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Can you escape the virtual room? A novel paradigm to assess avoidance behaviour

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ABSTRACT

Anxiety patients often experience conflicts between approaching (pass barking dog) and avoiding (take detour) feared situations. In most experimental avoidance paradigms, response options are limited or forced, making it difficult to generalize the results to daily life situations. The aim of the present study was twofold: 1) to develop a more ecologically valid avoidance paradigm; 2) to examine the influence of individual characteristics (trait anxiety; distress tolerance) on approach-avoidance behaviour. To encourage free exploration behaviour, a virtual reality (VR) escape room was developed. In this room, participants searched for cues to decipher a code-locked door. Opening a marked vase (conditioned stimulus, CS) was followed by a jump scare, a rat jumping out of the vase (unconditioned stimulus, US). Avoidance was measured via questionnaires and relative manipulation time of CS-marked (EXPgen) or nonmarked (CONT) objects in the room; questionnaires measured trait anxiety and distress tolerance. EXPgen participants reported higher US expectancies and more avoidance of the (marked) vase compared to the CONT participants, yet behavioural data did not support these ratings. Additionally, higher trait anxiety scores coincided with higher US expectancies before the jump scare. The current flexible free-exploratory paradigm provides multiple opportunities to examine avoidance behaviour in different populations and settings.

1. Introduction

Avoidance of actual threatening stimuli or situations is a core characteristic of adaptive fear. It is wise to run away from a forest fire and to take a detour to avoid a wild-barking dog. These avoidance tendencies are important as they foster survival. However, it is equally important to be able to modify this behaviour when new information is available. For example, you might reconsider passing the dog if you see it is on a tight leash, saving you valuable time. If not, avoidance loses its adaptive value and may become maladaptive, hindering daily functioning. This maladaptive avoidance is a core characteristic of a variety of mental disorders such as anxiety disorders, trauma and stress-related disorders, and obsessive compulsive disorder (American Psychiatric American Psychiatric Association, 2013). For example, avoidance keeps a person from taking a plane (flight phobia) or pressing an elevator button (contamination fear), making the world smaller and fostering fear that hinders daily-life routines.

Because avoidance plays an important role in a variety of mental disorders, it is essential to understand the processes that contribute to the development and the maintenance of avoidant behaviour. After an initial interest in –mostly animal– avoidant behaviour (see for reviews LeDoux, Moscarello, Sears, & Campese, 2017; Mineka, 1979; Rescorla & Solomon, 1967), researchers have regained attention regarding this topic (see for a reviews, Dymond, Bennett, Boyle, Roche, & Schlund, 2018; Dymond & Roche, 2009; Krypotos, Effting, Kindt, & Beckers, 2015; Pittig, Treanor, LeBeau, & Craske, 2018; Pittig, Wong, Glück, & Boschet, 2020). Since then, several human laboratory studies have been carried out and linked avoidance behaviour to psychopathology (see for reviews Dymond et al., 2018; Pittig et al., 2018; Servatius, 2016).

In classical lab active avoidance procedures, a discrete instrumental avoidance response typically results in the cancellation (escape) or omission of an aversive event (Unconditioned Stimulus, US). This behaviour can be, for example, a button press to avoid a shock (Engelhard, van Uijen, van Seters, & Velu, 2015; Lovibond, Mitchell, Minard, Brady, & Menzies, 2009; San Martín, Jacobs, & Vervliet, 2020; Vervliet & Indekeu, 2015; Vervliet, Lange, & Milad, 2017) or pressing “enter” on a keyboard (Nitta, Takahashi, Haitani, Sugimori, & Kumano, 2018). The disadvantage of these paradigms is that avoidance costs are often low,

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responses are forced, and response options are limited.

In daily life, alternative (costly) options are often present. In the dog example, you do not need to pass the dog; a detour is available although this will cost you time. Tasks that tap on these conflict situations often rely on avoidance that is (more) passive. For example in an approach-avoidance conflict task, participants can select a safe –less rewarding—stimulus over a high rewarding stimulus with a high punishment (e.g., air puff or shock) probability (Lemmens, Smeets, Beckers, & Dibbets, in press; Sierra-Mercado et al., 2015; Talmi, Dayan, Kiebel, Frith, & Dolan, 2009; Wong & Pittig, 2020), or can select two out of three CS—(no)US contingency alternatives (Grillon, Baas, Cornwell, & Johnson, 2006). Alternatively, behavioural approach tests (BATs) can be employed, in which participants approach a feared stimulus (e.g., spider) or endure a fear-eliciting situation (stay in an elevator). Like the previous task, these situations create a conflict between carrying out the social demand to approach the feared situation and the tendency to avoid or escape. Especially, this social component makes the BAT prone to instruction biases. Though informative, in none of the paradigms, free exploration behaviour is possible and the amount of response alternatives is limited, making it a simplification of real life. In sum, this calls for novel avoidance paradigms (see for a reviews LeDoux et al., 2017; Pittig et al., 2018; Pittig et al., 2020).

The first aim of the present study was to develop a more complex, avoidance paradigm. Instead of using a static computer set-up, or a simple approach-avoidance choice, we wanted to create an interactive virtual environment that encourages participants to freely explore and manipulate their surroundings, as is the case in daily life (see for a VR choice paradigm Grillon et al., 2006). This type environment can assess subjective self-reported avoidance, but also physical distance to the aversive material. To this end, a virtual escape room was developed. This allows examination of explorative behaviour, namely searching for codes, can incorporate relations between neutral and aversive events (CS—US associations), and can be easily adapted for different populations (e.g., persons with spider phobia). Additionally, this paradigm creates the opportunity to look at generalization of avoidance across different stimuli and environments.

The second aim was to use the novel paradigm to examine differences in approach-avoidance tendencies. Though people have the inherent propensity to approach rewarding stimuli and to avoid threatening stimuli (i.e., Thorndike's "Law of effect", Thorndike, 1898), the degree of these approach-avoidance tendencies varies among people. Two factors that are linked to differences in approach-avoidance tendencies are trait anxiety or neuroticism –which are believed to be part of the same underlying personality trait dimension– and distress tolerance. Research has indicated that higher levels of trait anxiety (e.g., Pittig et al., 2018; Pittig & Scherbaum, 2020; Pittig, Schulz, Craske, & Alpers, 2014; Vervliet & Indekeu, 2015) or neuroticism (e.g., Lommen, Engelhard, & van den Hout, 2010) are linked to more avoidance and generalization of avoidance to similar, but harmless, stimuli. This seems logic as high anxious persons are more prone to (incorrectly) label situations as threatening, resulting in avoidance of these situations (i.e., exploiting a better-safe-than-sorry strategy). A second personality trait that might play a crucial role in approach-avoidance tendencies is distress tolerance. Distress tolerance refers to the perceived capacity to experience and endure negative emotional states (Simons & Gaher, 2005). Low distress tolerance individuals are said to be prone to non-adaptively respond to present or upcoming stressful events. Consequently, they are highly motivated to search for negative reinforcement alternatives by, for example, avoiding or escaping from these events (Leyro, Zvolensky, & Bernstein, 2010). There is ample evidence for the relation between trait anxiety and avoidance; however, the relation between distress tolerance and avoidance has received considerably less attention. Recently, Vervliet and colleagues investigated the relation between distress tolerance and instrumental avoidance using a conditioning paradigm (San Martín et al., 2020; Vervliet et al., 2017). In these studies, persons with lower distress tolerance indeed (tended to) generalized their avoidance response more often to unproductive or unnecessary situations (e.g., unavoidable CS+). The present study wants to add to this sparse literature on distress tolerance, avoidance and generalization of avoidance behaviour.

As an interactive environment was created, we expected that the novel virtual escape room would encourage exploration behaviour. Based on previous studies, we hypothesized that predictors (CSs) of an aversive event (US) would not (or postponed) be manipulated to avoid the US. We also expected that higher levels of trait anxiety and lower levels of distress tolerance would result in more subjective and behavioural avoidance to an avoidable CS previously paired with an US.

2. Method

2.1. Participants

Sixty-one participants were recruited from Maastricht University via pin boards and online advertisements. Due to equipment failure ($n = 3$) and pre-knowledge about the experiment ($n = 1$) the sample included for data analyses consisted of 57 students (13 males, 43 females, 1 non-specified, mean age: 19.96 years, *SD*: 1.52 years). Exclusion criteria were pregnancy and prior or current anxiety disorders. Participants were randomly assigned to the control (CONT) or experimental avoidance generalization (EXPgen) condition. Participation was rewarded with course credit. Ethical permission was obtained by the Ethical Research Committee of Psychology and Neuroscience (Master_181_02_07_2017_A1) and the experiment was carried out according to the ethical principles of the Declaration of Helsinki (Williams, 2008).

2.2. Virtual reality (VR)

The study was conducted in the VR lab of Maastricht University, a room of 6 by 4 m. Participants could freely walk while wearing headphones, a head mounted display (HMD, HTC Vive®, Seattle, USA) that provides a 3D stereoscopic view, and using a controller (HTC Vive controller®, Seattle, USA) to manipulate virtual objects. The task was programmed using Unity®.

2.3. Practice and escape room

The practice room consisted of a plain white room containing a desktop with books, drawers and doors. A code could be entered on a door opposite the desktop. The fear conditioning paradigm was carried out in a virtual escape room (see Fig. 1.). The room represented a classic home office including several searchable elements such as bookcases, drawers, a writing desk, cushions, chairs, pendulum clock, several statues and side tables. Elements could be manipulated, for example opened and closed or lifted and turned by using the controller. Codes were hidden in the room and entering all codes in the correct order unlocked the door.

2.4. Stimuli fear conditioning

The CS used was a compound stimulus consisting of a visual part (post-it note with question mark on a large vase with a lid) and an auditory part (scratching sound, inside the vase). The US was a jump scare; a black rat with red eyes jumping out of the marked vase while making hissing and screeching sounds.

2.5. Fear conditioning task

The VR part of the task started with a practice phase. The experimental task consisted of an Exploration phase, a Fear conditioning phase and a Generalization or Second exploration phase. Each phase took place in the same home office and participants had to find three unique codes in order to escape the room. The locations of the codes different across the rooms (i.e., 9 different locations).

Fig. 1. Pictures of the room used (A and B), example of a code (C) the door with the code entrance (D), CS (E) and US (F), generalization stimuli (G and H).

2.5.1. *Practice phase*

The practice phase took place in the practice room. In order to familiarize the participants with VR and usage of the controller, they were invited to pick up the books from the desktop, open the doors and drawers and walk around. The code, 1234, could be entered by clicking the numbers at the display at the door. Entering the correct code automatically led to the Exploration phase.

2.5.2. *Exploration phase*

The participants were invited to search for three codes in order to escape the room. The codes were hidden and not directly visible (e.g., behind a cushion, at the back cover of a book), if necessary, the experimenter provided hints to help the participants. After entering the three codes, the next phase was started.

2.5.3. *Fear conditioning phase*

The participants re-entered the classic home office and were encouraged to search for three new codes; hints were no longer provided. This time the CS–US combination was presented. The post-it note was placed on a vase and an accompanying scratching sound emerged from the vase. Lifting of the lid from the vase resulted in a jump scare (US), with the rat jumping out of the vase towards the participant, while making a screeching sound. Subsequently, the rat would return to the bottom of the vase and continued making hissing sounds. Opening the vase triggered the television screen to display, after a couple of seconds, the last escape room code. Depending on the condition assignment, the next phase was either the Generalization phase or a Second exploration phase.

2.5.4. *Generalization phase*

Only participants of the EXPgen carried out this phase. Participants were once more invited to find three codes. The CS (post-it plus sound) was placed at three locations: the original location, the vase; on a single wooden door beneath the television; on the left door of a double glass door. The CS vase contained the third code and was therefore, unavoidable if the participants wanted to solve the room, the other two CSs (generalization) were avoidable as no codes were hidden there (or previously).

2.5.5. *Second exploration phase*

The second exploration task was only carried out by the CONT participants and strongly resembled the first exploration phase. No US, post-it notes and scratching sounds were present; the vase was still at the same spot and participants could escape the room by entering the three codes (placed at the same locations as the Generalization phase).

2.6. Stimulus ratings: fear conditioning phase

2.6.1. US ratings

Participants indicated with a slider on a visual analogue scale (VAS) how much the US (rat) startled/scared them (VASstartle) and how much they expected the rat to jump out of the vase (VASexp#1). The scales ranged from 0 not at all to strongly 100.

2.6.2. CS ratings

Participants indicated which sign predicted the occurrence of the rat. They could select one or more options: the post-it, the scratching sound, the vase or nothing particular. Next, they were invited to indicate the best predictor.

2.7. Questionnaires last room

2.7.1. Generalization phase & second exploration phase

Participants were asked about the strategy used to solve the last room (multiple answers possible). Answer options were: a specific order (e.g., from left to right); previous code locations first, previous code locations last, other strategy (text entry). For the EXPgen participants additional answer options were: the post-it locations first and the post-it locations last. If the post-it locations first was selected, an additional explanation was asked. Our previous, unpublished, study (n = 40) indicated that searching the CS—US location first was used for competing reasons, for example, curiosity or "to get it over with" (part of a research master thesis, Cappelletti, 2019).

Several VASs were used to examine avoidance and US expectancy of Room 3. The range of each scale was 0 (not at all) to 100 (strongly). Avoidance of the (CS-marked) vase was measured (VASav-vase), US expectancy regarding the vase (VASexp#2), how much they expected the US at the (CS-marked) cabinets (VASexp-csgen) and, for the EXPgen participants how much they avoided the CS-marked cabinets (VASav-csgen).

2.8. Questionnaires

2.8.1. State-Trait Anxiety Inventory-Y (STAI-Y)

Trait anxiety was assessed with the trait part of the STAI-Y (Spielberger, Gorsuch, & Lushene, 1970). The list contains 20 items that can be scored on a 1–4 scale ranging from "not at all/almost never' to "very much so/almost always" (Range: 20–80). The STAI-Y has shown good internal consistency and test-retest reliability (Ortuño-Sierra, Garcia-Velasco, Inchausti, Debbane, & Fonseca-Pedrero, 2016). Cronbach's alpha for the trait part, STAI-T, of the present study was, α = 0.923.

2.8.2. Distress Tolerance Scale (DTS)

The Distress Tolerance Scale is a 15 item self-report scale that measures perceived ability to tolerate emotion distress. (Simons & Gaher, 2005). The questionnaire contains four factors regarding (1) tolerability and aversiveness, (2) appraisal and acceptability (3) tendency to absorb attention and disrupt functioning, and (4) regulation of emotions. Items can be rated on a 5-point scale ranging from strongly disagree to strongly agree. High scores represent high distress tolerance. The DTS has shown good internal consistency, as well as convergent and divergent validity (Simons & Gaher, 2005). Cronbach's alpha for the present study was, α = 0.826.

2.9. Procedure

The procedure is depicted in Fig. 2. After reading the information about the experimental set up and signing the informed consent, participants filled in the STAI-T and DTS. Next, for all participants the VR task started with the practice room followed by the first two escape rooms (Exploration phase/Room 1 and Fear conditioning phase/Room 2). Then participants carried out either the Generalization phase (EXPgen condition) or the Second exploration phase (CONT condition). After finishing this last room, Room 3, the stimulus ratings and questionnaires regarding the VR escape rooms were filled out. All questionnaires used were presented via Qualtrics. Finally, participants were debriefed and rewarded with one course credit.

2.10. Statistical analyses

The design and analyses of the study were preregistered (AsPredicted, #31713).

Avoidance and generalization of avoidance were operationalized in two ways, via the questionnaires (VASav-vase and VASav-csgen) and behaviourally via the escape room patterns. Four escape room patterns were calculated by taking the relative time point of object manipulation (time of manipulation divided by total time spent in the room, range 0–1). First, the time to lift off the lid of the vase, VASE_rt. Second, the time to open the CS-marked (non-marked for the CONT) locations, CSgen1_rt (closed wooden door beneath the television, Fig. 1, H) and CSgen2_rt (glass door, Fig. 1, G). Finally, the relative time to open the glass door next to the (non-marked for the CONT) CS location leading to the same cabinet space, CSgen3_rt (Fig. 1, G). In case an object was not

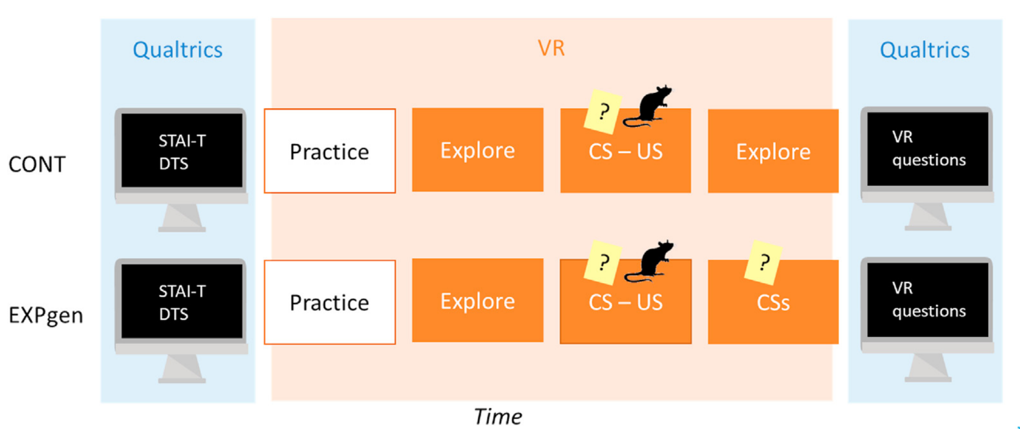

Fig. 2. General outline of the experimental procedure. Different colours in the virtual reality (VR) block represent different rooms. CONT = control condition; EXPgen = experimental generalization condition.

manipulated, the score was set at the maximum value of 1 (complete avoidance). The questionnaire data were analysed using univariate analyses of variance, with condition as fixed factor. The escape room patterns were analysed using a GLM repeated measures, with time (Room 2 and Room 3) as within-subjects factor and condition as between-subjects factor. Trait anxiety (STAI-T) and Distress tolerance (DTS) were separately entered as covariates in the abovementioned data analyses to examine the influence of these factors on avoidance behaviour. In case of multiple comparisons Bonferroni Holm corrections were made, Greenhouse-Geisser corrections were applied when Mauchly's tests of sphericity was significant. The rejection criterion was set at $p < .05$ throughout.

3. Results

3.1. Demographic variables, CS- and US-ratings

The data of the study are presented in Table 1. No differences between EXPgen and CONT were observed regarding gender distribution, χ^2 (1) = 1.75, p = .19, STAI-T or DTS scores, $Fs < 1$. We did observe a difference between the conditions regarding age, F (1, 55) = 5.51, p = .023. As age did not correlate with any of the dependent variables, $|rs| <$ 0.22, $ps > .11$, and including age as a covariate did not change the results, we decided not to incorporate age into our models.

The conditions did not differ regarding the amount they were startled/scared by the US (VASstartle) or expected the US (VASexp#1) to occur during the Fear conditioning phase (Room 2), $Fs < 1$. Neither did they differ in selection of the best predictor for the US, χ^2 (1) = 0.81, p = .89. Overall, the scratching sound and post-it were mentioned as best predictor (>90%) for the occurrence of the US.

STAI-T and DTS. Univariate analyses of variance with STAI-T or DTS as covariates and VASstartle and VASexp#1 as dependent variable revealed only one main effect between STAI-T and VASexp#1, F (1, 55) = 6.24, p = .016, $\eta_p^2 = 0.10$; with higher trait anxiety correlating with higher US expectancies, r (57) = 0.32. No other effects were observed, Fs < 1.

3.2. Avoidance and expectancy questionnaires

Univariate analyses of variance were carried out to examine differences in condition regarding US expectancy (VASexp#2), generalization of these expectancies (VASexp-csgen) and avoidance of the vase (VASav-vase) in Room 3 (see Table 2). In each of these analyses, condition (EXPgen and CONT) served as factor. These analyses indicated that the EXPgen gave higher US expectancies than did the CONT condition for both the vase (VASexp#2), F (1, 54) = 18.45, $p < .001$, $\eta_p^2 = 0.25$, and the marked/non-marked objects (VASexp-csgen), F (1, 55) = 4.59, p = .037, $\eta_p^2 = 0.077$. EXPgen also indicated that they avoided the vase more than the CONT did, F (1, 55) = 4.05, p = .049, $\eta_p^2 = 0.069$.

STAI-T and DTS. Including STAI-T or DTS as covariates in the analyses, yielded no significant covariate (interaction) effects, $Fs < 1$. The effects as reported above remained similar.

Table 1
Data escape room.

	CONT	EXPgen
gender m/f/n	9/18/1	4/25
age	20.43 (1.71)	19.52 (1.18)
STAI-T	41.04 (9.50)	42.41 (9.70)
DTS	3.26 (.66)	3.27 (.46)
VASstartle	67.67 (25.88)	69.10 (27.79)
VASexp#1	33.64 (31.68)	39.28 (36.90)
CS best predictor		
Post-it	39.3%	41.4%
Scratching	60.7%	48.3%
Vase		6.9%
Nothing		3.4%
VASav-vase	24.43 (28.77)	40.83 (32.54)
VASexp#2	37.04 (28.58)	69.14 (27.35)
VASexp-csgen	38.96 (32.66)	57.90 (34.02)
VASav-csgen		29.19 (29.53)
Strategies used		
specific order	15	20
previous code locations first	2	1
previous code locations last	6	5
post-it locations first	n.a.	8
post-it locations last	n.a.	4
other/no strategy	7	4

STAI-T = State-Trait Anxiety Inventory, Trait part; DTS = mean Distress Tolerance Scale; VAS = visual analogue scale.

3.3. Avoidance VR escape rooms

The data of the escape Rooms 2 and 3 are depicted in Fig. 3. A GLM repeated measures was carried out to examine the relative time to manipulate the listed objects (see Fig. 1). In each analysis, time (Room 2 vs. Room 3) served as within-subjects factor and condition (EXPgen vs. CONT) as between-subjects factor. For both groups the vase was labelled in Room 2 (Fear conditioning phase), but none of the other objects. In Room 3 all listed objects were CS-labelled for the EXPgen, none of these objects was labelled for the CONT.

Vase_rt. The GLM of the VASE_rt revealed no effect of time, F (1, 55) = 2.16, p = .15, $\eta_p^2 = 0.038$, and no main effect of condition or time × condition interaction, $Fs < 1$.

CSgen1_rt. The analysis of CSgen1_rt (wooden door below television) revealed no main or interaction effects, $Fs < 1$.

CSgen2_rt. The GLM of the CSgen2_rt (glass door) yielded a time × condition interaction, F (1, 55) = 4.39, p = .041, $\eta_p^2 = 0.074$. An ANOVA indicated that the conditions did not differ in relative time in Room 2, F < 1, but did in Room 3, F (1, 55) = 12.64, p = .001, with the CONT taking more time to open this location.

CSgen3_rt. The analyses of the door adjacent to CSgen3_rt revealed a similar interaction, F (1, 55) = 4.84, p = .032, $\eta_p^2 = 0.081$. The ANOVA revealed that in Room 2 no condition differences were observed, $F < 1$, but that the CONT was relatively slower to approach this location in Room 3, F (1, 55) = 13.38, p = .001.

STAI-T and DTS. The analyses were repeated with STAI-T or DTS added as covariate. Only the effects of the covariates will be reported as other results were similar to the results reported before. The GLMs revealed no interactions between the STAI-T and time, $Fs < 1.25$, $ps >$ .26, $\eta_p^2 < 0.023$, but did reveal a main effect for VASE_rt, F (1, 54) = 4.74,

Table 2
Exploratory correlations between the questionnaire and escape room outcomes.

	VASstartle (Room 2)	*VASexp#2 (Room 3)*	*VASav-vase (Room 3)*	*VASexp-csgen (Room 3)*	*VASav-csgen (EXPgen, Room 3)*
VASstartle (Room 2)	–				
VASexp#2 (Room 3)		–			
VASav-vase (Room 3)	.27*	.58**	–		
VASexp-csgen (Room 3)	.41**	.55**	.37**	–	
VASav-csgen (EXPgen, Room 3)			.40*	.52**	–
VASE_rt			.41**		
CSgen1_rt					
CSgen2_rt			-.28*	-.29*	
CSgen3_rt		-.26*	-.30*	-.31*	

VAS = Visual Analogue Scale, exp = US expectancy, av = avoidance, CS = conditioned stimulus, gen = generalization, rt = reaction time (relative), EXPgen = experimental generalization condition.

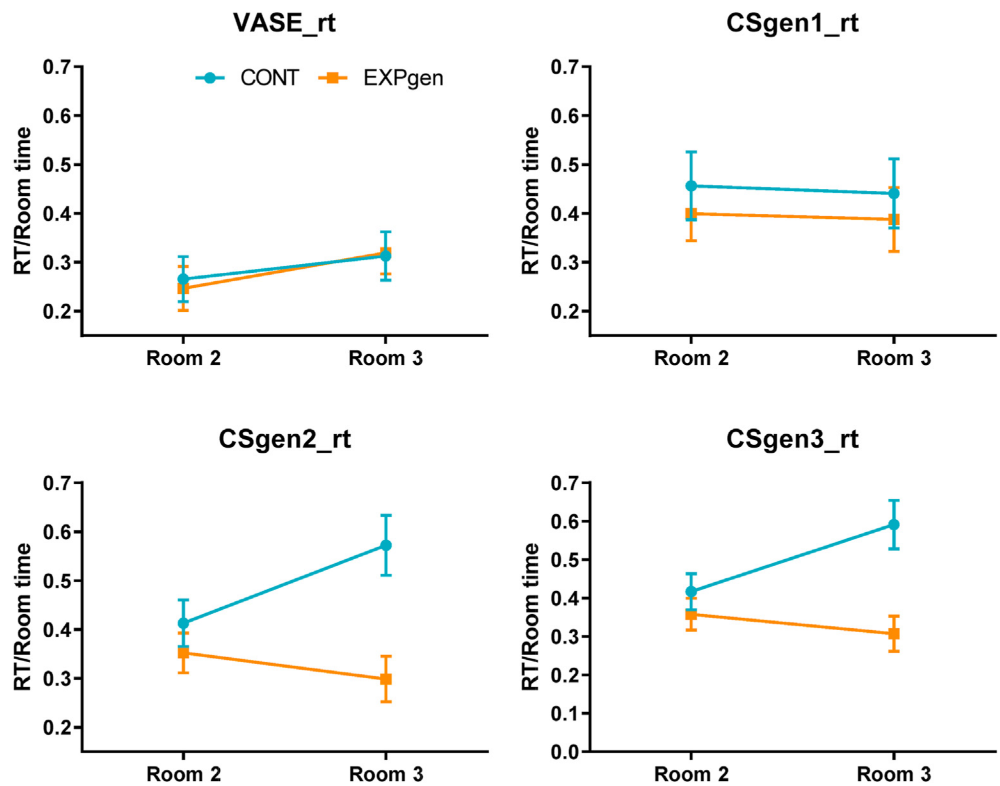

Fig. 3. The relative reaction time to open the lid of the vase (top left), wooden door (top panel right), glass door (bottom left) and the door adjacent to the glass door (bottom right) in Room 2 (CS—US pairing) and Room 3. For the experimental condition (EXPgen) the objects in Room 3 were marked with a post-it (CS); for the control condition (CONT) no markings were used in Room 3.

$p = .034$, $\eta_p^2 = 0.081$, and CSgen1_rt (wooden door), $F(1, 54) = 5.96$, $p = .018$, $\eta_p^2 = 0.099$. Overall, higher STAI-T scores resulted in relatively faster approach of the vase, $r(57) = -0.32$, $p = .015$, and the wooden door $r(57) = -0.28$, $p = .032$. Including DTS as covariate revealed no interaction effects, $Fs < 1.87$, $ps > .17$, $\eta_p^2 < 0.034$. The effect of DTS on VASE_rt approached significance, $F(1, 54) = 3.29$, $p = .075$, $\eta_p^2 = 0.057$, with the tendency of higher distress tolerance coinciding with relatively slower opening times of the vase, $r(57) = 0.24$, $p = .073$.

3.4. Exploratory analyses

Several exploratory analyses were carried out to get more insight in the novel paradigm. Note that all participants explored the rooms and successfully solved the three rooms.

3.4.1. Strategies used

Most of the participants used a specific order as strategy (e.g., from left to right). From the other strategies ($n = 11$), 7 mentioned that they would search in new locations first, as the codes would probably be located at novel locations. In the experimental group, 8 participants indicated visiting the post-it notes locations first as their strategy. Five of these, indicated that they thought the post-it note would be related to the codes, 1 indicated that curiosity was the main reason, and 2 participants indicated that they preferred to face their fear immediately.

3.4.2. Self-reported measures

Several correlations were carried out to link the self-reported measures to each other and to link these measures to behaviour in Room 3. Only significant observations are reported. To summarize, higher expectancies coincided – in general—with more avoidance. Self-reported avoidance of the vase coincided with relative longer approach times of the vase, but with shorter approach times to the other (non-marked) CS-locations. Note that this pattern did not change if only the EXPgen condition was included.

4. Discussion

Avoidance and generalization of avoidance behaviour are core characteristics of several mental disorders such as anxiety disorders, trauma and stress-related disorders, and obsessive-compulsive disorders (American Psychiatric Association, 2013). As avoidance hampers daily life, it is important to examine factors that influence (generalization of) avoidance behaviour. The objectives of the current study were: 1) to create a novel paradigm that enables an ecologically valid assessment of behavioural avoidance; 2) to provide insight in individual differences –trait anxiety and distress tolerance– that might relate to (generalization of) approach-avoidance behaviour. To this end, a virtual escape room was created to encourage exploration behaviour and to examine generalization of avoidance of a feared stimulus across several situations. Avoidance was measured via questionnaires and the relative time spent to manipulate (CS-marked) objects in the escape rooms.

First, all participants successfully solved the three escape rooms. This indicates that the virtual escape room encourages exploration behaviour and manipulation of the objects. The questionnaire results indicated that, as expected, after contingency learning (Room 2) the presence of the CSs (EXPgen) elicited stronger US expectancies than did the absence (CONT, Room 3). This higher expectancy level was not limited to the original CS location, but also spread to other locations marked by the CS, indicative of expectancy generalization. In line with our hypothesis, the EXPgen condition reported more avoidance of the CS-marked vase than did the CONT condition. Additionally, a positive correlation was observed between trait anxiety and US expectancy in Room 2; no effects were observed for distress tolerance.

The results of the behavioural escape room data contradicted the questionnaire results and our expectations. If anything, the EXPgen condition was faster to open a novel CS-marked location than the group without CSs. The individual factors indicated that, overall, higher levels of trait anxiety coincided with faster approach of the vase and one of the generalization CSs. However, this latter observation was non-specific, as no interaction with condition or room was observed. For distress tolerance, only a trend across rooms was detected, with higher tolerance coinciding with slower vase approach time. As we did not preselect participants on STAI-T or DTS scores, the deviation in scores was not very large, making it harder to detect the effect of these characteristics on avoidance. Preselecting participants or perhaps using other measures, such as uncertainty tolerance, might have provided more information about individual differences in generalization of avoidance (e.g., San Martín et al., 2020).

The questionnaire data are in line with previous studies on fear learning and avoidance. US expectancies generalized to other, similar situations; more avoidance was observed in the presence of the CS than in its absence (see for reviews, Krypotos et al., 2015; Pittig et al., 2018). The exploratory analyses indicated that both being more startled/scared by the US and having higher US expectancies (Room 3) correlated with more avoidance of the vase. For the EXPgen group higher levels of self-reported avoidance generalized to more avoidance of other CS-marked objects. In sum, if you expect something bad will happen, or it previously scared you, you are more likely to avoid it.

Regarding the individual differences, higher trait anxiety did correlate with initial higher US expectancies (Room 2), but not with higher expectancies in the last room, Room 3. This comes as no surprise, before onset of the experiment there was only a vague indication that something aversive might happen (e.g., scratching sound, post-it note), creating more chances to express individual differences regarding the CS—US relation (Chan & Lovibond, 1996; Lommen et al., 2010; Wong & Lovibond, 2018). However, disambiguating the role of the post-it note and sound resulted in the abolishment of this US-expectancy expression. The lack of relation between avoidance and trait anxiety ties in nicely with findings by San Martín et al. (2020), who also reported null findings. According to these authors this absence –in combination with their distress tolerance observations– supports the involvement of beliefs that one can tolerate distress or uncertainty, rather than general levels of anxiety.

In previous research distress tolerance was related to the proportion of avoidance responses on an unavoidable CS+ (San Martín et al., 2020). We did not observe this effect. However, the current set up deviated from the active avoidance studies of Vervliet et al. (2017, 2020), expectancies rather than relief was measured, and free exploration was deployed instead of fixed (single) stimulus presentations. These changes may have affected CS + avoidance behaviour, as safe alternatives were available and, therefore, the CS was always avoidable. If so, the results do resemble the data of San Martín et al. (2020), as no effect of distress tolerance was observed for the avoidable CS.

We included two measures of avoidance to cross-validate our novel paradigm. However, the self-reported avoidance did not concord with behavioural indices of avoidance. Though not expected, a diversion in response system outcomes occurs more often (see for a review Boddez et al., 2013). A self-expressed inclination to avoid does not necessarily need to translate in the physical avoidance (Boddez, Moors, Mertens, & De Houwer, 2020). Alternatively, this discrepancy can also be explained by looking at the strategy data. In the EXPgen group, eight participants indicated that the post-it note encouraged them to search that place first, as it might either indicate the location of the code or in order to immediately face their fear. This link between the CS and code location was unexpected. In the second room the CS was linked to the US, no code was hidden in the vase. However, in the last room the post-it notes were placed on locations that were not previously linked to codes. As the codes were relocated each time, it makes sense to search these areas first, with the post-it note serving as a guide. For a next study, it would be wise to use a novel room, with novel hiding places. Such approach would undermine the novel-location strategy and provide more insight in generalization of avoidance behaviour (see for an overview Dymond, Dunsmoor, Vervliet, Roche, & Hermans, 2015). An additional option is to use the vase and scratching sound as CS. At test, the vase can be placed at different locations in the same room or similar-looking vases varying in size, shape and colour can serve to explore avoidance generalization effects further.

A limitation that needs to be addressed is the included sample. We used a student sample without anxiety disorders, it is well thinkable that a clinical population –or even a population with fear of rats—might react differently, displaying more behavioural avoidance. In the near future, we want to use a spider as US in the virtual escape room and compare the avoidance patterns of spider-fearful and non-fearful participants. Additionally, we did not check for other mental disorders that might influence the results observed, such as autism, posttraumatic stress disorder, or depression (see for reviews Pittig et al., 2020; Servatius, 2016). Depression, for example, might result in increased (passive) avoidance (see for an explanation Pittig et al., 2018) or, on the contrary, in lack of active avoidance (e.g., learned helplessness Seligman, 1972). For a next study, we would advise to include measures for a broad range of psychopathology next to anxiety problems.

In conclusion, though the behavioural and self-reported measures do not match, the virtual escape room does trigger exploration behaviour. The set up provides a unique opportunity to examine avoidance behaviour. Stimuli can be adjusted for specific target groups (e.g., spiders for spider phobics) and environments can be customized (e.g., testing context-dependent effects), creating a legion of opportunities to examine avoidance and avoidance generalization.

Declaration of competing interest

The authors state that they do not have any conflict of interest.

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