Journal of Experimental Child Psychology 191 (2020) 104741

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Under the influence of the environment: Children's responding invigorated and biased by predictive cues

Daniel E. Alarcón *, Charlotte Bonardi

School of Psychology, University of Nottingham, University Park, Nottingham NG7 2RD, UK

ARTICLE INFO

Article history:
Received 8 June 2018
Revised 23 October 2019
28 October 2019
Available online 3 December 2019

Keywords:
Learning
Behavior
Pavlovian-to-instrumental transfer
Motivation
Eating
Choice

ABSTRACT

Cues that signal motivationally significant consequences can elevate responding and bias choice. A task known as Pavlovian-to-instrumental transfer (PIT) has been used to assess the influence of these cues on independently trained responses and to study the effect of drug-related and food-related cues on behavior in adult populations, but it has not yet been employed in children. This study aimed to develop a simple computer task to study PIT in children. Participants, aged 7–11 years, observed a screen in which different pairings of distinct cartoon images and specific outcomes were presented (images of foods and drinks in Experiment 1 and images of pets in Experiment 2). After this, the participants pressed two keys, each consistently reinforced with one of the two outcomes. Finally, the children pressed both keys in the absence of any outcome, and each cartoon image was presented periodically so that the effect of these cues on behavior could be measured. Experiment 1 showed that the cartoons' presentations biased responding toward the key that was trained with the same outcome as the cartoon being presented, that is, outcome-specific PIT. Experiment 2 replicated this finding and also showed that a cartoon trained with an outcome different from that reinforcing the responses elevated performance of both responses relative to a cartoon that was not paired with any outcome in training, that is, general PIT. These findings are consistent with those reported in the adult population and might be a useful tool to study the early development of maladaptive behaviors.

---

* Corresponding author at: Departamento de Psicología, Universidad de Chile, Santiago, Chile.
E-mail address: dealarcon@u.uchile.cl (D.E. Alarcón).

https://doi.org/10.1016/j.jecp.2019.104741

Introduction

Research has consistently shown that a stimulus (S) that signals the delivery of a motivationally significant outcome (O), such as food, can acquire motivational properties similar to those of the consequence it predicts, granting it the ability to influence behavior in different manners (Boakes, 1979; Konorski, 1967; Robinson & Berridge, 1993). For instance, cues that have been paired with food, such as its smell, taste, or even the context in which the food was consumed, can elicit physiological responses similar to those produced by the food itself (Jansen et al., 2003; Nederkoorn, Smulders, & Jansen, 2000; Rodin, 1985; Wardle, 1990). But these cues can also invigorate or reduce responses that earn motivationally significant outcomes (e.g., Bindra, 1968), meaning that they are capable of biasing choice. This effect on responding has been studied by using the Pavlovian-to-instrumental transfer (PIT) procedure, which has three components: Pavlovian conditioning, instrumental training, and a PIT test. In the Pavlovian conditioning phase, predictive relationships between cues are established by presenting one or more cues, usually neutral images, each followed by a distinct outcome. These outcomes can be rewards such as foods and drinks, but they can also be symbolic such as images of foods, drinks, and money. In the instrumental phase, one or more responses are each reinforced with one of the outcomes. For instance, pressing a particular key is rewarded by the presentation of a food image, and pressing a different key is rewarded by a drink image. At test, participants are allowed to perform the instrumental response(s) in the presence and absence of each of the Pavlovian cues, and the effect that these cues exert on performance is measured (for a review, see Holmes, Marchand, & Coutureau, 2010), which is thought to reflect to the Pavlovian properties of the stimuli (see Dickinson & Balleine, 2002).

Researchers using this type of task have reported that PIT can take two different forms. In the *outcome-specific* form, stimulus presentations at test bias choice by selectively elevating performance of a response trained with the same outcome as the stimulus relative to a response trained with a different outcome. For instance, if two responses are trained, one with chocolate and the other with popcorn, an elevation in the response trained with chocolate is found if the stimulus presented was also trained with chocolate but not if the stimulus was trained with popcorn (and the opposite for the response trained with popcorn). However, if a stimulus signals an outcome different from that used to train the instrumental responses, this stimulus will also invigorate responding but regardless of the identity of the reinforcers (*general* PIT). For instance, if a stimulus was trained with nuts, this stimulus elevates both the response trained with chocolate and the response trained with popcorn (Watson, Wiers, Hommel, & de Wit, 2014). Whereas the general PIT effect can be explained by a nonselective motivational effect on behavior elicited by the stimulus (cf. Rescorla & Solomon, 1967), the selectivity of the outcome-specific PIT effect can be explained only by a mechanism that encodes the sensory aspects of the outcome (cf. Trapold & Overmier, 1972).

The PIT effect has been extensively reported in human and nonhuman animal studies (e.g., Alarcón & Bonardi, 2016; Alarcón, Bonardi, & Delamater, 2018; Colwill & Rescorla, 1988; Delamater, 1996; Holland, 2004; Kruse, Overmier, Konz, & Rokke, 1983), and it has been related to a number of different phenomena such as drug addiction, overeating, stress, schizophrenia, and depression (e.g., Alarcón & Delamater, 2019; Colagiuri & Lovibond, 2015; Garbusow et al., 2016; Lamb, Ginsburg, & Schindler, 2017; Morris, Quail, Griffiths, Green, & Balleine, 2015; Quezada, Alarcón, Miguez, & Betancourt, 2009; Quail, Morris, & Balleine, 2017; Watson et al., 2014). Although PIT has proved to be a versatile task that yields robust effects, it has been used only to study adults and there are as yet no studies exploring the effect in the child population. Although one might assume that children will show both outcome-specific and general PIT exactly as adults do, this is not necessarily the case given that there is a substantial literature suggesting that children have difficulties in some learning tasks. For example, adults outperform children in choice tasks (e.g., pressing right and left keys) in which feedback is important; children learn at a lower rate than both adolescents and adults (Hämmerer, Li, Müller, & Lindenberger, 2010), they are not as good as adults at identifying relevant feedback (Crone, Jennings, & van der Molen, 2004), and they are less accurate than adults when feedback is not entirely consistent (Eppinger, Mock, & Kray, 2009). Moreover, there are a number of reports that both children and adolescents are worse than adults in acquiring classically conditioned discriminations between one stimulus that predicts an aversive outcome and another one that does not (Glenn et al., 2012; Jovanovic et al., 2014; Lau et al., 2011; Waters, Theresiana, Neumann, & Craske, 2017), although others have not reported differences (Craske et al., 2012; Liberman, Lipp, Spence, & March, 2006; Neumann, Waters, & Westbury, 2008; Waters, Henry, & Neumann, 2009). Although it is not clear how these specific differences might affect the observation of PIT, they do suggest that it might not be safe to assume that children will perform like adults on all learning tasks. Thus, given the potential importance of PIT for clinical studies, it is important to demonstrate the effect in young people. If children do show PIT like adults, this task could be used to study maladaptive behavior from an earlier age. For instance, in the case of overeating, one important factor is the influence of environmental cues on eating. Finding a simple tool to study the effect of these cues becomes critical, especially considering that overeating in childhood is highly correlated with obesity in adulthood (Deckelbaum & Williams, 2001).

One interesting aspect of PIT research is the diversity of outcomes used in these studies. In animal PIT studies, caloric stimuli such as food pellets and sugared solutions can be used as outcomes. Similarly, in some human studies, valuable outcomes (e.g., snacks, money, cigarette puffs) are delivered either during or at the end of the task. However, some human research has used symbolic rewards (e.g., fictitious currency, neutral images, pictures of foods and drinks). The use of discrete symbolic outcomes allows the researcher to better manipulate the temporal aspects of the relations being studied, but more importantly it provides evidence that a cue does not necessarily need to be directly paired with a valuable consequence to affect behavior. This is critical considering the effect that daily environmental stimuli have on our behavior, for instance, advertising on the streets and in supermarkets and publicity transmitted on television and the internet and in video games in the form of commercials and product placement.

Here we report the results of two PIT experiments conducted in children aged 7–11 years. Similar age groups were used in the studies mentioned above in which the rates of learning were compared between children and adults (Crone, Jennings, & van der Molen, 2004; Crone & van der Molen, 2004; Eppinger, Mock, & Kray, 2009; Koolschijn, Schel, de Rooij, Rombouts, & Crone, 2011). The aim of Experiment 1 was to assess whether outcome-specific PIT is found in child participants, whereas the aim of Experiment 2 was to extend the scope of the study by assessing outcome-specific and general PIT effects in the same task. In addition, the goal of both experiments was to demonstrate PIT using symbolic outcomes rather than real outcomes. Experiment 1 aimed to replicate the effect using images of foods and drinks, which are the traditional outcomes used in this type of task. In Experiment 2, the generality of the PIT effects was assessed by using images of pets.

Experiment 1: outcome-specific PIT

The task was a computer game consisting of a Pavlovian conditioning phase, an instrumental training phase, and a PIT test (see Table 1). In the Pavlovian phase, presentations of different neutral stimuli (cartoon images of children: S_1, S_2, and S_3) were each paired with presentations of either a particular outcome (images of foods or drinks: O_1 and O_2) or a white square representing the absence of the outcome (i.e., S_1-> O_1, S_2-> O_2, and S_3-> no outcome). In the instrumental training phase, pressing one key (R_1) was rewarded with one of the outcomes (O_1), whereas pressing a different key (R_2) was rewarded with the alternative outcome (O_2). In the test, participants had the chance to perform both responses

Table 1
Design of Experiment 1.

Pavlovian phase	Instrumental phase	PIT test	Rating stage
S_1-> O_1	R_1-> O_1	S_1: R_1? R_2?	S_1: O_1 or O_2?
S_2-> O_2	R_2-> O_2	S_2: R_1? R_2?	S_2: O_1 or O_2?
S_3-		S_3: R_1? R_2?	S_3: O_1 or O_2?

Note. R_1 and R_2 refer to keyboard responses; S_1, S_2, and S_3 refer to neutral cartoon images of children; O_1 and O_2 refer to food and drink images; - refers to a blank square.

(R_1 and R_2) in the presence and absence of the neutral stimuli. If PIT is also found in children, then presentations of S_1 and S_2 at test should elevate responding relative to S_3. Furthermore, if this effect is outcome specific, then S_1 and S_2 should selectively elevate a specific response depending on the outcome it had earned; specifically, presentations of S_1 should elevate R_1 more than R_2, whereas presentations of S_2 should elevate R_2 more than R_1. In contrast, the control stimulus S_3 should produce no change in responding. After the test, and to assess whether participants were paying attention throughout the task, participants were asked to identify each of the stimulus–outcome (S-O) relationships.

Method

Participants

A total of 12 children aged 7–10 years (6 boys and 6 girls) participated in this experiment. The participants were attending Summer Scientist Week (http://www.summerscientist.org), an event organized by the University of Nottingham in which families visit the university and their children participate in different research studies.

The studies reported here, their procedures, and consent forms were approved by the School of Psychology ethics committee of the University of Nottingham. Participants' parents or caregivers gave informed consents for their children to participate in the studies conducted in the Summer Scientist Week, and all the participants gave verbal assent before participating in the task.

Apparatus and materials

The experiment was programmed in PsychoPy (Peirce, 2007) and conducted on a computer with a 15.4-in. screen. The screen showed general instructions at the beginning of the task and specific instructions before each phase. Three cartoon images of children were used as Ss (S_1, S_2, and S_3), and 16 pictures of foods and drinks (8 of each) were used as outcomes (see Fig. 1). All the images were 100×100 mm in size. On the non-reinforced trials, a white square image (100×100 mm) was used as the outcome. Each S, when presented, was located to either the left or right side of the screen (100 mm from the center), and each outcome image was positioned at the center of the screen. Each Pavlovian trial began with a black fixation dot (3×3 mm) at the center of the screen, which was replaced by a black fixation cross (10×10 mm) in the instrumental training phase and PIT test. The instrumental responses consisted of pressing the "z" and "m" keys, each of which was covered with a red sticker

Fig. 1. Neutral stimuli and outcomes used in Experiment 1.

to highlight its position. Pressing the left key (z) was reinforced with drink images, and pressing the right key (m) was reinforced with food images. The space bar was used to start each of the phases after the instructions were read, and it was marked with green stickers. The identities of S_1, S_2, and S_3 were fully counterbalanced, resulting in 6 counterbalanced subgroups. For half of each of these subgroups, O_1 was a drink image and O_2 was a food image, and the reverse was the case for the remainder, resulting in a total of 12 counterbalanced subgroups with 1 participant in each one (see online supplementary material).

Procedure

Participants were walked to a room in which the experiments were conducted, and they were seated in front of a computer. Then they received general instructions orally from the researcher, and they were asked to read out loud the following specific instructions before continuing with each of the experimental phases.

Pavlovian phase. Participants read the following instructions:

> “Now you will see some children. Some of them will get food, some will get drinks, and some will get nothing.
> Are you ready to find out which child gets which reward?
> When you are ready, press the green button.”

Each trial began with the fixation dot, which remained on the screen for 2 s. After this, an S was presented on either the left or right side of the screen, and 2 s later the corresponding outcome appeared next to the S (in the center of the screen). After an additional 2 s, the S and outcome were replaced by the fixation dot, starting a new trial. This phase was divided into four blocks, each of them comprising 2 trials of each of the trial types S_1-> O_1, S_2-> O_2, and S_3-> nothing presented in a semirandom order (8 trials of each type in total).

Instrumental training phase. Participants read the following instructions:

> “Now press the red keys to see food and drink pictures!
> One key will produce food pictures and the other drink pictures. You must get 30 of each, but sometimes the pictures won’t appear, so you must keep pressing!
> When you are ready, press the green button.”

The fixation cross was present throughout this phase except when an outcome image was delivered. Each of the responses was reinforced according to a variable ratio 3 schedule. For example, after an average of 3 R_1 responses, an O_1 was presented on the screen; R_2 responses were followed by presentations of O_2 according to the same schedule. Each of the outcome presentations lasted 0.8 s. If participants pressed either “z” or “m” during the outcome presentation, that outcome image was immediately replaced by the fixation cross. Two counters showing the exact number of outcomes earned at any given time were positioned at the top corners of the screen, each incrementing by 1 every time the corresponding outcome was delivered. The text “Drink =” in orange letters, together with the number of drink images obtained by participants, was displayed in the left corner, whereas the text “Food =” in blue letters, together with the corresponding number of earned food images, was displayed in the right corner. This phase ended when participants had obtained at least 30 outcomes of each type.

PIT test. Participants read the following instructions:

> “Now it’s time to press the red keys again to get food and drink pictures.
> You will not see the food and drink pictures you are getting, so you must keep pressing!
> “When you are ready, press the green button.”

In this test, participants could perform R_1 and R_2 as much as they wanted, but no outcomes were delivered. The test began with the fixation cross alone on the screen, and it remained present throughout the entire test. Each of the trials comprised a 2-s pre-S baseline period, in which only the cross was present, after which an S appeared on either the left or right side of this cross (S period). The S remained on the screen for 4 s and was then replaced by the cross alone for an additional 1 s (intertrial interval). Then the next trial commenced immediately. The food and drink counters used in the instrumental training phase remained on the screen in this phase, but the symbol "?" replaced the numbers that had indicated the number of outcomes earned in the previous phase. This test was divided into two blocks, each of them consisting of 2 trials each of S_1, S_2, and S_3 presented in a semirandom order (4 trials per type in total). The numbers of R_1 and R_2 responses performed in the pre-S and S periods were recorded.

Rating stage. Participants read the following instructions:

> "Now you will see the children again. Can you remember which child got which reward?
> If they got a drink, click the line near the DRINK picture. If they got food, click the line near the FOOD picture. If they got nothing, click the line in the middle.
> When you are ready, press the green button."

In each of the trials, the text "What did this child get?" was located at the top of the screen with the corresponding S image below it and a visual rating scale at the bottom of the screen. A drink image together with the word "Drink" in orange letters was presented on the left of the scale, and a food image together with the word "Food" in blue letters was presented on the right of the scale. On each trial, different food and drink images were used (3 × 3 cm in size), selected from the group of images used in the previous phases. This test was divided into two blocks, each comprising one trial each of S_1, S_2, and S_3.

Data treatment

The data were analyzed using analysis of variance (ANOVA), and sets of orthogonal contrasts were used to further analyze significant differences. Partial eta-square (η^2_p) and its 90% confidence interval (CI) were given for significant effects and interactions. The responses made during the PIT tests were transformed to responses per minute (rpm). Then, to reveal any elevation of instrumental responding produced by the various Ss, PIT scores were calculated for each response and each S type by subtracting response rates during the prestimulus period from responding during the S presentation that followed it. Finally, these PIT scores were grouped as Same or Different, depending on whether the outcome that previously reinforced the response matched that signaled by the S. Thus, R_1 responses during S_1 and R_2 responses during S_2 were grouped as Same, whereas R_2 responses during S_1 and R_1 responses during S_2 were grouped as Different. PIT scores for responding during the Ss that did not signal any outcome (S_3 in Experiment 1 and S_4 in Experiment 2) were collapsed and grouped as Control. Positive scores reflected an elevation on instrumental responding during the stimuli presentations, whereas negative scores reflected a reduction. One-sample two-tailed *t* tests were conducted to assess whether these scores significantly differed from zero. In the rating stage, each position on the scale provided a value from 0, left of the scale, to 1, right of the scale ("nothing," in the middle of the scale, was 0.5). Scores for each trial were calculated by subtracting participants' responses on the scale from the expected response, such that a value of 0 represented a correct answer. A learning criterion based on the rating scores was defined to exclude those participants who did not learn the associations; however, all of them answered all the questions virtually correctly (see below).

Results

All participants obtained 30 outcomes of each type in the instrumental training phase. The results of interest from the PIT test are presented in Fig. 2. It is clear from the figure that S presentations elevated instrumental responses trained with the same outcome as the S (Same: R_1 during S_1 and R_2 during S_2) relative to the S that signaled the alternative outcome (Different: R_1 during S_2 and R_2 during S_1). An ANOVA with response type (Same, Different, or Control) as a factor showed a significant main effect of response type, $F(2, 22) = 9.77$, $p = .001$, $\eta^2_p = .47$, CI = [.166, .611], and planned orthogonal comparisons confirmed that participants' PIT scores were higher for Same responses than for both Different and Control responses, $F(1, 11) = 10.93$, $p = .007$, $\eta^2_p = .498$, CI = [.106, .679] and also that Different

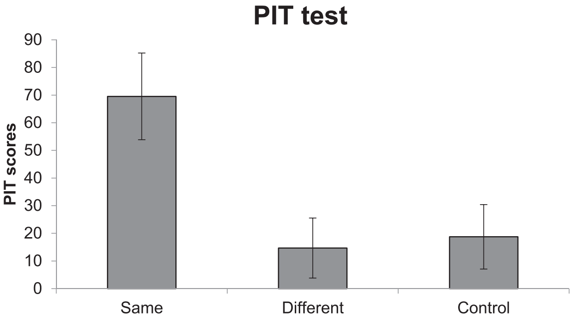

Fig. 2. Instrumental responding expressed as Pavlovian-to-instrumental transfer (PIT) scores ± standard errors of the mean (conditioned stimulus [CS] – pre-CS responding) during the stimulus trained with either the same outcome as the instrumental response (Same: R_1 during S_1 and R_2 during S_2), different outcome (Different: R_1 during S_2 and R_2 during S_1), or no outcome (Control: R_1 and R_2 during S_3), averaged over the two blocks of the PIT test of Experiment 1.

and Control PIT scores did not differ ($F < 1$). One-sample *t* tests on these scores showed significant difference for Same ($p = .001$) but not for Different ($p = .203$) or Control ($p = .136$). The mean response rates during the prestimulus periods were 19.1 rpm (*SEM* = 7.3), 19.8 rpm (*SEM* = 8.4), and 19.8 rpm (*SEM* = 8.1) for Same, Different, and Control, respectively. These differences were not statistically significant (*F*s < 1).

All the participants answered all the questions correctly (very close or right on the expected end of the scale). The mean calculated scores to the questions about S_1, S_2, and S_3 were 0.01 (*SEM* < 0.01), 0.02 (*SEM* = 0.01), and 0.02 (*SEM* < 0.01), respectively.

Experiment 2: outcome-specific and general PIT

The results of Experiment 1 confirmed that the task was effective in reproducing the outcome-specific PIT effect in children using symbolic rewards. Presentations of images that signaled food or drink pictures increased responding, but only if the stimulus and the response were trained with the same outcome. In Experiment 2, the design was slightly modified to assess whether outcome-specific and general PIT could be found in the same task with child participants (see Table 2). The critical modification was the inclusion of a new S-O relationship (S_3-O_3). This new stimulus signaled the presentation of an outcome that was not used to reinforce either of the instrumental responses. Because of this, we predicted that S_3 would produce an elevation of both R_1 and R_2 relative to the effect of the control cue that signaled no outcome (S_4-). In addition, and as in Experiment 1, S_1 and S_2 should produce a selective elevation of the response that produced the same outcome (outcome-specific PIT).

Method

Participants

A total of 37 participants were initially recruited from three local primary schools; however, 11 of these performed an incorrect version of the task and were immediately excluded from the study. Of

Table 2
Design of Experiment 2.

Pavlovian phase	Instrumental phase	PIT test	Questions
S_1-> O_1	R_1-> O_1	S_1: R_1? R_2?	S_1: O_1 or O_2?
S_2-> O_2	R_2-> O_2	S_2: R_1? R_2?	S_2: O_1 or O_2?
S_3-> O_3		S_3: R_1? R_2?	S_3: O_1 or O_2?
S_4-		S_4: R_1? R_2?	S_4: O_1 or O_2?

Note. R_1 and R_2 refer to keyboard responses; S_1, S_2, S_3, and S_4 refer to neutral cartoon images of children; O_1, O_2, and O_3 refer to images of pets; - refers to a blank square.

the remaining 26 participants, 2 performed at 50% correct or less in the final Pavlovian assessment (see "Data treatment" section). Therefore, these participants were excluded, leaving a total of 24 children participating in the experiment; these were aged 7–11 years and comprised 13 boys and 11 girls.

Participants' parents or caregivers gave informed consent for their children to participate in this study, and all the participants gave verbal assent before participating in the task.

Apparatus and materials

An additional cartoon image was added to the set of images used as Ss in Experiment 1, and the food and drink images were replaced by pictures of pets: 8 puppies, 8 kittens, and 8 bunnies (Fig. 3). The stimuli and outcomes were counterbalanced (see supplementary material). Because of the additional outcome, the rating scale was replaced by a series of questions about the S-O relationships.

Procedure

Everything was the same as in Experiment 1 unless otherwise stated.

Pavlovian phase. Participants read the following instructions:

> "Some of these children really want a pet, and you are going to help them to get one!
> One of the children wants a puppy, another wants a kitten, another wants a bunny, and one does not want a pet.
> Now you will see the children and the pets they want, so you need to remember which child wants each of the pets so you can help them later!
> When you are ready, press the green button."

The phase was divided into four blocks, each of them consisting of 2 trials of each of S_1-> O_1, S_2-> O_2, S_3-> O_3, and S_4- (8 trials of each type in total).

Instrumental training phase. Participants read the following instructions:

> "Now press the red keys to catch ____ and ____! Another friend will be catching the ____, so you do not have to worry about that.
> One key will help you to catch ____ and the other ____. Once you get 30 of each, you will give the pets to the children!
> Sometimes the keys will not do anything, but just keep pressing!
> When you are ready, press the green button."

Fig. 3. Outcomes used in Experiment 2.

One of the keys was trained with O_1, and the other key was trained with O_2. The spaces marked as _____ were filled with the word "puppies," "bunnies," or "kittens," depending on the experimental condition assigned to the participant (O_1 or O_2). The words "Food" and "Drink" in the counters were replaced by "Puppies," "Bunnies," and "Kittens," also depending on the counterbalancing condition.

PIT test. Participants read the following instructions:

> "Now it's time to help the children to get their pets! You can give them pets by pressing the red keys again.
> You will not see the pets, but the children will receive them anyway so just keep pressing!
> When you are ready, press the green button."

The counters were modified as described in the previous phase. The test was divided into two blocks, each consisting of 2 trials of each of S_1, S_2, S_3, and S_4 (4 trials of each type in total).

Questions. Participants read the following instructions:

> "Now you will see the children again. Can you remember which pets they preferred?
> You need to press the numbers 1, 2, 3, or 4 for each of the children, and you will see the pets to help you to remember.
> When you are ready, press the green button."

On each trial, the question "What did this child want?" was located on the top of the screen and one of the Ss was presented at the center of the screen. Below the S, there were four smaller images (O_1, O_2, O_3, and the blank square). Different images were presented in each trial (3 × 3 cm in size), semirandomly selected from the group of images used in the previous phases. The corresponding name was written below each image ("Puppy," "Kitten," "Bunny," or "No pet"), and above each image there was a number (1, 2, 3, or 4). Each trial ended when participants pressed one of the keys. The test was one block comprising 2 trials with each cue (S_1, S_2, S_3, and S_4).

Data treatment

Rates of each response during each stimulus were converted into responses per minute, and the corresponding pre-CS (conditioned stimulus) response rates were subtracted to produce PIT scores, exactly as in Experiment 1. The data required to demonstrate specific PIT scores were extracted exactly as in Experiment 1: PIT scores for R_1 and R_2 during S_1 and S_2 were coded according to whether they were Same (when both response and stimulus had signaled the same outcome) or Different. Greater Same than Different scores indicated specific PIT. The measure of general PIT was necessarily a little different because this refers to a *nonspecific* elevation of responding during the reward-associated S_3 compared with the non-reward-associated S_4-, meaning that R_1 and R_2 were functionally equivalent for this measure. Thus, PIT scores for R_1 and R_2 during S_3 and S_4 were pooled; greater scores during S_3 than during S_4 would indicate general PIT. As in Experiment 1, one-sample two-tailed *t* tests were conducted on the PIT scores to assess whether they were significantly different from zero. For the "Questions," each correct response was assigned a value of 1 and each incorrect response was assigned a value of 0. The mean values for the questions about each cue were calculated and converted into a scale from 0 to 100. For the exclusion criterion, a single mean for all questions was calculated for each participant, and those participants scoring less than 50% were excluded from the experiment. This exclusion criterion is similar to that used in a previous PIT task in an adult population (Alarcón & Bonardi, 2016). Two participants were excluded from this study because they failed to meet this exclusion criterion. One of them answered the questions about S_1 and S_3 incorrectly, whereas the other one incorrectly answered one question about S_1, two questions about S_3, and one question about S_4. This left a total of 24 participants, all of whom performed to a high degree of accuracy (see below).

Results

The instrumental training phase was completed uneventfully, and all participants obtained the 30 outcomes produced by each of the two instrumental responses. The results of the PIT test are presented in Fig. 4, which shows, as in Experiment 1, a selective elevation of instrumental responding produced by S_1/S_2, that is, higher PIT scores for R_1 than for R_2 during S_1, and the reverse pattern in S_2. Moreover, presentation of S_3 (S Other) also elevated performance of the two instrumental responses relative to presentations of S_4 (S Control). An ANOVA with trial type (Same, Different, Other, or Control) showed a significant main effect, $F(3, 69) = 10.10$, $p < .001$, $\eta_p^2 = .305$, CI = [.139, .412]. Planned orthogonal comparisons confirmed a significant difference between Same and Different, $F(1, 69) = 15.28$, $p < .001$, $\eta_p^2 = .18$, CI = [.062, .306], and also between Other and Control, $F(1, 69) = 5.74$, $p = .019$, $\eta_p^2 = .20$, CI = [.054, .306]. One-sample *t* tests on each of the scores showed significant differences for Same ($p = .004$) but not for Different ($p = .335$), Other ($p = .08$), or Control ($p = .445$). The mean response rates during the prestimulus periods were 3.8 rpm (*SEM* = 3.0), 3.7 rpm (*SEM* = 2.7), 3.7 rpm (*SEM* = 3.0), and 6.1 rpm (*SEM* = 4.4) for Same, Different, Other, and Control, respectively. The same analysis on the pre-CS data showed no significant differences, $F(3, 69) = 2.14$, $p = .104$.

The mean scores for the questions about Ss were 97.9 (*SEM* = 2.1), 97.9 (*SEM* = 2.1), 91.7 (*SEM* = 4.9), and 100 (*SEM* = 0) for the questions about S_1, S_2, S_3, and S_4, respectively. Statistical analysis showed no significant differences, $F(3, 69) = 1.53$, $p = .21$.

General discussion

The aim of the experiments reported here was to assess whether children show evidence of PIT in a computer-based learning task. Experiment 1 focused on determining whether the outcome-specific form of PIT can be observed when a standard PIT task is used. Children were shown different relationships between distinct cartoon images and symbolic rewards (food or drink pictures) or the absence of the rewards. Then the children were trained to press two different keys, each rewarded by one of two symbolic outcomes (food or drink pictures). When tested, children showed an elevation of key pressing in the presence of the cartoon images, but only with the key that was trained with the same reward as that signaled by the cartoon image, that is, outcome-specific PIT. In Experiment 2, a new cartoon image signaling a new outcome, different from that used to reinforce the key presses, was added to the task. At test, children again showed outcome-specific PIT, a selective elevation of key pressing in the presence of the cues that signaled one of the reinforcers. But in addition, in the presence of the new cartoon, the rate of *both* key presses was increased relative to the cartoon image S_4 that signaled no reward; in other words, children also showed general PIT.

These results are consistent with previous findings on outcome-specific and general PIT in the adult population and nonhuman animals, and they can be explained by the stimulus–outcome–response (S-O-R) account (cf. Trapold & Overmier, 1972). According to this account, in the first experiment, each of the cartoon images became capable of activating a representation of either food, drink, or nothing.

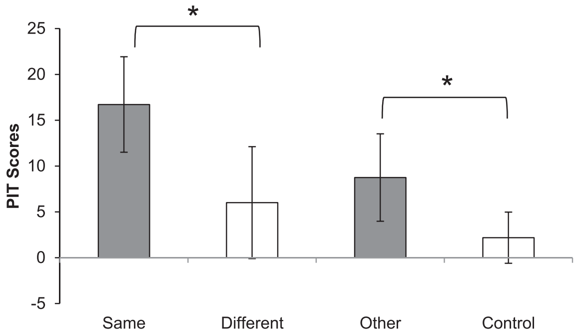

Fig. 4. Instrumental performance, expressed as Pavlovian-to-instrumental transfer (PIT) scores ± standard errors of the mean (conditioned stimulus [CS] – pre-CS responding) of the response paired with the same outcome as the stimulus (Same: R_1 during S_1 and R_2 during S_2), the response paired with the alternative outcome (Different: R_1 during S_2 and R_2 during S_1), and both responses during the stimulus paired with the third outcome O_3 (Other; R_1 and R_2 during S_3) or with no outcome (Control: R_1 and R_2 during S_4), averaged over the two blocks of the PIT test of Experiment 2. *$p < .05$.

Then each presentation of these cartoons at test evoked the corresponding representation, which biased choice toward the response that also evoked the same representation. Because the pictures of foods and drinks presumably shared a similar motivational value, the selectivity of the effect can be mediated only by the distinct sensory aspects of the pictures. The outcome-specific effect found in Experiment 2 is explained in the same manner; the cartoons evoked a representation of one of the pets, which in turn elicited a response that was trained with the same pet. However, when the sensory properties of the representation evoked by the cartoon did not correspond with those evoked by either of both responses, the cartoon presentation also elevated responding relative to a stimulus signaling no outcome. In this case, the motivational elements shared between the two outcome representations are likely to be responsible for this general elevation of performance.

The outcome-specific PIT effect has been commonly reported in nonhuman animals and in the adult population, but to our knowledge this is the first report of the effect in children. Conclusive demonstrations of the general form of PIT, however, are rarer, in part because some researchers have used designs that do not allow us to distinguish between the two forms of PIT, for instance, by training only one cue to predict outcome delivery (e.g., Lovibond & Colagiuri, 2013; Saddoris, Stamatakis, & Carelli, 2011; Talmi, Seymour, Dayan, & Dolan, 2008). Nevertheless, there have been some reports in which both outcome-specific and general forms of PIT were found in the same task, first with rodents (Corbit & Balleine, 2005, 2011; Corbit, Fischbach, & Janak, 2016) and later with humans (Morris et al., 2015; Nadler, Delgado, & Delamater, 2011; Quail et al., 2017; Watson et al., 2014).

One important aspect of this report is that outcome-specific and general PIT both were found in the same task and using symbolic rewards, which has not usually been achieved in the literature (but see Morris et al., 2015; Quail et al., 2017). For instance, Nadler et al. (2011, Experiment 1a) made a first attempt by using a design similar to that used in our Experiment 2 with adults as participants. Although, unlike us, they conducted instrumental training before the Pavlovian phase, they also used symbolic rewards, namely images of a coin, a star, and a key, as outcomes. In their experiment, participants showed evidence of outcome-specific PIT but not general PIT. Nadler et al. argued that the low motivational value of the outcomes could have been responsible for the absence of general PIT, which is thought to be mainly a motivational effect. They made a second attempt in which they replaced the outcome with an image representing money that was given to the participants at the end of the experiment (Experiment 1b), but this also failed to reveal general PIT. Finally, Nadler et al. took a different approach and used a computer game, based on a task developed by Paredes-Olay, Abad, Gámez, and Rosas (2002), in which participants needed to defend a country by shooting (by pressing keys) planes and ships (response–outcome [R-O] relationships). The results of this experiment successfully showed both outcome-specific and general PIT, although it is not clear which aspects of this new task were responsible for this effect. It is likely that in our task the images of foods, drinks, and pets had a higher motivational value than those used by Nadler et al. (2011) because they might have evoked a representation or memory of the actual foods and drinks directly. It is possible, then, that using natural rewards as outcomes might result in an even larger effect, although to our knowledge there has been no direct comparison between the PIT effect produced by symbolic outcomes and natural rewards. An additional factor might be the age of the participants; the images might have greater motivational value for children than for adults.

Because this task was created for children, the cover story and instructions were aimed to keep the participants engaged and were not identical to those used in other PIT tasks. Adult PIT experiments commonly use images such as fractals and geometrical figures (e.g., Alarcón & Bonardi, 2016; Watson et al., 2014) that are simply followed by an outcome. In contrast, in the experiments reported here, although there was still a clear predictive relationship between the different children and the various outcomes—the conditions required to produce Pavlovian conditioning—the participants were told that the cartoon images of children that served as CSs *obtained* the outcomes that followed them. It could be argued that this feature might have led participants to perform instrumental actions at test due to a reasoning process rather than purely based on the Pavlovian associations. For example, in Experiment 2 the participants were instructed at test to respond to "get the children their pets," and so they could have solved the task by means of a reasoning process; for example, seeing the child who wanted a rabbit made them press the key that produced rabbits. However, we think that this is unlikely. First, although this logic could in principle generate the specific PIT effect observed in

Experiment 2, it is less clear how it would generate the general PIT effect, where participants were pressing keys to obtain pets that were *not* those wanted by the child CS presented. Second, it cannot easily explain the results of Experiment 1, in which at test the participants were simply told to press for the food and drink without any implication that these would be received by the child CSs. Another case in which the instructions might have confounded our interpretations is in Experiment 2 where participants were told at the beginning of the task that one of the characters "does not want a pet" (S_4, the control cue for general PIT). Because of this, reasoning should have led participants to suppress responding when this cue was presented at test, making S_4 a less than ideal control cue. However, if this were correct, then this cue should have reduced responding relative to the baseline (pre-CS), but numerically this was not what we found (although there might have been a floor effect that did not allow us to detect any possible suppression).

But even if we reject these possibilities, we still cannot state with any certainty that the PIT we observed was due to associative learning processes rather than some form of reasoning. However, this is true for most human PIT tasks; moreover, the involvement of reasoning does not preclude the formation and contribution of Pavlovian associations to PIT. Some authors have even argued that PIT is essentially propositional in nature (e.g., Seabrook, Hogarth, & Mitchell, 2016) and that humans make a deliberate choice at test based on the information provided by the Pavlovian cues. In this regard, one could argue that reasoning might be *less* likely in the younger children, meaning that the current findings could in principle bear on this debate. The purpose of our study, however, was not to dwell on the nature of PIT but rather to provide a simple tool to study the effect of Pavlovian cues on behavior. The PIT effects found in both experiments required learning about the relationships trained in the Pavlovian phase as well about the instrumental associations, and they are comparable to those found in animal and adult PIT studies. Nevertheless, future versions of this task could use instructions more similar to those in adult studies in order to help rule out these potential alternative explanations.

We believe that our task could be a useful tool for assessing the effect on behavior caused by different types of discrete and environmental cues, which is especially important early in life. These cues can develop associations with consequences that are not always desirable and might become capable of automatically triggering maladaptive behaviors such as binge eating, drinking, and gambling. For example, in modern society there is an overabundance of food, especially food of high calorie content, and children are constantly bombarded by marketing oriented to affect their consumption and preferences through their influence on families' purchases, their own growing purchasing power, and their choices and eating behavior (Andreyeva, Kelly, & Harris, 2011; Boyland & Halford, 2013; Folkvord, Anschütz, & Buijzen, 2016; Uribe & Fuentes-García, 2015). Some advertising strategies have used popular cartoon characters as brand images to influence children's preferences (Boyland, Harrold, Kirkham, & Halford, 2012; Connor, 2006; Story & French, 2004; Weber, Story, & Harnack, 2006). Thus, better understanding the scope of such stimuli to influence behavior (either through directly promoting product consumption or via a broader behavioral effect) can be useful to protect our children from the negative impact of advertising.

Another aspect of the task worthy of comment is the use of symbolic outcomes rather than real foods and drinks. Symbolic outcomes of the type used here can be regarded as conditioned reinforcers, that is, stimuli that possess reinforcing properties based on their associative history with real outcomes. Therefore, it is an empirical question as to whether similar results would be obtained with outcomes that participants could consume. But given that both the outcome-specific and general forms of PIT have been replicated in adults using both symbolic and real outcomes, indicating that the underlying learning processes of these tasks are equivalent, it seems unlikely that children would differ in this regard. Moreover, the use of symbolic outcomes has advantages, allowing better control over delivery of the outcomes and the time in which participants can access them (see (Alarcón et al., 2018)). However, in some cases the use of real outcomes becomes more important. For instance, some experiments have examined whether outcome-specific PIT persists after the motivational value of one of the outcomes has been reduced, and whereas some experiments using symbolic rewards have found a reduction in PIT (Allman, DeLeon, Cataldo, Holland, & Johnson, 2010), others using real outcomes have found PIT to be unaffected by outcome devaluation (Watson et al., 2014). Although the idea that these differences were caused by the use of symbolic or real outcomes has been proposed

(Eder & Dignath, 2016), this is not entirely clear and systematic research exploring differences between the two types of outcomes is required.

Another interesting issue is that the magnitude of PIT might vary depending on the characteristics of the populations being studied. For instance, it has been shown that obese people pay more attention to food-related cues than normal-weight people (Boutelle & Bouton, 2015; Castellanos et al., 2009; Hendrikse et al., 2015; Werthmann et al., 2011). It might be that obese people are also more sensitive to the effect of these cues on food-seeking behavior. A recent study found that the PIT effect observed in overweight participants was larger than that found in normal-weight participants (Lehner, Balsters, Herger, Hare, & Wenderoth, 2017), although obese people showed a smaller effect than overweight participants. It is not clear why these cues might affect overweight and obese people differentially; thus, additional research is needed to better understand how these cues affect behavior and with which other factors they interact.

Overall, we have developed a task to study PIT effects in the child population—something that, to our knowledge, has not been done before. This task allows us to observe both outcome-specific and general forms of PIT. Importantly, this was achieved by using symbolic rewards rather than natural rewards, which presents a series of practical advantages. We believe that the results reported here are a contribution to the current knowledge about PIT and how it extends to the child population. This will facilitate future research into the maladaptive behavior that is observed in adults in response to reward-related stimuli when it appears at an earlier stage of development.

Acknowledgment

The elaboration of this article was supported by a postdoctoral grant awarded by CONICYT (Comisión Nacional de Investigación Científica y Tecnológica) (FONDECYT [Fondo Nacional de Desarrollo Científico y Tecnológico] No. 3170166) to Daniel E. Alarcón.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jecp.2019.104741.

References

Alarcón, D., & Bonardi, C. (2016). The effect of conditioned inhibition on the specific Pavlovian-instrumental transfer effect. *Journal of Experimental Psychology: Animal Learning and Cognition, 42*, 82–94.

Alarcón, D. E., Bonardi, C., & Delamater, A. R. (2018). Associative mechanisms involved in specific Pavlovian-to-instrumental transfer (PIT) in human learning tasks. *Quarterly Journal of Experimental Psychology, 71*, 1607–1625.

Alarcón, D. E., & Delamater, A. R. (2019). Outcome-specific Pavlovian-to-instrumental transfer (PIT) with alcohol cues and its extinction. *Alcohol, 76*, 131–146.

Allman, M. J., DeLeon, I. G., Cataldo, M. F., Holland, P. C., & Johnson, A. W. (2010). Learning processes affecting human decision making: An assessment of reinforcer-selective Pavlovian-to-instrumental transfer following reinforcer devaluation. *Journal of Experimental Psychology: Animal Learning and Cognition, 36*, 402–408.

Andreyeva, T., Kelly, I. R., & Harris, J. L. (2011). Exposure to food advertising on television: Associations with children's fast food and soft drink consumption and obesity. *Economics and Human Biology, 9*, 221–233.

Bindra, D. (1968). Neuropsychological interpretation of the effects of drive and incentive-motivation on general activity and instrumental behavior. *Psychological Review, 75*, 1–22.

Boakes, R. A. (1979). Interactions between type I and type II processes involving positive reinforcement. In A. Dickinson & R. A. Boakes (Eds.), *Mechanisms of learning and motivation: A memorial volume to Jerzy Konorski* (pp. 233–268). New York: Psychology Press.

Boutelle, K. N., & Bouton, M. E. (2015). Implications of learning theory for developing programs to decrease overeating. *Appetite, 93*, 62–74.

Boyland, E. J., & Halford, J. C. G. (2013). Television advertising and branding: Effects on eating behaviour and food preferences in children. *Appetite, 62*, 236–241.

Boyland, E. J., Harrold, J. A., Kirkham, T. C., & Halford, J. C. G. (2012). Persuasive techniques used in television advertisements to market foods to UK children. *Appetite, 58*, 658–664.

Castellanos, E. H., Charboneau, E., Dietrich, M. S., Park, S., Bradley, B. P., Mogg, K., & Cowan, R. L. (2009). Obese adults have visual attention bias for food cue images: Evidence for altered reward system function. *International Journal of Obesity, 33*, 1063–1073.

Colagiuri, B., & Lovibond, P. F. (2015). How food cues can enhance and inhibit motivation to obtain and consume food. *Appetite, 84*, 79–87.

Colwill, R. M., & Rescorla, R. A. (1988). Associations between the discriminative stimulus and the reinforcer in instrumental learning. *Journal of Experimental Psychology: Animal Behavior Processes, 14*, 155–164.

Connor, S. M. (2006). Food-related advertising on preschool television: Building brand recognition in young viewers. *Pediatrics, 118*, 1478–1485.

Corbit, L. H., & Balleine, B. W. (2005). Double dissociation of basolateral and central amygdala lesions on the general and outcome-specific forms of Pavlovian-instrumental transfer. *Journal of Neuroscience, 25*, 962–970.

Corbit, L. H., & Balleine, B. W. (2011). The general and outcome-specific forms of Pavlovian-instrumental transfer are differentially mediated by the nucleus accumbens core and shell. *Journal of Neuroscience, 31*, 11786–11794.

Corbit, L. H., Fischbach, S. C., & Janak, P. H. (2016). Nucleus accumbens core and shell are differentially involved in general and outcome-specific forms of Pavlovian-instrumental transfer with alcohol and sucrose rewards. *European Journal of Neuroscience, 43*, 1229–1236.

Craske, M. G., Wolitzky-Taylor, K. B., Mineka, S., Zinbarg, R., Waters, A. M., Vrshek-Schallhorn, S., ... Ornitz, E. (2012). Elevated responding to safe conditions as a specific risk factor for anxiety versus depressive disorders: Evidence from a longitudinal investigation. *Journal of Abnormal Psychology, 121*, 315–324.

Crone, E. A., Jennings, J. R., & van der Molen, M. W. (2004). Developmental change in feedback processing as reflected by phasic heart rate changes. *Developmental Psychology, 40*, 1228–1238.

Crone, E. A., & van der Molen, M. W. (2004). Developmental changes in real life decision making: Performance on a gambling task previously shown to depend on the ventromedial prefrontal cortex. *Developmental Neuropsychology, 25*, 251–279.

Deckelbaum, R. J., & Williams, C. L. (2001). Childhood obesity: The health issue. *Obesity, 9*(Suppl. 4), 239S–243S.

Delamater, A. R. (1996). Effects of several extinction treatments upon the integrity of Pavlovian stimulus-outcome associations. *Animal Learning & Behavior, 24*, 437–449.

Dickinson, A., & Balleine, B. W. (2002). The role of learning in the operation of motivation systems. In H. Pashler & C. R. Gallistel (Eds.), Steven's handbook of experimental psychology, Vol. 3: Learning, motivation, and emotion (3rd ed., pp. 497–533). New York: John Wiley.

Eder, A. B., & Dignath, B. (2016). Cue-elicited food seeking is eliminated with aversive outcomes following outcome devaluation. *Quarterly Journal of Experimental Psychology, 69*, 574–588.

Eppinger, B., Mock, B., & Kray, J. (2009). Developmental differences in learning and error processing: Evidence from ERPs. *Psychophysiology, 46*, 1043–1053.

Folkvord, F., Anschütz, D. J., & Buijzen, M. (2016). The association between BMI development among young children and (un) healthy food choices in response to food advertisements: A longitudinal study. *International Journal of Behavioral Nutrition and Physical Activity, 13*, 16.

Garbusow, M., Schad, D. J., Sebold, M., Friedel, E., Bernhardt, N., Koch, S. P., ... Heinz, A. (2016). Pavlovian-to-instrumental transfer effects in the nucleus accumbens relate to relapse in alcohol dependence. *Addiction Biology, 21*, 719–731.

Glenn, C. R., Klein, D. N., Lissek, S., Britton, J. C., Pine, D. S., & Hajcak, G. (2012). The development of fear learning and generalization in 8–13 year-olds. *Developmental Psychobiology, 54*, 675–684.

Hämmerer, D., Li, S. C., Müller, V., & Lindenberger, U. (2010). Life Span Differences in Electrophysiological Correlates of Monitoring Gains and Losses during Probabilistic Reinforcement Learning. *Journal of Cognitive Neuroscience, 23*(3), 579–592. https://doi.org/10.1162/jocn.2010.21475.

Hendrikse, J. J., Cachia, R. L., Kothe, E. J., McPhie, S., Skouteris, H., & Hayden, M. J. (2015). Attentional biases for food cues in overweight and individuals with obesity: A systematic review of the literature. *Obesity Reviews, 16*, 424–432.

Holland, P. (2004). Relations between Pavlovian-instrumental transfer and reinforcer devaluation. *Journal of Experimental Psychology: Animal Behavior Processes, 30*, 104–117. https://doi.org/10.1037/0097-7403.30.2.104.

Holmes, N. M., Marchand, A. R., & Coutureau, E. (2010). Pavlovian to instrumental transfer: A neurobehavioural perspective. *Neuroscience and Biobehavioral Reviews, 34*, 1277–1295.

Jansen, A., Theunissen, N., Slechten, K., Nederkoorn, C., Boon, B., Mulkens, S., & Roefs, A. (2003). Overweight children overeat after exposure to food cues. *Eating Behaviors, 4*, 197–209.

Jovanovic, T., Nylocks, K. M., Gamwell, K. L., Smith, A., Davis, T. A., Norrholm, S. D., & Bradley, B. (2014). Development of fear acquisition and extinction in children: Effects of age and anxiety. *Neurobiology of Learning and Memory, 113*, 135–142.

Konorski, J. (1967). *Integrative activity of the brain: An interdisciplinary approach*. Chicago: University of Chicago Press.

Koolschijn, P. C. M. P., Schel, M. A., de Rooij, M., Rombouts, S. A. R. B., & Crone, E. A. (2011). A three-year longitudinal functional magnetic resonance imaging study of performance monitoring and test-retest reliability from childhood to early adulthood. *Journal of Neuroscience, 31*, 4204–4212.

Kruse, J. M., Overmier, J. B., Konz, W. A., & Rokke, E. (1983). Pavlovian conditioned stimulus effects upon instrumental choice behavior are reinforcer specific. *Learning and Motivation, 14*, 165–181.

Lamb, R. J., Ginsburg, B. C., & Schindler, C. W. (2017). Conditioned stimulus form does not explain failures to see Pavlovian-instrumental-transfer with ethanol-paired conditioned stimuli. *Alcoholism: Clinical and Experimental Research, 41*, 1063–1071.

Lau, J. Y., Britton, J. C., Nelson, E. E., Angold, A., Ernst, M., Goldwin, M., ... Pine, D. S. (2011). Distinct neural signatures of threat learning in adolescents and adults. *Proceedings of the National Academy of Sciences of the United States of America, 108*, 4500–4505.

Lehner, R., Balsters, J. H., Herger, A., Hare, T. A., & Wenderoth, N. (2017). Monetary, food, and social rewards induce similar Pavlovian-to-instrumental transfer effects. *Frontiers in Behavioral Neuroscience, 10*. https://doi.org/10.3389/fnbeh.2016.00247.

Liberman, L. C., Lipp, O. V., Spence, S. H., & March, S. (2006). Evidence for retarded extinction of aversive learning in anxious children. *Behaviour Research and Therapy, 44*, 1491–1502.

Lovibond, P. F., & Colagiuri, B. (2013). Facilitation of voluntary goal-directed action by reward cues. *Psychological Science, 24*, 2030–2037.

Morris, R. W., Quail, S., Griffiths, K. R., Green, M. J., & Balleine, B. W. (2015). Corticostriatal control of goal-directed action is impaired in schizophrenia. *Biological Psychiatry, 77*, 187–195.

Nadler, N., Delgado, M. R., & Delamater, A. R. (2011). Pavlovian to instrumental transfer of control in a human learning task. *Emotion, 11*, 1112–1123.

Nederkoorn, C., Smulders, F. T. Y., & Jansen, A. (2000). Cephalic phase responses, craving and food intake in normal subjects. *Appetite, 35*, 45–55.

Neumann, D. L., Waters, A. M., & Westbury, H. R. (2008). The use of an unpleasant sound as the unconditional stimulus in aversive Pavlovian conditioning experiments that involve children and adolescent participants. *Behavior Research Methods, 40*, 622–625.

Paredes-Olay, C., Abad, M. J. F., Gámez, M., & Rosas, J. M. (2002). Transfer of control between causal predictive judgments and instrumental responding. *Animal Learning & Behavior, 30*, 239–248.

Peirce, J. W. (2007). PsychoPy—Psychophysics software in Python. *Journal of Neuroscience Methods, 162*, 8–13.

Quail, S. L., Morris, R. W., & Balleine, B. W. (2017). Stress associated changes in Pavlovian-instrumental transfer in humans. *Quarterly Journal of Experimental Psychology, 70*, 675–685.

Quezada, V., Alarcón, D., Miguez, G., & Betancourt, R. (2009). Aumento de la conducta operante tras la presentación de estímulos condicionados asociados al efecto del etanol. *Revista de Psicología, 18*(2), 65–79.

Rescorla, R. A., & Solomon, R. L. (1967). Two-process learning theory: Relationships between Pavlovian conditioning and instrumental learning. *Psychological Review, 74*, 151–182.

Robinson, T. E., & Berridge, K. C. (1993). The neural basis of drug craving: An incentive-sensitization theory of addiction. *Brain Research Reviews, 18*, 247–291.

Rodin, J. (1985). Insulin levels, hunger, and food intake: An example of feedback loops in body weight regulation. *Health Psychology, 4*(1), 1–24.

Saddoris, M. P., Stamatakis, A., & Carelli, R. M. (2011). Neural correlates of Pavlovian-to-instrumental transfer in the nucleus accumbens shell are selectively potentiated following cocaine self-administration. *European Journal of Neuroscience, 33*, 2274–2287.

Seabrook, T., Hogarth, L., & Mitchell, C. J. (2016). The propositional basis of cue-controlled reward seeking. *Quarterly Journal of Experimental Psychology, 69*, 2452–2470.

Story, M., & French, S. (2004). Food advertising and marketing directed at children and adolescents in the US. *International Journal of Behavioral Nutrition and Physical Activity, 1*, 3.

Talmi, D., Seymour, B., Dayan, P., & Dolan, R. J. (2008). Human Pavlovian instrumental transfer. *Journal of Neuroscience, 28*, 360–368.

Trapold, M. A., & Overmier, J. B. (1972). The second process in instrumental learning. In A. H. Black & W. F. Prokasy (Eds.), *Classical conditioning II: Current research and theory* (pp. 427–452). New York: Appleton–Century–Crofts.

Uribe, R., & Fuentes-García, A. (2015). The effects of TV unhealthy food brand placement on children: Its separate and joint effect with advertising. *Appetite, 91*, 165–172.

Wardle, J. (1990). Conditioning processes and cue exposure in the modification of excessive eating. *Addictive Behaviors, 15*, 387–393.

Waters, A. M., Henry, J., & Neumann, D. L. (2009). Aversive Pavlovian conditioning in childhood anxiety disorders: Impaired response inhibition and resistance to extinction. *Journal of Abnormal Psychology, 118*, 311–321.

Waters, A., Theresiana, C., Neumann, D., & Craske, M. (2017). Developmental differences in aversive conditioning, extinction, and reinstatement: A study with children, adolescents, and adults. *Journal of Experimental Child Psychology, 159*, 263–278.

Watson, P., Wiers, R. W., Hommel, B., & de Wit, S. (2014). Working for food you don't desire: Cues interfere with goal-directed food-seeking. *Appetite, 79*, 139–148.

Weber, K., Story, M., & Harnack, L. (2006). Internet food marketing strategies aimed at children and adolescents: A content analysis of food and beverage brand web sites. *Journal of the American Dietetic Association, 106*, 1463–1466.

Werthmann, J., Roefs, A., Nederkoorn, C., Mogg, K., Bradley, B. P., & Jansen, A. (2011). Can(not) take my eyes off it: Attention bias for food in overweight participants. *Health Psychology, 30*, 561–569.