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Effect of combined multiple contexts and multiple stimuli exposure in spider phobia: A randomized clinical trial in virtual reality

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ABSTRACT

Background: Our previous study indicated that treatment in multiple contexts (MC) improved the outcome of exposure treatment by reducing return of fear. This effect was evident when the test was conducted immediately post treatment. In the present study, we conducted a treatment analogue study where we investigated whether an exposure to multiple stimuli (MS) and a combination of both MS and MC would further improve treatment efficacy in the short and long terms.
Method: Spider-phobic patients (N = 58) were randomly allocated to one of four groups. Each group received virtual reality (VR) exposure treatment in either one or four different contexts and was exposed to either one or four different spiders. All participants completed both a VR test with a novel spider in a novel context and an in vivo behavioral avoidance test (BAT) pre-, post-treatment and at follow-up.
Results: Short-term but not long-term return of fear was attenuated by multiple context exposure in VR. Long-term effect of fear attenuation was observed only in the MS single context group. In the BAT, the multiple stimuli condition seemed to be more beneficial in both the short and long term. Notably, there was no evidence for superiority of the combined multiple stimuli and contexts condition.
Conclusion: Change of contexts during exposure significantly reduced return of fear post treatment; however, similar results could not be observed with a follow-up test. The implementation of multiple stimuli during exposure seems to have both short-term and long-lasting beneficial effects on the treatment outcome. We recommend further investigation of this phenomenon and introduce further possible improvements to our paradigm.

Exposure-based treatment is well established and has been proven highly efficacious for anxiety disorders (Deacon & Abramowitz, 2004). However, return of fear (ROF) after successful treatment is still a major challenge: For instance, in some cases a ROF rate of up to 62% has been documented (Mystkowski, Craske, Echiverri, & Labus, 2006). Several approaches have been utilized to reduce the ROF in conditioning paradigms and in pre-clinical and clinical samples (reviewed in Craske et al., 2008; Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014). Two relevant methods include the use of Multiple Contexts (MC) or Multiple Stimuli (MS) during extinction.

There are some studies demonstrating that MC extinction is more effective in reducing contextual renewal (measured as renewal induced through context change in the test phase) compared to single context (SC) extinction, both with animals (Denniston, Chang, & Miller, 2003; Laborda & Miller, 2013; Thomas, Vurbic, & Novak, 2009) and humans (Balooch, Neumann, & Boschen, 2012; Glautier, Elgueta, & Nelson, 2013). Also, a few studies have successfully implemented this method with clinical and pre-clinical samples by conducting exposure treatment in multiple contexts (MacKillop & Lisman, 2005; Shiban, Pauli, & Mühlberger, 2013; Vervliet, Vansteenwegen, Hermans, & Eelen, 2007). Other studies, however, found no benefits to MC exposure in humans (Bouton, Garcia-Gutierrez, Zilski, & Moody, 2006). Neumann, Lipp, and Cory (2007) did not find any reduction in renewal for the multiple contexts group in a conditioning study on a human sample using electrical shocks as US. In conclusion, it seems that multiple contexts do benefit in the short run (Vervliet, Craske, & Hermans, 2013).

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Studies investigating MS vs. Single Stimulus (SS) exposure are very rare. We are aware of only one study by Rowe and Craske (1998a) that exposed two groups of spider-phobic participants to SS vs. MS treatments (one vs. four different tarantulas). Participants were then tested using two spiders: a novel spider and a control spider, which was shown to all participants three times: pre-treatment, post-treatment and at follow-up. The authors found that anticipated anxiety towards the control spider increased from post-treatment to follow-up (three weeks later) only in the SS exposure condition. Importantly, the benefits of MS exposure did not extend to the efficacy of the other measures of treatment, e.g., BAT, physiological fear responses, or fear responses towards the novel spider.

The literature explaining the underlying mechanisms of fear learning has evolved remarkably over the past two decades. According to the emotional processing theory (EPT) by Foa and Kozak (1986), treatment will only be effective if it induces high initial fear activation and includes within and between session reductions of fear. However, empirical evidence challenges the assumptions of the EPT, revealing that short-term fear reduction or initial fear activation has no bearing on the treatment outcome in the long run (for a review, please see Craske et al., 2008). Inhibitory learning models were next to emerge and introduced the idea that a new inhibitory association capable of suppressing the fear association is learned during extinction (Bouton, 2004; Bouton & King, 1983). Therefore, the long-term effect of treatment highly depends on the strength and retrievability of this new no-fear memory (for a review, please see Vervliet et al., 2013). How can the strength and retrievability of such memories be enhanced? According to the New Theory of Disuse (NTD), retrieval strength of an association is an indicator of its current accessibility, whereas storage strength (ST) determines the long-term retrievability of a memory (Bjork & Bjork, 1992). Increasing the number of associations learned during the learning phase (in our case during the extinction) enhances the ST of a memory due to generalization processes. Consequently, we expect that an increase in the variability of the material and the context that has to be learned enhances the ST and therefore the long-term retrievability of a memory.

As virtual reality exposure (VRE) has already been acknowledged as an effective treatment method for specific phobia (Shiban, Brütting, Pauli, & Mühlberger, 2015; for reviews, please see Meyerbroker & Emmelkamp, 2010; Opris et al., 2012; Turner & Casey, 2014), we conducted an exposure treatment analogue study in virtual reality (VR) with a sample of spider-phobic patients which were randomly assigned to one of four groups: SS/SC, SS/MC, MS/SC and MS/MC. ROF was tested immediately post-treatment and about two weeks later in a follow-up test where participants were exposed to a novel spider in a novel context. At the test and follow-up, we expected the SS/SC group to show higher ROF compared to the other three groups. In line with previous results (Shiban et al., 2013; Vervliet et al., 2007), we expected low ROF for both MC exposure groups in the post-treatment test, but we had no hypotheses about the difference between the MS and MC groups regarding ROF. We also expected an attenuation of ROF at follow-up in the MS conditions as had been demonstrated before by Rowe and Craske (1998b).

1. Method

1.1. Participants

Participants were recruited through advertisements in local newspapers, via the Internet and with flyers. Inclusion criteria were diagnosis of a specific spider phobia according to the DSM IV (APA, 2000). The diagnosis of spider phobia and further Axis I diseases was established in the course of a clinical interview (similar to Shiban et al., 2013). Exclusion criteria were pregnancy, current involvement in psycho- or pharmacotherapy, cardiovascular or neurologically related diseases, dyschromatopsia and hearing damage, further Axis I diagnoses, 3D-simulation sickness and fear ratings after the first presentation of the virtual spider at less than 4 on a ten-point-scale. The exclusion criteria (except for the Axis I diagnosis and the initial fear ratings) were assessed by self-report during a screening procedure via telephone. All participants had normal or corrected-to-normal vision. As can be seen in the flow diagram (Fig. 1), 13 of seventy-one participants were excluded, as they did not meet inclusion criteria. In total, fifty-eight participants (8 males, 49 females, ages: 18–38 years, $M = 22.7$, $SD = 4.28$) successfully completed the experiment. In the follow-up, eight participants dropped out and 50 remained. Some participants were excluded from the analysis of physiological data due to technical problems: 51 remained for the analysis of SCR during the exposure session (38 in the follow-up session). For detailed analysis of participant dropout, please see the dropout section.

Participants were randomly allocated to one of the four groups (SS/SC, MS/SC, SS/MC and MS/MC group) using online randomization software.[2] By the end of the experiment, the SS/SC and MS/SC groups had 14 participants, while the other two groups had 15.

1.2. Stimulus material

A virtual reality (VR) environment with five clearly distinct virtual exposure rooms (see Fig. 2) and one room with doors leading to each of the exposure rooms was generated. Steam Source engine (Valve Corporation, Bellevue, Washington, USA) was used to generate the virtual environment. In order to control the VR environment during the experiment, in-house design software called "Cybersession" was used. The virtual environment was displayed via a Z800 3D Visor head-mounted display (HMD; eMagin, New York, USA). In order to adapt the field of view to participants' head movements, head positions were monitored using the Patriot electromagnetic tracking device (Polhemus Corporation, Colchester, Vermont, USA).

The presented stimuli were five clearly distinct virtual spiders (see Fig. 3). Spiders and rooms were rated in a pilot study with 79 non-phobic persons with respect to the fear they elicited (results of the pilot study will not be presented in detail). We found that the test room differed slightly from the other rooms in terms of valence and fear ratings. Since it was rated most negatively on the dimension of valence and was the most fear-inducing, it was chosen as the test room in order to maximize the return of fear during the test and follow-up. For the same reason, the test spider was chosen. The other virtual spiders did not differ from each other on any dimension. The same spider was presented in both single stimulus conditions. Likewise, the same room was presented in both single context conditions. Both the spider and the room for the single stimulus and the single context conditions were randomly selected prior to the experiment and were the same for all participants.

The virtual spiders were presented at the center of the virtual room and were programmed to wiggle slowly without changing position. In the MS/SC, SS/MC and MS/MC groups, the order of different exposure stimuli and contexts was pseudo-randomized. In order to increase the comparability of the two tests, identical spiders and rooms were used in the post-treatment test and follow-up test.

1.3. Measures

By using a battery of questionnaires and an interview, the following information was collected: age, gender, presence of

[2] http://www.randomizer.org/form.htm.