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The role of relief, perceived control, and prospective intolerance of uncertainty in excessive avoidance in uncertain-threat environments[☆]

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ABSTRACT

Excessive avoidance is a key feature of pathological anxiety. However, the precise mechanisms underlying the development of excessive avoidance are still unknown. In the present study, we tested the hypothesis that excessive avoidance, especially in individuals with high Intolerance of Uncertainty (IU) is aimed at distress reduction via the enhancement of subjective perceived control in uncertain-threat environments. In our experiment, participants learned to avoid an uncertain aversive sound through a discriminated free operant procedure. In a later test phase in extinction, we manipulated the amount of avoidance responses available per trial by creating a limited and an unrestricted response condition. Nonetheless, the aversive sound could be effectively avoided in both conditions. We measured response frequency, avoidance confidence ratings and anxiety-predisposing traits such as intolerance of uncertainty, trait anxiety and distress tolerance. The degree of distress suffered during trials was inferred from post-trial relief ratings that were requested after trials in which the aversive sound had been omitted. In the avoidance acquisition phase, we found a positive association between prospective intolerance of uncertainty (P-IU) and the decline rate of distress. This relationship was not significant, however, when inhibitory intolerance of uncertainty (I-IU) was controlled for. At test, we found that the increase in avoidance responses led to distress reduction through the enhancement of avoidance confidence. Finally, we found a significant modulating role of P-IU in the effect of response limit on distress reduction that lends further support to our hypothesis. Specifically, P-IU was positively associated with the effect of response limit on distress. However, such modulating role was not significant when controlling for trait anxiety or I-IU.

1. Introduction

Pathological anxiety has been conceived as the result of a series of unadjusted anticipatory reactions to uncertain threats (Grupe and Nitschke, 2013; Tanovic et al., 2018). One of them is excessive avoidance, which may be one of the most important maladaptive reactions due to its dysfunctional consequences on patients, and to its causal role in the development, maintenance, and relapse of anxiety (Cameron et al., 2015; Krypotos et al., 2015; Lovibond, 2006; Pittig et al., 2018; van Uijen et al., 2018a, 2018b; Vervliet and Indekeu, 2015; Vervliet et al., 2017). Notwithstanding the role avoidance and uncertainty play in anxiety disorders, little experimental research has been conducted to analyse the underlying mechanisms responsible for excessive avoidance in uncertain threat situations.

Resolving uncertainty has been claimed to be of primary concern for human and non-human animals, and there is good evidence showing that it exacerbates aversive reactions (Tanovic et al., 2018). In normal circumstances, overcoming uncertain threat situations requires the identification of informative cues and effective behaviours to gain predictability and control over the threatening event. For instance, wearing well-fitted masks in indoor public settings reduces uncertainty concerning the possibility of being infected with SARS-CoV-2. In this sense, learning to avoid should be viewed as an adaptive reaction. But when avoidance becomes excessive, a good amount of the avoidance responses

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made have, by definition, no objective effects on the occurrence of the feared event. If any, in true life situations, the excess of avoidance is likely to have undesirable consequences in the long term, interfering with life goals, maintaining fear levels, and hindering the action of exposure therapies (Craske et al., 2014; Dymond, 2019; Lovibond et al., 2009; Papalini et al., 2021; Pittig et al., 2018; Treanor and Barry, 2017; van Uijen et al., 2018a, 2018b; Vervliet and Indekeu, 2015).

If excessive avoidance has no objective effect on uncertain threats, why do people engage in this sort of behaviour? Previous studies that focused on individual differences regarding intolerance of uncertainty and avoidance may shed some light on this question. Intolerance of uncertainty (IU) has been defined as "an individual's dispositional incapacity to endure the aversive response triggered by the perceived absence of salient, key, or sufficient information, and sustained by the associated perception of uncertainty" (Carleton, 2016, p. 31). This personality trait is considered as a vulnerability factor for several anxiety-related mental disorders (Boswell et al., 2013; Carleton et al., 2012; Gentes and Ruscio, 2011; Hong & Cheung, 2015; McEvoy and Erceg-Hurn, 2016; Mahoney and McEvoy, 2012; McEvoy and Mahoney, 2013; Norr et al., 2013; see also Carleton, 2016 for a review). Freeston et al.'s (1994) IU scale, one of the most frequently used IU questionnaires, has been found to have a factorial structure of two components (Birrell et al., 2011): A prospective intolerance of uncertainty component (P-IU), defined as the "desire for predictability and an active engagement in seeking certainty", and an inhibitory intolerance of uncertainty component (I-IU), defined as the "paralysis of cognition and action in the face of uncertainty".

A few studies have provided evidence for a role of IU in excessive avoidance. In one of them, Flores et al. (2018, 2020) found a positive association between P-IU and avoidance frequency in a discriminated free-operant avoidance learning task (see also San Martín et al., 2020 for related results; but see the review by Morriss et al., 2021, for studies reporting non-significant relationships between IU and avoidance behaviour). Specifically, they found a positive association between P-IU and avoidance frequency at the end of an avoidance learning phase, and a positive association between P-IU and persistent avoidance detected in a later test phase in which the threatening stimulus was much weaker or was no longer administered. Flores et al.'s rationale behind their study was that participants scoring high in P-IU, compared with those scoring low, should feel more distress about uncertain aversive events. Consistently with the definition of P-IU provided by Birrell et al. (2011), these participants should be highly motivated to engage in avoidance responses to enhance subjective perceived control and to reduce uncertainty as much as possible. Such uncertainty reduction should eventually lead to distress reduction. In a similar vein, excessive avoidance, and more generally, over-engagement, has been argued to be among the main behavioral expressions of intolerance of uncertainty, and is thought to increase the subjective perception of certainty in uncertain threat situations (Boswell et al., 2013; Bottesi et al., 2019; Sankar et al., 2017; San Martín et al., 2020).

The idea of excessive avoidance as a behaviour aimed to reduce distress via the enhancement of subjective perceived control, especially in people high in IU, is commonplace but has not received compelling empirical support so far. In the present study, we used a modified version of Flores et al.'s (2018) avoidance learning task to test this hypothesis. This task includes a first Pavlovian learning phase in which participants learn the predictive relationships between three conditioned stimuli (CSs) consisting of fractal images and an unconditioned stimulus (US) consisting of an aversive sound presented either to the left or to the right ear. Two of the CSs are followed by the US in 50 % of the trials (CS_A+ and CS_B+), whereas a third CS (CS−) is never followed by the US. This phase is followed by an instrumental learning phase identical to the previous one except for the fact that participants can avoid the US by pressing specific keys on a computer keyboard. Finally, a test phase similar to the instrumental learning phase is included in which, unbeknownst to participants, the US is never administered. A key aspect of this task is that participants can make as many avoidance responses as they wish during every single training trial of the instrumental learning phase to avoid the US, which may occur at some unpredictable point in time. The US can be precluded provided that one of the avoidance responses, at least, is made within the one-second interval preceding the precise moment at which the US has been programmed to occur. As the duration of each trial is 20 s, this procedure tends to increase the number of avoidance responses per trial, allowing us to study avoidance frequency as a function of different manipulations or different anxiety-predisposing traits.

In the present study, we manipulated the availability of avoidance responses by imposing a limit in the amount of avoidance responses in half of the trials of the test phase. If excessive avoidance leads to distress reduction via subjective perceived control enhancement, we should expect more distress and less perceived control in limited-response trials than in unrestricted-response trials. Subjective perceived control was measured in a judgement phase after the test phase in which participants had to rate their confidence in avoiding the aversive noise in limited-response and in unrestricted-response trials. Participants' distress was inferred from post-trial relief ratings. Such ratings were requested in every trial in which the US was omitted. Relief has been defined as a pleasant emotion resulting from a sudden distress reduction (Hoerl, 2015). In other words, the degree of relief experienced by participants when they find out that the US has been omitted after the end of a trial is assumed to be the mirror image of the distress suffered before the end of such trial. Accordingly, high relief ratings after the termination of an avoidance trial would indicate high distress during the trial, whereas low relief ratings would indicate a small degree of distress. Consequently, we should expect higher relief ratings in the response-limit condition than in the unrestricted-response condition. Moreover, the reinforcing consequences of excessive avoidance in terms of distress reduction may be directly inferred from the difference in relief ratings between these response conditions.

In accordance with our hypothesis relating distress reaction to uncertainty, excessive avoidance, enhanced perceived control, distress reduction and P-IU, we also expected to find other results evidencing individual differences related to P-IU. Specifically, we expected to find heightened within-trial distress, therefore heightened post-trial relief ratings, in participants scoring high in P-IU compared with participants scoring low. In the Pavlovian learning phase, this positive association between P-IU and relief ratings should be especially clear in CS+ rather than in CS− trials, as only the former involves relatively long periods of time waiting for an uncertain threatening US. A similar result was expected regarding the instrumental learning phase. However, throughout this phase, especially in CS+ trials, participants should develop confidence and certainty about the occurrence of the US as they learn to avoid it completely, which may be easily achieved in this task. Consequently, the positive association between P-IU and relief ratings should weaken throughout trial blocks. Also, consistently with Flores et al. (2018), we expected to find a positive association between P-IU and avoidance frequency in the instrumental learning phase. Regarding the test phase, we expected to find a modulating effect of P-IU on the effect of the response limit manipulation on both avoidance frequency and relief ratings, especially in CS+ trials. Specifically, a positive association between P-IU and avoidance frequency was expected in the unrestricted but not in the limited response condition. Conversely, a stronger positive association between P-IU and relief ratings was expected to be found in the limited than in the unrestricted response condition. As in previous studies (Flores et al., 2020; Morriss et al., 2018; San Martín et al., 2020), we tested the specificity of P-IU controlling for trait anxiety (TA), distress tolerance (DT), and inhibitory intolerance of uncertainty (I-IU) when testing all of the above predictions involving P-IU.

2. Method

2.1. Participants

Ninety undergraduate students from the Faculty of Psychology and Speech Therapy at the University of Málaga (Spain) volunteered to take part in the experiment in exchange for course credits. The data from eight participants were not recorded due to a computer failure. Additionally, one of them did not fulfil any of the questionnaires used in this study, which resulted in a final sample of 81 participants (73 females, mean age 20.9 years old). This sample size could not be calculated on the basis of the effects expected in the test phase because we had no previous reference to estimate the effect size of the manipulated factors. However, we conducted a repeated measures ANOVA CS type × trial block × P-IU (as a covariate) on avoidance frequency from the instrumental learning phase in Flores et al.'s (2018) study, which revealed a significant P-IU effect of size $\eta_p^2 = 0.19$, and observed power $1\text{-}\beta > 0.95$, with sample size $N = 68$. Although there are some procedural differences between our instrumental learning phase and Flores et al.'s, we think that a sample size between 70 and 80 should be powerful enough to, at least, detect an effect size of $\eta_p^2 = 0.19$ of P-IU on avoidance frequency with $\alpha = 0.05$.

2.2. Questionnaires

The participants completed three personality questionnaires: Spanish adaptations of the Intolerance of Uncertainty Scale: IUS (Freeston et al., 1994; adaptation: González-Rodríguez et al., 2006), the State-Trait Anxiety Inventory: STAI (Spielberger et al., 1983; adaptation: Seisdedos, 1990), and the Distress Tolerance Scale: DTS (Simons and Gaher, 2005; adaptation: Sandín et al., 2017). These questionnaires were used to evaluate IU, trait anxiety (TA), and distress tolerance (DT), respectively. TA and DT were evaluated to assess the specificity of the association between P-IU and the different dependent measures of interest. All the participants gave written informed consent before completing the questionnaires.

The IUS (internal consistency ranged from 0.91 to 0.94 and test-retest reliability ranged from 0.74 to 0.83) is a 27-item self-report measure that assesses the degree to which individuals find uncertainty to be distressing and undesirable. Items are rated on a five-point Likert scale ranging from 1 (*not at all characteristic of me*) to 5 (*extremely characteristic of me*). The IUS includes two subscales to assess the two factors mentioned in the Introduction: Prospective Intolerance of Uncertainty (11-items) and Inhibitory Intolerance of Uncertainty (16-items).

The STAI (internal consistency ranging from 0.86 to 0.95 and test-retest reliability coefficients ranging from 0.65 to 0.75) is a 40-item self-report measure for assessing TA (i.e., *I worry too much over something that really doesn't matter*) and State Anxiety (i.e., *I feel calm and secure*). Given our focus on TA, the participants were only administered the 20 items corresponding to the trait anxiety subscale. Items are rated on a four-point Likert scale ranging from 0 (*hardly ever*) to 3 (*always*).

The DTS (internal consistency 0.82 and test-retest reliability 0.7) is a 15-item self-report measure for assessing how well people tolerate feelings of distress (i.e., *Being distressed or upset is always a major ordeal for me*). Items are rated on a five-point scale ranging from 1 (*strongly agree*) to 5 (*strongly disagree*). Given that DT has been found to correlate with relief and the tendency to avoid in previous studies (San Martín et al., 2020; Vervliet et al., 2017), we were interested in testing whether we could get the same results with a very different task and design.

2.3. Stimuli and design

As in Flores et al. (2018), two different black-and-white fractal images were used as excitatory conditioned stimuli (CS_A and CS_B counterbalanced) which signalled an unconditioned stimulus (US) consisting of an aversive sound that could be presented either to the left or the right ear (i.e., US_1 or US_2 counterbalanced). An additional black-and-white fractal image was used as an inhibitory CS (CS−) preceding the absence of any noise (see Fig. 1). All fractals had an approximate size of 9 × 8 cm and appeared in the centre of the screen. By using two CSs signalling the US, we remained close to Flores et al.'s (2018) avoidance learning task, which proved to be useful to detect individual differences related to IU. At the same time, doubling the CS+ condition would involve doubling the number of repeated measures, leading, thus, to more sensitivity to get statistical significance. The background of the screen was always black. The aversive sound was a 3-second high-pitch beep of 44,100 Hz and high-volume (97 ± 3 dB).

As shown in Fig. 1, one of the main manipulations of our experiment was the avoidance response limit imposed in the test phase. For this purpose, a limit of 20 responses was imposed in half of the test trials, whereas no response limit was imposed in the other half. Note that, as the time window within which the US could occur was 12 s long, the number of responses available in the limited response condition allowed, in principle, to avoid the US with complete certainty provided that the participants responded at a rate of one (or slightly above one) response per second.

2.4. Measures

The main dependent measures used in our experiment were the participants' relief ratings made on every trial in which the US was omitted, the avoidance response frequency in each trial, and the participants' estimations, made after the test phase, of how confident they felt in avoiding the US provided that they pressed the correct response key. However, we also registered the participants' predictive ratings to assess each possible CS-US relationship just after the Pavlovian and the instrumental learning phase. Additionally, participants also made unpleasantness ratings for the US after the instrumental learning phase and after the test phase.

2.5. Procedure

The procedure used in this experiment complied with the Helsinki Declaration and was approved by the local ethical committee of the University of Málaga (registry code 46-2020-H). The participants entered the experimental room in groups of 10 and sat at a minimum distance of 2 m. Additional measures to protect the participants from

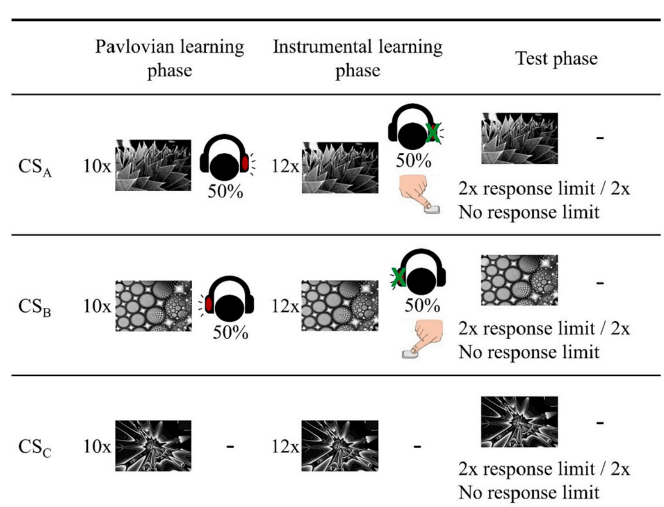

Fig. 1. Design and phases of the avoidance learning task, and images used as conditioned stimuli (CS). CS_A, CS_B and CS− refer to the different CSs used across the different phases of the task. The multiplying numbers represent the number of repetitions per trial type (see main text for further details).

COVID-19 infection included hand washing with hydroalcoholic gel and keeping the windows and door open to ensure adequate ventilation. Additionally, the participants and the experimenters wore face masks during the whole time they were in the experimental room. The participants fulfilled the questionnaires and performed the task using an IBM-compatible PC. The experimental task was programmed in Psychopy 2020.2.6 (Peirce et al., 2019). The task files are available in the Open Science Framework (https://osf.io/zk68s/). The sound used was delivered via headphones (Manufacturer: Audio-Technica model ATH-M20x). Participants' responses were registered through a standard QWERTY keyboard and the PC mouse. The participants started by carefully reading an informed consent document on the computer screen, and were invited to accept or cancel their participation. Then, they fulfilled the IUS, followed by the STAI (only the TA subscale), and the DTS. After fulfilling all the questionnaires, the participants started reading the instructions of the avoidance learning task. The participants sharing the same session could get out of the experimental room only after all of them had completed the avoidance learning task.

2.6. The avoidance learning task

As shown in Fig. 1, the avoidance learning task comprised three phases: A Pavlovian learning phase followed by an instrumental learning phase, and a final test phase. All the participants started by putting on the headphones and reading the instructions concerning the Pavlovian learning phase. The instructions told the participants that they would be presented with a series of three possible fractal images, and that one of them would occasionally be paired with an upcoming unpleasant sound presented to the left ear, whereas another image would occasionally be paired with the same sound presented to the right ear. The participants were asked to pay attention to learn the relationship between each image and the sound presented to each ear because this would be important to avoid the unpleasant sound in a later phase. They were also told that they would have to rate their degree of relief in those trials in which the unpleasant sound was omitted.

On each trial of the Pavlovian phase, a fixation cross appeared in the centre of the screen for 1 s. Immediately after the offset of the fixation cross, one of the three images (i.e., CS_A, CS_B, and CS−) was displayed at the centre of the screen for 20 s. The participants were presented with US_1 in five out of ten CS_A trials, and with US_2 in five out of ten CS_B trials. The onset of the noise was programmed according to a variable interval schedule of 10 s (from the onset of the CS) that followed a rectangle distribution with amplitude of 12 s. That is, the aversive noise could appear randomly at second 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, or 16 from the onset of the CS, namely around the middle part of the 20-s CS time window. The time window for the onset of the noise was independent from its duration (always 3 s). Consequently, there were two sources of uncertainty regarding the occurrence of the US: a) The non-deterministic occurrence of the US given the excitatory CSs, and b) the unpredictability of the exact moment in which the US was delivered.

The US-onset time window used was three times as large as that used in Flores et al. (2018) for two main reasons. First, we were interested in increasing uncertainty regarding the moment at which the US occurred to heighten the participants' distress and to promote exaggerated avoidance responses. This should increase the sensitivity of our procedure to the response limit manipulation. The second reason is that a wider threatening time window within the CS display time would lead to high feelings of relief just after the CS offset, especially when the CS signalled the uncertain US. Again, this procedural measure could increase the sensitivity of relief ratings to the response limit manipulation.

The relief rating scale was presented immediately after the offset of the CS in every trial in which the US was omitted. It consisted of an analogue and numerical, horizontally displayed scale with anchors "0 = No relief at all", "50 = Moderate relief", and "100 = A lot of relief". The question "How much relief did you feel at the offset of the image?" prompted the participants to use the scale. A message below the scale indicated to the participants that they had to place a triangular marker with the mouse on the position of the scale that best reflected their degree of relief. Changes in the marker position were immediately translated into the corresponding numerical expression (from 0 to 100), which was displayed just below the scale. By clicking on the numerical rating, the participants confirmed their acceptance and moved on to the next trial.

Training trials were distributed in five blocks of six trials: Two CS_A trials (one reinforced and another non-reinforced), two CS_B trials (one reinforced and another non-reinforced), and two CS− trials. After concluding the Pavlovian learning phase, participants were requested to make predictive ratings for each CS. The question "To what extent do you think that this image will be followed by the noise through your (left/right) ear?", which could be read at the upper centre of the screen, prompted these ratings. The rating scale went from 0 ("Very sure that this image was not followed by the noise through this ear") to 9 ("Very sure that this image was followed by the noise through this ear") and appeared at the bottom centre of the screen. Participants used the computer keyboard to provide their responses. As there were three conditioned stimuli (CS_A, CS_B, and CS−) and two USs (left/right-ear noise), participants had to rate a total of six predictive relationships.

After the predictive ratings, the participants read the instructions of the instrumental learning phase. They were told that they could avoid the unpleasant sound by pressing 'Q' or 'P' on the computer keyboard to preclude the presentation of the sound to the left or to the right ear, respectively. The instructions also stated that the inhibitory effect of each single key press on the unpleasant noise lasted for only 1 s. Thus, to ensure the avoidance of the noise, they were advised to press again before 1 s from the last response. The participants were explicitly told that they could avoid the noise with complete certainty by pressing at a rate of one response per second or more. Conversely, the noise could appear if they responded at a slower rate. They were also told that the noise could appear at different points in time from the onset of the CS in different trials, just as in the previous learning phase.

No immediate feedback was provided regarding the consequences of individual responses. Consequently, the participants could only be completely certain that they had effectively avoided the aversive sound after the offset of the CS. This way, the instrumental learning phase not only had an important component of uncertainty regarding the occurrence of the US but also uncertainty regarding the effectiveness of individual responses. As in the Pavlovian learning phase, relief ratings were requested immediately after the CS offset on every trial in which the US was omitted whether because of successful avoidance or otherwise.

This phase comprised six training blocks, each one including 2 CS_A trials (only one reinforced, unless successfully avoided), 2 CS_B trials (only one reinforced, unless successfully avoided), and 2 non reinforced CS− trials. Trial order was randomized on a block and participant basis. After completing the instrumental learning phase, predictive judgements were required as described above. The only exception was that judgements were now prompted by the sentence: "To what extent do you think that this image will be followed by the noise through your (left/right) ear if the correct key is not pressed?" After the predictive judgements, the participants received one presentation of the aversive noise and were requested to rate its unpleasantness on a 9-point horizontal scale with anchors "0 = Not at all" and "9 = Extremely unpleasant".

Before the test phase, the participants read the corresponding instructions, which stated that the task would continue as in the previous phase with the only difference that, in half of the trials, a limit of twenty key presses would be imposed. The instructions also indicated that trials affected by the response limit would be easily recognised by the presence of an analogical indicator (i.e., a grey rectangular bar below the image), and a numerical indicator (the number '20' displayed in the bar) of the key presses available. The participants were then presented with an example trial and were asked to repeatedly press either 'Q' or 'P' to see how the bar length and the numerical indicator decreased on every key press. If the participants pressed any avoidance key after running out of responses, a text message in red appeared above the image indicating that the response limit had been exceeded. The instructions made it clear that key presses made after exceeding the limit had no effect on the unpleasant noise. Trials with no response limit were as in the previous learning phase, and the participants could respond at free will.

The test phase comprised four blocks of trials, each one including a CS_A, a CS_B, and a CS− trial. For half of the participants, CS_A and CS− were limited-response trials in the first block, and CS_B was an unrestricted-response trial. In the following block, the limit condition was reversed for each CS. This block sequence was repeated once more. For the other half of participants, trial blocks followed the reverse order. Trial order was randomized on a block and participant basis. Unbeknownst to the participants, no aversive US was programmed to occur, and, therefore, relief ratings were requested on every trial.

After the test phase, the participants were asked to rate their perceived control in the different response-limit conditions. Specifically, for each CS+ (CS_A and CS_B), the message "When this image appeared, how confident were you in inhibiting the unpleasant sound (with/without) response limit?" prompted the participants to make their judgements on a 10-point horizontal scale with anchors "0 = No confident at all" and "9 = Very confident". Finally, the participants were presented with a new image for 20 s and were told through instructions that the aversive sound would be administered 1 s before the image offset. The sound was actually omitted and, immediately after the image offset, the relief rating scale appeared, and the participants were requested to estimate their degree of relief. This final rating allowed us to assess the relationship between P-IU and relief ratings after the omission of a certain threat. To ensure that the participants expected the occurrence of the sound without doubt, they went through a previous trial in which the same image appeared for 20 s and were told through truthful instructions that the sound would be administered 10 s before the image offset. Immediately after the image offset, the participants were requested to rate the unpleasantness of the sound just to conceal the actual purpose of the trial.

2.7. Data analysis

The raw data file has also been uploaded to the Open Science Framework repository and can be found by clicking on the link https://osf.io/zk68s/.

2.7.1. Selection criteria

We removed the data from those participants who did not discriminate between CS_A and CS_B above chance during the instrumental learning phase. For this purpose, we calculated the proportion of correct avoidance responses throughout this phase and removed those participants with a proportion of correct responses less than or equal to 0.5, which reduced the sample size to 78 participants (71 females). Additionally, we observed in the experimental room that some participants skipped the relief rating scale by immediately clicking on the acceptance button in many trials in a systematic way. This strategy may have been beneficial to the participants to shorten the duration of the task. Fortunately, we could detect these participants because the systematic skipping of the relief rating scale generates a large series of zero-rating scores in the data file. To be conservative, we decided to remove only those participants with zero rating scores in every trial of any of the learning phases, which reduced the sample size to 75 participants (69 females, mean age 20.36, ranging from 19 to 24). All statistical analyses reported adopted an α of 0.05 and were performed using IBM SPSS version 23.0 (IBM Corp., 2015). Greenhouse-Geisser corrected p values were used in case of sphericity violation when appropriate.

2.7.2. Questionnaires

Bivariate correlational analyses were performed to assess the relationship between scores in P-IU, I-IU, TA, and DT.

2.7.3. Pavlovian learning phase

A repeated measures ANOVA 5 (trial block: 1 through 5) × 2 (CS type: CS+ vs CS−) was conducted to analyse the effects of trial block, CS type, and their interaction. Relief ratings in CS_A and CS_B trials were collapsed into a single mean per trial block and participant and so were relief ratings in CS− trials. To assess the role of P-IU, TA and DT in the participants' relief ratings, we performed three independent trial block × CS type ANOVAs including each personality trait as a covariate in each test.

2.7.4. Instrumental learning phase

First, relief ratings and avoidance response frequency in CS_A and CS_B trials were collapsed into a single relief-rating and response-frequency mean per trial block and participant. The same calculations were made regarding relief ratings and response frequency in CS− trials. Then, we conducted a repeated measures ANOVA 6 (trial block: 1 through 6) × 2 (CS type: CS+ vs CS−) on the participants' relief ratings and on the participants' correct avoidance-response frequency. Subsequently, we performed the same analysis on relief ratings three more times including P-IU, TA, and DT as a covariate in each test. As we found some significant effects involving P-IU, we conducted further identical ANOVAs including P-IU and TA as covariates to assess the specificity of the significant effects of P-IU (DT was excluded because the effects including this trait factor were far from significance and its correlation with P-IU was close to 0). Finally, we used the same statistical approach to analyse the role of P-IU, TA and DT in the participants' avoidance response frequency.

2.7.5. Test phase

To check if the possible effect of response limit could be attributed to differences in avoidance response rate between the limited and the unrestricted condition, we conducted a repeated measures ANOVA 2 (response limit: limited vs unrestricted) × 2 (CS type: CS+ vs CS−) on the participants' correct-response frequency. To test if the response limit manipulation affected the participants' relief ratings, we conducted the same analysis on the participants' relief ratings. Previous to this analysis, relief ratings in CS_A and CS_B trials were collapsed into a single mean per response condition and participant (mean relief ratings in the CS+ condition), and relief ratings in CS− trials were collapsed into a single mean per response condition and participant. Paired t-test analyses were performed as follow-up analyses to interpret the significant interaction effect. To test if the effect of response limit on relief ratings in the CS+ condition was related to the increase in perceived control, we compared the participants' avoidance-confidence ratings in the different response limit conditions through a paired t-test analysis. Ratings from CS_A and CS_B items were previously collapsed into a single mean per response condition and participant. Moreover, as our hypothesis states that excessive avoidance leads to post-trial relief reduction through increased perceived control, we conducted a mediation analysis to test if the association between avoidance frequency and relief in CS+ trials was mediated by perceived control. To run this mediation analysis, we rearranged the data file and generated a new one which included two cases per participant, each case in a different row. For each participant, one case included the mean avoidance frequency in CS+ trials, the mean avoidance-confidence ratings, and the mean relief ratings in CS+ trials in the limited condition, whereas the other case included the values in the same variables in the unrestricted condition. Then, we performed a mediation analysis using PROCESS, version 2.16.3 (Hayes, 2013) to test the mediation model Avoidance Frequency → Avoidance Confidence → Relief. For this analysis, we used the nonparametric bootstrap method relying on 5000 samplings with replacement (Efron and Tibshirani, 1993). To assess the role of P-IU, TA and DT on relief ratings and avoidance response frequency, we conducted several independent repeated measures ANOVA 2 (response limit: limited vs unrestricted) × 2 (CS type: CS+ vs CS−) on the participants' relief ratings and on the participants' correct-response frequency including P-IU, TA, and DT as a covariate in each test. As we found some significant effects involving P-IU and TA on relief ratings we conducted further ANOVAs including both personality traits in the same test to assess the specificity of such effects.

2.7.6. Additional analyses

In case of finding individual differences associated with the participants' scores in P-IU, TA, or DT, we planned Pearson correlation analyses to assess the relationship between such dispositional factors and the participants' contingency and aversiveness ratings. These analyses were intended to discard alternative explanations based on individual differences in learning or in subjective unpleasantness regarding the US presentation. Also, to help have a visual picture of the role of P-IU in relief ratings and avoidance frequency, we elaborated figures representing the results found in high P-IU and low P-IU participants, i.e., those who scored above the second tertile and below the first tertile, respectively. Some of these figures have been included in the Supplementary Materials. Finally, the results from additional analyses to assess the specificity of P-IU or TA controlling for I-IU have also been included in Supplementary Materials as well as information about the distribution of the participants' scores in each personality trait scale and subscale, and about the correlations between them.

3. Results

3.1. Questionnaires

Table 1 shows the results of the bivariate correlation analyses between P-IU, I-IU, TA, and DT.

3.2. Pavlovian learning phase

Fig. 2 shows the participants' mean relief ratings as a function of CS type and trial block. As expected, relief ratings tended to be higher in the CS+ than in the CS− condition and the difference between these conditions tended to increase along the Pavlovian phase. This impression was confirmed by a repeated measures ANOVA on the participants' relief ratings, which yielded the significant effects of CS type, $F(1, 74) = 60.25$, $p < .001$, $\eta_p^2 = 0.45$; and the CS type × trial block interaction, $F(4, 296) = 11.7$, $p < .001$, $\eta_p^2 = 0.14$. If we interpret post-trial relief ratings in terms of within-trial distress, the results indicate that whereas distress tended to increase throughout CS+ trials, it tended to decline throughout CS− trials.

3.2.1. Individual differences

The later inclusion of P-IU, TA or DT as covariates in the CS type × trial block ANOVA did not yield any significant effect involving these dispositional factors. However, an inspection of Fig. S2 in Supplementary Materials reveals a trend towards higher relief ratings in the high P-IU group compared with the low P-IU group.

3.3. Instrumental learning phase

3.3.1. Relief ratings

Fig. 3 (Panel A) shows the mean relief ratings as a function of CS type

Table 1
Results from bivariate Pearson correlation analyses to assess the relationship between P-IU, I-IU, TA, and DT.

	P-IU	I-IU	TA
I-IU	0.685***		
TA	0.573***	0.805***	
DT	0.044 (0.707)	0.02 (0.867)	0.213 (0.066)

Note: *** stands for significance below 0.001; non-significant *ps* are in parentheses.

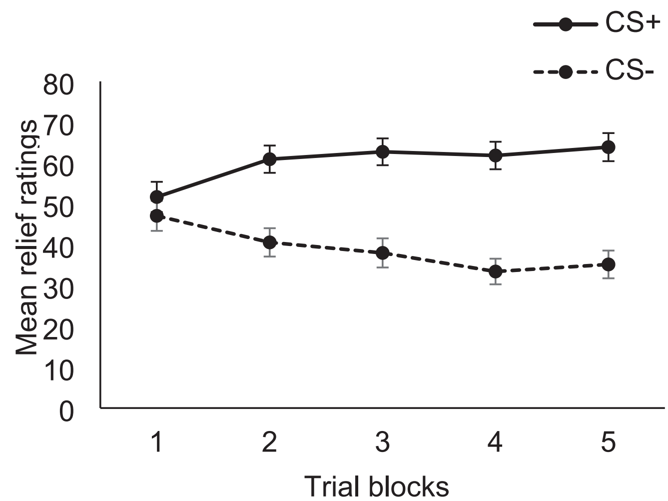

Fig. 2. Results from the Pavlovian learning phase. The figure shows the mean relief ratings as a function of CS type and trial block.

and trial block. As expected, relief ratings were higher in the CS+ than in the CS− condition and tended to decline along trial blocks. A steeper decline of relief ratings is observed in the CS+ than in the CS− condition, indicating that the participants learned to avoid the US in CS+ trials and, therefore, tended to expect the threatening event to a lesser extent as training progressed in the instrumental learning phase. The less steep decline in the CS− condition is hardly surprising as this CS should have been established as a reliable safety signal in the Pavlovian learning phase. These impressions were confirmed by a repeated measures ANOVA on the participants' relief ratings, which yielded the significant effects of CS type, $F(1, 74) = 60.3$, $p < .001$, $\eta_p^2 = 0.45$, trial block, $F(5, 370) = 48.88$, $p < .001$, $\eta_p^2 = 0.4$ and the CS type × trial block interaction, $F(5, 370) = 9.21$, $p < .001$, $\eta_p^2 = 0.11$. The simple effect of trial block was significant within both the CS+, $F(5, 370) = 38.39$, $p < .001$, $\eta_p^2 = 0.34$, and the CS− condition, $F(5, 370) = 21.59$, $p < .001$, $\eta_p^2 = 0.23$.

3.3.2. Avoidance response frequency

The results concerning avoidance response frequency were also highly expected. An inspection of Fig. 3 (Panel B) reveals a remarkable increase of response frequency throughout trial blocks in the CS+ condition, whereas, in the CS− condition, response frequency remained much lower and almost flat along the instrumental learning phase. Consistently with this description, the CS type × trial block repeated measures ANOVA on the participants' correct avoidance-response frequency yielded the significant effects of CS type, $F(1, 74) = 168.76$, $p < .001$, $\eta_p^2 = 0.7$, trial block, $F(5, 370) = 55.36$, $p < .001$, $\eta_p^2 = 0.43$ and the CS type × trial block interaction, $F(5, 370) = 83.52$, $p < .001$, $\eta_p^2 = 0.53$. The simple effect of trial block was significant in the CS+ condition, $F(5, 370) = 93.25$, $p < .001$, $\eta_p^2 = 0.56$, and marginally significant in the CS− condition [$F(5, 370) = 2.48$, Greenhouse-Geisser corrected $p = .076$, $\eta_p^2 = 0.56$].

3.3.3. Individual differences regarding relief ratings

In this section, we will only report the statistical results of effects involving any of the three personality traits considered in our study. The three independent repeated measures ANOVAs including P-IU, TA or DT as a covariate in each test only yielded the significant effects of trial block × P-IU, $F(5, 365) = 4.27$, Greenhouse-Geisser corrected $p = .013$, $\eta_p^2 = 0.06$, and CS type × trial block × P-IU, $F(5, 365) = 3.28$, Greenhouse-Geisser corrected $p = .028$, $\eta_p^2 = 0.04$ (for the remaining effects involving P-IU, TA or DT, all Fs < 2.4, all ps > .124). Fig. 4 shows the mean relief ratings from the high and low P-IU groups as a function of CS type and trial block. A look at the figure reveals a steeper decline of relief ratings in the high than in the low P-IU group, which is consistent

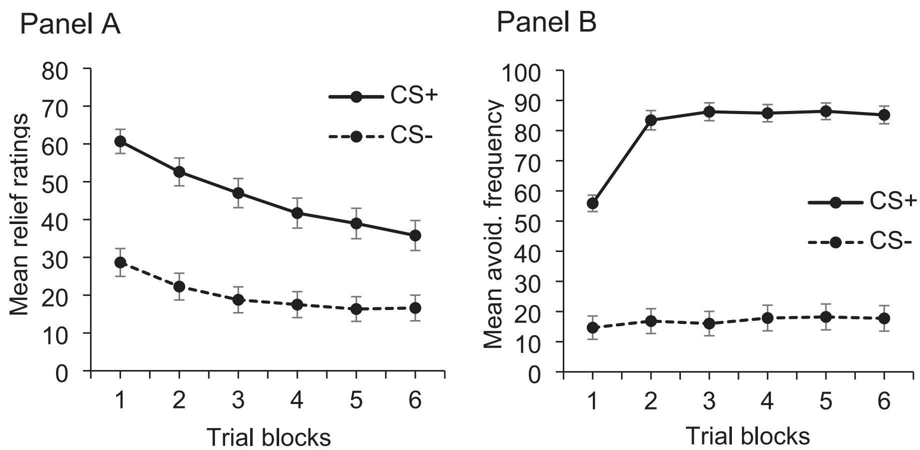

Fig. 3. Results from the instrumental learning phase. Panels A and B show the mean relief ratings and the mean avoidance response frequency, respectively, as a function of CS type and trial block.

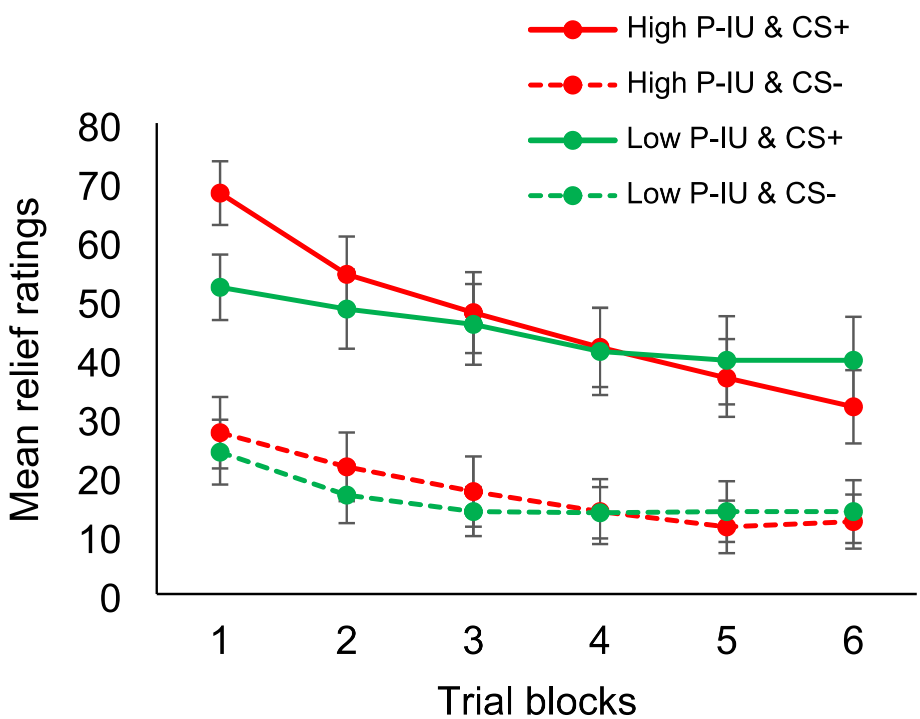

Fig. 4. Mean relief ratings from the instrumental learning phase as a function of CS type, trial block and P-IU group. High and low P-IU participants scored above the second and below the first tertile, respectively.

with the significant trial block × P-IU interaction. However, this pattern is much more evident in the CS+ than in the CS− condition, which is consistent with the three-way interaction involving P-IU. This interpretation of the results was confirmed by a repeated measures ANOVA within each CS type condition, which revealed a significant interaction effect between trial block and P-IU within the CS+ condition, $F(5, 365) = 5.33$, $p = .004$, $\eta_p^2 = 0.07$, but not within the CS− condition (greatest $F = 1.29$, smallest $p = .267$). Interestingly, within the CS+ condition, relief ratings were higher in the high than in the low P-IU group within the first trial block, $t(47) = 2.09$, $p = .042$ (two-tailed test), Cohen's $d = 0.6$; and did not differ between groups within the remaining trial blocks (greatest $t = 0.844$, smallest $p = .403$).

Therefore, the modulating role of P-IU in relief ratings is strongly consistent with the idea that high P-IU, compared with low P-IU, participants tended to experience more distress while expecting an uncertain threat. However, as the participants learned to avoid the threatening US, they gradually gained certainty about the occurrence of the US, thus rendering P-IU dissociated from distress. Finally, adding TA to the CS-type × trial block × P-IU ANOVA model, rendered the three way interaction non-significant [$F(5, 360) = 2.13$, Greenhouse-Geisser corrected $p = .107$]. However, the trial block × P-IU interaction was still significant in the overall ANOVA, $F(5, 360) = 3.31$, Greenhouse-Geisser corrected $p = .034$, $\eta_p^2 = 0.04$, and within the CS+ condition, $F(5, 360) = 3.93$, Greenhouse-Geisser corrected $p = .018$, $\eta_p^2 = 0.05$. Adding DT as a covariate did not qualitatively change the results and was pointless as the effects involving DT were very far from significance and the correlation between P-IU and DT was very small ($r = 0.044$, $p = .707$). Further analyses to test the specificity of the significant effects found for P-IU controlling for I-IU revealed no significant effects involving any of these IU dimensions (see the Supplementary Materials for more details).

3.3.4. Individual differences regarding avoidance frequency

The three independent repeated measures ANOVAs including P-IU, TA or DT as covariates yielded no significant effects involving any of the three anxiety-predisposing traits (all *Fs* < 1.69, all *ps* > .13). Therefore, we failed to replicate Flores et al.'s (2018) results concerning the relationship between P-IU, TA, and avoidance frequency. However, the results showed a clear trend towards more avoidance responses in high P-IU than in low P-IU participants, especially in the CS+ condition, which is consistent with Flores et al.'s results (see Fig. S3 in the Supplementary Materials). Also, when our data were analysed together with those from Flores et al.'s (2018) study, we still found significant positive associations of P-IU, I-IU, and TA with avoidance frequency (see the Supplementary Materials for further details). Although when the three trait factors were included in the same ANOVA as covariates, only the effect of P-IU remained significant, and the effects of I-IU and TA were far from significance (see the Supplementary Materials for more details).

3.4. Test phase

3.4.1. Relief ratings

We started by analysing the effect of CS type and response limit manipulation on relief ratings. Fig. 5 (Panel A) shows the participants' mean relief ratings as a function of CS type and response limit condition. As expected, the repeated measures ANOVA analysis yielded a significant main effect of response limit, leading to higher relief ratings in the limited than in the unrestricted condition, $F(1, 74) = 35.11$, $p < .001$, $\eta_p^2 = 0.32$; CS type, with higher ratings in the CS+ than in the CS− condition, $F(1, 74) = 67.10$, $p < .001$, $\eta_p^2 = 0.48$; and a significant interaction effect between both factors, $F(1, 74) = 37.39$ $p < .001$, $\eta_p^2 = 0.34$. Follow-up analyses to study the interaction effect revealed a significant effect of response limit within the CS+ condition, $t(74) = 7.06$, $p < .001$, Cohen's $d = 0.82$; but not within the CS− condition, [$t(74) = 1.31$, $p = .195$].

3.4.2. Avoidance frequency

We also analysed the effect of CS type and response limit manipulation on avoidance frequency for checking purposes. Fig. 5 (Panel B) shows the mean avoidance response frequency in the test phase as a function of response limit and CS type. The repeated measures ANOVA analysis yielded the significant effects of response limit, $F(1, 74) = 230.32$, $p < .001$, $\eta_p^2 = 0.76$; CS type, $F(1, 74) = 159.15$ $p < .001$, $\eta_p^2 = 0.68$; and the interaction between both factors, $F(1, 74) = 122.25$, $p < .001$, $\eta_p^2 = 0.62$. Follow-up analyses of simple effects revealed that the response frequency was significantly higher in the unrestricted than in the limited condition within the CS+ condition, $t(74) = 17.87$, $p < .001$, Cohen's $d = 2.06$; and within the CS− condition, $t(74) = 3.59$, $p = .001$, Cohen's $d = 0.42$. Interestingly, even though the instructions made it explicit that the aversive sound could be avoided by responding at a rate of one response per second, the mean response frequency increased up to nearly 80 responses per trial in the unrestricted-CS+ condition, i.e., about four responses per second. Response frequency was also higher in the unrestricted-CS− than in the limited-CS− condition, but the difference in this case was much smaller.

3.4.3. Avoidance confidence ratings

The results from the analysis of the avoidance-confidence ratings in CS+ trials were also consistent with our hypothesis. Specifically, confidence ratings in the unrestricted condition (*Mean* = 8.42, *SD* = 1.4) were significantly higher than in the limited condition (*Mean* = 5.91, *SD* = 1.97), $t(74) = 11.56$, $p < .001$, Cohen's $d = 1.33$.

3.4.4. The relationship between avoidance frequency, avoidance confidence, and relief ratings

To test if the increase in avoidance frequency found as a consequence of the response limit manipulation led to a reduction in relief ratings through an increase in perceived control, we conducted a mediation analysis to test the mediation model Avoidance Frequency → Avoidance Confidence → Relief. The analysis yielded a significant total effect for the Avoidance Frequency → Relief association, $\beta = -0{,}1469$, BCa CI 95 % [−0,2829, −0,0109], a significant direct effect for the Avoidance Frequency → Avoidance Confidence association, $\beta = 0.0307$, BCa CI 95 % [0.0233 0.0381], a significant direct effect for the Avoidance Confidence → Relief association, $\beta = -36{,}786$, BCa CI 95 % [−66,059, −0,7514], a non-significant direct effect for the Avoidance Frequency → Relief association, $\beta = -0{,}0340$, BCa CI 95 % [−0,1950, 0,1271] and a significant indirect effect for the Avoidance Frequency → Relief association, $\beta' = -0{,}1129$, BCa CI 95 % [−0,2156, −0,0045]. In other words, as we hypothesised, the effect of avoidance frequency on relief was mediated by perceived control.

3.4.5. Individual differences regarding relief ratings

As in previous sections, we started by conducting three independent ANOVAs including P-IU, TA and DT as covariates in each test. These analyses yielded the marginally significant CS type × response limit × P-IU interaction, $F(1, 73) = 3.7$, $p = .058$, $\eta_p^2 = 0.05$, and the significant effect of CS type × response limit × TA interaction, $F(1, 73) = 5.73$, $p = .019$, $\eta_p^2 = 0.07$. None of the effects involving DT was significant (all *Fs* < 0.91, all *ps* > .344). Follow-up analyses to interpret the three way interaction involving TA revealed a significant response limit × TA interaction within the CS+, $F(1, 73) = 4.95$, $p = .029$, $\eta_p^2 = 0.06$, but not

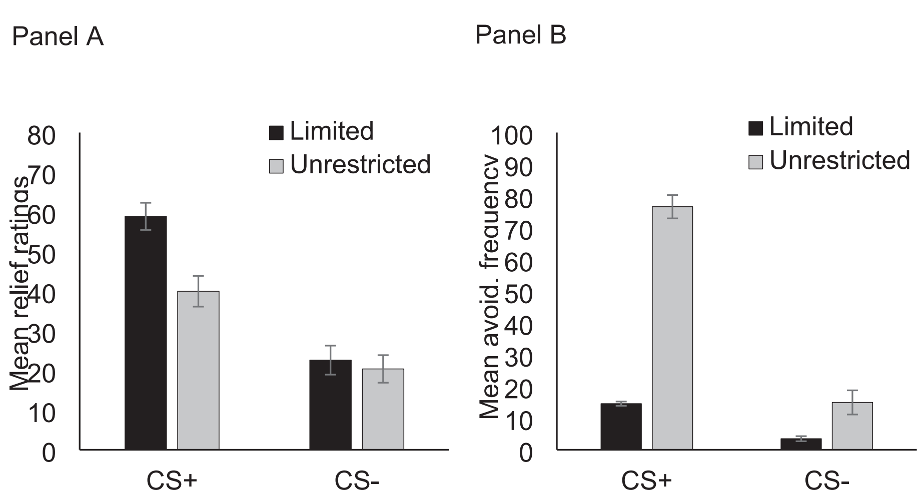

Fig. 5. Results from the test phase. Panels A and B show the mean relief ratings and the mean avoidance response frequency, respectively, as a function of CS type and response condition.

within the CS− condition [$F(1, 73) = 0.9$, $p = .76$]. As we also expected to find a modulating effect of P-IU only within the CS+ condition, we also conducted the same follow-up analyses focused on P-IU, which yielded the significant response limit × P-IU interaction within the CS+ condition, $F(1, 73) = 4.04$, $p = .048$, $\eta_p^2 = 0.05$, but not within the CS− condition [$F(1, 73) < 0.01$, $p = .943$]. Pearson correlation analyses between the differential relief ratings within the CS+ condition (limited response condition – unrestricted response condition), and P-IU and TA revealed positive and significant correlations in both cases, $r = 0.229$, $p = .048$, $r = 0.252$, $p = .029$, respectively. These results indicate that the increase in P-IU or TA was associated with an increase in the impact of the response limit manipulation on the participants' relief ratings within the CS+ condition. However, these last results from post-hoc analyses concerning P-IU should be taken cautiously because no correction procedure was used to avoid an increase in type-I error. Such procedures would have been a bit conservative, and, after all, these analyses can be justified given that we expected P-IU to play a role within the CS+ rather than the CS− condition. Finally, when both P-IU and TA were included in the overall ANOVA and in the ANOVAs conducted within each CS type condition, none of the effects involving P-IU or TA remained significant (all Fs < 1.69, all ps > .197). These results clearly indicate that neither P-IU nor TA had specific modulating effects. Rather, the shared variance between both anxiety predisposing traits seemed to modulate the interaction between response limit and CS type. Finally, a CS type × response limit × I-IU ANOVA also revealed a significant three-way interaction. Moreover, when I-IU and P-IU were included together as covariates in the CS type × response limit ANOVA, none of the effects involving P-IU or I-IU were significant, which indicates that the significant effects involving P-IU were not specific of this IU dimension (see the Supplementary Materials for more details).

3.4.6. Individual differences regarding avoidance frequency

Again, we conducted three independent ANOVAs including P-IU, TA, and DT as covariates in each test. In this case, none of the effects involving anxiety predisposing traits reached statistical significance (all Fs < 2.4, all ps > .125). However, post-hoc additional analyses revealed a clear trend towards higher avoidance response frequency in the high than in the low P-IU group in the unrestricted CS+ condition. Such trend virtually vanished in the remaining conditions. For further information, see the Supplementary Materials.

3.5. Additional analyses

Correlation analyses were conducted to test if scores in P-IU and TA were related to contingency judgements about the relationship between each CS and each US, or to the US aversiveness ratings. None of the correlations were significant (greatest $r = -0.151$, smallest $p = .196$). Interestingly, the correlation between P-IU and the pre-test and post-test aversiveness ratings were particularly small (0.028 and 0.094, respectively), and so were the correlation between TA and such ratings (0.072 and − 0.017, respectively). Therefore, the evidence found for a relationship between these dispositional factors and relief ratings can hardly be explained by the idea of a positive association between P-IU or TA and the extent to which the US was considered aversive or individual differences in CS-US contingency learning (see the Supplementary Materials for additional results concerning contingency judgements).

4. Discussion

Excessive avoidance, a hallmark of anxiety-related mental disorders, does not serve any objective effect on the prevention of threats and has undesired and dysfunctional consequences. In the present study, we tested the hypothesis that excessive avoidance is, in part, a goal-directed behaviour aimed to reduce the distress caused by an uncertain threatening event by enhancing the subjective perception of certainty and controllability. Although this mechanism is expected to operate in the general population, it could be modulated by individuals' prospective intolerance of uncertainty (P-IU). Specifically, individuals high in P-IU, compared with those low in P-IU, may be more motivated to engage in excessive avoidance as this anxiety predisposing factor entails an intensified aversive reaction to uncertain threats. The set of results reported here supports our hypothesis conceived as a general mechanism and partially supports our predictions regarding the role of P-IU.

In our experiment, we used Flores et al.'s (2018) avoidance learning task, though with some changes. Thus, our participants learned to avoid an aversive US through a procedure in which there were three sources of uncertainty: a) the US occurred in 50 % of CS+ trials, b) it could be delivered at any moment within a wide time window in CS+ trials, c) no information was provided about the consequences of avoidance responses within each trial. Additionally, we employed post-trial relief ratings as a proxy of the distress suffered during the previous trial, and we manipulated the amount of avoidance responses available in each trial of the test phase. The analysis of relief ratings from the Pavlovian learning phase revealed a reasonably good discrimination between CS+ and CS− trials that improved significantly across trial blocks. In general, the participants' relief ratings tended to be higher when requested after CS+ than after CS− trials, which is consistent with suffering more distress in the presence of the former than in the presence of the latter CS type. However, at odds with the predictions drawn from our hypothesis, we failed to find evidence of a role of P-IU in the participants' distress as measured through post-trial relief ratings, although we found a trend towards higher relief ratings in high P-IU than in low P-IU participants. Regarding the instrumental learning phase, we found evidence of a moderating role of P-IU. Specifically, our results indicated that when the participants confronted the high threat uncertainty entailed by the first CS+ trials, high P-IU was found to be associated with higher relief ratings. This association, however, vanished gradually across CS+ trials as the participants learned to avoid the US and gained certainty about the US omission. This moderating role of P-IU was not found in CS− trials, which may be explained by the fact that this CS predicted the certain absence of the US. Interestingly, this moderating role of P-IU remained significant even when controlling for trait anxiety (TA) and distress tolerance (DT) but not when controlling for inhibitory intolerance of uncertainty (I-IU) -see the Supplementary Materials for more details. Regarding avoidance behaviour, our results did not show the expected positive association between P-IU and avoidance response frequency found in Flores et al. (2018). However, as shown in the Supplementary Materials, we found a remarkable trend towards more avoidance responses in high P-IU than in low P-IU participants.

As for the test phase, the results concerning the effect of the response limit manipulation are very consistent, in general, with our hypothesis. Specifically, relief ratings after CS+ trials were higher in the limited than in the unrestricted condition. No differences were found within the CS− condition. Limiting the amount of avoidance responses available also reduced the participants' confidence in avoiding the aversive US in CS+ trials. In addition, a mediation analysis within the CS+ condition showed that the increase in avoidance frequency led to a reduction in relief ratings through the increase in avoidance confidence. Interestingly, the avoidance response frequency in the CS+ unlimited condition was far higher than what was objectively required by the task conditions to avoid the US. Specifically, though one response per second across the 20 s duration of the trial ensured the avoidance of the US according to the task instructions, the mean response rate during the trial was close to four times this value. This great amount of excessive avoidance found in the CS+ unrestricted condition is likely to be due to the three sources of uncertainty described above, and is consistent with Leng and Vervliet's (2022) study showing a relationship between increase in unproductive avoidance and increase in threat uncertainty. However, the use of a low-cost avoidance response may have also been crucial in this finding (see Pittig, 2019, and Pittig and Wong, 2021, for evidence of the effect of response cost on avoidance response frequency). Finally, we found weak evidence of a modulating role of P-IU in the effect of response limit.

Specifically, we found a positive association between P-IU and the magnitude of the effect of response limit on relief ratings within the CS+ but not within the CS− condition, although the P-IU × CS type × response limit interaction was only marginally significant. Interestingly, TA did significantly modulate the CS type × response limit interaction and was also found to be positively associated with the magnitude of the effect of response limit on relief ratings within the CS+ but not within the CS− condition. However, these modulating effects of TA and P-IU disappeared when both anxiety-predisposing traits were included as covariates in the analyses. Finally, consistent with the results found in the instrumental learning phase, we found a trend towards a positive association between P-IU and avoidance response frequency within the CS+ unrestricted condition. However, this association was not significant, nor did we find a significant P-IU × CS type × response limit interaction effect on avoidance frequency (see the Supplementary Materials for more details).

Despite having found some trend towards a positive association between P-IU scores and avoidance frequency, we could not replicate the significant positive association found by Flores et al. (2018). Additionally, the participants in the present study tended to respond, in general, at a much higher rate compared with the participants in Flores et al. (2018). This impression has been confirmed by an ANOVA conducted to compare the results from the two studies (see Fig. S4 and the results from the analyses in the Supplementary Materials). The only difference between the experimental procedure used in our study and that used in Flores et al. that may be relevant to understand these discrepancies is the duration of the time window within which the threatening US could occur. Such time window was increased from 4 s around the middle part of the 20-second CS interval in Flores et al. (2018) to 12 s in the present study. This change may have heightened the uncertainty regarding the time at which the US could occur, which, in turn, may have led our participants to make more avoidance responses to reduce such uncertainty. Additionally, this heightened threat uncertainty may have diminished the sensitivity of our experiment to detect individual differences in avoidance frequency associated with P-IU. However, when the data from both experiments were analysed together, P-IU, TA and I-IU were found to be significantly associated with increase in avoidance frequency when included in separate ANOVAS (see the Supplementary Materials for more details). However, when these factors were included in the same ANOVA, only the positive association between P-IU and avoidance frequency remained significant. The associations between TA and I-IU, and avoidance frequency were far from significance.

The reasons for having found evidence of a modulating role of P-IU in relief ratings in the instrumental learning but not in the Pavlovian phase are unclear. The latter phase might need further trial blocks to have more chances of detecting individual differences associated with P-IU. Alternatively, the interruption between the Pavlovian and the instrumental learning phase plus the change in the dynamics of the task by having participants learn to avoid the US without any specific feedback may have added more sources of uncertainty. These added sources of threat uncertainty might have been crucial to detect individual differences in distress (as measured through post-trial relief ratings) associated with P-IU. In line with this account, Morriss et al. (2021) suggest that implementing several “layers of uncertainty” may be important to find evidence of a modulating role of IU in fear conditioning and avoidance learning preparations. They explain that the different quantity of unknowns or layers of uncertainty used in studies on IU and fear conditioning and avoidance learning may account for the inconsistent results found regarding the role of IU. Future studies could manipulate the quantity of unknowns in a precise way to systematically assess its impact on the modulating role of IU in excessive avoidance.

Our attention regarding individual differences was on P-IU because over-engagement behaviours aimed at enhancing perceived control has been found to be positively associated with P-IU and negatively associated with I-IU (Bottesi et al., 2019). Consistently, Flores et al. (2018) found that this factor, but not I-IU, was positively associated with excessive active avoidance in the instrumental learning phase. However, the same analyses conducted here to analyse the role of P-IU in relief ratings from the present study and avoidance frequency from the present study together with Flores et al.'s (2018) were also carried out to assess the role of I-IU. In general, the results tended to be less reliable or non-significant compared with P-IU. Finally, its inclusion as a covariate together with P-IU and TA rendered the effects of P-IU on relief ratings non-significant, although the effect of P-IU on avoidance frequency when both experiments were analysed together remained significant (see the Supplementary Materials for more details). Thus, although the evidence accumulated in our laboratory seems to suggest that P-IU has a specific modulating role in avoidance frequency beyond I-IU, we failed to find strong evidence of a specific modulating role of P-IU in relief ratings.

Our results concerning individual differences in relief ratings throughout the instrumental learning phase may be viewed as conflicting with previous studies conducted by Vervliet et al. (2017) and San Martín et al. (2020). In these studies, anxiety predisposing traits such as distress tolerance and intolerance of uncertainty were found to be (negatively and positively, respectively) associated with persistent high levels of relief ratings across the avoidance acquisition phase, especially within CS+ (US avoidable) trials. Moreover, San Martín et al. (2020) found a negative correlation between IU and the decrease of differential (CS + avoidable minus CS−) relief from the first to the second block of the avoidance acquisition phase. A look at Fig. 3 above reveals that, if any, our results point to the opposite direction: High scores in P-IU, compared with low scores, was associated with a steeper decline of differential (CS+ minus CS−) relief. If we interpret post-trial relief ratings in terms of distress suffered during the previous trial, it seems that avoidance responses in CS+ trials led to less distress reduction in participants scoring high than in participants scoring low in IU in San Martín et al. (2020), and to more distress reduction in participants scoring high than in participants scoring low in P-IU in our study. There is, however, a crucial difference between our study and those conducted in Vervliet's laboratory that may explain this apparent conflict. Participants in Vervliet's laboratory could only make one avoidance response per trial, whereas participants in our task could make as many responses as they wished. Thus, our participants scoring high in P-IU could reduce their distress by overengaging in avoidance responses. This strategy could not be used by participants scoring high in IU in San Martín et al.'s or by low DT participants in Vervliet et al.'s studies, which may explain why their relief ratings tended to remain high, especially in CS+ (US avoidable) trials. This explanation receives some support from the trend found in our experiment towards a positive association between P-IU and avoidance response frequency in the instrumental learning phase. Also, when participants confronted limited-response CS+ trials at test, we found a clear trend towards higher relief ratings in participants scoring high in anxiety predisposing traits such as P-IU or TA, which is more in line with the results found in Vervliet's laboratory with the one-response procedure.

One limitation of our study is the lack of physiological measures. Previous studies have used skin conductance response (SCR) together with relief ratings to study the dynamics of fear and relief during avoidance acquisition, extinction, and generalization (Papalini et al., 2021; San Martín et al., 2020; Vervliet et al., 2017). An interesting advantage of measuring the SCR is the possibility of testing our hypothesis in a more direct way. Instead of inferring the distress suffered during training trials from post-trial relief ratings, we could measure the aversive reaction experienced by registering the SCR throughout the 20-s period of the CS presentation. This way, the different manipulations implemented in our study may have an impact on SCRs. For example, it would be reasonable to expect an increase in SCR as a consequence of limiting the number of avoidance responses in CS+ trials at test. Individual differences associated with anxiety-predisposing traits could also be tested. For example, it could be assessed if changes in SCR as a result of the response limit manipulation are positively associated with P-IU or

TA.

Another limitation is the unbalanced proportion of female and male participants. Our final sample included 69 females in a total of 75 participants. This great proportion of female participants may produce biased results, especial when it comes to the study of individual differences related to anxiety-predisposing traits. Also, although the vast majority of our participants were White European, we did not request information regarding race or ethnicity. Future studies should recruit a greater proportion of male participants, and should request information regarding race and ethnicity to enhance the generalisability of our results.

To sum up, our results shed light on the question of what is reinforcing excessive avoidance beyond any objective prevention of an uncertain threat. There is a goal at which apparently unproductive avoidance is aiming at, namely, enhancing the perception of control to decrease the distress produced by uncertain threats. Additionally, it seems that people scoring high (vs low) in P-IU and I-IU may be more vulnerable to this relief craving because they feel more distress when waiting for uncertain threats. We have shown that subjective distress reduction can be an effective reinforcer of avoidance responses in our laboratory model, beyond any objective effect on actual threatening events. So far, relief and subjective perceived control ratings have proved to be useful to show that excessive avoidance is likely to be, at least in part, a goal-directed behaviour to some extent detached from environmental consequences. However, it remains to be known if this mechanism is resistant to response cost and if excessive avoidance habitualises with extended practice, especially in clinical populations. Further studies are needed to shed light on these questions and to improve our understanding of the mechanisms responsible for excessive and dysfunctional avoidance in anxiety-related disorders.

Data availability

The data and the software for the experimental task have been uploaded to OSF. The project is public and the link is included in the manuscript

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijpsycho.2022.07.002.

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