OFFSET-CONTROL ATTENUATES CONTEXT CONDITIONING INDUCED BY US-UNPREDICTABILITY IN A HUMAN CONDITIONED SUPPRESSION PARADIGM

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We investigated whether offset-control of the unconditioned stimulus (US) reduces context conditioning induced by US-unpredictability within a human conditioned suppression preparation. We also examined lack of control *vs.* loss of control. Three groups (No Controllability, NC; Controllability, C; Loss of Controllability, LC) received unsignaled USs during two learning phases (ACQ1-2). The NC group, never had offset-control, whereas the C group, always had offset-control. The LC group, had offset-control during ACQ1, but not during ACQ2. Results indicated that US-unpredictability led to contextual conditioned suppression during ACQ1, only when participants did not have offset-control; when they did, no context conditioning was established. From ACQ1 to ACQ2, contextual conditioned suppression increased in the LC group, but it was not more pronounced than in the NC group. These data suggest that offset-control attenuates context conditioning induced by US-unpredictability and – at least in this paradigm – loss of control is not worse than lack of control.

Introduction

In general, the ability to predict important life events allows an organism to prepare adequately for upcoming events and sometimes even control (e.g., escape/avoid or approach) them (Dickinson, 1980; Hollis, 1997). When important life events are unpredictable, however, an organism cannot initiate proper preparatory responses. A large number of animal studies demonstrates that exposure to unpredictable stressors evokes more negative emotional consequences, such as generalised anxiety and enhanced autonomic responding, than exposure to identical predictable stressors (Abbott, Schoen, & Badia,

1984; Mineka, Cook, & Miller, 1984; Rosellini, Warren, & DeCola, 1987). Furthermore, impaired performance after exposure to unpredictable stressors and preference for predictability have been often reported both in animals (Fanselow, 1980) and in humans (Craske, Glover, & DeCola, 1995; Lejuez, Eifert, Zvolensky, & Richards, 2000).

Contemporary models of classical conditioning provide a rich theoretical framework to understand the emotional and behavioural/motivational disruption induced by unpredictable stressors. In particular, these effects can be attributed to context conditioning (Fanselow, 1980; Odling-Smee, 1975). In a typical cued fear conditioning experiment, an unconditioned stimulus (US) and a conditioned stimulus (CS) are repeatedly presented together. After a few paired CS-US presentations, the initially neutral CS will start to elicit conditioned fear responding in anticipation of the US. Associative learning models assume that the formation of an excitatory CS-US association underlies such cued fear responses (Rescorla & Wagner, 1972). Likewise, a context in which unpredictable shocks are administered acquires associative strength and therefore evokes more contextual fear and thus chronic (i.e., long-lasting) conditioned fear than a context in which predictable shocks are presented (Balsam & Tomie, 1985; Meulders, Vervliet, Fonteyne, Baeyens, Hermans, & Vansteenwegen, 2012; Vansteenwegen, Iberico, Vervliet, Marescau, & Hermans, 2008).

Experimental research devoted to context conditioning in humans is rather scant and is largely restricted to fear conditioning experiments. Important pioneer work by Grillon stimulated the research interest in this topic (Grillon, 2002). In a between-subjects paradigm (Grillon & Davis, 1997), one group of participants received paired presentations of a light-CS and a shock-US (predictable group), whereas another group received explicitly unpaired CS-US presentations (unpredictable group). Basically, results corroborated the animal conditioning findings, that is, the unpredictable experimental context elicited more contextual fear responding compared to the predictable context in an immediate test as well as in a test after a retention interval (Grillon & Davis, 1997). Vansteenwegen and co-workers (Iberico, Vansteenwegen, Vervliet, Dirikx, Marescau, & Hermans, 2008; Vansteenwegen et al., 2008) subsequently replicated and extended these findings in an elegant within-subjects design. Recently, Meulders, Vervliet, Vansteenwegen, Hermans, and Baeyens (2011) replicated the basic findings of Grillon and Vansteenwegen in a human conditioned suppression paradigm and they added an important feature to the procedure, more precisely, a US-only group. A US-only manipulation typically comprises the presentation of temporally unpredictable, unsignaled USs in absence of any predictors for their occurrence or absence. In other words, USs are presented temporally unpredictable and without any cue signalling their occurrence just like in an explicitly unpaired

manipulation, but also safety signals indicating the non-occurrence of the US are omitted. In human fear conditioning research, unpredictable aversive experiences are commonly modelled by delivering shocks and CSs in an explicitly unpaired manner (Fonteyne, Vervliet, Hermans, Baeyens, & Vansteenwegen, 2010; Grillon, 2002; see Meulders et al., 2012, for an exception). In animal research, however, US-only presentations are typically used to produce US-unpredictability (e.g., Fanselow, 1980). According to the safety signal hypothesis (Seligman & Binik, 1977), the identification of safety signals (present in the unpaired procedure, but not in the US-only procedure) might be able to reduce context conditioning because they offer a short period of relief. In line with this hypothesis, Meulders et al. (2011) showed that the US-only manipulation yielded higher levels of context conditioning as compared with the unpaired manipulation – at least in a between-subjects design.

Given the empirical evidence that has accumulated to support the notion that US-unpredictability induces context conditioning and a myriad of negative emotional consequences, one might wonder how these emotional disturbances might be alleviated. One possible way to counter the debilitating effects of US-unpredictability might be, to offer the opportunity to terminate the negative effects of the US (i.e., offset-control). Previous research indeed showed that offset-control over a series of unsignaled 20% CO_2 inhalations reduced self-reported anxiety and intense panic experiences in individuals with high levels of suffocation fear (Zvolensky, Lejuez, & Eifert, 1998). Therefore, in the present paper, we focus on the intriguing question of what happens when USs are presented unpredictable (US-only procedure) but their negative consequences can be controlled (offset-control). More specifically, we address the question whether unpredictable USs still produce context conditioning if their adverse consequences can be terminated.

Research also indicates that a lack of control over aversive stimuli often results in negative emotional responding evidenced by elevated psychological arousal and catastrophic cognitions (Sanderson, Rapee, & Barlow, 1989). Catastrophic cognitions refer to chronic anticipation and expectations of catastrophic outcomes, that is, continuously having the idea that something bad is going to happen, impeding the ability to relax and feel safe. Loss of control over aversive events is even more detrimental (in terms of elevated autonomic responding, emotional disturbance and impaired performance) than lack of control (Crombez, Eccleston, De Vlieger, Van Damme, & De Clercq, 2008; Zvolensky, Eifert, Lejuez, & McNeil, 1999). Because the few studies on this topic applied biologically potent USs (e.g., painful shock and 20% CO_2 inhalation) our second aim was to explore whether loss of control would also have a larger impact on performance than mere lack of control when biologically non-significant, instructional USs are used.

We predicted that: a) US-unpredictability induces context conditioning in the group without offset-control, but not in the groups having offset-control, and that b) loss of offset-control in the group that previously had control leads to more context conditioning compared with the group that never had any control at all. Furthermore, the response patterns for the group that always had control or never had control are not expected to change during the experiment.

Method

Participants

Thirty undergraduate psychology students (14 males and 16 females, mean age in years = 19, ranging from 18-23) participated in this study in return for course credit. None of them had previous experience with the Martians preparation, and they were all uninformed with respect to the purpose of the experiment. All participants were randomly assigned to one of the three experimental groups: No Controllability (NC) group, Loss of Controllability (LC) group or Controllability (C) group.

Apparatus, software, and stimuli

The experimental procedure (referred to as the Martians task) was implemented within a flexible Windows 95 environment by Baeyens and Clarysse (1998) using Microsoft Visual C++ 5.0. The experiment was run on a Pentium III 730 MHz, 128 Mb RAM multimedia PC (Dell Optiplex GX110); participants responded on the spacebar and the escape button of the computer keyboard.

The US consisted of the simultaneous presentation of a 0.5-s white flashing screen (5 flashes at a rate of 10 flashes/s; flash-time = 50 ms, inter-flash-time = 50 ms) accompanied by a metallic sound (Windows^{TM} 95 "In the computer program error.wav"). Auditory stimuli were played back in continuous looping and presented in stereo at 85 dB through a Typhoon^{TM} Bass Vibration Headset. Following the procedure of Meulders et al. (2011), context was manipulated by changing the background colour of the computer screen. During the pretraining, the baseline measurement, the instructional US phase, and the control instruction phase the background colour remained black, but during the context conditioning phase it was coloured pink.

Procedure

In the present study, we employed the US-only procedure described by Meulders et al. (2011) to establish US-unpredictability in all experimental groups. In order to manipulate offset-control, a *control button*[1] was introduced as a means to terminate the negative consequences of the US. Conditioned suppression was assessed as an index of context conditioning. Three between-subjects groups were included: the No Controllability (NC), the Controllability (C), and the Loss of Controllability (LC) groups. The experiment consisted of five phases: the pretraining, the baseline assessment, the instructional US phase, offset-control instruction phase and the context conditioning phase. Note that the pretraining phase, the instructional US phase, and offset-control instruction phase served to practice the operant task (i.e., bar-pressing) and to instruct participants about the effects of the US and the control button, whereas the context conditioning phase was the actual learning phase with intermittent test trials after each block. During the first part of the context conditioning phase (ACQ1), unpredictable and uncontrollable USs were delivered in the NC group, whereas in the C and the LC groups USs were unpredictable but their consequences could be terminated. During the second part of the context conditioning phase (ACQ2), loss of control was operationalized by making the use of the control button ineffective in the LC group, whereas the C and the NC groups continued the training that they received during the first part of this phase.

Pretraining

The purpose of the pretraining phase was to teach participants to continuously press the spacebar of their computer keyboard. Participants were told that "Martians were trying to invade Earth" and that their landing could be prevented by pressing the spacebar ("shooting a laser gun at each of the Martians that would try to land"). Instructions told that in case of a hit an explosion rather than a Martian would be depicted on the screen. We further emphasised the importance of emitting a regular bar-pressing pattern because a new Martian would appear about every 0.25 s and they just had one single missile per Martian.

Martians appeared one by one in rows on the screen, from left to right and from top to bottom, at intervals of 0.25 s, with a space of 0.8 cm in between each Martian (or explosion). If the participant pressed the spacebar before a new Martian was displayed, an explosion appeared at that position. The main

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1. Note that the control button was available in all groups during the entire experiment, but that pressing this button was effective only when participants were provided with offset-control.

goal was to have as few Martians and as many explosions as possible on the screen. Only one bar-press per Martian was allowed. If more than one bar-press was recorded (that is, if either the participant's bar-pressing rate exceeded 4/s, or she/he held the space bar down), a Martian was displayed. The screen was filled when 70 Martians or explosions (10 in each of 7 rows; inter-row distance was 2 cm) had been presented. At the time the screen was filled, it scrolled up, one line at a time, to make room for new Martians. The pretraining phase lasted for 50 s. At the end of this phase, participants received feedback about the total hit rate and the number of killed and missed Martians.

Baseline assessment

This phase was identical to the pretraining phase except that it lasted only for 25 s. At the end of this phase, during a 3-s period bar-pressing behaviour was recorded to serve as a baseline test, during which participants did not notice any changes i.e., Martians just kept landing at the same rate and the background colour of the computer screen (i.e., context) remained the same.

Instructional US phase

In this phase, the instructional US was introduced. Instructions explained that the Martians developed a powerful anti-laser shield (US = white flashing screen accompanied by a metallic sound). If participants continued "to fire their laser gun" (press the spacebar) when this anti-laser shield is activated, their "gun shots" would bounce back and "an inescapable invasion of Martians would be triggered". An invasion lasted for 20 s and consisted of a white flashing screen accompanied by a complex sound pattern (Windows^{TM} 95 "Robotz~2.wav"). Martians now invaded the screen and bar-pressing was ineffective during the invasion (no explosions appeared consequently after bar-pressing). Participants were told that they can avoid invasions, if they cease firing their "laser gun" during the activation of the anti-laser shield or in other words, if they suppress their bar-pressing behaviour during US presentation. Basically, if no key press was registered during the US, the Martians kept appearing on the computer screen and nothing else happened, but if a response was recorded, the US was followed by an "invasion of Martians".

During the instructional US phase, four USs were presented and the experimenter explicitly illustrated the impact of bar-pressing during the US. On the first trial, the experimenter refrained from pressing the spacebar before the presentation of the US; at the second trial, he kept pressing the spacebar during the US in order to trigger an invasion; the third trial, the experimenter again ceased bar-pressing during the US and demonstrated that there was no danger of starting to press the spacebar again immediately after

the US had disappeared from the computer screen; and at the fourth trial, the experimenter demonstrated that it was essential to stop "firing" before the US was actually presented, by showing the impossibility of avoiding the invasion when stopping firing once the US appeared.

Offset-control instruction phase

In this phase, a "new weapon" to terminate invasions was introduced. The newly developed weapon could be activated by pressing the "control button" (escape button on the keyboard) in case an invasion is triggered. Furthermore, instructions told that this modern weapon is a prototype and that it is not reliably tested yet. It is possible that during the experiment the weapon a) works effectively all the time, b) is never operational, or c) sometimes works and sometimes fails to work effectively. When participants finished reading the instructions, the experimenter showed them the use of this control button.

Context conditioning phase

This phase was divided in two learning stages (ACQ1 and ACQ2), each comprising four 4-trial blocks (B1-B2 for ACQ1 and B3-4 for ACQ2). All participants received four US-only trials per block in which the USs were scheduled temporally unpredictable (mean ITI = 10 s, range = 7.5 s-12.5 s). As a consequence, participants could not avoid invasions. After each block a context assessment trial (3 s) was run.

The three experimental groups were distinguished based on the crucial controllability manipulation: in the No Controllability (NC) group, pressing the control button never terminated the invasion of Martians once it had been triggered, whereas in the Controllability (C) group, participants could always successfully terminate the invasion by using the control button. For the Loss of Controllability (LC) group, pressing the control button reliably ended the invasion during the first part of the context conditioning phase (ACQ1), but during the second part (ACQ2) participants could no longer terminate the invasion by pressing the control button.

Response definition: conditioned suppression of bar-pressing behaviour

As mentioned before, after each acquisition block (Block 1-8), a context assessment trial was run. During a context assessment trial the total number of bar-presses was recorded for each participant during a 3-s period. Obviously, no USs were presented during the context assessment. Because a Martian was about to land every 0.25 s, the optimal response rate is 12 bar-presses/3 s, resulting in the elimination of all Martians and thus providing an indication of optimal operant responding. Following Meulders et al. (2011)

suppression of bar-pressing during these context assessment trials, indicated by lower bar-pressing levels than during the baseline assessment, will be used as an index of context conditioning[2]. Due to US-unpredictability in the present set-up, the US can be expected to occur at any moment. This chronic anticipation of US is thought to result in a more general contextual suppression compared with the suppression of bar-pressing behaviour in response to the CS in the classical Martian task. Based on the fact that the unsignaled USs are actually contingent upon the presence of the experimental background context, this context should gain some associative strength and start to elicit expectancy of the US, resulting in a true conditioned response (i.e., suppression of bar-pressing compared with the baseline). Note – for the statistical analyses, means were calculated over two blocks (i.e., eight trials).

Results

Descriptive statistics

Use of the control button

We expected that participants would use the control button more frequently when it effectively terminated the negative consequences of the US i.e., the invasion of Martians. Although the control button was only effective in the groups with offset-control, the majority of participants in each group pressed this button on every trial in which an invasion was triggered; 100%, 80% and 70% of the participants, in the C, LC and the NC groups, respectively. More specifically, only three participants in the NC group did not use the control button on every trial with a triggered invasion, respectively on 43%, 15%, and 11% of these trials. Further, two participants in the LC group did not use the control button on every trial with a triggered invasion (always during the training without offset-control, i.e., ACQ2), on 38% and 19% of the trials, respectively.

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2. The standard Martian preparation was mostly used to assess conditioned responding to discrete CSs (Baeyens, Vansteenwegen, Beckers, Hermans, Kerkhof, & De Ceulaer, 2005). Consequently, suppression ratios were calculated to analyse bar-pressing data, using the following formula: A/(A+B), with A being the number of bar-presses during the CS and B being the number of bar-presses in absence of the CS. Because the main interest of the present study was not cued (CS) conditioning but contextual conditioned responding, we followed the suggestion of Meulders et al. (2011). As no clear-cut equivalent for B is at hand (the context is omnipresent), they analysed the absolute bar-pressing behaviour and used a pre-treatment baseline measurement as a comparison.

Triggered invasions

Invasions were triggered on at least half of the US-only trials in all experimental groups during the entire experiment, suggesting that participants could not predict the US and avoid the invasions merely on the basis of temporal conditioning. Invasions were triggered on 91%, 88%, and 61% of the trials, respectively in the C, LC and NC group. It seems reasonable that participants without offset-control after a while would elicit less invasions compared to participants with offset-control. Because more context conditioning is established in the groups without control, indexed by more suppression of bar-pressing behaviour, evidently more invasions will be avoided compared with the groups with control. Moreover, we acknowledge that invasions were typically longer in the groups without offset-control since they were not able to terminate them once they were triggered like in the groups with control.

Conditioned suppression of bar-pressing behaviour

We analysed the mean number of bar-presses during the context assessment trials (3 s) averaged over two conditioning blocks. As a result, the two learning phases (ACQ1 and ACQ2) were each divided in two blocks of eight trials, respectively referred to as B1/B2 and B3/B4.

Baseline differences

A simple one-way ANOVA was carried out to assure that no baseline differences were present between the respective conditions before the experimental treatment was applied. The analysis showed that baseline responding did not differ between groups, $F(2, 27) = 1.31$, $MSE = 2.63$, $p = .29$.

Test of context conditioning: ACQ1

As can be seen in Figure 1, by the end of the first learning phase (B2), bar-pressing behaviour was more suppressed during the context in the NC group than in the C group and the LC group. A 3 x 3 [Block (Baseline, B1, and B2) x Group (NC, LC, and C)] repeated measures ANOVA was performed on the absolute bar-pressing data. This analysis showed a significant main effect of Group, $F(2, 27) = 9.20$, $MSE = 6.09$, $p < .001$, and a significant main effect of Block, $F(2, 54) = 6.44$, $MSE = 3.82$, $p < .01$. The Block x Group interaction, however, was not significant, $F(4, 54) = 1.86$, $MSE = 3.82$, $p = .13$.

Planned comparisons confirmed that bar-pressing behaviour in the NC group became more suppressed from baseline to B2 as compared to the LC group and the C group, $F(1, 27) = 4.22$, $MSE = 5.54$, $p < .05$. At B2, the bar-pressing behaviour between the LC group and the C group did not differ, $F <$

1, whereas more contextual conditioned suppression of bar-pressing behaviour was present in the NC group compared with the C group, $F(1, 27) = 8.01$, $MSE = 7.21$, $p < .01$, as well as compared with the LC group, $F(1, 27) = 10.54$, $MSE = 7.21$, $p < .01$. Next, within-group contrasts calculated from baseline to B2 also were in line with our predictions. In the C group and the LC group, no differences in bar-pressing behaviour occurred from baseline to B2, both $F < 1$, whereas bar-pressing during the context in the NC group became more suppressed from baseline to B2, $F(1, 27) = 9.83$, $MSE = 5.54$, $p < .01$.

Taken together, these data suggest that the experience with unpredictable USs enhances context conditioning as indicated by contextual conditioned suppression of bar-pressing, only when participants are not able to terminate the negative consequences of the US (NC group). In contrast, when participants are able to control these adverse consequences (C and LC group), no context conditioning is established. In brief, offset-control seems to attenuate context conditioning as induced by onset-unpredictability of the US.
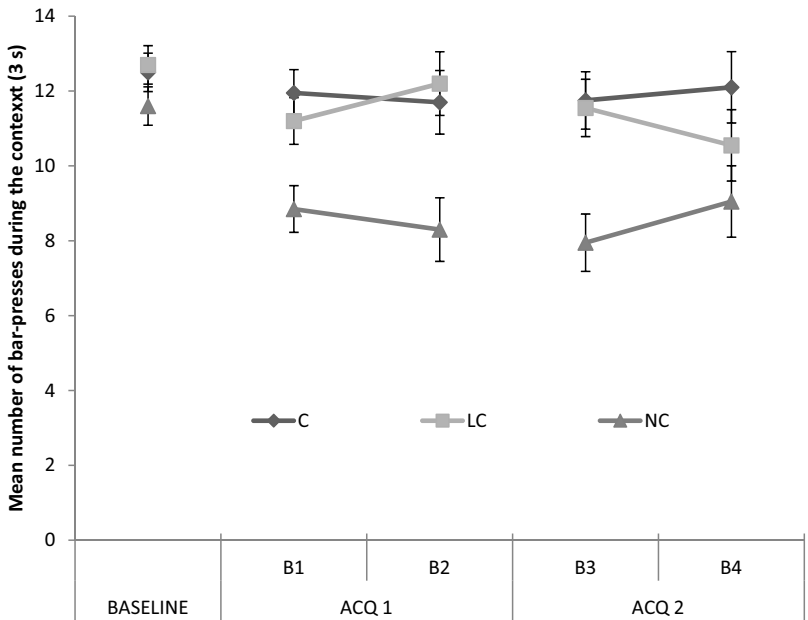

Figure 1

Mean number of bar-presses (and SE's) during baseline assessment and both parts of the context conditioning phase (ACQ1-2) for the three experimental groups: the Control (C) group, the No Control (NC) group, and the Loss of Control (LC) group. Note that "B1", "B2", "B3", and "B4" respectively refer to the mean triggered invasions for Block 1-2, Block 3-4, Block 5-6, and Block 7-8

Test of context conditioning: ACQ2

As can be seen in Figure 1, bar-pressing levels in the C and in the NC groups remained stable, that is, more contextual conditioned suppression was observed in the NC group than in the C group. Moreover, bar-pressing during the context became more suppressed in the LC group when comparing the Baseline-B2 difference and the Baseline-B4 difference, but this conditioned suppression was still relatively smaller than in the NC group (Baseline-B4 difference). To evaluate the effect of loss of control on context conditioning, we carried out a 3 x 3 [Block (B2, B3, and B4) x Group (NC, LC, and C)] repeated measures ANOVA on the bar-pressing data. This analysis yielded a significant main effect of Group, $F(2, 27) = 6.11$, $MSE = 17.06$, $p < .01$, whereas the main effect of Block and the Block x Group interaction did not turn out significant, respectively, $F < 1$, and, $F(4, 54) = 1.91$, $MSE = 2.56$, $p = .12$.

Although, the data-pattern in Figure 1 seems to suggest that bar-pressing behaviour in the respective experimental groups evolved differently from ACQ1 to ACQ2, this difference was not statistically significant for C group and the LC group, $F(1, 27) = 2.58$, $MSE = 4.08$, $p = .11$, nor for the C group and the NC group, $Fs < 1$. Bar-pressing behaviour did tend to become more suppressed in the LC group as compared to the NC group from B2 to B4, $F(1, 27) = 3.53$, $MSE = 4.08$, $p < .07$. Pairwise contrasts calculated at B4 showed that no differences were present between the LC group and the C group, $F(1, 27) = 1.32$, $MSE = 9.08$, $p = .26$, and the LC group and the NC group, $F(1, 27) = 1.24$, $MSE = 9.08$, $p = .28$. As expected the difference between the C group and the NC group was still present at the end of ACQ2 (B4), $F(1, 27) = 5.12$, $MSE = 9.08$, $p < .05$. Finally, within-group contrasts from the end of ACQ1 (B2) to the end of ACQ2 (B4) were calculated to evaluate how contextual conditioned suppression of bar-pressing behaviour evolved within each group. As expected, for the C group and the NC group, no differences occurred from B2 to B4, both $F < 1$. For the LC group, bar-pressing behaviour during the context tended to become more suppressed from B2 to B4, $F(1, 27) = 3.34$, $MSE = 4.08$, $p = .07$, and compared with baseline, significantly more contextual conditioned suppression was observed at B4, $F(1, 27) = 5.53$, $MSE = 4.18$, $p < .05$. These results provide only minimal evidence for the hypothesis that in the case of US-unpredictability, loss of off-set-control is manifested in context conditioning. No evidence was found to support the notion that loss of control is worse than lack of control in terms of performance.

Discussion

Unsignaled presentations of unconditioned stimuli are known to produce context conditioning in animals (e.g., Bouton, 1984; Fanselow, 1980) as well as in humans (Fonteyne, Vervliet, Hermans, Baeyens, & Vansteenwegen, 2009; Grillon, 2002; Meulders et al., 2012; Meulders et al., 2011; Vansteenwegen et al., 2008). The present paper addresses the empirical question of whether context conditioning induced by US-unpredictability can be attenuated by providing the opportunity to terminate the negative consequences of the US, that is, by offset-control. Furthermore, we also wanted to explore whether losing control is more debilitating than lacking control per se.

In a human conditioned suppression preparation (e.g., Arcediano, Ortega, & Matute, 1996; Meulders et al., 2011), three experimental groups received unsignaled, temporally unpredictable USs. During the context conditioning phase, we manipulated the opportunity to control the offset of the US-consequences in these three conditions. During the entire context conditioning phase, participants in the No Controllability (NC) group never had offset-control, whereas participants in the Controllability group always had offset-control. The Loss of Controllability (LC) group, had offset-control during the first part of the context conditioning phase (ACQ1), but lost it in the second part (ACQ2). Suppression of bar-pressing behaviour compared with the baseline bar-pressing level was assessed to index context conditioning.

First and most importantly, results indicated that offset-control (the ability to terminate the negative consequences of the US) reduces context conditioning as induced by US-unpredictability. More specifically during ACQ1, contextual conditioned suppression of bar-pressing was more substantial in the group without offset-control (NC group) than in both groups having offset-control (LC and C groups). These data can be interpreted as follows: in general, two different behavioural responses optimise performance on the experimental task in the present set-up: a) suppression of bar-pressing behaviour in order to avoid invasions (avoidance behaviour), and b) pressing the control button in order to terminate invasions once triggered (escape behaviour). In this experiment, escape behaviour is driven by the operant response-outcome contingency whereas avoidance behaviour is driven by the Pavlovian context-US pairings[3]. A functional analysis of these behaviours demonstrates that

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3.   This is mainly a procedure-specific argument and is not intended to explain complex and persistent avoidance behaviour in e.g., anxiety disorders. In the Martians task, due to the pairings of the context and the US (temporal US-unpredictability) contextual suppression will develop. Because a negative outcome is avoided due to this behaviour (i.e., a possible invasion) this can be labelled as avoidance behaviour. On the other hand, the contingency between the operant (pushing the control button) and the ending of an ongoing negative outcome (i.e., ending an invasion) can be labelled as escape behaviour.

for participants in the offset-control groups, the avoidance behaviour has a higher cost than the escape behaviour, since the latter is always effective, but the former is not. In fact, if they use the control button when an invasion is already triggered, it will reliably terminate the invasion. If participants in the offset-control groups, however, suppress their bar-pressing behaviour and no US is presented, Martians will be able to land and therefore this has a relative higher cost in terms of poorer task performance in the specified game context. In contrast, for participants in the group without offset-control, the escape behaviour is not costly but also not effective. Therefore, in order to perform well, they have to engage in the more costly avoidance behaviour.

Second, loss of control did not seem to have a more detrimental impact on performance than just lacking control. In particular, although loss of control resulted in more contextual conditioned suppression of bar-pressing from ACQ1 to ACQ2, participants in the Loss of Controllability (LC) group did not have higher levels of contextual conditioned suppression than the group that never had offset-control (NC group) during ACQ2. These data suggest that at least in this paradigm, using a non-biologically significant, instructional US, loss of control is not worse than mere lack of control. These results seem to diverge from those reported with biologically significant USs such as pain (electrocutaneous shock) or panic (20% CO_2 inhalation) (Crombez et al., 2008; Zvolensky et al., 1999). Nonetheless, we do acknowledge that the lack of a statistical significant difference between the lack of control and loss of control groups should be interpreted with caution and claims about the genuine absence of differences at this moment is preliminary. Future research should investigate whether prolonged training within the present set-up might still generate the predicted differences between these conditions.

Third, an observation that needs further attention is the fact that even when participants had no offset-control at all, they used the control button frequently and quite persistently. That is, also the Loss of Controllability (LC) group kept pressing the control button as much as the group that never had controllability (NC), although, participants in the former group factually experienced the disconfirmation of offset-control (i.e., the fact that the control button was no longer effective). These results can be tentatively interpreted as an "illusion of control" effect (Langer, 1975; Matute, 1995; Matute, Vadillo, Vegas, & Blanco, 2007). The persistent use of the control button in the groups without offset-control might suggest that participants overestimate the potential effectiveness of their own behaviour to terminate the invasions and thus demonstrate wrongful perceived control beliefs (possibly due to delayed operant trace conditioning). Alternatively, it might be that participants acted following the adage "better safe than sorry". As no additional punishment followed if the control button was pressed when it was ineffec-

tive, the cost of the escape behaviour (i.e., pressing the control button) always remained relatively low. It is also possible that participants without offset-control kept trying to use the control button because they did not fully trust its (non-)functioning i.e., a lack of inhibitory learning of the response-no outcome contingency. Future research may address the possible mechanisms underlying this peculiar observation.

Fourth, the implications of these findings for the clinical practice should be considered as well. To date, several procedures to reduce contextual anxiety (i.e., context conditioning) have been advanced, such as repeated non-reinforced context exposure (Fonteyne et al., 2010) and signalling procedures (i.e., offering predictive cues in an unpredictable context) (Fonteyne et al., 2009). The latter procedure dovetails with the psychotherapeutic treatment protocols for panic disorder (PD), that is, perceived unpredictable panic attacks are put under control of internal (bodily) cues that occur before a typical full-blown panic attack (Craske & Barlow, 2008; Craske et al., 1995). Next to enhancing predictability of aversive events, eliminating the negative consequences of aversive events (offset-control) might be a pathway to reduce contextual anxiety and emotional distress. For example, asthma attacks are also often perceived as unpredictable due to inaccurate perception of asthma triggers (Janssens, Verleden, De Peuter, Van Diest, & Van den Bergh, 2009), leading to high comorbidity with PD (Lehrer, Karavidas, Lu, Feldman, Kranitz, Abraham et al., 2008) and poor asthma control (Put, Van den Bergh, Lemaigre, Demedts, & Verleden, 2003). Hence, from this point of view, providing offset-control over the negative effects of an asthma attack, for example by the use of an asthma inhaler, might reduce chronic anxiety and thus might reduce chronic apprehension and worrying about future unpredictable asthma attacks. Future research might further disentangle the benefits of offset-control *vs.* prediction in the treatment of clinical anxiety.

Finally, a limitation that is intrinsically entangled with the offset-control manipulation in the present set-up is that although the number of presentations of the primary (unpredictable) US (i.e., activation of the anti-laser screen) was kept constant across the experimental groups, the number and length of the invasions (i.e., the consequences of the US) was not optimally controlled for. Illusion of control (e.g., Matute, 1994; Matute, 1995) as well as learned helplessness paradigms (e.g., Maier & Seligman, 1976; Seligman & Beagley, 1975) typically use yoked designs to overcome this problem. Therefore, further research should consider using such yoked designs. Notwithstanding this limitation, the results clearly demonstrate that the controllability procedure attenuates context conditioning (effect). For example, from a clinical perspective, it would be interesting to have a way to reduce context conditioning i.e., to prevent spreading of chronic fear in an asthma patient by providing offset-control over unpredictable asthma attacks (e.g., through

medication), and that irrespective of the possible mechanisms underlying this effect. Another limitation might involve the context manipulation in the present set-up. Context typically refers to long-lasting cues as compared to discrete cues (CSs) with a clear on- and offset. Formulating a strict definition of context, however, is difficult and continuously under debate (e.g., Balsam & Tomie, 1985). A definition of context might be based on its perceptual characteristics (e.g., complexity, foreground/background), spatial characteristics (e.g., three-dimensionality), temporal characteristics (e.g., longer duration, see Grillon, 2002), and/or by its functional characteristics (e.g., modulatory properties, see Bouton, 2002). We believe that the contexts used in this experimental set-up (i.e., the background colour of the computer screen) comprise some of these features, such as background-foreground differentiation and the longer lasting duration of the context presentation than the presentation of the cues (i.e., US). However, the contexts used in our study contain no strict modulatory functions and are not three-dimensional. Therefore, the contexts used in this study might lack some ecological validity. However, changing the background colour of the computer screen has been used before to manipulate contexts in the Martians task (e.g., renewal studies, Havermans, Keuker, Lataster, & Jansen, 2005). The background colour of the computer screen seems a highly task relevant contextual feature since it is embedded in the broader game context of the Martians task.

To recapitulate, the present study provided evidence for the notion that offset-control reduces context conditioning as induced by exposure to unpredictable USs. Contrary to previous research with biologically potent USs, loss of control did not turn out to have worse effects on performance than mere lack of control.

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