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ORIGINAL ARTICLE

Avoidance Extinction in Equivalence Classes

Leandro S. Boldrin

Email : leandro.sboldrin@gmail.com
Affiliationids : Aff1, Correspondingaffiliationid : Aff1

Paula Debert Affiliationids : Aff1 Aff2

Simon Dymond Affiliationids : Aff3 Aff4

Aff1 Department of Experimental Psychology, São Paulo University, São Paulo, Brazil

Aff2 Instituto Nacional de Ciência e Tecnologia sobre Comportamento, Cognição e Ensino, São Carlos, Brazil

Aff3 Swansea University, School of Psychology, Swansea, UK

Aff4 Department of Psychology, Reykjavík University, Reykjavík, Iceland

Abstract

Extinction of a response in the presence of one stimulus in an equivalence class can transfer to other related stimuli, but difficulties in establishing extinction can compromise analyses. The present study evaluated the transfer of avoidance extinction with two extinction procedures. In particular, avoidance or nonavoidance was always (Experiment 1) and never (Experiment 2) followed by point loss in the crucial extinction test phase. Both experiments began with the establishment of two equivalence classes with four abstract figures in each (A1-B1-C1-D1 and A2-B2-C2-D2). Clicking a button to avoid loss of points was trained with B1 and subsequently observed without direct training in the presence of C1 and D1. Extinction was then conducted with one group of participants with stimuli that underwent avoidance training (direct extinction with B1 and B2) and with another group with stimuli who did not undergo avoidance training (derived extinction with C1 and C2). Finally, the transfer of extinction was evaluated with stimuli from both classes. In Experiment 1, 10 of 14 participants met the avoidance extinction criteria, and the transfer of extinction occurred for 2 (1 in the direct and 1 in the derived extinction group). In Experiment 2, 10 of 13 participants met the avoidance extinction criteria, and the transfer of extinction occurred for 6 (5 in the direct and 1 in the derived extinction group). Overall, the transfer of extinction occurred only with the combination of an extinction procedure without aversive events and direct extinction.

Keywords

Avoidance
Extinction
Equivalence
Transfer
Fear
Human

According to Sidman (1994), equivalence classes are established when arbitrary conditional relations between stimuli are trained (e.g., A-B and B-C), and new relations that were not directly trained emerge in accordance with the properties of reflexivity (A-A, B-B, and C-C), symmetry (B-A and C-B), transitivity (A-C), and equivalence (C-A). Once the equivalence class is established, responses trained in the presence of one stimulus will also occur in the presence of other stimuli of the same class, a phenomenon well documented by the literature over the years and called "transfer of function" (e.g., Augustson & Dougher, 1997; de Rose et al., 1988; Dougher et al., 1994; Dymond et al., 2011; Garcia-Guerrero et al., 2014; Markham et al., 2002; Perez et al., 2020). Of the responses shown to transfer in this way, recent studies have tested whether extinction procedures involving one stimulus in an equivalence class (Boldrin & Debert, 2020; Dougher et al., 1994; Vervoort et al., 2014) or other derived relations (Roche et al., 2008) lead to decreases in frequency or the complete removal of a response in the presence of other related stimuli.

A pioneering study by Dougher et al. (1994, Experiment 2) investigated the transfer of Pavlovian or respondently extinguished responses (measured via skin conductance) in equivalence classes. First, the MTS procedure was used to establish two equivalence classes with four abstract figures in each (Class 1: A1-B1-C1-D1 and Class 2: A2-B2-C2-D2). Class 1 stimuli were then paired with electric shock and showed increase in skin conductance whereas stimuli from Class 2 were just followed by the ITI. Next, B1 was presented in the absence of electric shock during the extinction procedure and it was verified that reduction in the skin conductance occurred not only for B1 that underwent the extinction procedure but also for other stimuli from the same class (i.e., A1, C1, and D1), results interpreted by the authors as a demonstration of the transfer of extinguished eliciting responses at the single-subject level. However, something to note when analyzing these results is that Dougher et al. (1994) did not provide data from the extinction phase. Also, individual subject skin conductance levels in the final tests showed small differences compared to the levels in the conditioning phase that were not analyzed statistically, as is usually the norm in between-group analyses with larger samples (see Lonsdorf et al., 2017, 2019).

Subsequent studies have focused on the comparison between extinction with either a stimulus that acquired its function directly by respondent or operant conditioning (*direct extinction*) or a stimulus whose function was acquired indirectly by being related, via equivalence or other derived relations, to the originally conditioned stimulus (*derived extinction*). Direct extinction can be considered an analog of treatments in which the patient is exposed to conditioned stimuli directly related to the traumatic event. For example, successive approximation to spiders with a client with a fear of spiders may help reduce conditioned fear responses. Derived extinction may be considered an analog of treatments in which the client is exposed to stimuli that are indirectly related to the traumatic or feared event. For example, imagining or talking in therapy about the fear of spiders can also help overcome fear and avoidance. Therefore, translational, laboratory-based analog studies of direct and derived extinction may help with planning effective strategies to reduce maladaptive fear and avoidance in the clinical setting (e.g., Assaz et al., 2018; Boldrin et al., 2020; Dymond et al., 2015, 2018; Dymond, 2019; Guinther & Dougher, 2015).

Roche et al. (2008) compared direct and derived extinction of avoidance responses in same and opposite relations. The relational training procedure was first used to establish same (A1-SAME-B1 and A1-SAME-C1) and opposite (A1-OPPOSITE-B2 and A1-OPPOSITE-C2) relations between nonsense syllables and subsequent tests evaluated new derived relations (B1-SAME-C1, C1-SAME-B1, B2-SAME-C2, C2-SAME-B2, B1-OPPOSITE-C2, C2-OPPOSITE-B1, C1-OPPOSITE-B2 e B2-OPPOSITE-C1). Next, pressing the spacebar key was programmed to cancel aversive images (e.g., mutilated bodies) in the presence of B1 or pleasure images (e.g., balloons) in the presence of B2 in the avoidance conditioning. As a result, avoidance also occurred in trials with C1 (stimulus related as same with B1 and opposite with B2) but not with C2 (stimulus related as opposite with B1 and same with B2). The extinction procedure was then conducted with presentations of B1 and B2 for the direct extinction group and with presentations of C1 and C2 for the derived extinction group. The keyboard was disabled and there were no images at this phase. Finally, B1, C1, B2, and C2 were presented in a test phase and it was observed that the percentage of trials with avoidance responses was lower in the derived extinction group compared to the direct extinction group, suggesting that derived extinction is more effective than direct extinction to produce transfer (or transformation) of extinction. However, when discussing their findings Roche et al. (2008) mention that avoidance extinction was not observed for most of the participants and they do not present data from the extinction phase, which means that there is an analysis of the transfer (or transformation) of extinction but without a guarantee that extinction was established in the extinction phase. Even though some reduction in the frequency of responses was observed in the test for the transfer of extinction, it is important to describe the extinction process in the previous phase to ensure that any observed reduction is a function of the extinction learning procedure and not due to other, extraneous variables.

Vervoort et al. (2014) also compared direct and derived extinction, but with respondent responses (skin conductance) and equivalence relations. A large sample and between-group designs were also used in this study. The MTS procedure was used to establish two equivalence classes with four abstract figures in each (Class 1: A1-B1-C1-D1 and Class 2: A2-B2-C2-D2) in the first phase of the experiment. Next, a respondent pairing procedure was conducted with B1 being followed by electric shock and B2 by the ITI. As a result, skin conductance levels increased in the presence of B1 and also in the presence of other related stimuli (A1, C1, and D1) as verified in subsequent tests. The extinction procedure was then conducted with presentations of B1 and B2 (direct extinction group) or with C1 and C2 (derived extinction group) without being followed by electric shock. Finally, stimuli from both Class 1 and Class 2 were presented in a test phase and it was observed a reduction of elicited responses in the presence of B1 in the direct extinction group but not in the derived extinction group. Shock expectancy on a 0–100 scale was also measured and showed a greater reduction in the direct extinction group compared with the derived extinction group when rated in the presence of Class 1 stimuli. Different from Roche et al. (2008), these results suggest that direct extinction is more effective than derived extinction to produce transfer of extinction. However, the question about analyzing the transfer of extinction without an unequivocal demonstration of extinction is raised again when inconsistent skin conductance data provided limited evidence of extinction in the extinction phase (see Lonsdorf et al., 2017, 2019).

Boldrin and Debert (2020) conducted a study aiming to evaluate the differences between the findings of Roche et al. (2008) and Vervoort et al. (2014). Avoidance response was trained and extinguished similarly to Roche et al. and transfer investigated via equivalence similar to Vervoort et al. If derived extinction were more effective than direct extinction, then differences between the results of Roche et al. and Vervoort et al. would be due to differences between the process (i.e., operant and respondent). If direct extinction were more effective than derived extinction, then differences between the results would be due to differences between the established relations (i.e., same and opposite relations and equivalence relations). Despite the results showing that extinguishing avoidance response was easier with C1 than with B1 during the extinction procedure, it was not possible to compare the direct and derived extinction groups regarding the transfers of extinction because few participants in each group met the criteria for extinction in the extinction phase.

The failure in establishing extinction in many studies about transfer of extinction and the contrasting results between them call attention to an issue that seems to be understudied in the area, which is whether, in fact, there is extinction of a response in the extinction phase that precedes the analysis of the transfer of extinction. The present study compared direct and derived extinction of avoidance responses in equivalence classes with two extinction procedures. In each of them, extinction was carefully assessed. In Experiment 1, avoidance extinction was conducted by making the aversive event noneliminable; that is, both avoidance and nonavoidance were followed by loss of points. In Experiment 2, avoidance extinction was conducted by eliminating the aversive event in the avoidance contingency; that is, both avoidance and nonavoidance were followed by the intertrial interval (ITI). Both procedures are known to be effective in extinguishing avoidance responses (Dymond, 2019; Lattal et al., 2013).

Experiment 1

Experiment 1 aimed to compare direct and derived extinction of avoidance responses in equivalence classes. Avoidance extinction was conducted by making the aversive event noneliminable (i.e. avoidance or nonavoidance were both followed by loss of points).

Method

Participants

Sixteen adults, 18 to 29 years old, participated in the experiment. None had been previously exposed to behavior analysis experiments, and they said to have no prior knowledge about stimulus equivalence. The participation of six participants was discontinued because they did not meet the criteria for avoidance training (one), transfer of avoidance function (one) or avoidance extinction (four). The study was approved by an ethics committee on human research. The experiment began only when the participants, after reading the study information, agreed to participate and signed a declaration of consent.

Setting, Equipment, and Stimuli

The experiment was conducted by remote access with the TeamViewer software as a recommended measure to prevent the spread of the coronavirus (SARS-CoV-2) during the pandemic period when the data were collected. So, the participant from home accessed the software developed for the experiment on the researcher's computer and performed the experimental tasks.

The researcher remained during the experiment in a room with a chair, table and notebook computer (processor 2.20 GHz, 4 GB RAM, 1 TB hard drive, 15-in monitor and Windows operating system). The room was clean, ventilated, bright and free of noise. It was suggested to the participant to stay in a room with similar conditions to the researcher's room and with a computer similar or better in terms of performance. The software MTS Pro2 (Boldrin & Debert, 2022b) was used in the first phase of the experiment for training and testing conditional relations. Another software program, Behavior Lab (Boldrin & Debert, 2022a), was used in the following phases which involved avoidance responses.

Twelve abstract figures from Dougher et al. (1994) were selected for training and testing conditional relations. The figures were randomly allocated in three sets with four figures in each and labeled with an alphanumeric notation (Set 1: A1, B1, C1, D1; Set 2: A2, B2, C2, D2; Set 3: A3, B3, C3, D3).

Procedure

The researcher called the participant and provided instructions for remote access. The phone call was finished right after the remote access was done to minimize possible interference during the execution of the experimental tasks. However, the researcher could still follow on the computer screen how the participant was performing during the experiment. The whole experiment was conducted in a single session with a 90–120 min duration and was composed of five phases as described below.

Phase 1: Training and Testing Conditional Relations Two classes with four abstract figures in each (Class 1: A1, B1, C1, D1; Class 2: A2, B2, C2, D2) were established in Phase 1. A third set (Set 3: A3, B3, C3, D3) was used only as incorrect comparisons to minimize the possibility of reject control (e.g., Carrigan & Sidman, 1992). Phase 1 was composed of three stages: (1) training conditional relations, (2) symmetry test, and (3) transitivity and equivalence tests (see Table 1).

Table 1

Conditional Relations Trained and Tested in Phase 1

	Class 1				Class 2			
Stage	**Sample**	**S+**	**S-**		**Sample**	**S+**	**S-**	
	A1	B1	B2	B3	A2	B2	B1	B3
Training	A1	C1	C2	C3	A2	C2	C1	C3
	A1	D1	D2	D3	A2	D2	D1	D3

Note. S+ and S- denote the “correct” and “incorrect” comparison stimuli, respectively. The positions of stimuli on the table are not the positions (left, middle, right) where the stimuli were presented on the screen

Stage	Class 1				Class 2			
	Sample	S+	S-		Sample	S+	S-	
Symmetry	B1	A1	A2	A3	B2	A2	A1	A3
	C1	A1	A2	A3	C2	A2	A1	A3
	D1	A1	A2	A3	D2	A2	A1	A3
Transitivity and equivalence	B1	C1	C2	C3	B2	C2	C1	C3
	B1	D1	D2	D3	B2	D2	D1	D3
	C1	D1	D2	D3	C2	D2	D1	D3
	C1	B1	B2	B3	C2	B2	B1	B3
	D1	B1	B2	B3	D2	B2	B1	B3
	D1	C1	C2	C3	D2	C2	C1	C3

Note. S+ and S- denote the "correct" and "incorrect" comparison stimuli, respectively. The positions of stimuli on the table are not the positions (left, middle, right) where the stimuli were presented on the screen

In each trial, a sample stimulus appeared on the top of the screen. After a mouse click on this stimulus, three comparison stimuli immediately appeared in each position on the bottom of the screen (left, middle, right). The positions of the comparisons on the bottom of the screen were randomized with the condition that each stimulus could not appear in more than two consecutive trials in the same position. Clicks on the comparisons were followed by a message "correct" or "incorrect" that remained on the screen for 3 s. The intertrial interval (ITI) was a blank screen of 2 s duration. There were no messages during the tests.

The following instructions (translated from Portuguese) were presented at the beginning of the first stage of Phase 1 (training conditional relations):

> An image will appear on the top of the computer screen. When you click on it, three other images will appear on the bottom of the screen. Your task is to choose the correct image on the bottom and click on it with the mouse in accordance with the image that appears on the top. A message that indicates whether you are right or wrong will appear after you make each choice. Try to get as many right as you can.

The A1-B1, A1-C1, A1-D1, A2-B2, A2-C2, and A2-D2 relations were trained in this stage. When sample A1 appeared only clicks on the comparisons B1, C1, or D1 were followed by the message "correct." When sample A2 appeared only clicks on the comparisons B2, C2, or D2 were followed by the message "correct." Any other relations were followed by the message "incorrect." All the six trained relations were presented in blocks of six trials and the sequence of trials in each block was randomized. The training was completed when 83% of correct responses were obtained in each block and for 10 consecutive blocks. The participation was discontinued if these criteria were not met after a maximum of 30 blocks. At the end of the training the message "Please, call the researcher." appeared on the screen. The participant sent a WhatsApp message to the researcher at this point, notifying the end of the stage. Then, the remote access was terminated for brief data analysis and selection of the next stage in the software if the criteria were met for training.

The second stage of Phase 1 (symmetry test) started with the presentation of the instructions (translated from Portuguese) "This is a new stage. Work in accordance with what you have learned. This time, the message that indicates whether you are right or wrong after each choice is not going to appear." on the screen. The emergence of the B1-A1, C1-A1, D1-A1, B2-A2, C2-A2, and D2-A2 symmetry relations was evaluated in this stage. There were no messages following clicks on the comparison stimuli. The presentation in blocks of six trials, randomization, and criteria to demonstrate the emergence of symmetry relations, were the same as described in the first stage. The participation was discontinued if these criteria were not met after a maximum of 12 blocks. At the end of the symmetry test the message "Please, call the researcher." reappeared and everything proceeded as described for the first stage.

The third stage of Phase 1 (transitivity and equivalence tests) started with the presentation of the same instructions presented in the symmetry test. The emergence of the transitivity (B1-C1, B1-D1, C1-D1, B2-C2, B2-D2, and C2-D2) and equivalence (C1-B1, D1-B1, D1-C1, C2-B2, D2-B2, and D2-C2) relations were verified in this stage. All the 12 tested relations were presented in blocks of 12 trials. The randomization, criteria to demonstrate emergence, discontinuation of participation, and interaction between researcher and participant, were the same as described for the second stage.

Phase 2: Operant Conditioning of the Avoidance Response An avoidance response (click on a button) was established with B1 and not with B2. The following instructions (translated from Portuguese) were presented at the beginning of Phase 2:

> Some images will appear and point loss will occur in the presence of some of them. You can prevent the point loss by clicking several times on the button that will appear just below the image, whenever you think it is necessary. If the button is not clicked several times, then point loss will occur right after. It is important that you pay attention and concentrate on the screen all the time. If you are ready click on the OK button to continue.

A point counter was initiated with 200 points and remained at the top of the screen all the time during Phase 2. Point loss was chosen as a consequence in the avoidance training contingency because it seems to be effective for the establishment and transfer of avoidance responses in equivalence classes (Gandarela et al., 2020). In addition, point loss is considered a precise, harmless method that is readily approved by ethics committees, compared to other stimuli usually employed in avoidance training procedures (e.g., Crosbie, 1998).

The B1 and B2 stimuli were successively presented in the center of the screen for 10 seconds and a button appeared at the bottom of the screen simultaneously with the presentation of these stimuli. The sequence of trials was randomized with the condition that the same stimulus could not be presented in more than two consecutive trials. Less than eight clicks on the button in the presence of B1 was first followed by the message "-10 POINTS" in red color for 1 s and then the subtraction of 10 points of the total amount of points, both events occurring inside of the rectangle delimiting the counter on the screen. Eight or more clicks on the button in the presence of B1 canceled the point loss and message that would occur after the 10 s of B1 presentation. There was no point loss or message in trials with B2 stimulus no matter whether clicks on the button occurred or not. The duration of the ITI was 2 s.

The avoidance training was completed when two criteria were satisfied: (1) eight or more clicks on the button in four consecutive trials with B1; (2) no clicks on the button in four consecutive trials with B2. If the criteria were not met after 20 consecutive trials with each stimulus (B1 and B2) then the participation was discontinued. Otherwise, the next phase started automatically by the computer software, without interruptions or further instructions.

Phase 3: Test for the Transfer of Avoidance Functions This phase verified if clicks on the button would occur in the presence of Class 1 stimuli and not in the presence of Class 2 stimuli.

The stimuli B1, C1, D1 and B2, C2, D2 were successively presented. Four trials of each stimulus (a total of 24 trials) were randomized with the condition that all six stimuli were presented before the same stimulus was presented again. There were no trials with A1 and A2 because clicks on the button in the presence of these stimuli could be interpreted as a result of second-order conditioning because the relations between A1 and A2 with B1 and B2 (the stimuli that participated in the operant conditioning) were directly trained in Phase 1. The button continued to appear on the bottom of the screen, but the counter was removed. So, there was no message or subtraction of points in this phase whether or not the button was clicked. The duration of the stimuli presentation and ITI were the same as described for Phase 2.

Two criteria were required to demonstrate the transfer of avoidance: (1) eight or more clicks on the button in at least three of the four trials with each Class 1 stimulus (B1, C1, and D1); (2) no clicks on the button in at least three of the four trials with each Class 2 stimulus (B2, C2, and D2). If the criteria were not met then the participation was discontinued. Otherwise, the next phase started automatically by the computer software, without interruptions or further instructions.

Phase 4: Extended Direct or Derived Extinction Procedure This phase aimed to extinguish the avoidance response with stimuli that underwent avoidance training in Phase 2 (B1 and B2; direct extinction group) and with stimuli that did not undergo avoidance training (C1 and C2; derived extinction group).

The participants were randomly allocated to the direct or derived extinction groups immediately before the extinction phase. The B1 and B2 stimuli were successively presented to the direct extinction group and the stimuli C1 and C2 were successively presented to the derived extinction group. The sequence of trials was randomized with the condition that the same stimulus could not be presented in more than two consecutive trials. The button continued to appear on the bottom of the screen and the counter reappeared on the top of the screen during the stimuli presentation. The 10 s duration of B1 or C1 presentations was always followed by the message "-10 POINTS" in red color and subtraction of 10 points, both events in the counter, whether or not the button was clicked. There was no message or point loss in trials with B2 and C2 stimuli. The duration of the stimuli presentation and ITI were the same as described for the previous stages.

The extinction was considered complete when the button was not clicked for four consecutive trials with each stimulus B1 and B2 (or C1 and C2) as conducted by Boldrin and Debert (2020). If the criteria were not met after 90 consecutive trials with each stimulus B1 and B2 (or C1 and C2) then the participation was discontinued. Otherwise, the next phase started automatically by the computer software, without interruptions or further instructions.

Phase 5: Test for the Transfer of Extinction This phase was the same as described for Phase 3 and verified possible differences between direct and derived extinction groups, resulting from the extinction procedure conducted in the previous phase.

Results

Table 2 shows the percentage of correct responses in the course of the trial block presentations at the first stage of Phase 1 in which the conditional relations (AB, AC, and AD) were trained.

Table 2

Percentage of Correct Responses in the Training (AB, AC, and AD) Conducted in the First Stage of Phase 1 in Experiment 1

Participant	Trial blocks														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
P1	83	100	100	67	100	*									
P2	50	67	100	*											
P3	83	67	83	67	67	100	*								
P4	33	50	50	67	83	*									
P5	17	0	50	67	83	*									
P6	17	67	83	*											
P7	33	50	50	83	*										
P8	0	0	67	67	100	*									
P9	17	50	50	50	67	50	83	*							
P10	50	33	67	33	50	33	50	33	17	33	50	67	67	100	*

* The percentage of correct responses remained equal to or higher than the required criteria (i.e., 83%) from the trial marked with an asterisk

The percentage of correct responses gradually increased in the course of the trial block presentations. The number of trial blocks to demonstrate the learning of the training relations ranged from 12 to 23 (*M* = 14.7, *SD* = 3.2). In the symmetry, transitivity, and equivalence tests, the percentage of correct responses was always equal to or higher than 83% and the criteria to demonstrate the emergence of conditional relations were met in the first 10 trial blocks.

Figures 1 and 2 show the results of Phases 2–5 for the direct and derived extinction groups, respectively.

Fig. 1

Number of Button Clicks for E **AQ1** ach Stimulus in Each Trial Block of Phases 2–5 in the Direct Extinction Group in Experiment 1

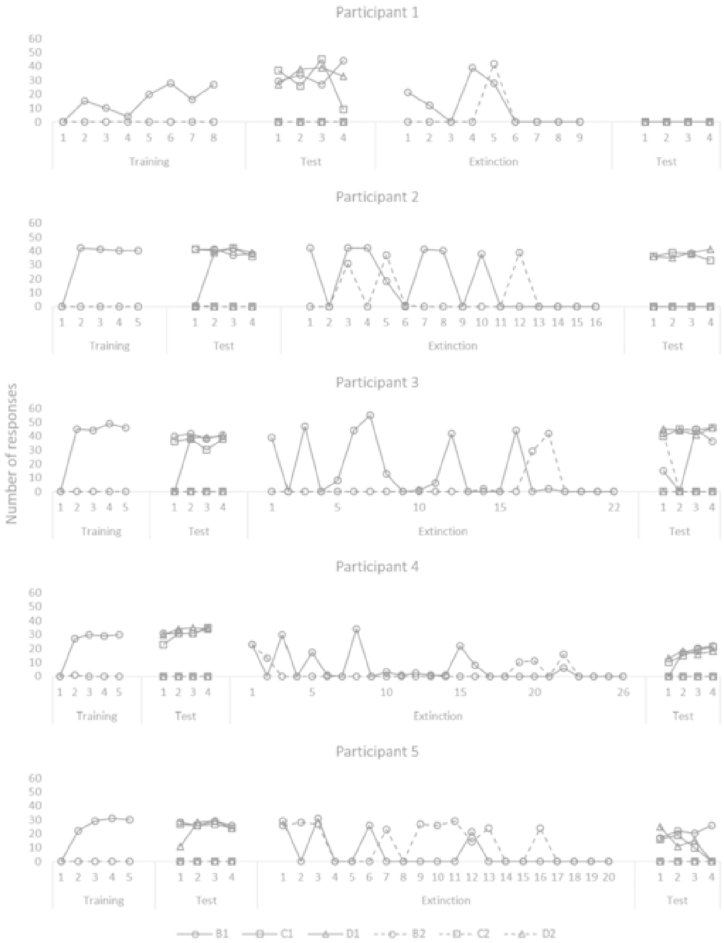
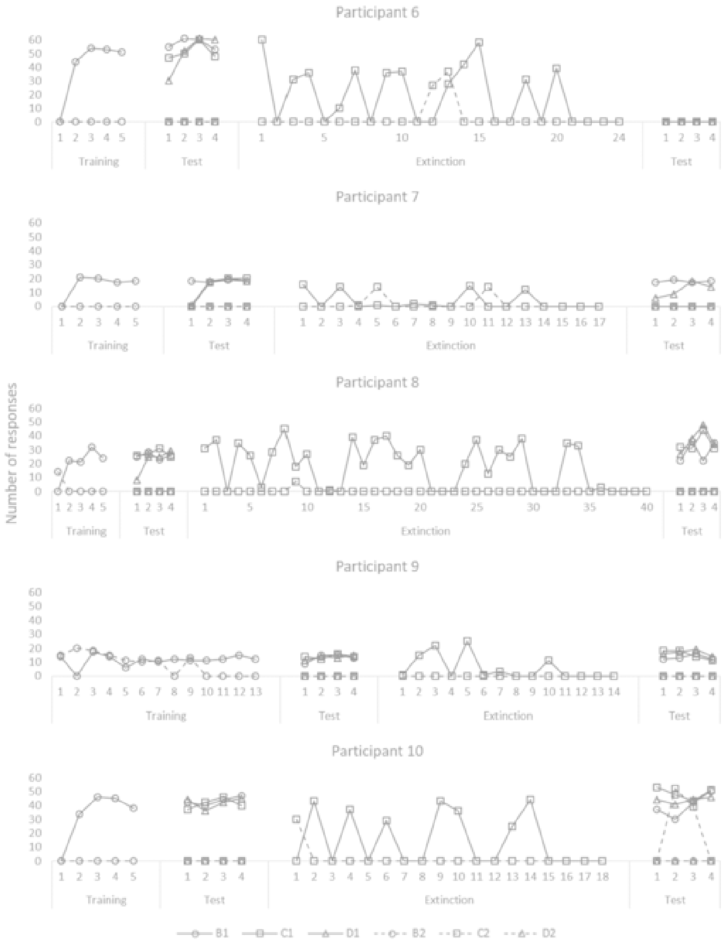


Fig. 2

Number of Button Clicks for Each Stimulus in Each Trial Block of Phases 2–5 in the Derived Extinction Group in Experiment 1



In avoidance training (Phase 2), for eight of 10 participants (P2, P3, P4, P5, P6, P7, P8, and P10) the number of clicks on the button increased and stabilized at most by the second trial with B1. In trials with B2, both P4 and P8 clicked on the button in one trial. The criteria to demonstrate the establishment of the avoidance response were reached in the first fifth trial with B1 and B2. For P1 and P9, the number of clicks on the button fluctuated in trials with B1, but the criteria were also reached. P1 reached the learning criteria in the eighth trial and did not click on the button in trials with B2. P9 reached the learning criteria in the 13th trial and clicked on the button until the ninth trial with B2.

In the test for the transfer of avoidance function (Phase 3), the number of clicks on the button in trials with Class 1 stimuli (B1, C1, and D1) remained similar to the final trials of the avoidance training for all participants. An exception occurred in the first trial for P5, P6, P8 who clicked less and for P2, P3, P7 who did not click on the button. There were no clicks on the button in trials with Class 2 stimuli (B2, C2, and D2).

In the extended direct or derived extinction procedure (Phase 4), the curves showed a fluctuating pattern in which clicks on the button with B1 and B2 successively increased and decreased in the course of the trials. The oscillating pattern continued to occur until the clicks eventually stopped occurring on the last four trials when the extinction criteria were met. The number of trials to reach the extinction criteria ranged from nine to 26 (M = 18.6, SD = 6.5) in the direct extinction group and from 14 to 24 (M = 18.3, SD = 4.2) in the derived extinction groups, except for P8 who reached the criteria in the 40th trial. Therefore, there were no notable differences between the groups in the extinction procedure phase.

In the test for the transfer of extinction (Phase 5), in the direct extinction group, only P1 stopped clicking on the button in trials with all Class 1 stimuli (B1, C1, and D1). P2 stopped clicking on the button in trials with B1 but continued to click in trials with C1 and D1, and the three other participants (P3, P4, and P5) continued to click in trials with all Class 1 stimuli. The results were similar in the derived extinction group. P6 stopped clicking on the button in trials with all Class 1 stimuli, P7 continued to click in trials with C1 and D1, and three others (P8, P9, and P10) continued to click in trials with all Class 1 stimuli. In trials with Class 2 stimuli, P3 clicked on the button in one trial with B2 and P10 in two trials with C2. Therefore, complete transfer of extinction was observed only for one participant in both direct and derived extinction groups.

Discussion

Experiment 1 aimed to compare direct and derived extinction of avoidance responses in equivalence classes. Results showed that avoidance response stopped occurring in trials with B1 (direct extinction) or C1 (derived extinction) in the extinction procedure phase, but returned to occur in trials with these same stimuli and continued to occur with other Class 1 stimuli (C1 and D1 for the direct extinction group; B1 and D1 for the derived extinction group) during the test for the transfer of extinction. Therefore, the criteria for extinction were met, but the transfer of extinction was not observed in the subsequent phase. One possible explanation is that some unexpected antecedent stimulus such as the point counter (or the removal of it in particular) controlled responding during the tests, enhancing the transfer of function in Phase 3 but also contributing to the return of responding in the test for the transfer of extinction in Phase 5, even though the response stopped occurring during the extinction procedure in Phase 4. However, when a pilot study was conducted showing the counter in all phases, transfer of function was not observed and it was not possible to move to the next phases where the extinction and transfer of extinction would be analyzed.

An alternative option that was considered is to change the extinction procedure and check whether the extinction would be maintained in the test for the transfer of extinction even with the removal of the counter in this phase. Boldrin and Debert (2020) conducted extinction by eliminating the aversive event. Avoidance or nonavoidance was just followed by the ITI. Although extinction was observed for a few participants in the extinction phase, it was maintained in the test for the transfer of extinction. Experiment 2 evaluated extinction procedure by eliminating the aversive event as employed by Boldrin and Debert (2020).

Experiment 2

Avoidance extinction by making the aversive event non-eliminable employed in Experiment 1 (i.e., avoidance or nonavoidance both followed by loss of points) was changed to avoidance extinction by eliminating the aversive event in Experiment 2 (i.e., avoidance or nonavoidance followed by the ITI).

Method

Participants

Sixteen adults, 18–35 years old, participated in the experiment. The participation of six participants was discontinued because they did not reach the criteria for the emergence of conditional relations (one), transfer of function (two) or avoidance extinction (three). The criteria for inclusion/exclusion in the study and ethical responsibilities were the same as described in Experiment 1.

Setting, Equipment, and Stimuli

The setting, equipment, and stimuli were the same as described in Experiment 1.

Procedure

The phases were the same as those described for Experiment 1, except that, for Phase 4 (Extended Direct or Derived Extinction Procedure), the trials with B1 presentation were never followed by a message indicating point loss or subtraction of points in the counter, whether or not the button was clicked.

Results

Table 3 shows the percentage of correct responses in the course of the trial block presentations at the first stage of Phase 1 in which the conditional relations (AB, AC, and AD) were trained.

Table 3

Percentage of Correct Responses in the Training (AB, AC, and AD) Conducted in the First Stage of Phase 1 in Experiment 2

Participant	Trial blocks												
	1	2	3	4	5	6	7	8	9	10	11	12	13
P1	50	83	17	50	50	33	50	50	67	33	50	33	50
P2	33	33	33	50	50	67	33	67	67	67	50	83	50
P3	50	67	33	67	67	67	67	83	*				
P4	33	33	33	33	50	50	67	67	83	*			
P5	33	33	50	67	100	*							
P6	50	67	17	33	50	50	17	17	50	67	50	50	33
P7	33	50	83	83	83	83	100	67	100	*			
P8	33	83	83	67	83	*							
P9	33	50	33	50	33	67	67	83	*				
P10	0	67	33	67	50	67	83	*					

Participant	Trial blocks											
	14	15	16	17	18	19	20	21	22	23	24	25
P1	50	50	50	67	67	67	100	*				
P2	67	67	83	*								
P3												
P4												
P5												
P6	50	33	17	50	33	50	67	33	67	67	100	*
P7												

* The percentage of correct responses remained equal to or higher than the required criteria (i.e., 83%) from the trial marked with an asterisk

Participant	Trial blocks												
	1	2	3	4	5	6	7	8	9	10	11	12	13
P8													
P9													
P10													

* The percentage of correct responses remained equal to or higher than the required criteria (i.e., 83%) from the trial marked with an asterisk

The percentage of correct responses gradually increased in the course of the trial block presentations. The number of trial blocks to demonstrate the learning of the training relations ranged from 14 to 33 (M = 20.1, SD = 6.6). In the symmetry, transitivity, and equivalence tests, the percentage of correct responses was equal to or higher than 83%, and the criteria to demonstrate the emergence of conditional relations were met in the first 10 trial blocks. One exception was P1 who met the criteria after 11 trial blocks because the percentage of correct trials in the first block of the symmetry test was 67%, which is less than the required criteria.

Figures 3 and 4 show the results of Phases 2–5 for the direct and derived extinction groups, respectively.

Fig. 3

Number of Button Clicks for Each Stimulus in Each Trial Block of Phases 2–5 in the Direct Extinction Group in Experiment 2

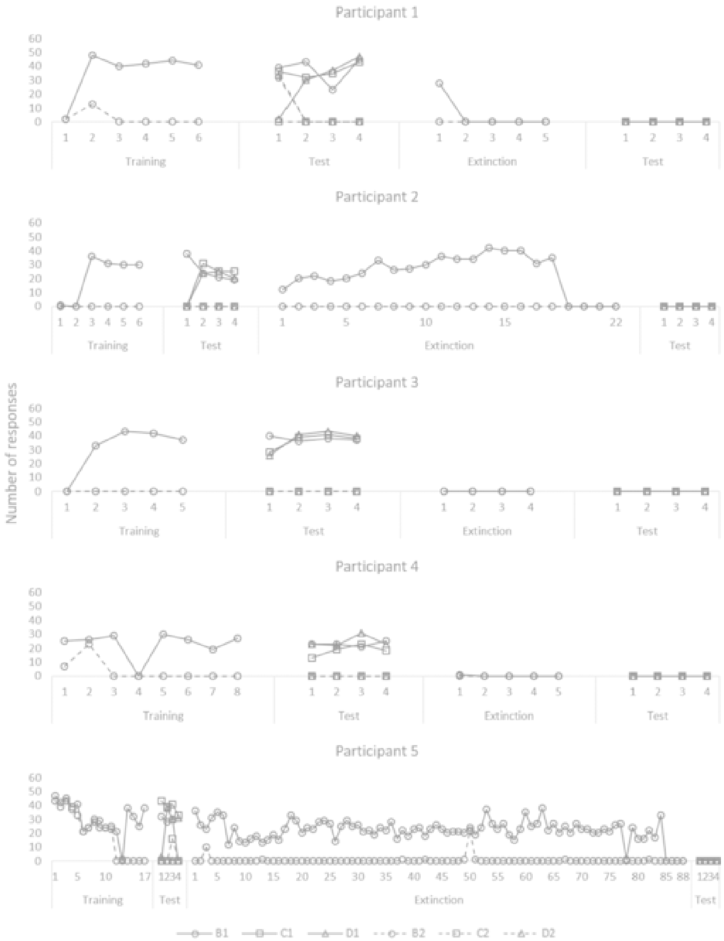
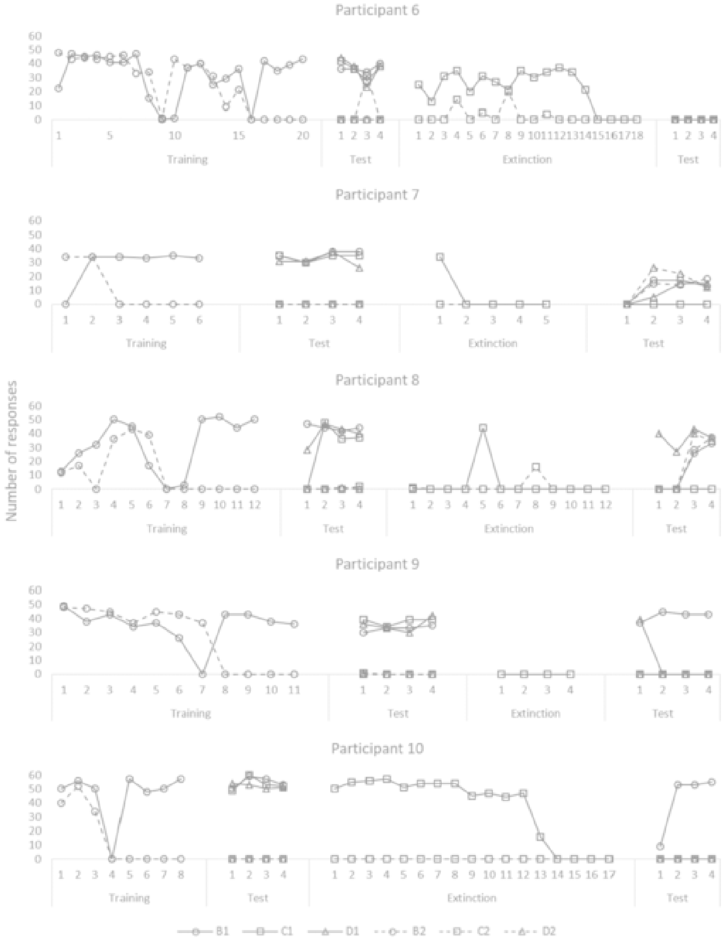


Fig. 4

Number of Button Clicks for Each Stimulus in Each Trial Block of Phases 2–5 in the Derived Extinction Group in Experiment 2



In the avoidance training (Phase 2), for 6 of 10 participants (P1, P2, P3, P4, P7, and P10) the number of clicks on the button increased and stabilized at most by the third trial with B1. In trials with B2, clicks occurred until the second trial for P1, P4, and P7. The criteria to demonstrate the establishment of the avoidance response were reached at most by the eighth trial with B1 and B2. For P5, P6, P8, and P9, the number of clicks on the button fluctuated across the trials with B1 and B2, which means that more trials were necessary to reach the avoidance learning criteria (11–20 trials). Because P5 and P6 were responding indiscriminately (i.e., clicking in the presence of both B1 and B2 stimulus) until the 10th trial, training was interrupted and the part of the instructions "point loss will only occur in the presence of some images" was repeated for these participants before the next trials.

In the test for the transfer of avoidance function (Phase 3), the number of clicks on the button in trials with Class 1 stimuli (B1, C1, and D1) remained similar to the final trials of the avoidance training. In trials with Class 2 stimuli (B2, C2, and D2), P6 and P9 clicked on the button in one trial with C2, P1 clicked in one trial with B2 and in one trial with D2, P5 and P8 clicked in one trial with C2 and one trial with D2. Some participants clicked less (P1) or did not click (P2, P5, and P8) on the button at the beginning of the test when the first Class 1 stimulus was presented, as already observed in Experiment 1.

In the extended direct or derived extinction procedure (Phase 4), the curves showed a pattern in which clicks on the button occurred mostly in trials with B1 (or C1) and rarely in trials with B2 (or C2), different from the fluctuating pattern observed in Experiment 1. The number of trials to reach the extinction criteria ranged from 4 to 22 (M = 9, SD = 8.7) in the direct extinction group and from 4 to 18 (*M* = 9.8, *SD* = 6.6) in the derived extinction group, except for P5 who reached the criteria in the 88th trial. Therefore, there were no notable differences between the groups in the extinction procedure phase.

In the test for the transfer of extinction (Phase 5), in the direct extinction group, all five participants stopped to click on the button in trials with all Class 1 stimuli (B1, C1, and D1) and did not click on the button in trials with Class 2 stimuli (B2, C2, and D2). Therefore, transfer of extinction was observed for all participants in the direct extinction group. In the derived extinction group, only P6 stopped clicking on the button in trials with all Class 1 stimuli. P7, P8, and P9 stopped clicking on the button in trials with C1 but continued to click in trials with B1 and D1, and P10 clicked on the button only in trials with B1. In trials with Class 2 stimuli, P7 clicked on the button in three trials with B2 and D2, and P8 clicked in two trials also with B2 and D2. Therefore, complete transfer of extinction was observed only for one participant in the derived extinction group.

Discussion

Avoidance extinction by making the aversive event noneliminable employed in Experiment 1 was replaced by eliminating the aversive event in Experiment 2. Results showed that avoidance response stopped occurring in trials with B1 (direct extinction) or C1 (derived extinction) during the extinction procedure, and transfer was observed for the direct extinction group (i.e., avoidance also stopped occurring in the presence of C1 and D1) but not for the derived extinction group (i.e., avoidance continued occurring in the presence of B1 and D1) in the test for the transfer of extinction.

Extinction was maintained in the test for the transfer of extinction despite the removal of the point counter in this phase. Even in the derived extinction group who kept clicking on the button in trials with B1 and D1 in the test for the transfer of extinction, clicks in trials with C1 were not observed, showing that the effects of the extinction in fact remained on the tests. However, the fact that some participants (P1, P3, P4, P7, and P9) quickly reached the extinction criteria (i.e., four and five trials were necessary) suggests that the counter, or the replacement of it in this case, could still have exerted some influence over the avoidance responding. So, future studies should attempt to identify possible antecedent stimulus control that changes from phase to phase, which could explain the kind of pattern observed in the extinction phase.

General Discussion

The present study aimed to compare direct and derived extinction of avoidance responses in equivalence classes. Two experiments were conducted with different extinction procedures. Experiment 1 employed an extinction procedure in which avoidance or nonavoidance was always followed by point loss. All 16 participants who started participation in the experiment showed the formation of the equivalence classes, 15 of 16 established the avoidance response, and 14 of 15 showed the transfer of avoidance function. Ten of 14 participants also met the criteria for avoidance extinction in the extinction phase, but avoidance responses returned to occur in the test for the transfer of extinction which could not be analyzed. Experiment 2 replaced the extinction procedure employed in Experiment 1 with a procedure in which avoidance or nonavoidance was just followed by the ITI (i.e., there is no point loss). All 16 participants who started participation in the experiment showed the formation of the equivalence classes, 15 of 16 established the avoidance response, 13 of 15 showed the transfer of avoidance function, and 10 of 13 also met the criteria for avoidance extinction in the extinction phase. Finally, the transfer of extinction could be analyzed and occurred for all five participants in the direct extinction group and for only one of five participants in the derived extinction group.

Previous investigations about transfer of extinction were conducted with data absent in the extinction phase (Dougher et al., 1994; Roche et al., 2008), irregular with no indicative of extinction (Vervoort et al., 2014), and insufficient for the analysis of the transfer of extinction (Boldrin & Debert, 2020). In Experiment 2, 10 of 14 participants met the avoidance extinction criteria in trials with B1 (or C1) in the extinction phase and the extinction effects remained in the subsequent phase that evaluated the transfer of extinction. Therefore, the present study extends previous findings by applying an extinction procedure, avoidance or nonavoidance never followed by point loss, that showed to be effective in satisfying the stipulated criteria for extinction and also for the analysis of the transfer of extinction. It is important to note that Phase 4 can be considered an extended extinction procedure because the test contingencies in Phase 3, avoidance or nonavoidance followed by the ITI, are functionally similar to extinction. Feedback or maintenance of the conditioning contingencies for one or more stimuli during the tests could be considered in future studies as a way of minimizing the effects of a test situation conducted in extinction (e.g., Dymond et al., 2007, 2011; Garcia-Guerrero et al., 2014; Luciano et al., 2013; Roche et al., 2008; Valverde et al., 2009).

It is also worth noting that all investigations about transfer of extinction so far have been conducted with discrete-trial procedures (e.g., Boldrin & Debert, 2020; Dougher et al., 1994; Roche et al., 2008; Vervoort et al., 2014). Discrete-trial procedures are characterized by the restriction of responding to isolated observation periods by removing the subject of the apparatus or removing/disabling the operandum, during intertrial intervals (Perone, 1991). In a typical experiment with rats in an operant chamber, a lever is inserted during the trials and removed during the intertrial intervals. With humans performing a computer task, elements of the task are presented during the trials and disappear (usually with the presentation of a blank screen) during the intertrial intervals. The percentage of trials on which the response occurs is the main measure taken for analysis. For example, in the present study, avoidance extinction was defined as 0% of trials with clicks on the button for four consecutive trials with B1 and B2 (or C1 and C2). Values other than these criteria would mean nothing but the establishment or not of extinction, which is a binary analysis of extinction. As an alternative, free-operant procedures are characterized by allowing responding at any time during the experimental session, without restrictions produced by the apparatus or experimenter (Ferster, 1953). A typical free-operant arrangement would be a rat inside a Skinner box with free access to the lever or a pigeon inside a small chamber with free access to the response key. In this arrangement, rate of responses could be registered continuously, allowing the researcher to examine changes in behavior moment-to-moment over time. Therefore, the description and accuracy of extinction could be improved even more by replacing the discrete-trial procedure with the free-operant procedure, which would make it possible to visualize the learning process and even typical characteristics of the acquisition and extinction curves that cannot be identified from the measures with discrete-trial procedures.

The findings from Experiment 2 also make it possible to start an analysis of the differences between the results from Roche et al. (2008) and Vervort et al. (2014), which could not be done by Boldrin and Debert (2020) due to difficulties in establishing extinction in the extinction phase. Roche et al. (2008) found that derived extinction is more effective than direct extinction in producing transfer of extinction of avoidance responses with stimuli related as same and opposite. Vervoort et al. (2014) on the other hand found that direct extinction is more effective than derived extinction of respondent responses (skin conductance) to produce transfer of extinction with stimuli related as equivalent. As noted by Boldrin and Debert (2020), the studies conducted by Roche et al. (2008) and Vervoort et al. (2014) differed in the established relations (i.e., same/opposite relations and equivalence relations) and in the behavioral process (i.e., operant and respondent conditioning), which could explain the differences between the results from these two studies. Compared to Vervoort et al. (2014), the present study is identical in the established relations (equivalence), different in the process (operant and not respondent), and the results are the same (direct extinction more effective). Compared to Roche et al. (2008), the present study is identical in the process (operant), different in the established relations (equivalence and not same and opposite), and the results are different (direct extinction more effective than derived extinction). Therefore, comparisons of findings from the present study (Experiment 2) with both Roche et al. (2008) and Vervoort et al. (2014) suggest that the effectiveness of the extinction condition (direct or derived) may change with the established relations and not necessarily with the process involved: Direct extinction was more effective with equivalence relations and derived extinction with same and opposite relations, regardless of whether the process is operant or respondent. Future studies should evaluate direct and derived extinction of respondent responses in same and opposite relations. Considering the four possible combinations between the two established relations (equivalence and same and opposite) and the two behavioral processes (respondent and operant), same and opposite relations and respondent is the only one that has not been evaluated so far. One can predict that if the effectiveness of the extinction condition (direct and derived) changes with the established relations and not with the process then the result would be derived extinction more effective than direct extinction, the same as observed by Roche et al. (2008) and different from Vervoort et al.

(2014) and the present study. Future studies should also investigate from the perspective of the relational frame theory (Hayes et al., 2001) in particular, why the type of relation could have an impact on the transfer of extinction. For example, equivalence and sameness can both be considered frames of coordination, but the procedure for establishing each one is different. Equivalence relations are usually trained and tested through the traditional MTS procedure without explicit contextual cues, whereas training and testing sameness relations involve the establishment of contextual cues (Crel and Cfunc) at earlier stages of the procedure. Contextual cues have already been shown to influence other phenomena such as the IRAP effect (see Barnes-Holmes et al., 2020) and this could also be the case for the transfer of extinction.

A question that remains is why in Experiment 1 the avoidance response stopped occurring in trials with B1 (or C1) in the extinction phase, but returned on trials with these same stimuli and continued to occur with other Class 1 stimuli, during the test for the transfer of extinction. One way to look at this phenomenon is renewal (Bouton & Bolles, 1979), in which a response that was trained (or tested) in a first environment and extinguished in a second environment, recurs when returned to the first environment. For example, Bouton and Bolles (1979) conducted a procedure with rats in which a noise conditional stimulus (CS) was paired with an electric shock unconditioned stimulus (US) in one context (activities box), producing as a result conditioned suppression. Next, the rats were placed in a second context (Skinner box) and exposed to a series of extinction trials in which the CS was presented without the US until a complete loss of conditioned suppression. Finally, when the rats were returned to the first context where the respondent pairing originally took place, suppression renewed to a level comparable to that observed before extinction. Bouton and Bolles (1979) also demonstrated renewed suppression in a third context different from the contexts where both respondent pairing and extinction were conducted, an arrangement that remembers the training, extinction, and test contexts implemented in Experiment 1. For example, extinction and test phases in Experiment 1 differed by the presence or absence of a point counter, loss of points and additional Class 1 stimuli, which could explain the renewal of the avoidance response as observed in Bouton and Bolles (1979). Similar results were observed by Luciano et al. (2013) who evaluated, using stimuli from one equivalence class, whether respondent extinction in one context would lead to the alteration of avoidance behavior in a different context. Respondent pairing and extinction procedures were conducted with A1 and B1 stimuli in a first context (i.e., white circle on the screen). Avoidance training also with A1 and B1, and both test for the transfer of function and test for the transfer of extinction with other stimuli from the same class (D1 and F1), were conducted in a second context (i.e., green circle on the screen). Even though the respondent extinction was guaranteed with A1 and B1 in the first context, avoidance responses remained occurring in the presence of A1, B1, and other stimuli from the same class in tests conducted later in the second context. Future investigations could address the question of renewal raised in the present study, for example, by using backgrounds or circles with different colors to emphasize the differences between the contexts of training, tests and extinction. Emphasizing contexts and directly comparing extinction procedures with and without loss of points could help to understand why the renewal of the avoidance response occurred in Experiment 1 but not in Experiment 2.

Regarding the transfer of avoidance function results, a pilot study was conducted with a procedure similar to Gandarela et al. (2020), who evaluated the effectiveness of loss of points in the transfer of avoidance responses in equivalence classes. However, transfer of function was not observed and it was not possible to move to the next phase in which the extinction and transfer of extinction would be analyzed. It was hypothesized that discriminations related to the change of phase might not be occurring and to improve them, the message indicating the loss of points that was presented in the center of the screen in Gandarela et al. (2020) was moved inside the rectangle delimiting the counter on the screen. So, both consequences, message and point loss, occurred inside the counter. Also, the point counter that remained on the screen all the time in Gandarela et al. (2020) was not shown in the test phases in the present study. These procedural modifications may have facilitated the occurrence of discriminations related to the change of phase and enhanced transfer of function as hypothesized, but at the same time may have contributed to the return of the avoidance observed in the test for the transfer of extinction in Experiment 1 and establishment of extinction observed in the extinction procedure in Experiment 2. Another difference between Gandarela et al. (2020) and the present study is that participants in Gandarela et al. (2020) executed the experimental tasks on a computer located in the laboratory room whereas in the present study, as a measure to prevent the spread of the coronavirus (SARS-CoV-2) during the pandemic period, participants from home accessed the researcher's computer using a software for remote access and performed the experimental tasks (e.g., Cameron et al., 2022). This difference, remote versus in-person data collection, could explain the difficulties in producing transfer of avoidance function comparing the pilot study and Gandarela et al. (2020). A third difference between the present study and Gandarela et al. (2020) is the absence in the present study of a respondent pairing phase (B1 paired with loss of points and B2 just followed by the ITI) before the avoidance training, which could have compromised the transfer of avoidance function. Future studies should attempt to replicate Gandarela et al. (2020) with in-person data collection and also assess to what extent the absence of a respondent pairing phase, even though the avoidance response is well established in the avoidance training, can affect performance in the test for transfer of avoidance function.

Although the instructions presented in the avoidance training phase do not explicitly state that participants should avoid point loss, the fact that some participants showed discriminated responding (i.e., clicking in the presence of B1 and not B2) right from the second trial of the avoidance training suggests that avoidance response could have been controlled by the instructions. In this case, it would be more appropriate to consider the avoidance response that was established as instructed avoidance (e.g., Galizio, 1979). Future studies could use minimal instructions if the objective is to reduce the influence of instructional control over responding (e.g., Dymond et al., 2008).

In conclusion, the present study extends the literature by improving the description and accuracy of the extinction procedure prior to the analysis of the transfer of extinction in the direct and derived conditions. Comparisons between the results of the present study and results from previous investigations (Roche et al., 2008; Vervoort et al., 2014) suggest that direct extinction may be more effective with equivalence relations and derived extinction with same and opposite relations. This is indicative that the effectiveness of direct and derived extinction in the transfer of extinction may be affected by different variables. Maybe there is not a most effective procedure, but a procedure that is most effective given a set of conditions. It is too early to say. Investigations conducted so far have experimental control limitations that may have compromised the results such as, for example, the already mentioned difficulties in establishing extinction before the analysis of the transfer of extinction. The studies also differ on more than one variable (i.e., there is no experimental continuity), making it difficult to perform conclusive comparisons between them. Therefore, a research agenda that includes continuity between investigations and improved experimental control is required to know more about the basic processes involved in direct and derived extinction, and then inform clinicians about which is the most effective procedure or even which is the most recommended procedure for each case.

Publisher's Note

Author' contribution

LSB and PD conceived the study. LSB prepared the material and collected the data. LSB and PD analyzed the data. All authors (LSB, PD, and SD) discussed the data and contributed to the writing of the article.

Funding

LSB was supported by the National Council for Scientific and Technological Development (CNPq, grant #149766/2018-1) and the Coordination of Superior Level Staff Improvement (CAPES, grant #88887.750009/2022-00). This research is part of the scientific program of the National Institute of Science and Technology on Behavior, Cognition, and Teaching (INCT-ECCE), supported by the National Council for Scientific and Technological Development (CNPq, grant #465686/2014-1) and the São Paulo Research Foundation (FAPESP, grant #2014/50909-8).

Data availability

Additional data may be provided upon request to the corresponding author.

Declarations

Human Ethics The study was appro AQ2 ved by the Human Research Ethics Committee of the Institute of Psychology of the University of São Paulo (process #29904920.1.0000.5561). All the procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee, and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

References AQ3

Assaz, D. A., Roche, B., Kanter, J. W., & Oshiro, C. K. B. (2018). Cognitive defusion in acceptance and commitment therapy: What are the basic processes of change? *Psychological Record, 68*(4), 405–418. https://doi.org/10.1007/s40732-017-0254-z

Augustson, E. M., & Dougher, M. J. (1997). The transfer of avoidance evoking functions through stimulus equivalence classes. *Journal of Behavior Therapy & Experimental Psychiatry, 28*(3), 181–191. https://doi.org/10.1016/S0005-7916(97)00008-6

Barnes-Holmes, D., Barnes-Holmes, Y., & McEnteggart, C. (2020). Updating RFT (more field than frame) and its implications for process-based therapy. *The Psychological Record, 70*(4), 605–624. https://doi.org/10.1007/s40732-019-00372-3

Boldrin, L. S., Assaz, D. A., & Debert, P. (2020). Estudos de pesquisa básica sobre transferência de extinção e suas implicações para as terapias baseadas em exposição. *Acta Comportamentalia, 28*(2), 205–221. http://www.revistas.unam.mx/index.php/acom/article/view/75951

Boldrin, L. S., & Debert, P. (2020). Direct and derived extinction of avoidance responses in equivalence classes. *Psychological Record, 70*(3), 433–444. https://doi.org/10.1007/s40732-020-00419-w

Boldrin, L. S., & Debert, P. (2022a). *Behavior lab software (Version 1.0)*[Computer Software]. Instituto de Psicologia da Universidade de São Paulo.

Boldrin, L. S., & Debert, P. (2022b). *Matching to sample procedure software (Versão 2.0)* [Computer Software]. Instituto de Psicologia da Universidade de São Paulo.

Bouton, M. E., & Bolles, R. C. (1979). Contextual control of the extinction of conditioned fear. *Learning & Motivation, 10*(4), 445–466. https://doi.org/10.1016/0023-9690(79)90057-2

Cameron, G., Zuj, D. V., Dymond, S., & Quigley, M. (2022). Remote, online assessment of avoidance learning. *Learning & Motivation, 78*, 101805. https://doi.org/10.1016/j.lmot.2022.101805

Carrigan, P. F., & Sidman, M. (1992). Conditional discrimination and equivalence relations: A theoretical analysis of control by negative stimuli. *Journal of the Experimental Analysis of Behavior, 58*(1), 183–204. https://doi.org/10.1901/jeab.1992.58-183

Crosbie, J. (1998). Negative reinforcement and punishment. In K. A. Lattal & M. Perone (Eds.), *Handbook of research methods in human operant behavior* (pp. 163–189). Springer. https://doi.org/10.1007/978-1-4899-1947-2_6 de Rose, J. C., McIlvane, W. J., Dube, W. V., Galpin, V. C., & Stoddard, L. T. (1988). Emergent simple discrimination established by indirect relation to differential consequences. *Journal of the Experimental Analysis of Behavior, 50*(1), 1–20. https://doi.org/10.1901/jeab.1988.50-1

Dougher, M. J., Augustson, E., Markham, M. R., Greenway, D. E., & Wulfert, E. (1994). The transfer of respondent eliciting and extinction functions through stimulus equivalence classes. *Journal of the Experimental Analysis of Behavior, 62*(3), 331–351. https://doi.org/10.1901/jeab.1994.62-331

Dymond, S. (2019). Overcoming avoidance in anxiety disorders: The contributions of Pavlovian and operant avoidance extinction methods. *Neuroscience & Biobehavioral Reviews, 98*, 61–70. https://doi.org/10.1016/J.NEUBIOREV.2019.01.007

Dymond, S., Bennett, M., Boyle, S., Roche, B., & Schlund, M. (2018). Related to anxiety: Arbitrarily applicable relational responding and experimental psychopathology research on fear and avoidance. *Perspectives on Behavior Science, 41*(1), 189–213. https://doi.org/10.1007/s40614-017-0133-6

Dymond, S., Dunsmoor, J. E., Vervliet, B., Roche, B., & Hermans, D. (2015). Fear generalization in humans: Systematic review and implications for anxiety disorder research. *Behavior Therapy, 46*(5), 561–582. https://doi.org/10.1016/j.beth.2014.10.001

Dymond, S., Roche, B., Forsyth, J. P., Whelan, R., & Rhoden, J. (2008). Derived avoidance learning: Transformation of avoidance response functions in accordance with the relational frames of same and opposite. *The Psychological Record, 58*, 271–288. https://doi.org/10.1007/BF03395615

Dymond, S., Roche, B., Forsyth, J., Whelan, R., & Rhoden, J. (2007). Transformation of avoidance response functions in accordance with same and opposite relational frames. *Journal of the Experimental Analysis of Behavior, 88*(2), 249–262. https://doi.org/10.1901/jeab.2007.88-249

Dymond, S., Schlund, M. W., Roche, B., Whelan, R., Richards, J., & Davies, C. (2011). Inferred threat and safety: Symbolic generalization of human avoidance learning. *Behaviour Research & Therapy, 49*(10), 614–621. https://doi.org/10.1016/J.BRAT.2011.06.007

Ferster, C. B. (1953). The use of the free operant in the analysis of behavior. *Psychological Bulletin, 50*(4), 263–274. https://doi.org/10.1037/h0055514

Galizio, M. (1979). Contingency-shaped and rule-governed behavior: Instructional control of human loss avoidance. *Journal of the Experimental Analysis of Behavior, 31*(1), 53–70. https://doi.org/10.1901/jeab.1979.31-53

Gandarela, L., Boldrin, L. S., & Debert, P. (2020). Transfer of the avoidance function in equivalence classes using loss of points as the aversive stimulus. *The Psychological Record, 70*(3), 471–479. https://doi.org/10.1007/S40732-019-00365-2

Garcia-Guerrero, S., Dickins, T. E., & Dickins, D. W. (2014). The gradual extinction of transferred avoidance stimulus functions. *The Psychological Record, 64*(3), 581–599. https://doi.org/10.1007/s40732-014-0062-7

Guinther, P. M., & Dougher, M. J. (2015). The clinical relevance of stimulus equivalence and relational frame theory in influencing the behavior of verbally competent adults. *Current Opinion in Psychology, 2*, 21–25. https://doi.org/10.1016/J.COPSYC.2015.01.015

Hayes, S. C., Barnes-Holmes, D., & Roche, B. T. (2001). *Relational frame theory: A post-Skinnerian account of human language and cognition*. Plenum Press.

Lattal, K. A., St. Peter, C., & Escobar, R. (2013). Operant extinction: Elimination and generation of behavior. *APA handbook of behavior analysis: Translating principles into practice* (2nd ed., pp. 77–107). American Psychological Association. https://doi.org/10.1037/13938-004

Lonsdorf, T. B., Menz, M. M., Andreatta, M., Fullana, M. A., Golkar, A., Haaker, J., Heitland, I., Hermann, A., Kuhn, M., Kruse, O., Drexler, M. S., Meulders, A., Nees, F., Pittig, A., Richter, J., Römer, S., Shiban, Y., Schmitz, A., Straube, B., ..., Merz, C. J. (2017). Don't fear "fear conditioning": Methodological considerations for the design and analysis of studies on human fear acquisition, extinction, and return of fear. *Neuroscience & Biobehavioral Reviews*, *77*, 247–285. https://doi.org/10.1016/j.neubiorev.2017.02.026

Lonsdorf, T. B., Merz, C. J., & Fullana, M. A. (2019). Fear extinction retention: Is it what we think it is? *Biological Psychiatry, 85*(12), 1074–1082. https://doi.org/10.1016/j.biopsych.2019.02.011

Luciano, C., Valdivia-Salas, S., Ruiz, F. J., Rodríguez-Valverde, M., Barnes-Holmes, D., Dougher, M. J., Cabello, F., Sánchez, V., Barnes-Holmes, Y., & Gutierrez, O. (2013). Extinction of aversive eliciting functions as an analog of exposure to conditioned fear: Does it alter avoidance responding? *Journal of Contextual Behavioral Science, 2*(3–4), 120–134. https://doi.org/10.1016/j.jcbs.2013.05.001

Markham, M. R., Dougher, M. J., & Augustson, E. M. (2002). Transfer of operant discrimination and respondent elicitation via emergent relations of compound stimuli. *The Psychological Record, 52*(3), 325–350. https://doi.org/10.1007/BF03395434

Perez, W. F., de Almeida, J. H., Soares, L. C. C. S., Wang, T. F. L., de Morais, T. E. D. G., Mascarenhas, A. V., & de Rose, J. C. (2020). Fearful faces and the derived transfer of aversive functions. *Psychological Record, 70*(3), 387–396. https://doi.org/10.1007/s40732-020-00390-6

Perone, M. (1991). Experimental design in the analysis of free-operant behavior. *Experimental Analysis of Behavior, Parts 1 & 2* (pp. 135–171). Elsevier Science.

Roche, B. T., Kanter, J. W., Brown, K. R., Dymond, S., & Fogarty, C. C. (2008). A comparison of "direct" versus "derived" extinction of avoidance responding. *The Psychological Record, 58*(3), 443–464. https://doi.org/10.1007/BF03395628

Sidman, M. (1994). *Equivalence relations and behavior: A research story*. Authors Cooperative.

Valverde, M. R., Luciano, C., & Barnes-Holmes, D. (2009). Transfer of aversive respondent elicitation in accordance with equivalence relations. *Journal of the Experimental Analysis of Behavior, 92*(1), 85–111. https://doi.org/10.1901/jeab.2009.92-85

Vervoort, E., Vervliet, B., Bennett, M., & Baeyens, F. (2014). Generalization of human fear acquisition and extinction within a novel arbitrary stimulus category. *PLOS ONE, 9*(5), e96569. https://doi.org/10.1371/JOURNAL.PONE.0096569