestner et al. (2015) in four ways. First, the present experiment was conducted with humans. Although experimentation using human participants generally relates to a basic issue of human–nonhuman differences and similarities (Perone, Galizio, & Baron, 1988), it may especially have applied implications in the present context. Effects of punishment on resurgence closely relate to an applied question of whether punishment, which suppresses problem behavior effectively when it is in effect (Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998), would maintain the suppression of the problem behavior after its removal. Thus, results obtained from humans

may have a relatively strong impact on the issue of using of punishment in applied fields (cf. Alberto & Troutman, 1999).

Second, the present experiment used response–dependent–point–loss as punishment. Points, which are exchangeable for money or other types of backup reinforcers, can function as punishment when they are lost as a result of emitting responses, a contingency usually called response cost (e.g., Alberto & Troutman, 1999; Crosbie, 1998). Electric shock, which was used in previous experiments (Kestner et al., 2015; Rawson & Leitenberg, 1973), is almost never used with humans in applied settings, whereas mild verbal reprimands, timeout, and response cost are used more often (Kestner et al., 2015). Thus, it is practically important to determine whether response–dependent–point–loss would affect resurgence.

Third, the present experiment selected two–response sequences as the classes of responses. For comparison, VI schedules were followed by extinction in the present experiment, as in previous ones (Kestner et al., 2015; Rawson & Leitenberg, 1973). However, most studies of resurgence by humans in laboratory settings have used discrete–trial procedures (e.g., Dixon & Hayes, 1998; Doughty, Cash, Finch, Holloway, & Wallington, 2010; Wilson & Hayes, 1996; but see also Marsteller & St. Peter, 2012). One of the reasons may be related to the issue of human schedule insensitivity. Human behavior often has been said to be insensitive to schedules of reinforcement (e.g., Baron, Kaufman, & Stauber, 1969; Okouchi, 2013). For example, Weiner (1964) found that responding that had been maintained by a fixed–interval 25–s schedule did not decline but continued at high rates throughout a 170–min extinction session for two of three participants. Such insensitivity to change in contingency from reinforcement to extinction may impede the net effects of resurgence. Some kinds of schedule–sensitive human behavior, however, have been obtained by manipulating procedural variables responsible for establishing such control (e.g., Galizio, 1979; Madden & Perone, 1999). Using a two–response sequence as the response class, for example, Okouchi (2009) demonstrated response acquisition by humans with free–operant schedules of delayed reinforcement. The present response classes were adapted from Okouchi's (2009). Eight filled white squares were presented on a black touch screen of a monitor. Touches on two of the eight squares in a specified sequence (target response) produced a reinforcer, depending on a VI schedule during a reinforcement phase, whereas the target response was not followed by reinforcers during, subsequent, elimination and resurgence test phases.

Fourth, the present experiment arranged control conditions in which the target response was never reinforced. Previous experiments examined effects of punishment on resurgence (Kestner et al., 2015; Rawson & Leitenberg, 1973) have not assessed resurgence by comparing previously reinforced responses with unreinforced ones. Such a lack of control conditions, however, leaves a possibility that the obtained results were contaminated by extinction–induced response variability (Antonitis, 1951).

In the present experiment, by contrast, the number of the target responses emitted during a resurgence test phase for participants, whose target responses had been reinforced then eliminated during previous phases, was compared with that for participants whose target responses had never been reinforced.

Method

Participants

Thirteen male and eleven female undergraduates recruited from educational psychology classes at Osaka Kyoiku University participated. They were 19 to 30 years old, and none had experience with operant conditioning experiments.

Apparatus

The experimental room was 1.70 m wide, 2.20 m long, and 2.17 m high. A Nihon Electric Company PC–MJ30Y microcomputer, located in an adjacent room, was used to control the experiment. The participant sat at a desk facing at an Eizo L362–T touch–sensitive color display monitor (340 mm wide by 275 mm high). During the experimental session, three, two, and three filled white squares (35 mm each side) were presented on the top (40 mm below the top of the screen), middle (99 mm below the top of the screen), and bottom (158 mm below the top of the screen) of the black screen, respectively. Figure 1 shows the configuration of these eight squares. At the top and bottom of the screen, three squares were presented at the left, center, and right, respectively, 59 mm apart from center to center, whereas two squares were presented at the left and right in the middle of the screen, respectively, 118 mm apart from center to center. When the schedule requirement was met, these eight squares disappeared and one filled white square (35 mm each side) for the "consummatory response" was presented in the middle center of the screen (not shown in Figure 1). Each touch to the eight squares was accompanied by a medium tone (440 Hz), the appearance of the middle–center square (delivery of a reinforcer) and each touch to that square (consuming the reinforcer) were accompanied by a high tone (1760 Hz), and point decrement (response–cost punishment) was accompanied by a low tone (110 Hz) through a speaker located on the desk. A point counter was located at the top right of the screen.

Procedure

Participants signed an informed consent agreement that specified the frequency and duration of their participation and the average earnings for such participation. At the beginning and end of the experiment, each participant was asked not to speak to

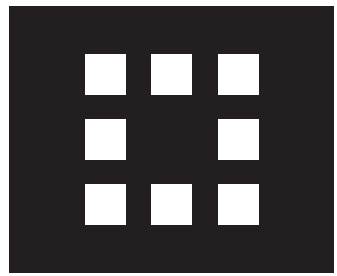

Figure 1. A depiction of the stimuli displayed to the participant on the computer screen.

anyone other than the experimenter about the study in an attempt to prevent discussion about the contingencies among participants (cf. Horne & Lowe, 1993). At the end of the experiment, participants were asked whether they had any information to offer about the study. None reported that they did.

Participants were randomly assigned in equal number to one of four groups: (a) reinforcement / punishment, (b) reinforcement / no punishment, (c) no reinforcement / punishment, and (d) no reinforcement / no punishment. Table 1 shows the conditions comprising the present experiment. Participants in the reinforcement groups were exposed to a baseline phase, a reinforcement phase, an elimination phase, and a resurgence test phase in that order. With the exception that they were not exposed to the reinforcement phase, participants in the no–reinforcement groups experienced same conditions as those in the reinforcement groups did.

Participants in the reinforcement groups participated first in a 90–min experimental period then in a 180–min experimental period, with the two periods occurring on different days within a week. During a 90–min experimental period, a maximum of seven variable–duration sessions occurred. Sessions were separated by 2– to 3–min breaks. During a 180–min experimental period, a maximum of 12 sessions occurred. More specifically, the last one, two, or five sessions of the reinforcement phase and all sessions of the elimination and resurgence test phases occurred within this single 180–min experimental period (Hirai, Okouchi, Matsumoto, & Lattal, 2011). A 10–min break occurred after 90 min. Except for Participants 13 and 15, participants in the no–reinforcement groups participated only in a single 180–min experimental period. Participant 13 experienced 180–min then 90–min experimental periods, whereas Participant 15 participated only in a 90–min period.

After every period, participants were paid for their performance (5 yen, approximately .043 U.S. dollars, per 100 points). On completion of the 180–min experimental period, participants were paid for their participation (100 yen per 90 min) and were debriefed. The overall earnings for each participant ranged from 1,030 to 2,800 yen (approximately 8.92 to 24.25 U.S. dollars).

Table 1
Contingencies in effect on each response sequence in each phase in each group.

Group	Sequence	Phase			
		Baseline	Reinfocement	Elimination	Resurgence test
Reinforcement / punishment	Target	N	R	P	N
	Alternative	N	N	R	N
Reinforcement / no punishment	Target	N	R	N	N
	Alternative	N	N	R	N
No reinforcement / punishment	Target	N		P	N
	Alternative	N		R	N
No reinforcement / no punishment	Target	N		N	N
	Alternative	N		R	N

Note. The Label R describes that a given response sequence produced 100 points depending on a variable–interval schedule. The Label P describes that a target response sequence lost 100 points depending on a fixed–ratio 1 schedule. The Label N describes that a given response sequence had no consequence.

Each participant was asked to leave wristwatches, cellular phones, and books outside the experimental room. Once in the room, the participant was given the following printed instructions (translated here from Japanese into English):

> Your task is to earn as many points as you can. A hundred points are worth five yen. Payment for the points will be made at the end of each visit. In addition, you will be paid 100 yen for every 90 min you spend in the experiment. Payment for participation will be made at the end of the last visit. Points will be sometimes subtracted. If balance of the account is against you at the end of the experiment, you will not be paid for the points.
>
> Eight white squares will be shown on the screen of the display monitor. Sometimes these squares may disappear, then a square will appear in the center of the screen. By touching the center square, you can earn points. Accumulated points will be shown in the top right of the screen. It is up to you whether you touch the eight squares or not. If you touch these squares, the center square may appear. Or, the appearance of the center square may be unrelated to touching the eight squares.
>
> The words "READY" and "GO" will appear in sequence on the screen. When the word "GO" disappears, do the task until the words "GAME OVER" appear

on the screen. The task will be repeated several times. When the words "GAME OVER" appear, please wait until the word "READY" reappears.

The Experimenter read the instructions out loud to the participant. Questions regarding the experimental procedure were answered by rereading out loud the appropriate sections of the instructions to the participant. The printed instructions remained on the desk throughout the experiment. Then the words "READY" and "GO" were presented in sequence at the top left of the screen. After the word "GO" disappeared, eight squares were presented on the screen as shown in Figure 1.

When the schedule requirement was met, the eight squares were darkened and the square for the consummatory response was presented in the middle center of the screen. A touch darkened the square and accumulated 100 points on the counter, followed by a 1–s timeout. After the session terminated, the words "GAME OVER" appeared at the top left of the screen.

Baseline phase. Except for Participant 2, who experienced two 10–min sessions, a single 10–min session was conducted in the baseline phase to measure the operant levels of two–response sequences of touching the eight squares and to determine the target and alternative response sequences. Every touch to each square was recorded while no points were delivered.

For each participant except Participant 2, a two–response sequence that occurred at least once and most infrequently during the baseline session was selected as the target response sequence. One of the second most infrequent two–response sequences, which did not include responses comprising the target sequence, was selected as the alternative–response sequence. Except for Participants 2 and 12, each of the target and alternative sequences occurred only once during the baseline session. For Participant 12, the target and alternative sequences occurred twice and three times during the baseline session, respectively. A second session was added for Participant 2 because no sequence occurred during the original baseline session. However, no sequence occurred again during the second session. Thus, his target and alternative sequences were selected arbitrarily. Table 2 shows the target and alternative response sequences for each participant.

Reinforcement phase. The procedure of the reinforcement phase was identical to that of the baseline phase with the following exceptions. Participants in the reinforcement groups experienced this phase, whereas those in the no–reinforcement groups did not (Table 1). The target response sequence produced points depending on the schedule in effect, whereas the alternative response sequence produced no points.

A fixed–ratio (FR) 1 schedule, a VI 2–s schedule, and a VI 10–s schedule were in effect during one, one, and five sessions in that order. Each session lasted until 40 re-

inforcers occurred or 60 min (including the time taken for consummatory responses and timeouts) elapsed, whichever came first. A constant–probability progression (Fleshler & Hoffman, 1962) consisting of 20 intervals was used to generate the VI schedules.

Table 2
Target and alternative two-response sequences for each participant

Participant	Target sequence	Alternative sequence
Reinforcement / punishment		
1	UL-MR	BC-ML
2	UC-BL	BR-ML
3	BC-ML	MR-UR
4	UC-UL	ML-BC
5	UC-MR	BL-UL
6	UC-ML	BL-UL
Reinforcement / no punishment		
7	UL-MR	BL-UR
8	ML-BC	BR-BL
9	UC-UR	BL-ML
10	UC-MR	BC-UR
11	UR-ML	BR-UC
12	UC-BR	BC-UL
No reinforcement / punishment		
13	UL-ML	BR-MR
14	UL-BL	UR-BC
15	UL-UC	BL-ML
16	UR-ML	UL-MR
17	ML-UL	BC-BR
18	UR-UL	BC-BL
No reinforcement / no punishment		
19	ML-UR	UC-BR
20	UL-BR	UC-MR
21	BL-UR	UL-UC
22	BR-UC	ML-BL
23	UR-ML	UC-MR
24	BR-UC	ML-MR

Note. U, M, B, L, C, and R, donate upper, middle, bottom, left, center, and right, respectively, and indicate the location of squares being touched. UL–MR for Participant 1, for example, indicates that touching the upper–left square then the middle–right one was her target response sequence.

Participant 2 required two sessions consisting of the FR 1 schedule to emit the target sequences. Thus, he experienced eight sessions in the reinforcement phase.

Elimination phase. The procedure of the elimination phase was identical to that of the reinforcement phase with the following exceptions. All participants experienced this phase. The target response sequence produced no points, whereas the alternative response sequence produced points according to a VI 2–s schedule. Furthermore, whenever participants in the punishment groups emitted the target response, 100 points were subtracted from the counter (FR 1 point loss). Except for Participants 13 and 16, this phase lasted for five sessions.

Participants 13 and 16 experienced seven and six sessions in the elimination phase, respectively. Because of a mechanical error, the first session of the resurgence test phase did not begin for Participant 13. His session was discontinued and resumed on a subsequent day. During the second experimental period, additional two sessions of the elimination phase were followed by the resurgence test sessions for Participant 13 so that sessions of the elimination and resurgence test phases could occur within a single experimental period, as was the procedure with the other participants. One session of the elimination phase was added for Participant 16 because no alternative response sequence occurred during her first elimination session.

Resurgence test phase. The procedure of the resurgence test phase was identical to that of the baseline phase except for the number of sessions being conducted. Three sessions occurred for Participants 1, 3, and 7. Because three sessions without reinforcement seemed upsetting for those participants, the number of sessions was reduced to two for the remainder of the participants. Due to time constraints, only one resurgence test session occurred for Participants 15 and 16. Participant 16 spent much time for the first elimination session, whereas Participant 15 participated only in a 90–min experimental period because of personal reasons.

Results

For both high and low values to be discernible, rates of response sequences were plotted graphically on a logarithmic scale. Because logarithms based on 10 of zero responses are undefined and such cases were not infrequent, each datum was transformed by adding one. Figure 2 shows the transformed number of target or alternative response sequences per minute for each participant in each session of the reinforcement, elimination, and resurgence test phases.

Figure 3 shows group means of the transformed number of target response sequences per minute. Data during the last session of the baseline phase, the first four and the last three sessions of the reinforcement phase, the first two and the last three sessions of the elimination phase, and the first two sessions of the resurgence test phase are shown. The data point during the second session of the resurgence test phase

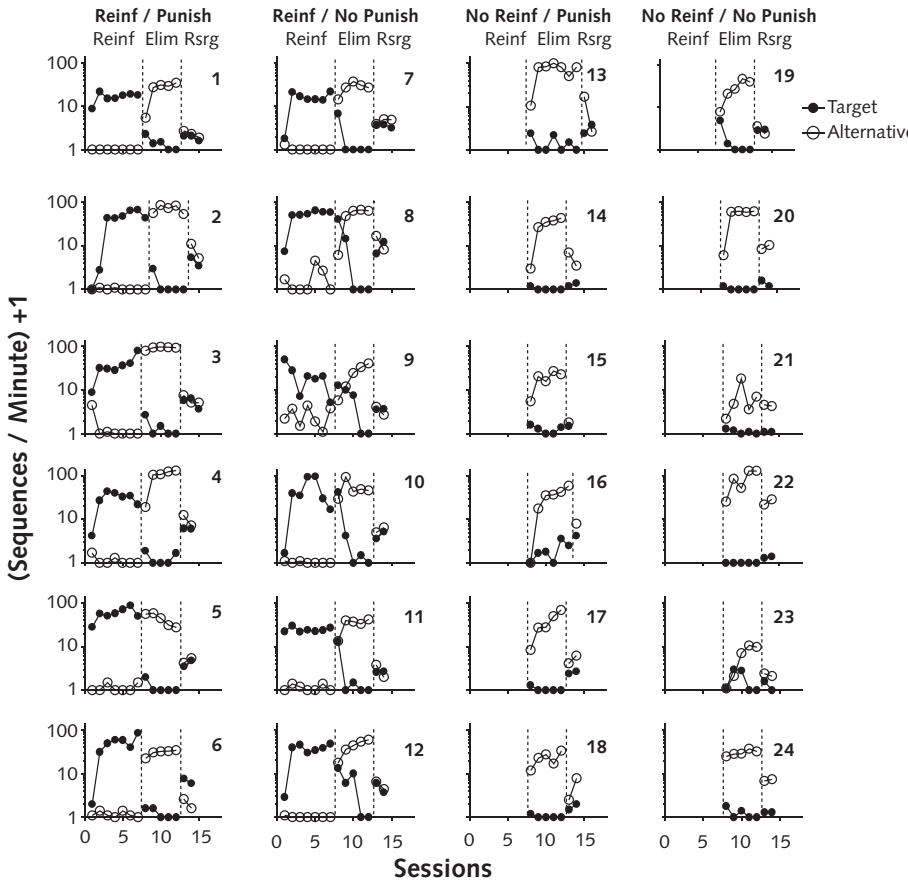

Figure 2. Rates of the target and alternative response sequences in each session for each participant. From left to right, data for participants in the reinforcement / punishment group, the reinforcement / no punishment group, the no reinforcement / punishment group, and the no reinforcement / no punishment group are shown. Each datum was transformed by adding one. Therefore, values on the x-axis mean that the actual rates are zero. The y-axis is presented on a log scale. Reinf identifies the reinforcement phase. Elim identifies the elimination phase. Rsrg identifies the resurgence test phase. Data during the baseline phase are not shown. Filled circles represent rates of the target response sequence. Open circles represent rates of the alternative response sequence.

for the no reinforcement / punishment group was from data from four participants (Participants 13, 14, 17, and 18).

Differences in untransformed response sequence rates between the groups were evaluated statistically by using two–way (reinforcement × punishment) analyses of variance (ANOVAs) or two–tailed *t*–tests. The alpha value was set at the 0.05 level in all analyses.

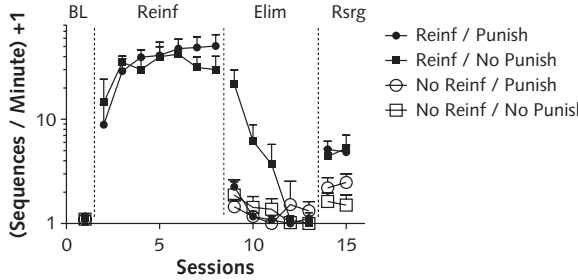

Figure 3. Mean of the target response sequence rate for each group during the last session of the baseline phase, the first four and the last three sessions of the reinforcement phase, the first two and the last three sessions of the elimination phase, and the first two sessions of the resurgence test phase. Filled circles, filled squares, open circles, and open squares, respectively, represent rates of the sequence in the reinforcement / punishment group, the reinforcement / no punishment group, the no reinforcement / punishment group, and the no reinforcement / no punishment group. Error bars represent standard errors. BL identifies the baseline phase. Other details are as in Figure 2.

Baseline phase

Because low rates of response sequences during the baseline phase were selected as target and alternative, the rates of target and alternative sequences during that phase were equal to or less than 0.3 in each participant in each session, suggesting that the operant levels of the target and alternative sequences were extremely low. There was no main effect or interaction for the target or alternative sequence, Fs (1, 20) ≤ 2.00. Thus, there was no difference in the rates of the target or alternative sequence across four groups before exposure to the programmed contingencies (see also Figure 3).

Reinforcement Phase

When the target response sequence produced points during the reinforcement phase, the rates increased gradually (Participants 2, 3, 4, and 6 in the reinforcement / punishment group, and Participants 7, 8, 10, and 12 in the reinforcement / no punishment group) or rapidly (Participants 1 and 5 in the reinforcement / punishment group, and Participants 9 and 11 in the reinforcement / no punishment group, see Figure 2). The rates of the target sequence for participants in the reinforcement groups during the last session of the reinforcement phase ranged from 4.2 to 85.4, and were higher than their baseline levels. These results indicate that the contingency of the response–sequence–dependent–point–delivery functioned as reinforcement and that the target sequences were acquired during this phase. There was no significant difference in the rates of the target sequence during the final reinforcement session between the reinforcement / punishment and the reinforcement / no punishment groups (t (10) = 1.294, Figure 3).

Rates of the alternative response sequence, which produced no consequences, remained low throughout the reinforcement phase (Figure 2). There was no significant difference in the rates of the alternative sequence during the final reinforcement session between the reinforcement / punishment and the reinforcement / no punishment groups (t (10) = 0.753).

Elimination phase

During the elimination phase, participants in the punishment groups lost points ranging from once to 20 times. Thus, all participants in the punishment groups were exposed to the contingency of the response–sequence–point–loss.

When the reinforcement was withdrawn and the contingency of response–sequence–point–loss was introduced, rates of the target response sequence decreased rapidly for participants in the reinforcement / punishment group (Figure 2). For participants in the reinforcement / no punishment group, for whom the reinforcement was withdrawn but the point–loss contingency was not introduced, by contrast, rates decreased gradually. As Figure 3 shows, the rates of the target sequence during the first session of the elimination phase for participants in the reinforcement / punishment group were significantly lower than those in the reinforcement / no punishment group (t (10) = 2.742, p <.05). This result indicates that the contingency of response–sequence–point–loss functioned as punishment. Rates of the alternative sequence during the first elimination session were not different between the reinforcement / punishment and the reinforcement / no punishment groups (t (10) = 1.897).

The target response sequence, which had been reinforced during the reinforcement phase, ultimately was eliminated almost completely during the elimination phase for participants in the reinforcement groups (Figure 2). Except for Participant 4, who emitted one such sequence, no other participant emitted the target sequence during the last elimination session. For participants in the no reinforcement groups, the rates of the target sequence were extremely low, too. Except for Participants 15 and 16, who emitted on one occasion, no participant emitted the target sequence during the last elimination session. A two–way ANOVA for the last elimination session revealed no main effect or interaction for the target or alternative sequence, Fs (1, 20) ≤ 2.00. Thus, there was no difference in the rates of the target or alternative sequence across four groups immediately before the resurgence test phase (see also Figure 3).

Resurgence test phase

When the reinforcement of the alternative response sequence was terminated, rates of the alternative sequence decreased (Figure 2). For each participant, the rate

of the alternative sequence during the first session of the resurgence test phase was lower than it was during the last session of the elimination phase. This result, unlike Weiner's (1964) described above, indicates that the extinction procedure used in the resurgence test phase functioned as extinction.

The rates of the alternative response sequence during the resurgence test sessions were not different across four groups. There was no main effect or interaction for the first session, $F < 1$, or for the second session, Fs (1, 18) ≤ 1.04.

When the reinforcement of the alternative response sequence was terminated, the target response sequence recurred. Each of 11 participants in the reinforcement groups, who had emitted no target sequence during the last elimination session, emitted the sequence during the first session of the resurgence test phase (Figure 2). However, it should be noted that a similar phenomenon occurred for participants whose target sequences had not been reinforced. Each of 10 participants in the no–reinforcement groups, who had emitted no target sequence during the last elimination session, emitted the sequences during the first resurgence test session. Thus, the number of participants who reemitted the target response sequence was not different between the reinforcement and no reinforcement groups.

The rates of the target response sequence, by contrast, were different depending on whether the sequences had previously been reinforced or not (Figures 2 and 3). A two–way ANOVA for the rates of the target sequence during the first resurgence test session revealed that the main effect of reinforcement was significant, F (1, 20) = 23.60, $p < .01$, indicating that the rates of the target sequence for participants in the reinforcement groups were significantly higher than those for participants in the no reinforcement groups. Neither the main effect of punishment nor the reinforcement x punishment interaction was significant, Fs (1, 20) ≤ 1.25. These results are consistent with those by Rawson and Leitenberg (1973), demonstrating that punished responses resurged as unpunished, typically treated, responses did.

The results of the first session of the resurgence test phase were replicated in the second test session (Figures 2 and 3). A two–way ANOVA for the rates of the target sequence during the second resurgence test session revealed that the main effect of reinforcement was significant, F (1, 18) = 9.93, $P < .01$, and that neither the main effect of punishment nor the reinforcement x punishment interaction was significant, Fs < 1.

Discussion

The present results demonstrate the generality of resurgence across several levels. Resurgence has occurred with humans (e.g., Wilson & Hayes, 1996) and response sequences (e.g., Sanchez–Carrasco & Nieto, 2005) using discrete–trial procedures. The present experiment demonstrated resurgence of response sequences in humans

in a free–operant procedure. The results of rates of the target response sequence during the resurgence test phase illustrate that unreinforced responses also appeared or increased during the resurgence test phase (Antonitis, 1951), but that rates of previously reinforced responses were higher than those of such unreinforced ones. Resurgence occurred when the response was punished by response–produced–point–loss, as well as with it punished by electric shock (Rawson & Leitenberg, 1973; but see also Kestner et al., 2015).

Kestner et al. (2015) pointed out five procedural differences between Rawson and Leitenberg (1973) and their experiments that might account for their different results of the effects of punishment on resurgence: shock intensity, reinforcement scheduling during the elimination phase, response topography, test length, and reinforcement scheduling during the resurgence test phase. Now, the present results are consistent with those of Rawson and Leitenberg. Thus, the present procedural features may weigh the plausibility of each of these five variables.

Of Kestner et al.'s (2015) five candidates, reinforcement scheduling during the elimination phase, test length, and reinforcement scheduling during the resurgence test phase are implausible as explanations of the inconsistency of results between Kestner et al. and Rawson and Leitenberg (1973), and the present experiment. Kestner et al. suspected that the two–component multiple schedule, in which the target response was reinforced during the control component of the elimination and resurgence test phases, may have promoted the target response during the experimental component of the resurgence test phase of Rawson and Leitenberg's experiment (variables of reinforcement scheduling during the elimination and resurgence test phases). However, in the present experiment resurgence occurred with simple reinforcement schedules, just as Kestner et al. used. The test duration also is difficult as an explanation of the inconsistency. Kestner et al. noted that their resurgence test phase consisting of five sessions was substantially shorter than Rawson and Leitenberg's, which consisted of 15 sessions. They attributed their failure to observe resurgence to this shorter test phase; however, the present resurgence test phase consisting of one to three 10–min test sessions presumably would be shorter than Kestner et al.'s.

The remaining two hypotheses do not contradict the present procedures and results. Kestner et al. (2015) suggested that a weaker shock may have contributed to the results of Rawson and Leitenberg (1973). The 0.06–mA electric shock in Rawson and Leitenberg's experiment was weaker than 0.25–mA shock in Kestner et al.'s. Although point–loss in the present experiment is not easily compared with electric shock, response cost generally has been regarded milder than unconditioned punishers such as an electric shock (e.g., Albert & Troutman, 1999). The response topography also may be relevant. Kestner et al. noted that the topography of the target and alternative responses were the same (both lever presses) in Rawson and Leitenberg's experiment,

but different (lever presses and nose pokes) in themselves, suggesting that the identical topography between the target and alternative responses facilitated the resurgence in Rawson and Leitenberg's. As in Rawson and Leitenberg, the topography were same between the target and alternative responses (both screen touches) in the present experiment. It should be noted, however, that at least one other experimental finding does not support Kestner et al.'s response–topography explanation. Although they did not use punishment, Doughty, da Silva, and Lattal (2007) found that resurgence was greater with pigeons when the topography of the target and alternative responses were different (key pecking and treadle pressing) than when the topography were the same (both key pecking).

The present results with application–oriented species (humans) and punishment (response cost) do not support Kestner et al.'s (2015) view emphasizing punishment in eliminating problem behavior. Of the present ones, only the result that rates of the target response sequence during the elimination phase decreased more rapidly for participants whose target sequences lost points than for participants whose sequences did not (Figures 2 and 3) barely suggests an advantage of adding a punishment procedure to a schedule of differential–reinforcement–of–alternative–behavior in eliminating the behaviors, consistent with findings from basic (Kestner et al., 2015; Rawson & Leitenberg, 1973) and applied (Hagopian et al., 1998) studies. Another result of the present experiment that the target sequence rates during the resurgence test phase were indifferent across those participants, however, suggest that the advantage may be limited during the punishment contingency being in effect.

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