CONTEXT SPECIFICITY IN THE EXTINCTION OF LEARNED FEAR

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DECLARATION

UCL Doctorate in Clinical Psychology

Thesis declaration form

I confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Siobhan G. O'Leary

OVERVIEW

This thesis explores the role of context in the extinction of learned fear and environmentally specific renewal of the fear response. It has clinical relevance in relapse of previously extinguished anxiety.

Part 1 is a literature review that systematically examines the findings and methodologies within the behavioural field regarding the role of context in extinguished fear relapse in humans. It explores the main areas of investigation and critically appraises each study.

Part 2 is an empirical paper examining the effect of contextual change on fear responses following extinction. The research is framed in relation to the wider contextual fear and neurobiological literature and presents clinical and scientific implications.

Part 3 is a critical appraisal of Parts 1 and 2. It outlines the background context to the work, the methodological choices, theoretical issues, challenges that arose, and personal reflection on the significance and impact of the project.

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PART 1: LITERATURE REVIEW

CONTEXTUAL RENEWAL OF EXTINGUISHED FEAR:

A REVIEW OF THE FINDINGS AND METHODOLOGIES

IN HUMAN CONDITIONING STUDIES

ABSTRACT

Aims

This review aimed to systematically appraise the behavioural literature concerning the role of context in extinguished fear relapse in humans. Specifically, it asked what are the findings and methodological features within the field.

Methods

A comprehensive literature search was conducted. 17 studies were included having met specific criteria.

Results

The papers focused on the following areas: the basic renewal effect; involvement of multiple extinction contexts; manipulation of time; targeting the CS and/or US representation; and exposure therapy. The basic renewal effect was shown in all papers, with the ABA design producing larger renewal than the ABC. Three of four studies showed that multiple extinction contexts produced greater generalisation of extinction than a single context. The renewal effect was present over short and long-delay procedures. Manipulations of the CS and/or US representation(s) and mental reinstatement were shown to attenuate renewal. Overall the studies scored similarly on an appraisal tool but variations in the strengths and weaknesses in methodology and reporting existed.

Conclusions

It is still unclear as to whether the specific predictions of the commonly held view of behaviour change are valid, due to the lack of critical tests and possible subsequent misattribution of findings. Increased fine-tuning of experimental designs may serve to address this issue and ultimately better inform treatments against relapse.

1 INTRODUCTION

Fear conditioning includes the learning processes of fear acquisition and extinction. Acquisition is the procedure in which a previously non-fearful stimulus, the conditioned stimulus (CS), comes to provoke a fear response due to its previous pairing with an aversive unconditioned stimulus (US; Pavlov, 1927). This effect, the CS-US association, is a powerful and robust one, which has proven to be highly influential in the understanding of how anxiety disorders can develop and persist over time. Extinction is the process in which the repeated experience of the CS without the US produces a diminished or removed fear reaction. As extinction is concerned with the reduction of the fear response, it has strong clinical relevance and is central to many treatment explanations of psychological presentations, specifically, the anxiety disorders.

Extinction was originally thought to erase the learning association between the CS and US (Rescorla & Wagner, 1972). However, the occurrence of relapse (the recovery of the fear response despite its previous eradication by means of extinction) indicates that the original learning is preserved through the extinction process. Consequently, it has been argued that extinction may act as an inhibitor of the CS-US association through new learning. This inhibition view implies that the process of extinction generates a new, competing memory, which can contend with the original learned fear association for activation and behavioural involvement (Bouton, 1993). It is pertinent for clinical practice that the elements involved in determining whether it is the original fear association or the inhibitory memory that is activated are understood.

Anxiety disorders are common and can require extensive input from services (e.g. NICE, 2005; 2011), which also face the significant problem of relapse. A previously treated patient may relapse for multiple reasons. One feature known to be involved is spontaneous recovery; where after a period of time there is a full or partial return of the conditioned response (CR), despite its previously successful extinction (Robbins, 1990). This provides some explanation as to the difficulties with relapse rates following exposure therapy. Positively however, spontaneous recovery has been shown to be attenuated by extinction cues (ECs; Brooks & Bouton, 1993), suggesting that therapies that encourage the involvement of such reminders post treatment may be more efficacious. Relapse may also occur due to reinstatement, defined as the return of the extinguished fear response due to further exposure to the US (Hermans et al., 2005).

A third example of a reason for relapse, and the focus of this review, is renewal. Renewal describes the recovery of fear when tested for in a different contextual environment to that in which the extinction took place. This effect has a long history of investigation in rodents and the animal literature is well established. The ABA design is the key research paradigm in the animal field, which robustly shows renewal (Bouton & Bolles, 1979). The design demonstrates that when fear is acquired in a context (A), and then extinguished in a different context (B), there is renewal of fear when tested in the acquisition context (A). In other terms, the extinction learning does not generalise to the original context in which the fear was learned, and context is used to regulate memory retrieval (Harris, Jones, Bailey & Westbrook, 2000).

Animal research has extended the manipulations of context to other designs. For example, the renewal effect is also shown when testing takes place in a novel

environment to both the different acquisition and extinction contexts (ABC renewal), and to a lesser extent when both learning phases are the same but testing occurs in a second context (AAB renewal; Bouton & Ricker, 1994; Thomas, Larsen & Ayres, 2003). These findings show that an extinction memory becomes less retrievable in the absence of its context and suggests that extinction memories are more context-specific than acquisition memories.

Bouton's (1994; Bouton & Ricker, 1994) theory of extinction is predominantly interested in contextual renewal; integrating the findings from the animal field and producing the broadly adopted model of behaviour change. The theory is a common contributor to cognitive, affect and imaging investigations in the human clinical population because it provides clear predictions on the nature of fear extinction (Vervliet, Baeyens, Van der Bergh and Hermans, 2012). The model proposes that fear acquisition occurs independent of context, but extinction is context dependent, and therefore explains the ABA renewal effect.

Bouton's proposal explains renewal specifically by arguing extinction to be similar to inhibition learning, in which memories are formed for contingencies indicating an event will not happen. The repeated experience of a non-event during extinction produces competing counter-learning and essentially, a conflict. If the CS is experienced along with the extinction environment an 'AND gate' is triggered, whereby the inhibitory learning may influence behaviour. But if the CS is experienced away from the extinction context then the AND gate is not activated, while the original fear association is, and behaviour is influenced in isolation of the extinction learning. The theory states context is only merged in the extinction memory and not the acquisition representation. Thus, in the situation of conflict caused by the dual meaning of the CS, contextual specificity becomes necessary and

appropriate for encoding information to reduce this confusion. Finally, at the model's core is the prediction that it is the extinction context that retrieves the specific inhibitory CS-US association, modulating it. This is opposed to the extinction context activating or inactivating the representation of the US directly.

Considering the occurrence of learned fear is affected by context in both extinction and subsequent environmental exposure, an improved understanding of contextual renewal is of great importance to the clinical field. The animal literature and Bouton's model suggest that the environmental situation in which an exposure-based treatment for anxiety disorders occurs will be instrumental in the long-term benefits of therapy. In the reality of patients' lives, the encountering of contextually specific cues relating to the environment in which their fear was acquired may be common. Furthermore, patients are exposed to novel environments post extinction training, which will be involved in the success or failure of the generalisation of the extinction learning. Hence, optimising the exposure learning in therapies in aim of overcoming the renewal effect is something this research field hopes to positively impact upon.

It is only relatively recently that the evidence from animal studies regarding contextual renewal has been bridged to work in humans. There is now a growing body of research that is focused on replicating the findings from the animal literature, and furthering them by exploring the underlying mechanisms within human samples. Delgado, Olsson and Phelps' (2006) review describes how research in humans has confirmed the neural circuitry involved in emotional learning, i.e. the amygdala and its projections are involved in all stages, and prefrontal areas during extinction specifically. They also outline the distinction between fear learning that is specific to humans, and that which can be demonstrated in animal studies. Namely, that humans

acquire fear through socio-cultural means, for example, verbal communication and social observation.

In light of the developing translation of observations and understanding from the animal field to research in humans, Vervliet et al. (2012) emphasised the importance of meticulous attention to the specifics of the renewal findings. They argue that Bouton's commonly accepted theory is often assumed, in absence of the critical tests necessary to make such evaluations. They systematically outlined the six tests of the conditions in which extinction and renewal are predicted to manifest, as indicated by Bouton's theory. When reviewing the 23 studies that met their inclusion criteria, they found that the renewal effect was observed in all of them. The presence of some key tests meant the effect could be deemed not to be attributable to incomplete extinction or a simple summation effect. However, some critical tests of the theory were missing from the research. This means that an absolute evaluation of the theory was not possible and that other alternative mechanisms could be involved in the extinction and renewal of fear.

In summary, the research field of contextual involvement in the extinction of learned fear aims to establish an improved understanding of the mechanisms underlying renewal, a significant element in patient relapse. This in turn would feed into the development of more effective treatments of distressing anxiety based disorders. The exploration of this area in humans is relatively young and there is a need for appropriate translations from animal conditioning research to this population. This review therefore aimed to systematically appraise the behavioural literature concerning contextual renewal of extinguished fear in humans. Specifically, it asked what are the findings within the field and the methodological features of the research. This two-pronged question will be discussed in relation to

the predominant theory in contextual renewal (Bouton, 1994) and the tests suggested to be critical to adequately examine it (Verliet et al., 2012).

2 METHODS

2.1 LITERATURE SEARCH

The literature search was conducted within Embase, Medline PsycINFO, and PubMed databases. The search terms centred on the four domains of: fear conditioning, context, renewal and extinction. The results were limited to papers using a human sample that appeared in scientific peer-reviewed and English language journals only. See Appendix for the specific search terms used in both OVID and NCBI literature searches.

2.2 INCLUSION CRITERIA

In order to be selected the retrieved studies had to meet the following criteria:

- Described an analogue study that investigated the extinction of conditioned fear
- Focused on the effect of context on the above criterion
- Measured rates of renewal of fear
- Used a human sample
- To control for quality, be published in a peer-reviewed journal
- Be written in English

2.3 STUDY SELECTION

Firstly, duplicates from across the searches were removed. The titles and abstracts of the remaining papers were read and the aforementioned inclusion criteria were used to remove inappropriate search results. In cases where the title and abstract did not offer adequate information, the full paper was read to determine suitability. Review articles, those that were non-experimental and presented a theoretical model, studies that used rats or other animals, papers that involved neuroimaging methods such as fMRI, and investigations that were not specific to aversive or fear related responses such as disgust or appetite were discounted. The remaining papers were read in their entirety to ensure the title and abstracts accurately described the studies and therefore the suitability for inclusion. No further studies were removed following this check. The references of the remaining studies were reviewed to find any other appropriate studies for inclusion. Consequently, a total of 17 papers were included in this literature review.

3 RESULTS

3.1 DESCRIPTION OF STUDIES

Table 3-1 shows the main characteristics of each study. It includes features of the sample, the type of contexts that were manipulated, the design of the key experimental group(s), what was used as the CS or conditioned stimuli (CSs), what was used as the aversive US, how fear was detected (be that through psychophysiological and/or self-report measures), and whether the test was immediate or delayed (immediate is defined as testing for renewal within the same day of extinction, and therefore a break of 24 hours or more between the two phases is considered as delayed).

Table 3-1 Characteristics of included studies

Authors	H/CS *(F%)*	Context	Design *(Test)*	CS+/CS-	US	Fear measures: Autonomic/*(Online self-report)*	Test I/D
Alvarez et al. (2007)	H 16 *50%*	Virtual Reality public spaces	AB*AB*	High and low tones	Shock	SCR; Startle; *Retrospective discrete scale of anxiety*	I
Bandarian Balooch & Neumann (2011)	H 99 *68%*	In vivo room lighting level	AB*A* & ABCD*A*	Geometric shapes	Shock	*Discrete scale of US expectancy*	I
Bandarian Balooch et al. (2012)	H 52 *71%*	Indoor room images	AB*E* & ABCD*E*	Spider images	Shock	Startle; *Discrete scale of US expectancy*	I
Dibbets et al. (2008)	H 75 *72%*	Screen colour	AB*A*	Geometric shapes	Loud scream	SCR; *VAS of US expectancy*	I
Dibbets & Maes (2011)	H 183 *83%*	Screen colour	AB*A*	Neutral face images	Loud scream	Startle; *VAS of US expectancy*	I
Dibbets et al. (2012)	H 70 *71%*	Public space images	AB*A*	Vehicle images	Aver-sive image	SCR; *VAS of US expectancy*	I
Effting & Kindt (2007)	1. H 54 *76%* 2. H 81 *65%*	In vivo room colour	AB*A* & AB*C*	Neutral face drawings	Shock	SCR; *Scale of US expectancy*	I
Finlay & Forsyth (2009)	H 61 *41%*	In vivo room colour	AB*A* & AA*B*	Geometric shapes	CO_2 air	SCR; *VASs of CSs evaluations; Discrete scale of panic symptoms*	I
Huff et al. (2009)	H 66 *41%*	In vivo room setting	AB*A*	Spider & snake images	Shock	SCR	I & D
Milad et al. (2005)	H 30 *47%*	Indoor room images	AB*A*	Lamp colour images	Shock	SCR	D
Mystkowski et al. (2006)	C 48 *94%*	In vivo room setting	*B*A* & *B*C*	In vivo spider/No CS-	*	Behavioural avoidance; HR; *Discrete scale of fear*	D
Neumann et al. (2007)	1. H 48 *61%* 2. H 16 *63%*	In vivo room colour & sounds	1. AB*A* & ABCD*A* 2. ABCDEF*A*	Geometric shapes	Shock	1. SCR 1. & 2. *VAS of US expectancy*	I

Neumann & Longbottom (2008)	1. H 64 *84%* 2. H 72 *81%*	Indoor & outdoor setting images	AB*A*	Fear relevant/ irrelevant images	Shock	SCR; *VAS of US expectancy*	I
Neumann & Kitlertsirivatana (2010)	H 60 *82%*	Indoor room images	AB*A* & AB*C*	Object images	Shock	*Discrete scale of US expectancy*	I
Vansteenwegen et al. (2005)	H 40 /	In vivo room lighting level	AB*A*	Line drawings of faces	White noise	SCR; *Retrospective graph and discrete scales of US evaluations*	I
Vansteenwegen et al. (2006)	H 32 /	In vivo room lighting level	AB*A*	Line drawings of faces	White noise	SCR; *Retrospective graph and discrete scales of US evaluations*	I
Vansteenwegen et al. (2007)	C 54 *96%*	Indoor room images	*A*AD* & *ABC*AD*	Spider videos/No CS-	*	SCR; *Graph scales of US evaluations and fear*	I

Note: The table states only the first author of the studies, or both if there were two authors only.
H/C S refers to whether the sample consisted of healthy or clinical participants.
(F%) denotes the percentage of the sample that was female.
The design column states only the contexts pattern for the experimental group(s); it omits the control(s) design.
(Test) relates to the test context(s) in which renewal was measured.
Fear measure acronyms: SCR = skin conductance response, VAS = visual analogue scale, HR = heart rate.
I/D indicates whether the test of renewal took place immediately after the extinction phase or if it was delayed.
* signifies pre-experiment features or events, which were therefore not controlled within the study design.
/ is used when the information was not reported.

It is evident that the studies represent five discernable areas of investigation: the basic renewal effect, involvement of multiple extinction contexts, manipulation of time, targeting the representation of the CS and/or the US, and finally, exposure therapy. Key findings and methodological features of each area will be presented.

3.1.1 The basic renewal effect

Five of the papers investigated the basic renewal effect only, by contrasting an ABA design or the novel context design of ABC to a control design(s).

Effting and Kindt (2007) sought to test a prediction of Bouton & Ricker's (1994) model of behavioural change, which proposes that because fear acquisition is considered to be context independent, renewal in the acquisition context (ABA) and a novel context (ABC) will be proportional. Firstly, 54 undergraduate students were exposed to non-fear related CSs with an electric shock US. The lighting colour in the room served as the context variable. The preliminary ABA verses AAA experiment showed contextual fear renewal as demonstrated by online shock expectancy ratings and SCR. In a second experiment they found ABA renewal to be larger than renewal in a novel context, ABC renewal. The study therefore implies that the rules defining the contextual dependence and independence of extinction and acquisition respectively are less rigid than originally suggested within Bouton & Ricker's (1994) model.

Finlay and Forsyth's (2009) study was the only one of the 17 to use inhaled carbon dioxide-enriched air as the US. This aversive stimulus was paired with geometric shapes that acted as the CSs. These were presented within differing room lighting conditions to control for context. The experimental groups consisted of ABA and AAB designs, which were compared to the control of AAA. 65 undergraduates were measured for Skin Conductance Responses (SCRs) and gave self-reports of their subjective units of distress. Fear renewal was observed in the ABA group only showing that, following extinction in a novel context, the significant factor in the recovery of fear was the test context matching the acquisition context. The findings also show that extinguishing fear in the same context as acquisition can prevent the fear returning in a novel environment.

Neumann and Kitlertsirivatana (2010) investigated the more difficult to demonstrate ABC renewal effect. With images of non-fear related objects being

presented against pictures of indoor rooms serving as contexts, the psychology student participants gave expectancy judgements as to the presence of the shock US. The four groups of AAA, ABA, ABB and ABC were compared. Renewal was present in the ABA and ABC groups but was larger in the ABA design.

Neumann and Longbottom (2008) were interested in both the effect of context and the CSs themselves as measured by SCR and expectancy measures in a student sample. They used fear-relevant images of spiders and snakes, which were controlled against fear-irrelevant images of mushrooms and flowers. Photographic images of appropriate environments, an outdoor bush setting and an indoor office space, were used for the contextual shifts. Using an ABA design controlled against an AAA group they reported renewal for both CSs in the experimental condition. In addition, renewal for the fear-relevant stimuli was largest when the fear was acquired and tested for in the indoor office context but extinguished in the outdoor environment. This highlights the importance of the particularities of the context in relation to the CS.

Vansteenwegen et al. (2005) used the lighting of the room in which acquisition, extinction and renewal testing took place as the contextual change feature. They recruited 40 first-year psychology students to compare the ABA design to the control of AAA. The CSs were non-fear related and electrodermal activity was measured, along with retrospective ratings of the loud, aversive noise (US) expectancy. In contrast to the control group where no fear response recovery was observed, the ABA group displayed recovery of the fear that had been extinguished in the B context.

All five studies detected the ABA renewal phenomenon. Those that compared ABA to a novel context design, ABC, found the ABA renewal effect to be larger and therefore provided evidence against Bouton & Ricker's (1994) suggestion that ABA and ABC renewal should be equal. Neumann and Longbottom's (2008) work identified the importance of CSs relationship to the specifics of the context they are presented in on renewal. More specifically, the semantic connections between the context and CS were identified as influential. Neumann and Kitlertsirivatana's (2010) study was the only study to use an in-the-moment discrete scale of US expectancy as the only measure of fear (only one other study of the 17 did this but it was not intentional).

3.1.2 Extinction in multiple contexts

It has been proposed that extinction in multiple contexts could serve to reduce fear renewal (Bouton, 1991). If evidence supports this then relapse rates could be affected through treatments incorporating a variety of environments in which to conduct exposure.

Bandarian Balooch and Neumann (2011) recruited a continuous scale of changes in room lighting, rather than discrete contexts as their environmental change. A large sample of 99 students was divided into the following groups: ABA-d (one extinction context dissimilar to the test context), ABA-s (one extinction context similar to test context), ABCDA-d (three extinction contexts dissimilar to the test context), ABCDA-s (three extinction contexts similar to the test context) and the controls of AAA-d and AAA-s (a dissimilar and similar extinction context to test respectively). They used a self-report expectancy of shock but coupled this with recording the time taken to make the expectancy ratings following presentations of geometric shapes.

Renewal was found in the ABA-d group. Renewal was attenuated when extinction took place in multiple dissimilar extinction environments (ABCDA-d) and the similar single extinction design (ABA-s). No renewal occurred in the ABCDA-s group. Thus, multiple and similar extinction contexts were found to aid in reducing renewal.

In Bandarian Balooch, Neumann and Boschen's (2012) paper the 69 psychology students were presented with spider images within locations in a house to test the effect of multiple extinction contexts in a variation of the ABC design. The experimental groups followed an ABE and ABCDE environmental pattern, which were contrasted to the ABB control. Renewal was measured by startle blink responses and a self-report expectancy of shock. The renewal effect was found in the ABE group but was attenuated in the multiple extinction contexts group.

Unlike the two aforementioned studies which demonstrated an attenuation of renewal when extinction occurred in multiple contexts, Neumann, Lipp & Cory (2007) did not find evidence to support this. They used a VAS for the student sample to report their expectancy of shock by. The experimental room colour was manipulated for environmental change, and visual and auditory stimuli were paired with shocks. This paper used only shock expectancy ratings for the second part of the experiment and it therefore lacks data regarding autonomic arousal for the multiple extinction contexts element. A renewal of shock expectancy was found in the ABA group but this was not attenuated in the further, ABCDA and ABCDEFA, designs.

Vansteenwegen et al. (2007) used a clinical sample with a previously acquired fear of spiders to test the effect of multiple extinction phases. Using bluescreen technology the 18 participants saw moving images of the feared stimulus layered on

the different background contexts, which were still images of indoor rooms. There were two extinction groups, (note the acquisition phase is not represented) AAD and ABCAD, compared to a control group, AAD, which did not see the CS in the presentation. Both extinction groups produced a smaller renewal response than the control, as demonstrated by SCR and self-report data. However, the multiple extinction group displayed generalisation of that learning, whereas the single extinction group did not.

In summary, of these four studies only one did not report a lower rate of renewal for the multiple extinction contexts than the single extinction designs.

3.1.3 Temporal manipulation

There is evidence in the animal literature that in some time-based specific circumstances, extinction generalisation is not context dependent (Myers, Ressler & Davis, 2006). Three papers manipulated the time periods within the phases of the study to measure the effect on contextually specific renewal.

Alvarez, Johnson & Grillon (2007) used an ABA design to attempt to replicate findings from research with rodents, which showed extinction to generalise across contexts when a short delay separated the acquisition and extinction phases. The study incorporated fear-potentiated startle, SCR and fear ratings in response to shocks experienced in a virtual reality (VR) context. They did not find evidence that short-delay extinction can cause the removal of the fear learning, as the renewal effect was still detected. As this work did not replicate the finding from the animal literature it suggests that extinction conducted soon after acquisition does not attenuate renewal any more than delayed extinction.

Huff, Hernandez, Blanding and LaBar (2009) investigated whether manipulation of the amount of time that passes after fear acquisition would impact upon the level of renewal following extinction. SCR was recorded to measure the response to the shock US paired with fear-relevant stimuli. 66 university students completed extinction training with a delay following acquisition of either five minutes or one day. The room in which the phases took place acted as the contextual manipulation. Following a day's delay, testing took place. The groups followed an ABA and AAA design. It was evident that immediate extinction promoted fear renewal, which was found in the ABA group. It also caused spontaneous recovery in the control group, which delayed extinction did not.

Milad, Oor, Pitman & Rauch (2005) also looked at the effect of a delay in aim of replicating the established finding in the animal literature that different neural circuitry is involved in within-session extinction training to between-session extinction recall. They used a two-day differential conditioning protocol and SCR alone was the measure of conditioning. The visual contexts were different rooms and the different colours of an object within them served as the CSs. Participants recruited from the local community underwent acquisition and extinction training on day one, with extinction recall being tested for renewal on day two. Those in the control group had the extinction training omitted from their procedure. They found ABA renewal demonstrating the effect after a post extinction delay.

Collectively these findings show that the attenuating effect of short-delay extinction found in animals was not replicated in humans. Furthermore, the modulating effect of the inhibitory learning context was influential in all three different time manipulated ABA procedures: Firstly with ABA taking place all within short-delay, secondly with each phase being separated by a day, and finally

with A and B occurring on the same day and testing after 24 hours. Thus, the ABA effect was strong across temporal manipulations.

3.1.4 Targeting the CS and/or US representation

In the animal field Brooks and Bouton (1994) found that renewal could be attenuated during the testing phase by the presence of cues from the extinction learning, emphasising the power of learning and retrieval cues on the CS and/or US representation. Their finding is framed within the model as the cues aiding to disambiguate the conflict generated by the dual CS meaning, by promoting activation of the extinction memory. Additionally, research has shown that mental representations of the CS and/or US can be learned in the absence of the stimuli, through imagined associations (Dadds, Bovbjerg, Redd & Cutmore, 1997). This implies that mental imagery could be used to attenuate renewal also. Four studies investigated this area.

Two of the experiments conducted by Dibbets and others (Dibbets, Havermans & Arntz, 2008; Dibbets & Maes, 2011) used similar research paradigms to test the effects of cues on ABA renewal. They both investigated the question of whether a cue acts as a safety signal (a conditioned inhibitor, which predicts the absence of the US) or as an occasion setter (which is not directly involved in the non-occurrence of the US, but rather controls the activation of a specific CS-US representation). They manipulated the colour of screens as the contextual change and used loud auditory stimulation as the US. The large samples were measured for fear by SCR in the earlier study and startle response in the more recent one. The former argued that extinction cues act as a safety signal to inhibit the expectancy of the aversive outcome but only in context specific ways. The latter found that positive but not

negative cues had become safety signals. They therefore proposed that a positively valued extinction cue brings faster extinction, more renewal attenuation, and transfers more effectively to non-extinguished stimuli than a negatively valued one.

Vansteenwegen et al. (2006) used cues that had been present in either the acquisition or the extinction phase as retrieval cues in the testing phase. Stimuli of drawings of faces were conditioned with white noise acting as the US, in the context of the room lighting level. They found that the both autonomic and expectancy responses were most strongly renewed for the acquisition cue group. However, they could not say whether the effect was due to an elevated renewal effect due to the acquisition cue or an impairing effect of the extinction cue. Despite this, the study provides evidence for the power of contextually dependant retrieval cues in attenuating renewal.

In the first study of its kind, Dibbets, Poort and Arntz (2012) tested a large sample of 70 students to investigate if a change in the mental representation of the US (an aversive image), in the absence of it, could lead to a reduction in renewal. SCR and expectancy ratings were measured to test the effect of imagery rescripting delivered in the extinction phase. They found that renewal was less for the imagery-rescripting group than those who experienced a control script. Furthermore, it was only the former group that displayed a less negative representation of the US at the test phase.

Taken together these studies show that manipulations of the CS or the US or their association can have positive effects for reducing renewal.

3.1.5 Exposure therapy

One study used previously acquired fears of spiders to test the effect of exposure therapy on renewal. In Mystkowski, Craske, Echiverri & Labus' (2006) paper, 48

participants underwent exposure therapy in one of two contexts. Before the test phase, which took place in the treatment context, half of the participants used mental reinstatement of the therapy environment. Renewal, as measured by heart rate, self-report and behavioural avoidance, was less for the individuals who mentally reinstated the treatment context. At follow-up an ABC design was incorporated and demonstrated that the reinstatement group showed less fear when the CS was presented in the novel environment. Thus, evidence was obtained for the significance of mentally reinstating the treatment context for attenuating renewal.

3.2 CRITICAL APPRAISAL

To appraise the quality of each study an assessment tool was used. For ease of reference it will be termed the MQSQS (Manual for Quality Scoring of Quantitative Studies) found within the 'Standard quality assessment criteria for evaluating primary research papers from a variety of fields' (Kmet, Lee & Cook, 2004). Table 3-2 shows the scores each study obtained on the 14-item checklist:

1. Question or objective sufficiently described?
2. Study design evident and appropriate to answer study question?
3. Method of subject selection (and comparison group selection, if applicable) or source of information/input variables is described and appropriate?
4. Subject (and comparison group, if applicable) characteristics or input variables/information sufficiently described?
5. If random allocation was possible, is it described?
6. If interventional and blinding of investigators was possible, is it reported?

7. If interventional and blinding of subjects was possible, was it reported?

8. Outcome and (if applicable) exposure measure(s) well defined and robust to measurement/misclassification bias? Means of assessment reported?

9. Sample size appropriate?

10. Analysis described and appropriate?

11. Some estimate of variance if reported for the main results?

12. Controlled for confounding?

13. Results reported in sufficient detail?

14. Conclusions supported by the results?

Table 3-2 MQSQS critical appraisal

	Criteria														
Authors	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Score/28**
Alvarez et al. (2007)	2	2	0	2	0	0	0	2	1	2	1	2	2	2	18
Bandarian Balooch & Neumann (2011)	2	2	1	1	1	0	0	1	2	2	1	2	2	2	19
Bandarian Balooch et al. (2012)	2	2	1	1	1	0	0	2	2	2	1	2	2	2	20
Dibbets et al. (2008)	2	2	1	1	1	0	0	2	2	2	2	2	2	2	21
Dibbets & Maes (2011)	2	2	1	1	1	0	0	2	2	2	2	2	2	2	21
Dibbets et al. (2012)	2	2	1	2	1	0	0	2	2	2	2	2	2	2	22
Effting & Kindt (2007)	2	2	1	2	1	0	0	2	2	2	1	2	2	2	21
Finlay & Forsyth (2009)	2	2	1	2	1	0	0	2	0	2	1	2	2	2	19
Huff et al. (2009)	2	2	1	2	1	0	0	1	2	2	2	2	2	2	21
Milad et al. (2005)	2	2	2	2	1	0	0	1	1	2	2	2	2	2	21
Mystkowski et al. (2006)	2	2	1	2	1	0	0	2	2	2	2	2	2	2	22
Neumann et al. (2007)	2	2	1	1	1	0	0	1	1	2	2	2	2	2	19
Neumann & Longbottom (2008)	2	2	1	1	1	0	0	2	2	2	1	2	2	2	20
Neumann & Kitlertsirivatana (2010)	2	2	1	1	1	0	0	1	2	2	2	2	2	2	20
Vansteenwegen et al. (2005)	2	2	1	0	0	0	0	2	1	2	2	2	2	2	18
Vansteenwegen et al. (2006)	2	2	1	1	1	0	0	2	1	2	2	2	2	2	20
Vansteenwegen et al. (2007)	2	2	1	2	1	0	0	2	2	2	2	2	2	2	22

Note: 2 indicates the criterion was met, 1 signifies it was partially met, 0 is used when it was not met. The tool also allows for N/A when a criterion is not relevant. All criteria were appropriate for application here, hence all summary scores are out of a maximum of 28.

All studies gave a clearly defined and described research question or objective (1), which was investigated with an appropriate study design (2). All papers also used appropriate analyses that were adequately outlined (10), with their results reported in sufficient detail (13), leading to appropriately drawn conclusions (14). However, the reporting of estimates of variance was limited in many studies, with just 11 providing adequate details of range, distribution, confidence intervals and standard error (11). Partly due to this, determining if sample sizes were appropriate in those studies in the lower range of participant numbers was difficult, and perhaps the most subjective criterion (9).

Some studies demonstrated superior control at the design and analysis stage but all were deemed appropriate and scored the maximum for that criterion (12). No blinding either of the investigators (6) or the participants (7) was reported in any of the papers. All studies had at least partially robust measurements of fear, but there was a range from those without any autonomic measure, to those with three different methods across the autonomic and online self-report approaches (8).

The overwhelming majority of studies recruited from the student population, with one study not reporting its method of selection at all (3). Only one described wider participant sampling from the local community through advertisements, and was therefore the single paper to score 2 on that criterion. There was a large range in the effectiveness of communication for the characteristics, variables and information of the participants and comparison group(s) (4). No studies described their randomisation procedure, with a minority not making reference to randomisation at all (5).

4 DISCUSSION

4.1 THE FINDINGS

Taking the renewal effect to be defined as the extinguished CS+ eliciting fear in a different context to which it was extinguished, the basic renewal effect was reported in all papers. This provides strong evidence for the competing inhibition theory of extinction, rather than the previously held view that extinction learning erases the fear memory. With the exception of one multiple extinction context study and some discrepancies in the papers concerning short and long delay, the findings in the animal literature were generally replicated in the human field.

In terms of whether these studies supported Bouton's (1994) model of behaviour change or not, a clear conviction cannot be reached. Investigation into ABA and ABC renewal showed the latter to be weaker, however, the theory predicts it should be equal. Therefore, the implication that the rules defining the contextual dependence and independence of extinction and acquisition respectively are less rigid than originally suggested by Bouton was supported. However, other findings presented here aligned with the model's assumptions about the extinction context modulating the retrieved specific inhibitory CS-US association. And more generally, that contextual specificity serves to reduce conflict provoked by the dual meaning of the CS following acquisition and extinction.

An important background issue to the interpretation of these findings however, is the continued problem of a lack of critical tests to adequately explore Bouton's model, as highlighted and explained by Verliet et al. (2012). It was beyond the scope of this review to assess each study in relation to the six critical tests outlined in the paper. Yet, it is noted that few examples of the following tests were present in the included research: the observation of AAB renewal to show renewal is more than a

simple summation effect, a test to show it is more than simple protection from extinction by the extinction context, and finally, a procedure that would confirm it is the extinction context that acts as the retrieval cue for the extinction learning.

4.2 THE METHODOLOGIES

Verliet et al. (2012) also drew attention to the point that renewal is likely to be strongly impacted upon by the experimental paradigm, the tested sample and the renewal design used. In light of this, the overall effectiveness of the methodologies presented here needs to be considered.

A key element of the designs is the measure of fear. It is ideal that multiple approaches are used and integrated, and many studies did this. SCR and startle responses give an effective measure of the anticipatory emotional response, however, recording consistency across the field was variable, with many participants being excluded from the analysis due to difficulties with this type of measure. Furthermore, habituation effects are known to occur in the use of SCR. Other autonomic measures such as heart rate were under-utilised.

Expectancy of the US provides a cognitively involved self-report measure. The techniques used here varied greatly; some were recorded during the task when others were done so retrospectively, some were verbal while others required motor action, and some were loosely defined whereas others were on a more specific scale. While it is beneficial to have methodological pluralism across the field, caution should be paid to interpreting a multitude of techniques and their implications under the single term ‘expectancy ratings’. Specific problems were highlighted with verbal forms of this measure. It was noted to cause disruptions in other measures and could be generally inconsistent across participants and studies.

Perhaps with the exception of the study that utilised exposure therapy and those with an involvement of VR, a reoccurring issue across the areas of investigation was the generalisability of the experimental designs. Perhaps due to the strong history of researching renewal in animal test procedures, the investigation of it in humans is being limited in its creativity. For example, many studies did not use fear appropriate stimuli or manipulated context in relatively abstract ways, i.e. lighting colour. Alternatively, this problem could be attributable to the relative infancy of the work, and future work will build and expand upon these more simplistic designs.

Finally, the critical appraisal tool used in this review highlighted some weak areas in reporting. It was frequently difficult to judge the appropriateness of the sample size because important elements such as standard error were often not reported for the major outcomes. Clear explanations of randomisation procedures and the specifics of participant baseline measures, for example, were also lacking. Despite this, all the studies scored highly for their approach to the research question and their analytical exploration of it.

4.3 FUTURE RESEARCH

Studies should continue to build a solid foundation of replication research in humans, but attention should be focused on increasing the real-life helpfulness of the procedures. Improving generalisability through the use of VR paradigms and longer-delay exposure procedures is recommended. The incorporation of multiple and varied measures of fear would improve the developing field further. Specifically, an increased use of behavioural avoidance measures, along with the more established self-report and autonomic approaches would allow for greater significance to the clinical field.

As previously explored, there are critical tests of the predominant theory that are lacking. Future research should draw from Verliet et al.'s (2012) clearly defined examples.

Bouton, Winterbauer and Todd (2012) argue that evidence concerning extinction and relapse in instrumental learning is consistent with the established findings in classical conditioning. Namely, that how new learning manifests is contextually dependent. Thus, studies could explore the different types of learning, in light of what is already established in the renewal literature, to generate a more comprehensive model of fear learning.

And finally, the ABA design itself does not represent the common trajectory of learned fear for the majority of people who suffer with fear-based disorders. The acquisition of fear is multi layered and socio-culturally affected, and poorly explained as learned in one context. Furthermore, it is rare that individuals with fear acquired by classical conditioning revisit the exact context relatable to the original learning. Future research could therefore give more attention to the lesser understood, but more frequently experienced, ABC phenomenon.

4.4 CLINICAL IMPLICATIONS

It is evident from the material reviewed here that extinction training in humans and its use in exposure treatments does not eradicate the fear memory but rather generates a competing learning association; a finding that goes some way to explaining relapse in the clinical field. Furthermore, the contextual features of acquisition, extinction and the environments an individual is exposed to post treatment, are all significant in predicting the recovery of the fear response.

These studies suggest that clinical treatment should pay increased attention to defining the context of a patient's learned fear, and utilise the therapeutic context to optimise the therapy. These are examples of potentially useful elements to incorporate into practice: exposure in as many varied contexts as the therapy can allow, exposure environments that are semantically relevant to the CSs, imagery rescripting to reduce the fearfulness of the US memory, incorporating positive cues to the exposure context to act as safety signals, and mentally reinstating the treatment environment prior to further exposure.

4.5 LIMITATIONS

This review is limited by its inclusion criteria and scope. Ideally, this work would have integrated evidence into the biological underpinnings of renewal and the findings from neuroimaging studies. Additionally, although every effort has been made to incorporate the key research in the field, it may be that with more resources the search procedure could be expanded. It is worth noting that while the evidence has been reviewed systematically there will have been the opportunity for reviewer bias to enter the process. Finally, the individual interpretation and use of the MQSQS is open to subjectivity and it would therefore have been preferable to support its findings with other rater opinions.

4.6 CONCLUSIONS

The field of contextual renewal for extinguished fear is developing in humans, the animal literature providing a strong platform on which to progress. The renewal effect has been repeatedly demonstrated, and the incorporation of manipulation during each stage of learning is providing optimism for the enhancement of clinical practice. Definite conclusions in support of the dominant theory would be premature

due to on going methodological and test issues. Future research should therefore incorporate the critical tests of the model as routine.

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PART 2: EMPIRICAL PAPER

CONTEXT SPECIFICITY IN THE EXTINCTION OF LEARNED FEAR

ABSTRACT

Aims

Human and animal work has established that context is an important cue to fear learning and extinction, but to date few studies have utilised ecologically valid contexts. Here we use virtual reality to assess whether extinction training that occurred in the same context as the original fear acquisition was more successful than extinction in a different context to acquisition, as indexed by two fear measures.

Methods

Virtual reality environments were used as contexts, with fear-relevant stimuli used to produce conditioned fear. A two-day paradigm was used to allow for memory consolidation overnight. An experimental group (ABA; N=16) was compared to a control group (AAA; N=17) to ascertain if contextual change impacted upon the fear response. After the consolidation period and extinction training, testing for renewal of fear, both before and after reinstatement, occurred.

Results

Both fear measures - physiological responses and subjective ratings - detected acquisition conditioning. There was weak evidence that this learning generalised to the second day. After extinction and at pre reinstatement, the groups did not differ in electrodermal responses. Expectancy ratings were significantly different between the two groups at these points. Following reinstatement, renewal was found in skin conductance response only.

Conclusions

Some findings represent a divergence from established effects in the field and therefore only tentative conclusions can be drawn as to the underlying mechanisms involved. Further ecologically valid virtual reality research is recommended.

1 INTRODUCTION

Associating fear to a threatening stimulus is a survival-promoting function that exists across animal species. It can ensure that past experiences of danger inform safety in the future, and many fear inducing situations are successfully managed and forgotten. However, some circumstances can cause fear to persist over time and inappropriate fear associations can become problematic in humans. Learned fear is at the core of many psychopathological disorders, both in their causation and ongoing presentation. For example, the associations in aversive experience and perceived threat that constitute learned fear are central to the anxiety that is manifest in phobia, panic disorder, hypochondriasis, eating disorder and post-traumatic tress disorder (PTSD). Furthering understanding of how learned fear can be diminished is therefore an important and valid aim for clinical treatment development.

Classical conditioning is a dominant paradigm used in the exploration of how fear is acquired. It shows that pairing a physiologically significant stimulus (Unconditioned Stimulus; US) with a neutral one (Conditioned Stimulus; CS) can cause the latter to gain biological or affective features (Pavlov & Anrep, 1927). Research in animals has repeatedly demonstrated the acquisition of fear in this way, and has shown that different species share the same neural foundations involved in acquiring fear associations. For example, plasticity and activity in the amygdala (a structure of the medial temporal lobes; MTLs) and its projections are known to be of principal importance in fear conditioning circuitry (LeDoux, 1996).

In the interest of targeting fear in clinical anxiety, the classical conditioning paradigm is also of great importance for exploring how fear can be eradicated, principally through extinction. Extinction is understood as the process in which the

repeated experience of the CS without the US produces a diminished or removed fear reaction. Historically, extinction has been understood as a process of unlearning (Bouton 2004; Delamater 2004; Myers & Davis, 2002). However, it is now typically conceptualised as additional learning, which offers new, alternative information to update or compete with the learned fear associations (Delgado, Olsson & Phelps, 2006).

The mechanism of extinction occurs when a neutral stimulus, to which biological or affective responses have been conditioned (CS), is repeatedly experienced without the paired physiologically significant stimulus (US), such that the conditioned responses become removed (Pavlov & Anrep, 1927). Current interventions utilise this model by exposing people to their feared stimulus whilst inhibiting their fear response, and the amygdala has been identified as key in this process (Delgado et al., 2006). For example, mental exposure to feared stimuli from a traumatic event, whilst managing the fear response, is frequently used in the treatment of PTSD (Ehlers & Clark, 2000). Also, in vivo exposure to a feared object or situation, with allowance for a reduction of the fear response, is central to cognitive behavioural treatments of phobia and anxiety (Wells, 1997).

Fanselow's (2000) review of work in rodents has further explored the important neural components in fear acquisition. This study found that prior to conditioning, exploration of the context (in which the fear associations will be learned) is needed to produce contextual fear. Curzon, Rustay & Browman (2009) define contextual fear as the conditioning procedure that occurs when an animal is placed in a novel environment with an aversive stimulus, it is then removed from that environment, and when it is later returned to it, in absence of the aversive stimulus, the fear response (typically freezing in rats) will occur. Faneslow's (2000) work highlighted

that the environment, or context, of the fear conditioning is significant to the learning and that previous encoding of context is important for greater fear responses. Consequently, investigation into the brain regions involved in forming contextual memory was prompted. Lesion data showed the hippocampus, another structure located in the MTLs, to be critical in this process (Wiltgen, Sanders, Anagnostaras, Sage & Fanselow, 2006).

During the acquisition of fear associations it appears that a hippocampal representation is formed by recruiting prior contextual knowledge, and that when a threat is present it becomes paired to the hippocampal representation. It has been suggested however, that the brain can utilise a second system for contextual fear acquisition that is independent of the hippocampus. It has been argued that areas of the neocortex may become responsible for contextual fear learning in cases of a damaged hippocampus, although learning is less efficient and the system's contextual representations are inhibited when the hippocampus is functional (Wiltgen et al., 2006). Subsequent work into the debate concerning an extrahippocampal, alternative system however, has contradicted this and indicated that there may not be one at all. Rather, that detailed contextual memories utilise the hippocampus, but memories that have lost contextual precision do not (Wiltgen et al., 2010).

In terms of the features of context specificity, the hippocampus has been identified as necessary for the encoding of boundaries of spatial contexts (Doeller, King & Burgess, 2008) and for the construction of scenes in mental imagery, including retrieval of memories involving such context (Bird, Capponi, King, Doeller & Burgess, 2010). The hippocampus is also posited to play a crucial role in the aetiology of PTSD. Brewin, Gregory, Lipton and Burgess (2010) describe how highly traumatic experiences bring about a loss in hippocampal function and thus a

reduction in normal encoding. Consequently, the event is stored as a sensation-based, low-level memory that is egocentric, viewpoint-dependent and depictive (S-reps), rather than as a contextually bound memory that is allocentric, viewpoint-independent and structural (C-reps). Flashbacks then occur to allow the information to be contextually processed but continued C-reps inhibition, identified with the hippocampus, prevents this.

When investigating this area a key research design that is utilised is the ABA paradigm. In this procedure fear is learned in one context (A), extinguished in a different environment (B) and then tested for renewal of fear in the original context (A). The phenomenon of fear, which has been previously extinguished within the novel environment (B), reoccurring in the original learning environment (A) has been well established in the animal literature and is beginning to be explored in humans (Bouton & Bolles, 1979; Harris, Jones, Bailey & Westbrook, 2000). In contrast, the frequently used control procedure of AAA, which sees acquisition, extinction and the test for fear reoccurrence all take place within the same context, typically shows no renewal – the extinguished fear remains extinguished. As the ABA paradigm demonstrates that extinction learning in a novel context does not generalise to the environment of the original fear acquisition, it therefore shows that context is used to regulate the memory retrieval (Harris, Jones, Bailey & Westbrook, 2000).

Replication in humans of the rodent work investigating neural circuitry in contextual fear has supported the roles of the amygdala and hippocampus in contextual fear learning, as well as the orbitofrontal cortex in providing the amygdala with information regarding potential threat (Alvarez, Biggs, Chen, Pine & Grillon, 2008). Notably, such research has utilised virtual reality (VR) environments to

overcome methodological limitations of such study in humans. In terms of extinction, context has again been shown to be critical, with the amygdala, medial prefrontal cortex and hippocampus identified as the major neural correlates in the process (Martinez & Quirk, 2009). Although Alvarez et al.'s (2008) work has used the more naturalistic VR method to explore fear conditioning in humans, there is little research into the effect of context on extinction of fear memories specifically. Investigation is needed to understand the occurrence of extinction in environments similar and different to the learning context.

Along with renewal, the clinical field is also challenged by the phenomenon of reinstatement, another contributing factor in relapse rates (Bouton & Swartzentruber, 1991). Reinstatement describes the effect whereby the extinguished CS-US response is partially or fully recovered due to presentations of the US in absence of the CS following extinction (Rescorla & Heth, 1975). This has strong relevance for clinical patients as the US may be re-experienced following therapy. Hermans et al. (2005) were the first to demonstrate the reinstatement effect in humans using a differential fear conditioning procedure. However, response was observed only at the subjective level and physiological evidence in this area is lacking, specifically in relation to contextual renewal.

In summary, understanding of the important features of contextual fear learning is well explored in rodents, and expanding in humans, with representation of context being a principal component of hippocampus-dependent memory (Barry & Doeller, 2010). However, investigation of context specificity in extinction, as well as the reinstatement effect, is under explored. VR environments permit context research in humans that corresponds to that conducted in rodents, as well as affording a naturalistic approach to the study of contextual extinction. Researching these areas

has clinical relevance because behavioural interventions for fear memories, in relation to the context of the learning, suggests a theoretical advantage to established techniques that do not attend to the acquisition context (Brewin et al., 2010).

The aim of the current study was therefore to add to the understanding of the function of context in fear memories. It was intended to serve as part of a group of related studies within the Institute of Cognitive Neuroscience (ICN), exploring learned fear through the VR paradigm. The series of studies will inform future neuroimaging work that will investigate the brain circuitry involved in contextual fear. More broadly, it was aimed that this study may contribute to the collective thinking about future interventions for anxiety related psychopathologies, and the involvement of context within such interventions. These aims were addressed by testing the following key hypothesis: Extinction occurring in the same context as acquisition will produce lower renewal of fear, as measured by skin conductance response (SCR), than extinction in a different context to acquisition, and this will be supported by subjective expectancy ratings.

2 METHODS

2.1 DESIGN

A two-day, differential context, fear-conditioning paradigm within a VR, as established by Doeller et al. (2008) was used. Fear learning was acquired on day one, followed by an overnight delay to allow for consolidation of the memory (Chang & Maren, 2009). Participants returned after 24 hours to complete extinction training and be tested for renewal (of both pre and post reinstatement effects of context). Mild electric shocks acted as the aversive US. A between subject design was used, with one repeated measure factor being context. The study measured the overall level of

fear acquisition and the extinction of this learning, along with the amount of renewal that occurred. This was recorded through SCR and verbally reported expectancy ratings.

Group 1 was the control group and these participants experienced all parts of the study – acquisition, extinction and the tests for renewal – within the same environment (AAA). Group 2 was the experimental group and these participants underwent fear extinction in a different environment to acquisition and were tested for renewal in the original acquisition context (ABA). Participants were allocated to their group based on the random order in which they volunteered.

Two different contextual environments were presented within the VR: a grassy, mountainous landscape and a desert landscape. As a control, the two different contextual environments were balanced across the two groups. Therefore half of the participants in group 1 were in the mountainous context for the duration of the study, while the other half were in the desert context throughout. For group 2, half of the participants were in the mountainous environment for their acquisition learning and renewal testing, with the desert context serving as their novel extinction environment. The other half of this group experienced the reverse; they were in the desert landscape for acquisition and renewal testing, and their extinction occurred in the mountainous environment.

Another control within the design was to have two different CS, a spider and a bee. Each participant encountered both the spider and the bee equal amounts of times but they were only conditioned to fear one of them (the CS+), the other one was always unaccompanied by shock (CS-). A CS- was used so that the difference in fear response between the CS+ and CS- could be obtained. It was intended that like the

two contexts, the two CS would be balanced across the groups. However, unfortunately, due to researcher error, this did not occur. In this design therefore, all members of group 1 had the bee as their CS+ and the spider as their CS-, and they were therefore conditioned to be fearful of the bee. Conversely, all members of group 2 had the spider as their CS+ and the bee as their CS-, and they were therefore conditioned to be fearful of the spider. Figure 2.1 shows the design of the groups by representing the two different landscapes as coloured shapes (the grassy, mountainous context is shown as the green triangle, the desert context is represented as the yellow oblong). The top box, or first two rows of the figure, gives the AAA design of group 1, which had the CS+ of the bee. The box below, or the bottom two rows of the figure, is the ABA design of group 2, where the spider served as the CS+.

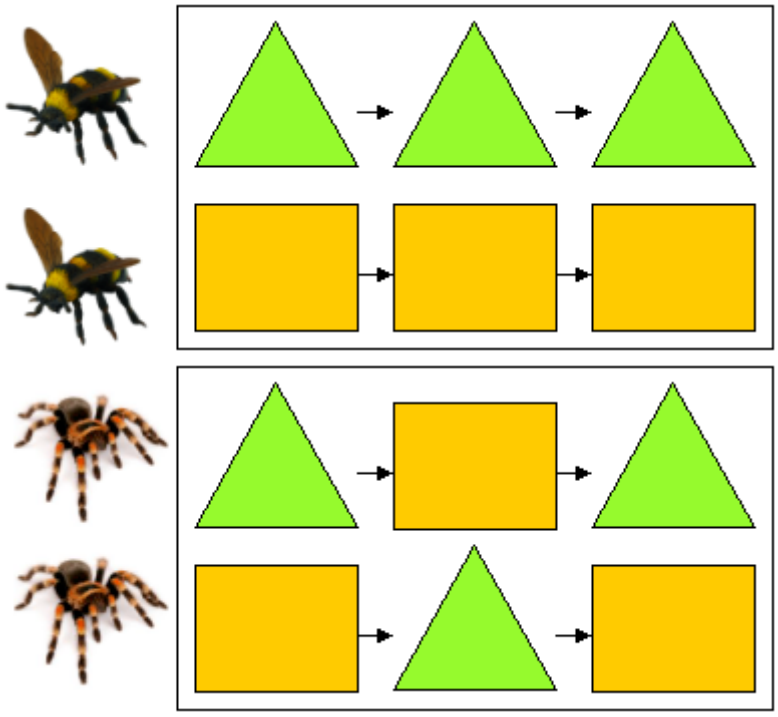

Figure 2.1 Pictorial representation of the design of the groups
Note: Green triangle = mountainous context, yellow oblong = desert context.
The animal pictured by the group is their CS+.
Top two rows = group 1, bottom two rows = group 2.

2.2 SAMPLE SIZE

There were few human studies looking at the effect of environmental context on fear conditioning. The most relevant, Alvarez, Johnson, and Grillon (2007), used a passive VR design in which participants were conditioned in one environment and underwent extinction in a different environment. Renewal was then measured in both of these. There was a very large effect of environment on renewal of SCR (d=1.25). In their study of reconsolidation and renewal following extinction, Schiller et al. (2010) observed a similar effect size in their non-reminded group. This magnitude of effect size suggested an estimated sample size of around N=6 (alpha = 0.05, beta = 0.2, using G*Power; Buchner, Erdfelder & Faul, 1997), but this clearly would have been insufficient as it would not have been sensible to assume such large effects. As the present study was much more exploratory, a more conservative medium effect size was suggested, which gave a sample size estimate of N = 34.

2.3 PARTICIPANTS

Ethical approval for this study was given by the UCL Graduate School Ethics Committee as part of a larger programme of research (Project Code 0366/002; see Appendix B). Following the ethical framework of the Helsinki Declaration, all participants took part having given informed consent and were aware that they could withdraw at any time. Compliant with these UCL ethics and guidance, 40 healthy volunteers were recruited from a psychology research pool and received either course credit or a £15 incentive for their participation.

To control for extraneous variance, all participants were required to meet criteria on set I of the Raven's Advanced Progressive Matrices (Raven, Raven & Court, 2003). Of the 12 items in the set, participants had to score 9 or above to pass for

inclusion. In addition, to reduce the likelihood of an adverse reaction, all participants were screened for previous medical and psychiatric conditions prior to the study, using a brief health questionnaire tool (see Appendix B). Anxiety was examined specifically using the State-Trait Anxiety Inventory (STAI; Spielberger, Gorssuch, Lushene, Vagg & Jacobs, 1983) before participation. No volunteers were excluded on the grounds of failing the Raven's test or due to a reported or detected history of a medical condition or psychiatric disorder. Participants were assigned to group 1 or 2 based on the random occurrence of their choosing to take part in the study. The only exception to this was when gender balancing took place.

Of the 40 that were recruited and completed the experiment, seven participants were excluded due to poor SCR recordings on either day of the study. The total remaining participants (N = 33; 18 female; M_{age} = 22.88, S.D. = 3.10) were included in the analyses, with gender having been balanced across the groups (Group 1: N = 17; 9 female; M_{age} = 22.59, S.D. = 3.45. Group 2: N = 16; 9 female; M_{age} = 23.19, S.D. = 4.61). Thus, this study was just one participant below the suggested sample size.

2.4 MATERIALS AND APPARATUS

2.4.1 Conditioned stimuli

Following the methods of prior successful studies in this area, the CS were fear relevant images; in this case clear close-up photographs of a Chile Rose spider and a Bumblebee. The animals appeared without any background to them in the image. These were presented as still pictures that appeared within the VR, taking up approximately 40% of the total screen size, within its centre. After approximately 4.5 seconds the image enlarged, moving forward on the screen, as if moving towards the

participant. This image-enlarging period was brief at approximately half a second. When the CS image appeared to fill the VR it immediately disappeared. At the exact moment the bee or spider enlarged to the full screen size, the US was delivered. The effect of the rapid image enlargement produced a percept of a looming creature.

2.4.2 Unconditioned stimulus

The paradigm used an electric shock as the US, which was paired with the CS. Delivery of the electric shock was controlled by a Digitimer DS7A (Hertfordshire, UK) via an electrode placed on the skin covering the first dorsal interroseus muscle of the non-dominant hand. Adhesive tape was placed along the thumb to secure the electrode. A well-established ethical procedure was used for delivering the mild electric shock (see below).

2.4.3 Contextual stimuli

Two virtual environments were used as contexts. This involved different environmental virtual landscapes chosen to be visually and geometrically dissimilar, which participants navigated around using computer controls. One was a circular, grass environment with mountains; the other was a square, desert context with irregular, lower boundary features.

2.5 PHYSIOLOGICAL AND SELF-REPORT INDICES

2.5.1 Electrodermal response

Electrodermal responses were continuously monitored during all parts of the experiment using silver/silver chloride (Ag/AgCl) electrodes, which were fastened to the distal phalanges of the middle and index fingers of the participant's non-dominant hand. The electrodes were attached to the skin surface by concentric

adhesive tape. SCR was controlled by a digital amplifier (Biopac Systems Inc.) and directly recorded in microsiemens (μs). Scores were derived by taking the base-to-peak difference for the first waveform that occurred during the 1 – 5.4 seconds after the onset of the stimulus, thus capturing the response prior to any direct physiological reaction to the US. There was a minimum response criterion of 0.02μs and lower responses were scored as zero.

2.5.2 Self-report expectancy ratings

Along with the aforementioned physiological measure, this study also recorded the subjective experience of fear. A scale of zero to nine was used for participants to verbally report the expected likelihood of shock each time they encountered a CS. Zero indicated a certainty that a shock would not accompany the CS presentation; nine indicated a certainty that a shock would accompany the CS presentation. Prior to testing, when the procedure was being explained to participants, they were told to say a number from zero to nine, representing how unlikely or likely they thought it was that they would be 'stung' or 'bitten' by the animal in the environment. They were directed that they should do this as soon as the CS appeared on the screen. Once the CS appeared and the participant had said their expectancy rating number, the researcher recorded the rating to avoid any motor activity, on behalf of the participant, interacting with their SCR.

2.6 PROCEDURE

The testing room consisted of two office chairs, a bench worktop and two desktop computers, (one for the VR in front of the participant, the other displaying the SCR for the researcher and therefore turned away from the participant). Participants were encouraged to adjust their chair to an appropriate height for them so that the

corresponding eyelevel to the screen was consistent across the people tested. They were asked to sit so that there was approximately one metre between their face and the screen. After being given all of the study information and choosing to take part, participants completed the screening tools. Once they had passed that stage the expectancy ratings scale was explained and discussed so that they were confident to use it correctly. It was important that participants were clear about the procedure of the subjective ratings to avoid any disruption during the actual testing.

Following this and the application of the SCR and shock electrodes, the shock work-up took place. This involved all participants receiving a low-level voltage shock, which was very tolerable and had been set based on agreement from previous studies. The level of shock was then incrementally increased in small amounts until the participant reported that it was uncomfortable (the shock should not have been painful and the researcher was attentive to each participant's experience of the shock, to avoid unacceptable discomfort). Participants were then instructed that their task was to actively search for bugs within the environment using the dominant hand to control the computer keys. Their task was to try and notice a relationship between location, bugs and stings/bites. This task was included to provide a goal to the navigation and promote engagement, but locations of the CS and the pairing of the US were in fact random. Prior to the presentation of the CS and recording of responses, participants explored the acquisition context to allow familiarity with the controls and promote contextual awareness (Fanselow, 2000). After a short exploration period of a couple of minutes, participants were asked if they were ready and then informed that the experimental procedure would begin.

One presentation of the CS+ (the stimulus they were being conditioned to fear) and one presentation of the CS- (the stimulus they were not being conditioned to

fear) constituted a trial. The acquisition phase in which fear was learned involved 16 trials. There were therefore 16 displays of the intermittently reinforced CS+ and 16 of the CS-, presented in a random order. Ten of the 16 CS+ presentations were accompanied by a shock at the moment the creature 'loomed' and filled the screen. Six CS+ presentations in the acquisition phase were therefore not paired with a shock. As day one involved the acquisition phase only, the total number of trials on the first day was 16.

After the acquisition phase, participants returned 24 hours later. Following a single test shock of the same voltage as the previous day, they were reminded of their task to notice a relationship between location, bugs and stings/bites. They were encouraged to explore the landscape, trying to find bugs and detect a pattern to their behaviour, as they had done the day before. The extinction phase then took place either in the same environment as acquisition (AAA) or the second context (ABA). This phase consisted of 10 trials, meaning 10 displays of the CS+ and 10 of the CS-. All CS presentations were unpaired and no shocks occurred at all during extinction. As before, SCR and verbally reported expectancy of shock were recorded.

The pre reinstatement test for renewal followed this; with group 1 remaining in the same environment as the previous two phases (AAA), and group 2 leaving the extinction environment to return to their original learning context (ABA). After just two further trials, consisting of two presentations of the unpaired CS+ and two of the CS-, a fixation screen appeared. While this grey screen with a black cross at the centre was present, three reinstatement shocks were delivered approximately two seconds apart. Participants then went back into their renewal context and just one further trial occurred, with one presentation of the unpaired CS+ and one of the CS-, to test for post reinstatement effects.

Table 2-1 shows the phases of the study, with its chronological order progressing from left to right. The difference between trial 1 and 16 of the acquisition phase related to whether fear learning had occurred. The difference between the final trial of acquisition and the first trial of extinction indicated whether the fear learning had been consolidated and generalised to the second day. Comparison of the beginning and end trials of the extinction phase related to the success of extinction. Any differences between the 10th and final extinction trial, and the first pre reinstatement trial would indicate renewal effects. Finally, post reinstatement testing occurred at the final trial. Differences between pre reinstatement and this end point indicated reinstatement effects.

Table 2-1 Chronology of the design

	Day 1	**Day 2**			
	Acquisition	**Extinction**	**Pre Reinstatement**	**3 Unpaired US Reinstatement Shocks**	**Post Reinstatement**
Number of Trials	16	10	2		1
Group 1 Context	A	A	A		A
Group 2 Context	A	B	A		A

Note: One presentation of CS+ in addition to one presentation of CS- = one trial.

2.7 DATA CORRECTIONS AND STATISTICAL ANALYSIS

The nature of SCR measurements meant the data were brought to a baseline to correct for the recording of irrelevant reactions. This was done by subtracting the unconnected response from the peak wave in the 5.4 seconds from stimulus onset to the end of the reaction period. To correct for skew, a log transformation (log[1+SCR]) was performed on SCR to normalize the distribution. Magnitudes were

range corrected by dividing each SCR by the mean log transformed US response for each participant.

Statistical analyses were conducted similarly for both SCR and expectancy ratings unless stated otherwise. To assess if fear had been learned in the acquisition phase, the two groups were considered together and a paired samples t-test was used. This is because no context effects were involved in the initial stage so there would be no differences between the groups. To examine the two groups at three points, the beginning of acquisition, the end of acquisition, and the beginning of extinction, an ANOVA with repeated measures was used (with a Greenhouse-Geisser correction for the expectancy rating measure, due to violation of the assumption of sphericity). For the extinction data, t-tests were used to compare the two groups, as it was only the first and last trials in the phase that gave indications of learning. To investigate renewal effects, t-tests analysed the two group differences at the isolated trials representing pre and post reinstatement.

3 RESULTS

The results are presented in order of the procedural phases, as shown in Table 2-1 above, with SCR appearing before expectancy ratings for each set of results. All SCR magnitude data are in microsiemens (μs). All expectancy rating (ER) magnitude data are on the scale of zero to nine. All scores are mean CS+/CS- differentiations, which is the result of the control CS- score subtracted from the experimental CS+ score. This differentiation score removes the effect of the CS to which fear has been paired from the effect of a non fear associated CS, and gives the experimental effect of fear learning in isolation. The only exception to the use of CS+/CS- differentiation is the first set of SCR and ER results presented within the acquisition section immediately below.

3.1 ACQUISITION

Figure 3.1 shows the average SCR to the CS, presented separately as CS+ and CS- scores, for each individual trial during acquisition. Considering group 1 and 2 together, it is evident that the responses to the CS started similarly at trial 1 but by the final trial at the end of acquisition, the CS+ appeared to have produced larger SCR than the CS- (Trial 16; SCR CS+; N = 33; M = 0.51, S.D. = 0.42. Trial 16; SCR CS-; N = 33; M = 0.24, S.D. = 0.30).

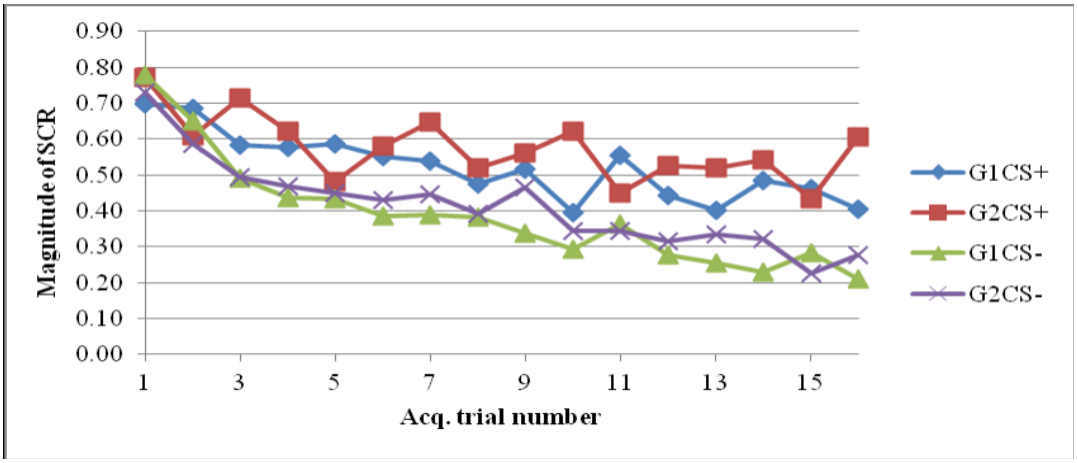

Figure 3.1 SCR (µs) to CS+ and CS- throughout acquisition

A paired samples t-test was conducted on the differences between the CS+ and CS-. It showed that the CS+ produced significantly greater fear responses than the CS-, and that participants conditioned successfully in the initial learning environment, as tested by SCR, $t(32) = -2.962$, $p = 0.006$.

Figure 3.2 shows the average expectancy rating of the CS, presented separately as CS+ and CS- scores, for each individual trial during acquisition. Again, considering the two groups together, it appears that by the 16th trial a difference between CS+ and CS- expectancy was present (Trial 16; ER CS+; N = 33; M = 7, S.D. = 2.61. Trial 16; ER CS-; N = 33; M = 1.30, S.D. = 2.28).

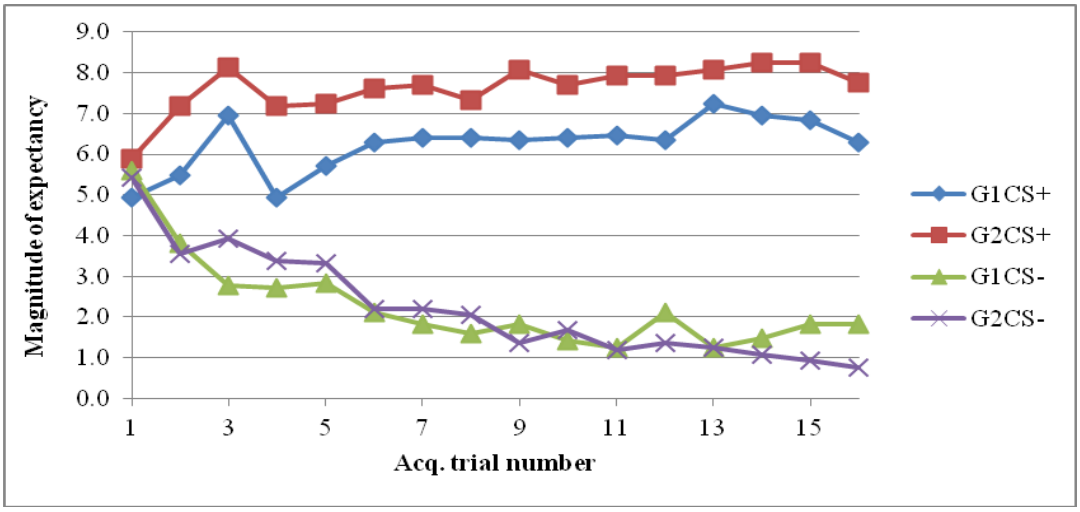

Figure 3.2 ER (0-9) of CS+ and CS- throughout acquisition

A paired samples t-test of the end of acquisition showed that participants became conditioned, with the CS+ producing significant fear responses compared to the CS-, as tested by expectancy ratings $t(32) = -7.625$, $p < 0.001$.

Whether conditioning was consolidated overnight by the two groups was investigated. Figure 3.3 shows that when SCR was measured at the first extinction trial after the 24 hour gap between phases, group 2 displayed a reduction in fear in their novel extinction environment. The learning in group 1 appears to have better generalised to the second day.

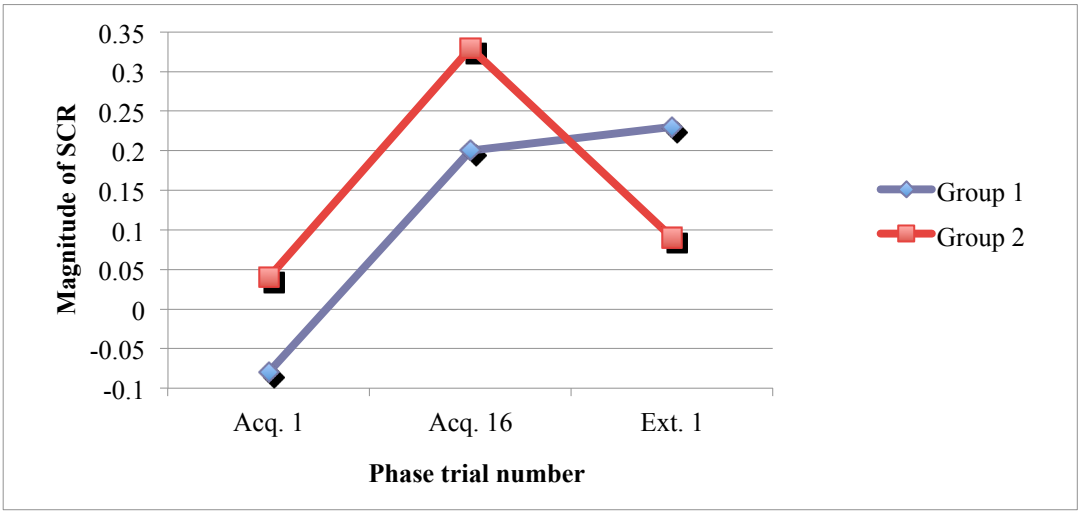

Figure 3.3 SCR (µs) at acquisition beginning and end, and pre extinction

An overall analysis of variance for repeated measures, defined as two groups tested at three points in time (acquisition beginning, acquisition end, extinction beginning), showed a significant main effect of time, $F(2,62) = 3.406$, $p = 0.039$, that was only explained by the acquisition of fear in both groups.

Figure 3.4 shows that both groups' expectancy rating scores were similar across the three points of testing.

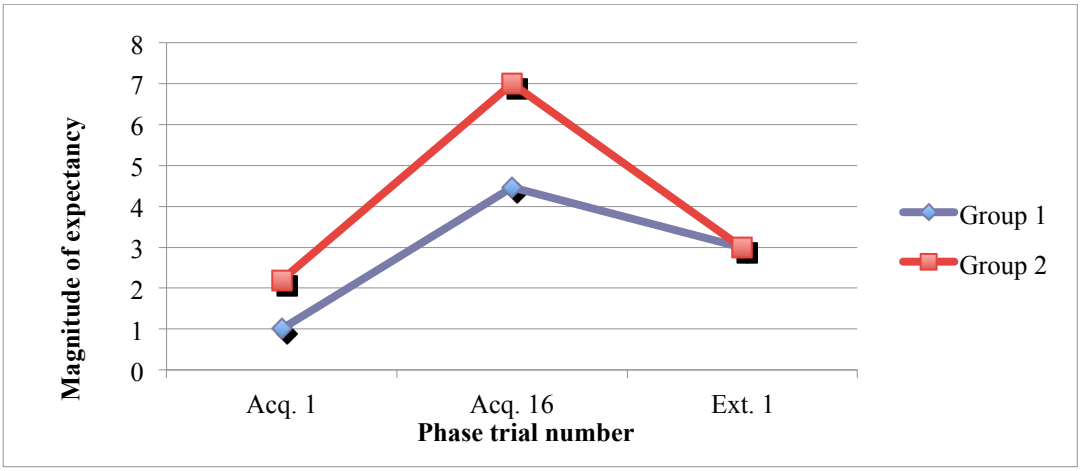

Figure 3.4 ER (0-9) at acquisition beginning and end, and pre extinction

A repeated measures ANOVA with a Greenhouse-Geisser correction showed a main effect of time on expectancy rating responses, $F(1.880,58.274) = 35.128$, $P < 0.005$, explained exclusively by fear acquisition in both groups.

3.2 EXTINCTION

Figure 3.5 shows the SCR during the extinction trials for the two groups. Both groups display similar start (Ext. 1; Group 1 SCR; N = 17; M = 0.26, S.D. = 0.433. Ext. 1; Group 2 SCR; N = 16; M = 0.08, S.D. = 0.85) and end scores (Ext 10; Group 1 SCR; N = 17; M = -0.02, S.D. = 0.38. Ext 10; Group 2 SCR; N = 16; M = 0.16, S.D. = 0.43).

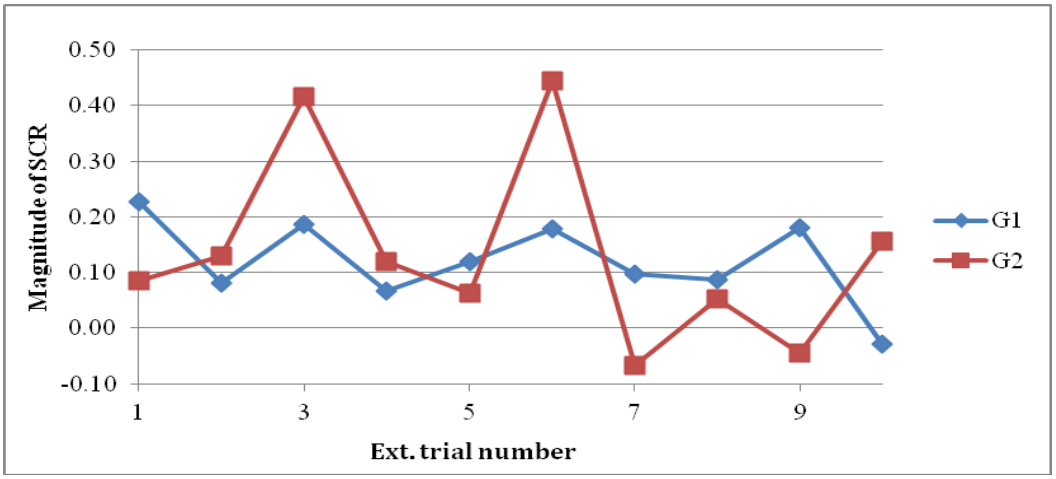

Figure 3.5 SCR (µs) throughout extinction

Both groups did not demonstrate extinction as the difference between the first and last extinction trials was non significant for SCR $t(32) = .657$, $p = 0.516$.

Figure 3.6 displays the expectancy rating scores during the extinction trials for the two groups. It indicates a progressive reduction in the magnitude of subjective expectancy. The groups show similar start (Ext. 1; Group 1 ER; N = 17; M = 3.41, S.D. = 4.33. Ext. 1; Group 2 ER; N = 16; M = 3.38, S.D. = 2.87) and end scores (Ext. 10; Group 1 ER; N = 17; M = 1.41, S.D. = 2.37. Ext. 10; Group 2 ER; N = 16; M = 0.81, S.D. = 1.33).

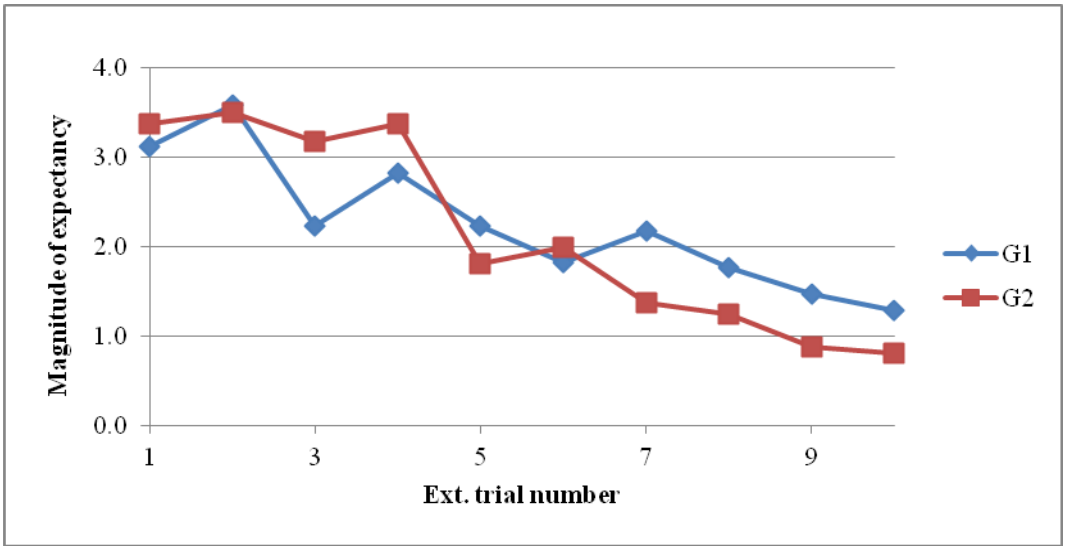

Figure 3.6 ER (0-9) throughout extinction

Together the groups demonstrated extinction through expectancy ratings as the difference between the first and last trials was significant $t(32) = 3.339$, $p = 0.002$.

3.3 RENEWAL PRE AND POST REINSTATEMENT

Figure 3.7 shows the SCR for each group at the two context effect testing points: firstly, pre reinstatement shocks, which is immediately after the extinction phase, and secondly, post reinstatement, which is at the last trial of the procedure. The difference between the groups, as shown in the 'Pre' column, did not reflect an ABA renewal effect as it was non significant $t(31) = -1.616$, $p = 0.116$. The difference between the groups as shown in the 'Post' column was significant $t(31) = -2.273$, $p = 0.030$. Group 1 SCR was significantly lower than group 2 following reinstatement (Group 1 SCR; M = <0.01, SD = 0.33. Group 2 SCR; M = 0.39, SD = 0.62).

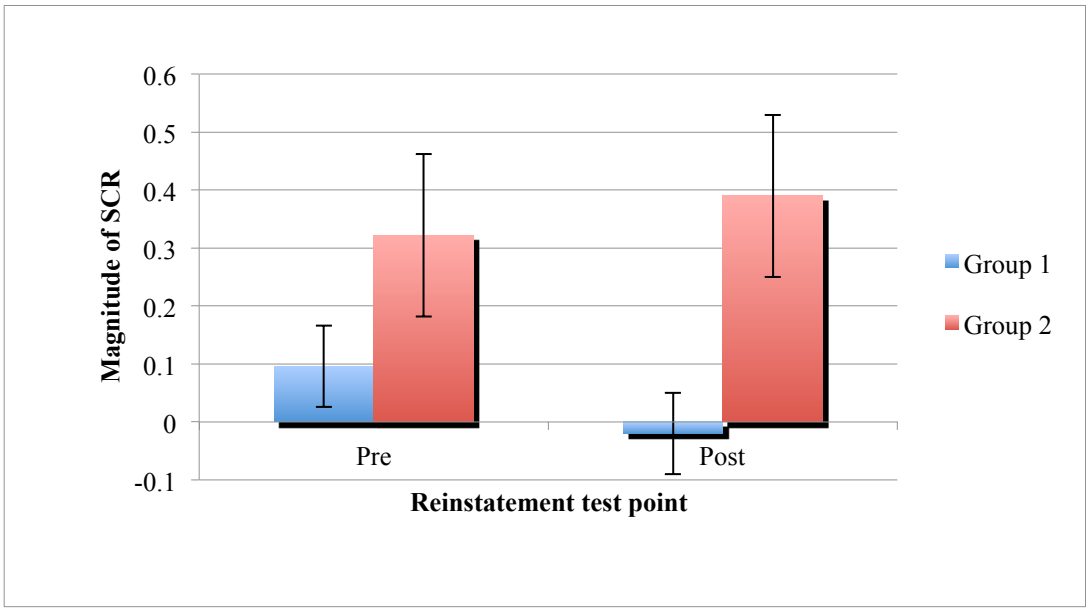

Figure 3.7 SCR (µs) pre and post reinstatement

Figure 3.8 shows the expectancy rating score for each group at the same two stages in the procedure.

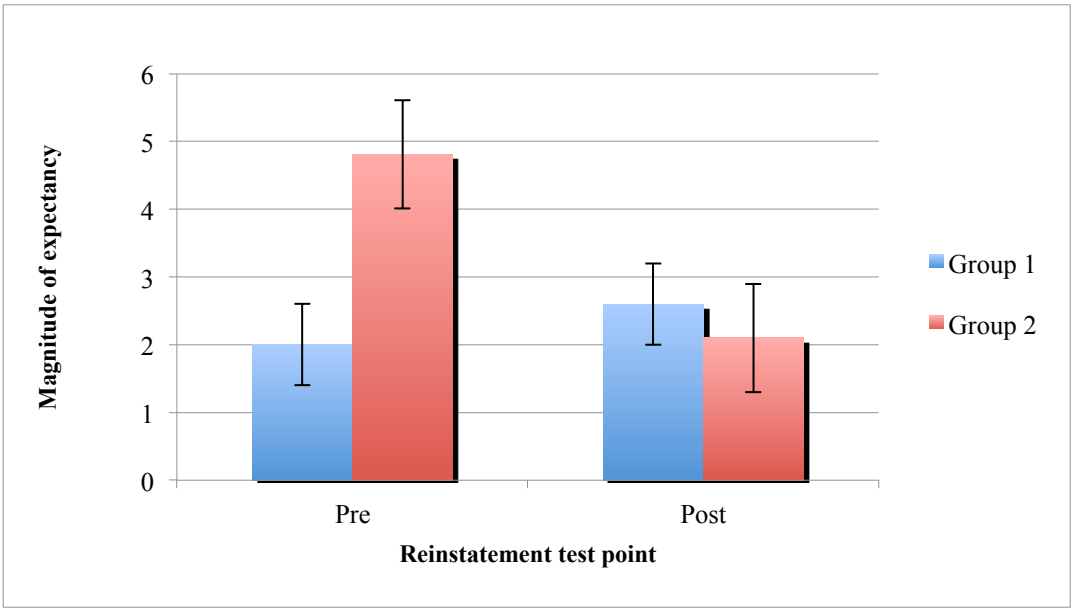

Figure 3.8 ER (0-9) pre and post reinstatement

The 'Pre' column difference between groups represents ABA renewal as it was significant $t(31) = -2.670$, $p = 0.012$. Group 2 verbal rating score was significantly higher than group 1 (Group 1 ER; M = 2.00, SD = 0.69. Group 2 ER; M = 4.64, SD = 1.62). An effect of context was not found in verbal self-report as shown by the 'Post' column $t(31) = -.836$, $p = 0.409$.

4 DISCUSSION

This study was successful in establishing the conditioning of fear in humans within a VR paradigm. Against what was expected, there was only weak evidence that this learning was carried through to the second day of the study. It is well established that learning transfers from acquisition to extinction in the animal literature (Thomas, Larsen & Ayres, 2003), and Hermans, Craske, Mineka and Lovibond (2006) highlight that it is a relatively robust effect in the human fear conditioning literature also. An explanation for the findings in the field may be that a short-delay procedure is the standard paradigm that is utilised. A short-delay procedure is considered to be one in which all testing phases are completed in under

24 hours, and the many are much less than this and do not involve a consolidation phase. The paradigm implemented here is therefore of longer duration, which inevitably allows for other, potentially significant memory processes to be involved. The convincing acquisition learning, which was demonstrated here, not generalising to the extinction phase could hint to methodological implications of a longer delay procedure within a human sample.

Similarly, it is also emphasised by Herman et al.'s (2006) review, and supported by Delgado, Olsson and Phelps' (2006) are the issues inherent in the translation of work in animals, specifically rodents, to human samples. For example, the large differences in brain anatomy, and the resulting symbolic and propositional analysis of conditioning experiences that humans are afforded, could impact upon replication studies. It is possible that such features that are specific to humans may bring a complexity to the study procedures. Moreover, it follows that such effects may be drawn out particularly by designs that are more representative of real-world situations, and are further removed from the rodent and less ecologically valid human studies, such as those utilising VR.

This study failed to detect extinction as measured by SCR, which again, is a robust finding in both the animal and human literature (Bouton, 2004). The fact that expectancy ratings did show extinction implies that the conditioning methodology used was successful in part. It is possible that the US was not aversive enough to translate to the physiological experience of fear. This may also explain the lack of the basic ABA renewal effect in SCR (a particularly well-researched phenomenon in rodents; Bouton & Bolles, 1979), but its occurrence in expectancy ratings. However, it should be noted that publication bias might be involved in the over of confidence in such effects within the field. Therefore it may be that contextually specific

renewal is not as robust an effect as commonly held and the SCR findings here reflect that.

Furthermore, the vast majority of studies demonstrating the ABA renewal effect have done so in relatively abstract designs, without particular relevance to real life clinical situations. For example, non fear-related stimuli are often used, the contextual shifts are overly simplistic and unrelated to the CS, and the US often produces only reflex-based fear, rather than semantically related anxiety. It is thus possible to argue that the ABA renewal effect has not been well established in terms of more contextually relevant fear. Within this view the findings presented here could reflect that the renewal effect is not such a dominant explanation of relapse in more ecologically valid situations.

Interesting generalisation effects occurred following reinstatement through presentation of the US. Furthering Herman et al.'s (2005) findings, a significant reinstatement effect was observed for SCR in the ABA group but not the control group. The effect was not replicated in the expectancy ratings. The result suggests that some contextually specific effects of the extinction learning generalised for the control group, but not for those who received extinction in a different context to acquisition. This shows an interaction between ABA renewal and reinstatement, which are usually researched separately.

In terms of the underlying mechanisms of context specificity in the extinction of learned fear, only tentative arguments can be made. Regarding the principal hypothesis of this study, in terms of SCR at least, it seems not to be the case that the CS+ was experienced differently in the acquisition context following a novel extinction training environment. Some cautiously proposed explanations for this

include: Firstly, participants may have learned that environments were safe due to a direct inhibitory context-US association. Secondly, context effects may have modulated the extinction process by arbitrating between CS-US and CS no US situations (Vansteenwegen et al., 2005). Thirdly, the VR contexts as they were may not have been significant enough representations of context change. And finally, although the sample size was only one participant short of that suggested by the power analysis, problems in the sample could have affected the study's ability to detect conditioning effects. This is in awareness that considerable inter-individual variation exists in the ability to learn and extinguish fear, with genetic variants being central to this (Lonsdorf & Kalisch, 2011).

4.1 FUTURE RESEARCH

Considering that the findings described in this study may reflect methodological issues in the research, future investigations should continue to explore the VR paradigm and its effects on contextual specificity. Attention should be paid to experience of conditioning that is specific to humans when developing such procedures. Furthermore, the ABC design has more real life application than the less experienced ABA paradigm and therefore VR should extend its focus to the novel testing context procedure. Reinstatement and renewal exploration should be incorporated more in future work, in light of the interaction of the two phenomena found in this study. More focus should be given to prolonged-delay procedures and test-retest reliability of longer-term paradigms (Zeidan et al., 2011).

Although SCR is a relatively robust approach to observing autonomic fear responses, providing continuous measurement, it does not record this activity in isolation. It detects other processes and is also a relatively slow measure of fear

response (Dawson, Schell & Filion, 2007). In addition, the verbal self-report scale used here provided a useful supporting fear measure, however, issues exist in terms of the high levels of individual differences in subjective response across participants. Thus, future research should aim to incorporate more varied and robust approaches to measuring fear responses, with a focus on an improved integration of their meanings.

4.2 CLINICAL IMPLICATIONS

The discrepancy between the self-reported experience of the fear situation and the electrodermal responses highlights an issue that is pertinent in exposure therapies. Many dominant interventions for anxiety disorders and phobias utilise patients self-reporting of their subjective experience of fear or distress, to indicate therapeutic success. The findings presented here support Craske et al's (2008) argument that performance during conditioning training, as measured by subjective self-report, is not proportionate to learning that is occurring at the process level. Therefore, the results suggest that the therapeutic field could benefit from improved measures of exposure therapy success beyond self-report.

This study highlights that context is undoubtedly significant in people's experience of fear reduction and relapse but that the particularities of its role are complex. This could be a manifestation of the multifaceted argument for the specifics of hippocampal involvement in contextual memories (Wiltgen et al., 2010). What is generally agreed is that interactions of the hippocampus, prefrontal cortex and amygdala are central to context specificity effects (Ji & Maren, 2007). In PTSD in particular, these structures, along with aberrant synaptic plasticity, are considered as the key neural circuitry components in symptom development and maintenance (Mahan & Ressler, 2012). A comprehensive review of the brain regions and

connections that mediate contextual processing and modulation in both healthy and abnormal samples across psychopathologies is needed to improve integration of physiological and behavioural evidence (Maren, Phan, & Liberzon, 2013).

4.3 LIMITATIONS

A limitation of this study's methodology is that ideally, renewal of a fear memory would be tested at least one day after extinction. This would allow for the consolidation of the extinction learning (Duvarci & Nader, 2004) and more confidant conclusions could have been drawn regarding the test of renewal. Additionally, in the interest of improved ecological validity in contextual renewal study designs, this would more accurately reflect the real world occurrence of fear conditioning for patients.

Another ideal methodological feature that was not possible due to feasibility issues was the inclusion of follow up testing. Preferably, long-term follow up would take place to test for spontaneous recovery of the fear memories. This would be of particular interest as investigation into the persistence of the contextual reinstatement and extinction effects would have strong clinical implications.

The sample size estimate for this study was N = 34. Seven participants' data were not appropriate for use. This meant that the original recruitment number of 40 people resulted in 33 individuals' data being used in the analyses. A limitation of this work is therefore that the suggested sample size was not met and it was under power. In addition, despite the gender of participants being considered at recruitment and balanced across groups, the differences between the sexes were not analysed statistically.

Finally, a researcher error was made concerning the stimuli groupings. The fear-relevant CS were not balanced across the groups as would have been preferable. Therefore, it cannot confidently be concluded that any group effects were not impacted upon by the CS+ that defined them. However, it is hoped that the similarity in visual presentation and the nature of the stimuli would have limited any confounding effects of this error.

4.4 CONCLUSIONS

This study has given a contribution to the work that aims to bridge the gap between the clinical demonstrations of contextually specific fear return and the animal literature. The main hypothesis that extinction occurring in the same context as acquisition would produce lower SCR renewal than extinction in a different context to acquisition, was unsupported. The underlying mechanisms involved in the study findings cannot be confidently concluded due to the divergence from some key established effects in the field. An improved understanding would rely on further research into the use of VR in relation to contextual specificity and environmentally determined reinstatement effects within humans.

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Part 3: CRITICAL APPRAISAL

1 INTRODUCTION

This critical appraisal first gives the background context to the genesis of the research reported in Parts 1 and 2. It then addresses the procedure of the literature review and the process of the empirical study in turn. For both sections attention is given to the choices made, methodological and theoretical issues, difficulties that arose, how challenges were tackled, and finally, a personal reflection on the significance and impact of the work.

2 BACKGROUND CONTEXT

In the final year of my undergraduate degree in Psychology I became interested in the field of Cognitive Neuroscience. Through teaching, reading and work with patients, the doctoral training course developed my knowledge of the clinically relevant aspects of the area. Specifically, my attention became focused on the improved development and delivery of interventions for neurologically significant disorders, namely PTSD and anxiety related psychopathologies. I was drawn to the rapidly advancing investigatory techniques within Cognitive Neuroscience, both in behavioural paradigms and imaging studies. It was evident that Clinical Psychology sits in a prime position to benefit from the understanding generated by Cognitive Neuroscience research, and I was keen to become involved in the continued bridging of these fields. Hence, when the prospect of working within the Institute of Cognitive Neuroscience (ICN) was made available for my major research project, I immediately pursued this opportunity.

The lab at the ICN, which was linked to the Clinical Psychology doctoral department, was in the preliminary stages of developing virtual reality paradigms for the testing of various memory processes. The investigation of fear conditioning

specifically was in the early pilot stages and provided the pertinent link to the clinical field that was necessary for my research. Hence I became involved in the initial investigation into extinction within virtual environments. This work was to form the foundation for subsequent studies to develop a robust paradigm to eventually be translated to imaging research. I placed great importance on being a building block in the construction of such valuable end-goal research.

3 LITERATURE REVIEW

The literature related to the extinction of learned fear and context specificity is both rich and far reaching in its scope. Because of this, identifying an appropriate and useful question for Part 1 of the research was challenging. I encountered that many clinically relevant issues had been well addressed in recent reviews and analyses, or were too broad to be feasibly investigated. In response to this challenge I focused my reading on the more isolatable and precise features of fear extinction and context specificity, in hope of narrowing the scope. Furthermore, I attended to any developments in the literature that were in their infancy, to increase the likelihood that a review would be of value. The area of contextual renewal was a particular element within the domain of fear extinction, which as an isolated phenomenon had strong clinical relevance. And whilst it had an established history in animal investigations, the translation to human samples was relatively young.

Vervliet, Baeyens, Van den Bergh & Hermans (2012) had recently reviewed the human fear extinction renewal literature but addressed the problem of the analysis and comprehension of such research. This was in light of the issues of such established analyses being translated from the animal field to human investigations. They highlighted that different extinction mechanisms were potentially responsible

for study results, and that detailed and specific behavioural analysis was critical for interpreting findings and further developing theories. A potentially useful accompaniment and progression from this work appeared to be a comprehensive review of the key methodological features and findings of the same research sample.

A principal choice involved in the literature review was what criteria to use for the study inclusion. The search terms themselves were guided by Vervliet et al.'s (2012) review and therefore the majority of the inclusion criteria were comfortably established. However, more concern was given to the decision to exclude neuroimaging research and papers investigating the neurobiology of the area, as their inclusion would take the scope of the review beyond what could feasibly be covered. Upon reflection, I do not think the two main limitations of the review (it not including as broad range of studies or further objective critical appraisal procedures as would have been ideal) prevented it from being successful. Certainly, the specific aims of the review were met, but more generally, I think it provided significant support for Vervliet et al.'s (2012) view that increased care should be given to study designs in the human field. Furthermore, caution should be raised against the occurrence of interpreting human data as a direct translation of the nature of interpretation in the animal literature. The issues discussed in Part 1 are important in adding to the validity and reliability of research that ultimately feeds into improved patient care.

4 EMPIRICAL STUDY

This empirical work was conducted alongside the other clinical and academic demands of the doctoral training course. As such I am grateful that the major decisions and processes involved in the work were frequently predetermined or I

received great assistance with. The initial decision concerning the research question was informed largely by the stage at which the ICN lab was at with developing the virtual reality research paradigm for investigation of context effects on extinction. Namely, one pilot study conducted by a Masters student took place, which served to ensure conditioning was detectable by the paradigm. Thus, the natural progression from this point was to investigate the contextual effects on renewal and the focus of my work was naturally apparent.

At the proposal stage of the research process it was thought that investigation of reconsolidation effects would be incorporated into the contextual fear work. This would have been in aim of replicating Schiller et al.'s (2010) exciting findings into reconsolidation update mechanisms. However, this would have necessitated an even longer or more complicated research paradigm. It also raised further issues of feasibility in a study that was already going to need to be conducted over two consecutive days. Therefore, this part of the study was not included. In hindsight I think this was of benefit to the research because it allowed for a greater focus on the included elements, and promoted a successful sample size and 100% participant completion rate.

I did not encounter any recruitment issues as the volunteer rate via the psychology subject pool was of a high frequency. If I were to conduct the research again however, I would have taken extra time in the early stages to develop more sophisticated advertising and recruitment procedures. This would be in aim of diversifying the sample, which, in this study, was predominantly students in its make up. It is a limitation generally across the research I encountered when producing Part 1 and 2 that the generalisability of studies could be enhanced by improved sampling procedures.

Deciding what background literature was drawn upon in the write up of Part 2 was a challenge because of the vast array of appropriate and pertinent literature, theories and models. Essentially, as Part 1 looked specifically at the basic renewal effect and its closely related phenomena, I chose for the write up in Part 2 to focus more on the inclusion of broader and more numerous relevant theory. It is hoped that this is not at the expense of the material touching too briefly on the matters of its content. The nature of the two parts of this research has therefore developed my abilities to draw out relevant material, although this is certainly an on going learning process and not a skill that has been realised fully in this work.

In terms of the findings of the empirical study, they were challenging to interpret. Electrodermal activity was frequently discordant to verbal expectancy self-reports and key predictions were not met. It is tempting to assume that in the face of such widely published and reportedly robust effects of extinction and renewal, the results reflect methodological issues and a need to fine-tune the research design and procedure. However, the issue I raised in the empirical paper discussion concerning the possible involvement of publication bias within the field should be attended to. It is a known issue that established effects can be self-perpetuating due to misinterpretation of evidence and skew in the results that are reported and published. Unfortunately though, the reality of this problem is rarely dealt with on a pragmatic level. The scientific discipline in general, not just in psychological research, should improve efforts to rectify the consequences of such issues. It could be that the contextually specific renewal effect is being misunderstood and a type I error regularly occurs. Ultimately, this would most negatively impact upon the clinical population and is therefore of huge significance.

If it was taken that a type II error occurred in relation to skin conductance responses (within the areas of generalisation of learning, the success of extinction, and the renewal effect) then explanations for this can be speculated. As detailed in the empirical paper discussion, problems with too weak an aversive stimuli or modulating effects of the context, amongst other suggestions can be made. More subjectively however, I wonder if factors such as inconsistencies in my own behaviour may have played a part. For example, such seemingly minor issues as individual differences in the delivery of instructions and too much variability in the application of the electrodes may have accumulated to major effects on the data. If I were to conduct the research again, and time and resources were not of concern, I would deliver numerous pilot studies to smooth out any methodological kinks and develop a more stringent and definite procedure with increased control of confounding variables.

5 SUMMARY

In summary, the major decisions involved in both parts, for example, the literature review search terms and the virtual reality features and procedure, were relatively simply taken; they were determined by other's work, which I was building upon. Part 1 provided specific conclusions, whilst part 2 was more difficult to interpret. I found the process of this major project to be highly rewarding. I believe the work goes some way to adding to the knowledge of context specificity in the extinction of learned fear within the broader relapse literature (Boschen, Neumann & Waters, 2009; Bouton, 2002).

6 REFERENCES

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APPENDIX A: LITERATURE SEARCHES

OVID literature search (Embase, Medline and PsychInfo included), January 2013:

1	conditioned fear.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	2308	Advanced
2	fear condition*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	3145	Advanced
3	condition* fear.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	2424	Advanced
4	1 or 2 or 3	4202	Advanced
5	context*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	227198	Advanced
6	renewal.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	2368	Advanced
7	extinction.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	13223	Advanced
8	4 and 5 and 6 and 7	70	Advanced
9	limit 8 to (peer reviewed journal and human and english language)	20	Advanced

NCBI literature search (PubMed included), January 2013:

Result:

69

Translations:

conditioned	"conditioning (psychology)"[MeSH Terms] OR ("conditioning"[All Fields] AND "(psychology)"[All Fields]) OR "conditioning (psychology)"[All Fields] OR "conditioned"[All Fields]
fear	"fear"[MeSH Terms] OR "fear"[All Fields]
extinction	"extinction, psychological"[MeSH Terms] OR ("extinction"[All Fields] AND "psychological"[All Fields]) OR "psychological extinction"[All Fields] OR "extinction"[All Fields]

Database:

PubMed

User query:

(((((conditioned fear) OR fear condition*) OR condition* AND fear) AND context*) AND renewal) AND extinction

Filter your results:

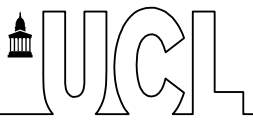
All (69)

English (69)

Humans (22)

APPENDIX B: APPROVED ETHICS APPLICATION

UCL RESEARCH ETHICS COMMITTEE



IMPORTANT: ALL FIELDS MUST BE COMPLETED. THE FORM SHOULD BE COMPLETED IN PLAIN ENGLISH UNDERSTANDABLE TO LAY COMMITTEE MEMBERS.

SEE NOTES IN STATUS BAR FOR ADVICE ON COMPLETING EACH FIELD. YOU SHOULD READ THE ETHICS APPLICATION GUIDELINES AND HAVE THEM AVAILABLE AS YOU COMPLETE THIS FORM.

APPLICATION FORM

SECTION A	APPLICATION DETAILS

A1	**Project Title:** The role of context in human fear learning	
	Date of Submission:	Proposed Start Date: 01/03/2010
	UCL Ethics Project ID Number: 0366/002	Proposed End Date: 01/03/2013
	If this is an application for classroom research as distinct from independent study courses, please provide the following additional details: Course Title: N/A	Course Number: N/A

A2	**Principal Researcher** *Please note that a student – undergraduate, postgraduate or research postgraduate cannot be the Principal Researcher for Ethics purposes.*	
	Full Name: Dr John Andrew King	Position Held: Lecturer
	Address: UCL Research Department of Clinical, Educational and Heath Psychology, 1-19 Torrington Place, London WC1E 7HB	Email: john.king@ucl.ac.uk
		Telephone: 45993
		Fax: N/A

Declaration To be Signed by the Principal Researcher

- I have met with and advised the student on the ethical aspects of this project design *(applicable only if the Principal Researcher is not also the Applicant).*
- I understand that it is a UCL requirement for both students & staff researchers to undergo Criminal Records Checks when working in controlled or regulated activity with children, young people or vulnerable adults. The required Criminal Record Check Disclosure Number(s) is: N/A
- I have obtained approval from the UCL Data Protection Officer stating that the research project is compliant with the Data Protection Act 1998. My Data Protection Registration Number is: Z6364106/2011/01/36
- I am satisfied that the research complies with current professional, departmental and university guidelines including UCL's Risk Assessment Procedures and insurance arrangements.
- I undertake to complete and submit the 'Continuing Review Approval Form' on an annual basis to the UCL Research Ethics Committee.
- I will ensure that changes in approved research protocols are reported promptly and are not initiated without approval by the UCL Research Ethics Committee, except when necessary to eliminate apparent immediate hazards to the participant.
- I will ensure that all adverse or unforeseen problems arising from the research project are reported in a timely fashion to the UCL Research Ethics Committee.
- I will undertake to provide notification when the study is complete and if it fails to start or is abandoned.

Signature: Date:

A3

Applicant(s) Details *(if Applicant is not the Principal Researcher e.g. student details):*

Full Name: Neil Burgess

Position Held: Professor

Address: UCL Inst of Cognitive Neuroscience, 17 Queen Square, London WC1N 3AR	Email: n.burgess@ucl.ac.uk
	Telephone: 02076791147 (UCL x21147)
	Fax:

A4	**Sponsor/ Other Organisations Involved and Funding** **a) Sponsor:** ☒ **UCL** ☐ **Other institution** If your project is sponsored by an institution other than UCL please provide details: N/A **b) Other Organisations**: If your study involves another organisation, please provide details. *Evidence that the relevant authority has given permission should be attached or confirmation provided that this will be available upon request.* N/A **c) Funding:** What are the sources of funding for this study and will the study result in financial payment or payment in kind to the department or College? *If study is funded solely by UCL this should be stated, the section should not be left blank.* UCL

A5	**Signature of Head of Department or Chair of the Departmental Ethics Committee** *(This must not be the same signature as the Principal Researcher)* **I have discussed this project with the principal researcher who is suitably qualified to carry out this research and I approve it. The project is registered with the UCL Data Protection Officer, a formal signed risk assessment form has been completed, and appropriate insurance arrangements are in place.** *Links to details of UCL's policies on data protection, risk assessment, and insurance arrangements can be found at: http://ethics.grad.ucl.ac.uk/procedures.php* **UCL is required by law to ensure that researchers undergo a Criminal Record Check if their research project puts them in a position of trust with children under 18 or vulnerable adults.** *Full details of UCL's policy on criminal record checks can be found at http://www.ucl.ac.uk/hr/docs/criminal_record.php* ***HEAD OF DEPARTMENT TO DELETE BELOW AS APPLICABLE*** **I am satisfied that checks:** **(1) have been satisfactorily completed** **(2) have been initiated** **(3) are not required**	
	Print Name:	
	Signature:	Date:

Chair's Action Recommended: ☒ **Yes** ☐ **No**

A recommendation for Chair's action can be based only on the criteria of minimal risk as defined in the Terms of Reference of the UCL Research Ethics Committee.

APPENDIX C: HEALTH QUESTIONNAIRE SCREENING TOOL

Health Questionnaire for Participants

Name of Participant:

Age:

1.a) Have you ever been treated by a doctor for any medical disorder?

Yes ☐

No ☐

1.b) If yes, please provide details of the medical disorder/s

_____

_____

2.a) Have you ever been treated by a doctor for any psychiatric disorder?

Yes ☐

No ☐

2.b) If yes, please provide details of the psychiatric disorder/s

_____

_____

Signed:

Date:

APPENDIX D: ADVERT

INSTITUTE OF COGNITIVE NEUROSCIENCE  UCL

Healthy volunteers aged 18 – 40 years
are invited to participate in a study:

The role of context in human fear learning

This is a study about the way in which we learn to be fearful of things and how fear can be unlearned. We believe that the place in which events happen is important for how this learning takes place.

If you take part you would be asked to move around in a computer game. From time to time, you would be given a mild electric shock on the hand - this is completely safe and only mildly uncomfortable. You would be able to stop the study at any time. From your reactions we will be able to understand the way you learn to link the shock with places in the game.

This study requires you to attend on two consecutive days for around an hour each. You would be reimbursed £7.50 per hour for your expenses, or in course credits, at the end of the second visit.

If you are interested in participating, please contact

siobhan.o'leary.10@ucl.ac.uk

APPENDIX E: INFORMATION SHEET

Information Sheet for Participants in Research Studies

Title of Project: The role of context in human fear learning

This study has been approved by the UCL Research Ethics Committee (Project ID Number): 0366/002

Name Ms Siobhan O'Leary Supervised by Dr John King

Address Institute of Cognitive Neuroscience, UCL

Contact Details Siobhan.o'leary.10@ucl.ac.uk 07841027366

We would like to invite you to participate in this research project. You should only participate if you want. Choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to read the following information carefully.

Background

We are interested in the way people sometimes learn to find things fearful. This is a normal aspect of our ability to learn from experience, but in very stressful situations it may also lead to problems. We wish to understand how the place in which this kind of learning happens can influence the learning and removal of fear. By better understanding how the environment plays a part, we hope to improve treatments for problems where people have become unhealthily fearful.

Who can take part?

Healthy individuals between 18-40 years

What is involved?

At the beginning of the study we will ask you to complete some brief questionnaires and a short intelligence test. The total time to complete the study is approximately 2 hours over two consecutive days. In the main part of the study we will be looking at the role of the environment in fear learning. If you participate we will ask you to perform a task on a computer, derived from a computer game - you will explore a computer generated world on the screen.

During the study you will be asked to wear a ring which measures how much your skin is sweating. You would also wear a wristband which will sometimes deliver a mild shock. This is completely safe and should be only slightly uncomfortable. At the start of the session we will adjust the shock to a point you find acceptable. You must let us know if it begins to be painful so that we can lower it. We will only use a comfortable level in the study.

The study will take place over two consecutive days and you would be reimbursed at the end of the second session.

It is up to you to decide whether to take part or not, choosing not to take part will not disadvantage you in any way. If you do decide to take part you are still free to withdraw at any time and without giving a reason.

Please discuss the information above with others if you wish or ask us if there is anything that is not clear or if you would like more information.

All data will be collected and stored in accordance with the Data Protection Act 1998. This means that only the investigators will have access to the data from the study. Your results will not be identified by your name as you will be given a participant number.

APPENDIX F: INFORMED CONSENT FORM

Informed Consent Form for Participants in Research Studies

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Project: **The role of context in human fear learning**

This study has been approved by the UCL Research Ethics Committee (Project ID Number): 0366/002

Thank you for your interest in taking part in this research. Before you agree to take part, the person organising the research must explain the project to you.

If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you to decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

Participant's Statement

I **…….**

- have read the notes written above and the Information Sheet, and understand what the study involves.
- have had the opportunity to ask questions and discuss the study;
- understand that if I decide at any time that I no longer wish to take part in this project, I can notify the researchers involved and withdraw immediately.
- consent to the processing of my personal information for the purposes of this research study.
- understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.
- agree that the research project named above has been explained to me to my satisfaction and I agree to take part in this study.
- I understand that I am being paid for my assistance in this research and that some of my personal details will be passed to UCL Finance for administration purposes.

Signed: Date: