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BRIEF REPORT

Outcome-Specific and General Pavlovian-to-Instrumental Transfers Involving Sexual Rewards

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Outcome-specific and general Pavlovian-to-instrumental transfers (PIT) affect our everyday decision-making behavior in 2 ways. Upon the perception of a reward-paired cue, the former selects and determines the direction of the action performed to obtain the reward, whereas the latter determines the vigor with which the action is performed. In the present study, we aimed to validate a paradigm to successfully measure both of these motivational biases toward cues associated with sexual rewards. Within the same paradigm and participants, we demonstrated the existence of outcome-specific PIT, in which participants mobilized more effort for the action associated with a specific sexual reward in the presence of its paired cue, as well as the existence of general PIT, in which participants mobilized more effort for any action associated with a sexual reward in the presence of sexual reward-paired cues than in the presence of a neutral cue. These findings contribute to the literature by providing a paradigm that could potentially help to better understand sexual desire and develop therapeutic interventions for people suffering from sexual desire disorders.

Keywords: outcome-specific motivation, general motivation, sexual rewards, Pavlovivan-to-instrumental task, decision-making

Every day, we are inundated with a colossal amount of information, some of which can influence our decision-making behavior (e.g., Sennwald et al., 2016). For instance, when an individual perceives a cue (e.g., a restaurant logo) that has previously been associated with a

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rewarding experience (e.g., eating a delicious meal), it will influence the action they take (e.g., walking to the restaurant). These Pavlovian-to-instrumental transfers (PIT), in which a Pavlovian cue influences an instrumental action, have been suggested to take two forms: outcome-specific and general (Dickinson & Balleine, 2002). While outcome-specific PIT selects and energizes the instrumental action leading to the reward associated with the perceived cue, general PIT determines the vigor with which the action is performed, independently of the specific outcome involved (Corbit & Balleine, 2011; Prévost, Liljeholm, Tyszka, & O'Doherty, 2012).

Experimental protocols investigating these types of motivational biases are fundamental in understanding human decision making given reward-paired cues' ability to affect adaptive and maladaptive behavior such as addiction (e.g., Hogarth, Balleine, Corbit, & Killcross, 2013). Recently there has been a growing interest in adapting this paradigm to a human population (see Cartoni, Balleine, & Baldassarre, 2016 for a review); however, only a few experimental designs have successfully measured both types of transfers within the same paradigm (e.g., Morris, Quail, Griffiths, Green, & Balleine, 2015; Prévost et al., 2012). Thus far, studies have not been able to consistently demonstrate the existence of general PIT (Jeffs & Duka, 2017). Therefore, more data and particularly more replications of the existing findings are required to validate a suitable paradigm to measure both biases behaviorally.

Moreover, human research has mainly investigated cues associated with food, drink, social, and monetary rewards (e.g., Eder & Dignath, 2016; Jeffs & Duka, 2017; Lehner, Balsters, Herger, Hare, & Wenderoth, 2017; Pool, Brosch, Delplanque, & Sander, 2015). Given the importance of sexuality on subjective well-being and life satisfaction (Schmiedeberg, Huyer-May, Castiglioni, & Johnson, 2017) and that sexual stimuli are one of the strongest types of rewards to exert influence on human cognition (e.g., Pool et al., 2015; Sennwald et al., 2016), it is crucial to validate a paradigm investigating both types of PIT to further understand variations of the intensity of sexual desire and to help develop appropriate therapeutic interventions in the future.

Accordingly, the present article aimed to disentangle outcome-specific and general PIT using sexual rewards. To that end, we adapted a paradigm (Prévost et al., 2012) to measure the influence both of specific sexual reward-related Pavlovian cues on their associated instrumental actions and of any sexual reward-related Pavlovian cue on any instrumental action available, within the same participants. We hypothesized that in the presence of sexual reward-related cues participants would increase the number of responses for the corresponding instrumental actions rather than for the incompatible actions available in outcome-specific PIT. Additionally, we postulated that participants would increase the number of responses for any sexual reward-related cue over a cue associated with a neutral outcome in general PIT.

Method

Population

Sixty heterosexual men[1] between the ages of 18 and 35 (M sexual orientation sum $= 0.23$, $SD = 1.00$; M age $= 24.31$, $SD = 4.26$) were recruited from the University of Geneva. Throughout this study, we have complied with all relevant ethical regulations, and the regional ethics committee in Geneva approved the study protocol.

Materials

Five complex geometric figures rated as equally neutral were utilized as Pavlovian stimuli (taken from Pool et al., 2015). The association between each geometric shape and Pavlovian identity (e.g., CS1+, CS2+, CS3+, and CS4+) was counterbalanced across participants. The unconditioned stimuli consisted of four images (three different erotic images of women and a scrambled image) chosen by each participant from a set of 36 images (256×384 pixels) composed of 24 images of partially or completely nude women and 12 scrambled images.

[1] The planned sample size was motivated by a power analysis conducted with G*Power (Faul, Erdfelder, Buchner, & Lang, 2013). The effect size of interest we focused on was the general motivation effect. This effect ($dz = 0.403$) was extracted from Prévost et al., (2012). The analysis revealed that a sample size of 55 participants was required to obtain a power of 90% for a one-tailed test, which we rounded up to 60.

Procedure

Participants first rated erotic images and then underwent an adapted version of the PIT task (Prévost et al., 2012) consisting of an instrumental, a Pavlovian, and a PIT phase.

Liking. Participants were asked to rate how much they liked seeing each of the 24 erotic pictures of women and the 12 scrambled images on a visual analogue scale (ranging from 1 *not at all* to 100 *extremely*). The three highest rated images that were also as closely liked as possible were selected as well as the scrambled image rated the most closely to 50. They were then used in the following PIT task.

Instrumental phase. During this phase, participants learned to associate three specific actions (R1, R2, and R3) with three distinct rewarding outcomes (O1, O2, and O3). Participants were asked to freely press on two of three available keys to remove a gray patch and reveal the image associated with the key pressed. Only two of three responses were available during each trial, and two gray squares at the bottom of the screen indicated which keys they could press to trigger the presentation of the erotic images. Each time they pressed on one of the available keys, the corresponding gray square flashed blue for 50 ms. As in Prévost et al. (2012), the responses were rewarded on a random ratio schedule of 0.1, so that an erotic image was revealed once every time a key was pressed a random number of times between 5 and 15 times. If participants pressed enough times, the erotic image was revealed for 1 second. Each trial lasted 6 seconds, followed by an intertrial interval (ITI) of 2–6 seconds. Depending on the participants' key pressing performance, they could potentially trigger the apparition of the images multiple times. The gray patch and the images were presented on either the left or right side of the screen with a geometrical figure on the other side. The geometrical figure was not predictive of any outcome and was present for all trials. The image's location was constant across the phases, but was counterbalanced across participants. There were three different trial types presented 10 times each for a total of 30 trials (see Table 1). Prior to the task, participants underwent instrumental training consisting of 2 trials per trial type to familiarize them with the task. The association between the images and keys was pseudorandomized across participants. Participants used their dominant hand to perform this task.

To ensure they understood the contingencies, participants were asked to indicate which key

Table 1
Configuration of the Instrumental Learning, Pavlovian Conditioning, and Transfer Trials

Phase	Number of trials	Pavlovian cue	Instrumental response		Outcome	
Instrumental learning	10		R1	R2	O1	O2
			R1	R3	O1	O3
			R2	R3	O2	O3
Pavlovian conditioning	10	CS1+			O1	
		CS2+			O2	
		CS3+			O3	
		CS4+			O4	
PIT—outcome specific	5	CS1+	R1	R2		
		CS1+	R1	R3		
		CS2+	R1	R2		
		CS2+	R2	R3		
		CS3+	R1	R3		
		CS3+	R2	R3		
PIT—general trials	10	CS1+	R2	R3		
		CS2+	R1	R3		
		CS3+	R1	R2		
PIT—neutral trials	10	CS4+	R1	R2		
		CS4+	R1	R3		
		CS4+	R2	R3		

Note. R = instrumental response; O = outcome; CS = conditioned stimulus.

was associated with which image at the end of this phase.

Pavlovian phase. Participants learned to associate four complex geometric figures with the three erotic images (CS1+, CS2+, and CS3+) and the scrambled image (CS4+). For each type of trial, a gray patch was presented on one side of the screen and a complex geometrical figure on the other. Participants were asked to learn which image was associated with which geometrical figure. They were instructed to press as quickly as possible on the right or left click of the mouse, with their nondominant hand, to reveal which image was present under the patch. Participants were clearly told that their performance was solely an indication of attention and that there was no link between their performance and the displayed images. Moreover, it was emphasized that even if they did not click on the mouse, the image would nevertheless appear after 5 seconds into the trial. Each trial lasted 6 seconds and was followed by a 2- to 6-second ITI. There were 10 trials for each association for a total of 40 trials (see Table 1). The associations between the geometric figures and the images as well as the trial order were randomized across participants. Pavlovian training consisting of 4 randomized trials, one of each type, was performed prior to the task.

After the Pavlovian conditioning task, to ensure participants learned the associations, they had to rate how pleasant they found the conditioned stimuli (CSs) on a visual analogue scale (ranging from 0 *not at all* to 100 *extremely*) and to indicate which CSs were associated with which images. More specifically, for the latter task, participants were shown the images one by one with the four CSs presented underneath at the same time. They were asked to click on the CS that was associated with the image.

PIT phase. During the PIT phase, the effects of the Pavlovian cues (CS1+, CS2+, CS3+, and CS4+) on the instrumental actions (R1, R2, and R3) the participants have learned in the first two phases were measured. Each trial consisted of a gray patch on either the left or right side of the screen, indicating where the image would appear, and a Pavlovian cue on the other side. Once more, participants were asked to freely press the two available responses for each trial, indicated by two gray squares at the bottom of the screen. To assess the effect of the Pavlovian cues on the instrumental actions without the confounding effects of the actual outcomes, this task was administered under extinction. The participants were fully aware they would not see any images during this phase, however, to ensure that their motivation was not affected, they were told that at the end of the experiment they would be able to see the images they had triggered during the task.

There were three different types of trials: outcome-specific, general, and neutral trials. In the outcome-specific trials, participants were expected to press more on the response that was previously associated with the rewarding outcome corresponding to the Pavlovian cue present during that trial. For instance, in the presence of the CS1+, participants were expected to press more on response 1 (R1) to trigger the apparition of the image associated with both that key and the geometric shape than the second available answer such as response 2 (R2). There were 6 subtypes of trials (see Table 1). Moreover, the subtypes of trials were pooled together and the trials in which participants correctly pressed more on the compatible key were differentiated from the trials in which the participants incorrectly pressed more on the incompatible key. There were 5 trials of each subtype for a total of 30 outcome-specific trials. In the general trials, a Pavlovian cue not compatible with any of the responses available was present. For example, when CS2 + was displayed, the keys associated with the other rewarding outcomes were available (R1 and R3). There were three subtypes of general trials (see Table 1), and 10 trials of each subtype were presented for a total of 30 general trials. As for neutral trials, the Pavlovian cue associated with the scrambled image was presented in three subtypes of trials (see Table 1), and 10 trials of each subtype were presented for a total of 30 neutral trials. Overall, there were 90 trials presented, which were randomized during this phase and across participants.

Results

For the analyses, we used repeated measures analysis of variance (ANOVA) and one-tailed planned contrasts where hypotheses were tested. Paired t tests with multiple comparisons were corrected using the Bonferroni correction. Effect sizes were measured as Cohen's d (d) for the planned contrasts.

Liking

The three erotic images of the women that were selected for the PIT task were liked by the participants (t tests comparing the mean to 0, all $ps < .001$; M woman image 1 = 93.05, SD = 10.13; M woman image 2 = 91.05, SD = 10.76; M woman image 3 = 89.61, SD = 11.34). Moreover, all the woman images were statistically more liked than the scrambled image (all $ps < .001$ and corrected for multiple comparisons; M scrambled image = 28.48, SD = 21.69), indicating the erotic images were more rewarding than the scrambled image.

Instrumental Conditioning

To assess whether participants were similarly motivated to obtain all three rewards, a repeated-measures ANOVA was conducted on the number of presses during the three trial subtypes, revealing a statistically nonsignificant effect across the three response-outcome pairs, $F(2, 118) = 0.22$, $p = .800$ (see Figure 1A). Additionally, the number of presses participants exerted on each key was not statistically significantly different, $F(2, 118) = 1.35$, $p = .262$, suggesting participants were both similarly motivated to obtain the rewards across subtypes of trials and each individual reward. Furthermore, on average participants were correct 86.67% of the time (SD = 30.81) about the associations between the keys and the images, which is significantly above chance (t test comparing the mean to 50%, $t(59) = 9.22$, $p < .001$, $d = 1.19$, 95% CI [78.708, 94.625]), suggesting participants successfully learned the specific actions associated with the images.

Pavlovian Conditioning

For the keypress task, the results revealed that participants were statistically quicker to trigger the apparition of the erotic images associated with CS1+ and CS3+ than to trigger the apparition of the scrambled image associated

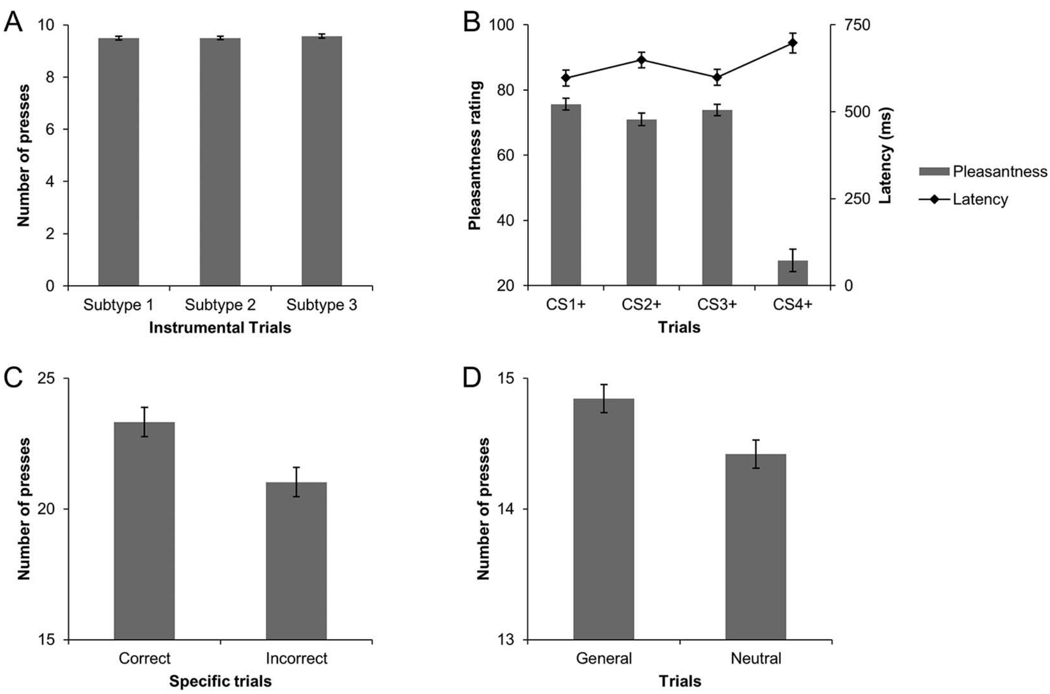

Figure 1. (A) Number of presses for each subtype of trial in the instrumental phase. (B) Pleasantness rating and reaction time (RT; ms) for each CS in the Pavlovian phase. (C) Number of presses for the correct versus the incorrect trials in the outcome-specific trials. (D) Number of presses for the general trials and the neutral trials. Error bars represent SEM (95%) adjusted for within design.

with CS4+ (paired *t* tests corrected for multiple comparisons, all *p*s $< .05$; *M* CS1+ = 596.93 ms, *SD* = 274.03 ms; *M* CS3+ = 598.64 ms, *SD* = 285.34 ms; *M* CS4+ = 697.54 ms, *SD* = 472.46 ms; see Figure 1B). However, the comparison between CS2+ and CS4+ was not significant after correcting for multiple comparisons ($p > .05$; *M* CS2+ = 648.81 ms, *SD* = 400.33 ms). Moreover, the CSs associated with the erotic images were statistically significantly rated as more pleasant than the CSs associated with the scrambled image (paired *t* tests corrected for multiple comparisons, all *p*s $< .001$; *M* CS1+ = 75.63, *SD* = 21.38; *M* CS2+ = 70.98, *SD* = 23.50; *M* CS3+ = 73.85, *SD* = 21.83; *M* CS4+ = 27.71, *SD* = 27.72; see Figure 1B). Additionally, participants were on average 92.92% accurate when determining which images were associated with which geometric shape (*t* test comparing mean to 50%, $t(59) = 20.77$, $p < .001$, $d = 2.68$, 95% CI [88.782, 97.051]). These findings indicate participants successfully learned the associations between images and geometric figures.

PIT Effects

First, outcome-specific motivation was measured by comparing the specific trials in which participants pressed more on the specific key associated with the displayed CS to the trials in which they pressed more on the incompatible keys. The results showed that participants statistically significantly pressed more on the compatible key ($M = 23.33$, $SD = 6.91$) in the presence of the rewarding associated CS than on the incompatible keys ($M = 21.03$, $SD = 8.41$; $t(59) = 2.07$, $p = .022$, $d = 0.30$, 95% CI [−0.587, −0.009]; see Figure 1C), thereby providing evidence of successful induction of outcome-specific motivation.

Second, general motivation was measured by comparing the number of presses on any action during the presentation of the CSs incompatible with the keys available to the number of presses for any action in the neutral trials during which the CS associated with the scrambled image was displayed. Participants statistically significantly pressed more on any action during the presentation of the noncompatible rewarding CSs ($M = 14.84$, $SD = 3.28$) than during the presentation of the CS4+ ($M = 14.42$, $SD = 3.29$; $t(59) = 1.97$, $p = .027$, $d = 0.13$, 95% CI [−0.260, 0.002]; see Figure 1D), indicating a successful induction of general motivation.

Discussion

In the present study, we adapted a paradigm to measure both outcome-specific and general PIT within the same participants (Prévost et al., 2012), using sexual rewards-related cues. In line with previous research, outcome-specific and general PIT were successfully measured in humans (e.g., Morris et al., 2015; Prévost et al., 2012). Participants mobilized more effort to perform the actions compatible with sexual reward-related cues presented, and they also increased the vigor with which they performed the actions upon the perception of any cue associated with a sexual reward over a neutral cue. More generally, although the effect size of the general motivation was small, these findings crucially replicate the usage of this paradigm both to measure motivational biases and to provide a useful tool to further investigate their influence on adaptive and maladaptive behaviors. Indeed, we replicated Prévost et al.'s (2012) behavioral findings specifically using sexual rewards instead of food, thereby demonstrating that this paradigm could potentially be suitable to measure PIT transfers using different types of rewards. Given the importance of, and the growing interest in, studying how motivational biases affect our behavior, this paradigm could prove to be highly fruitful and well worth adapting for all different areas of reward processing.

More specifically for our area of interest, this adapted paradigm using sexual rewards could be used to better understand the underlying mechanisms in the variations of sexual desire and could potentially help differentiate how the outcome-specific and general PIT contribute to sexual reward-seeking behaviors. Importantly, this study was only a first step in exploring sexual desire through this adapted paradigm. Future research should take into consideration more variables that can influence one's motivation to obtain a sexual reward, such as an individual's current sexual needs (e.g., sexual satiety) or their level of arousal at the time of the experiment, to see how they influence outcome-specific and general motivation. Additionally, the population recruited for this study was very restricted; it is therefore crucial to explore the influence of motivational biases in other populations. Recently, it has been shown that the current concerns of an individual, such as their sexual orientation, underlies effort mobilization in a PIT task and that one's subjective experience of their sexuality can be linked to their effort mobilization in obtaining a sexual reward in the presence of an associated cue (Sennwald et al., 2019). Consequently, investigating sexual reward-related Pavlovian cues' multiple influences on instrumental actions could potentially help better understand variations of sexual desire as well as help develop new therapeutic interventions targeting these motivational biases in sexual desire disorders.

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