The Return of Extinguished Conditioned Behaviour in Humans: Research findings and Clinical Implications

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The last five years has seen an explosion of interest in research on the return of extinguished conditioned behaviour in humans. This interest has resulted from the development of theoretical models of the phenomenon from non-human animal research and the potential application that the research has to explaining relapse following extinction-based treatments for psychological disorders. The recent research conducted with human participants is reviewed. The main return of conditioned behaviour phenomena are renewal, reinstatement, spontaneous recovery, and reacquisition, although recent human research has tended to focus on only the first two. Human research has employed three main paradigms in the laboratory: fear conditioning procedures, a conditioned suppression task, and causal learning tasks. The basic effects of renewal, reinstatement, and spontaneous recovery have been demonstrated in these tasks and in psychophysiological, behavioural, and subjective measures. However, research has also yielded some inconsistencies among measures as well as differences between the results obtained with human participants and those obtained with non-human animals. There may be some unique factors that mediate the return of extinguished conditioned behaviour in humans. Clinical studies on anxiety and substance dependence have also confirmed that renewal, reinstatement, and spontaneous recovery are potentially important mechanisms that may underlie relapse following extinction-based treatments. There is a clear need for future research to understand the psychological mechanisms behind the return of extinguished conditioned behaviour in humans and to develop ways to reduce its occurrence in clinical treatment.
INTRODUCTION

The discovery that extinguished conditioned responses could reappear at a later time was made by Pavlov (1927) when he observed spontaneous recovery in his experiments with dogs. Research on other means by which conditioned responses can return following extinction in animal subjects, such as renewal and reinstatement, began to develop momentum in the late 1970’s (e.g., Bouton & Bolles, 1979; Rescorla & Heth, 1975). However, it has only been recently that these phenomena have been studied in humans. Despite the late start, human research is accelerating at an astounding rate. The number of published reports on renewal, reinstatement, and spontaneous recovery in humans numbered fewer than one per year between 1995 and 2000. In the years 2001 to 2005, this number increased to just over two per year. In the years subsequent to 2005, there have been over 5 per year published reports to date. The recent surge of work on the return of extinguished conditioned behaviour indicates that it is a significant new direction in biological psychology research.

The reasons why the return of extinguished conditioned behaviour in humans is attracting increasing interest are not hard to find. The most obvious is that it has important implications for our theoretical understanding of the acquisition and extinction of conditioned responses. For instance, the fact that extinguished conditioned responses can reappear at a later time suggests that extinction does not erase the original learning (e.g., Bouton, 2002; 2004; Bouton, Westbrook, Corcoran & Maren, 2006). It also suggests that learning does not occur in a vacuum, but can be influenced by a constellation of contextual factors ranging from the physical environment, the passage of time, physical states, and psychological mood states. Similarly, it suggests that our memories can be influenced by contextual cues that are present during their formation or recall (Bouton, 1993). Research on the topic
facilitates cross-species comparisons of learning phenomena by determining the extent to which the many discoveries made in experiments using non-human animals applies to humans. There are important clinical implications because the fundamental process of extinction has been applied in the treatment of psychological disorders such as anxiety disorders and substance dependence disorders. Relapse remains as an ever present danger when extinction is used in therapy and increasing our understanding of what factors mediate the return of extinguished conditioned behaviour has the potential to produce greater long-term benefits of therapy (Bouton, 2000; 2002).

The present chapter will present a review of the human research on the return of extinguished conditioned behaviour. It aims to complement similar reviews that have largely examined non-human animal experiments (Bouton, 2002; 2004; Bouton, Westbrook et al., 2006) by focussing specifically on experiments that use human participants. It also updates and complements prior reviews of human research (Hermans, Craske, Mineka, & Lovibond, 2006; Vansteenwegen, Dirikx, Hermans, Vervliet, & Eelen, 2006) by incorporating newly published research and by drawing from the experimental literature that has employed a conditioned suppression and causal learning task in addition to the fear conditioning procedure. The examination of the return of extinguished conditioned behaviour in clinical studies is also considered. Before examining this research it is first necessary to define the relevant terms and methods of Pavlovian conditioning. There are various procedures by which a return of extinguished conditioned behaviour can be produced. The investigation of these in research with human participants will be addressed in turn by first considering studies conducted in the laboratory. The return of extinguished conditioned behaviour in the treatment of anxiety disorders and alcohol dependency
are finally considered.

**PAVLOVIAN CONDITIONING**

Pavlovian (or classical) conditioning is a form of associative learning in which the relationship is learned between two or more previously unrelated stimuli. In his seminal work with laboratory dogs, Ivan Pavlov (1849-1936) first observed that when the animals were presented with a salient *unconditional stimulus* (US) (e.g., meat), an unconditional response (UR) (e.g., salivation) was elicited. Moreover, he further observed that if a neutral *conditional stimulus* (CS) (e.g., a tone) was paired with the presentation of the meat US, the animals began to show a *conditional response* (CR) of salivation to the tone CS. Thus, the tone CS initially induced no response, but when an association between the CS and US was learnt after repeated pairings, the tone CS on its own became capable of eliciting a CR. Since Pavlov’s influential work, Pavlovian conditioning models have been used to explain a wide range of human behavioural phenomena, including drug addiction (e.g., Drummond, Tiffany, Glahtier, & Remington, 1995), taste aversion (e.g., Rosas & Bouton, 1998), and fear learning (e.g., Bouton, Mineka & Barlow, 2001). Indeed, the conditioning of emotional responses such as fear is a central component of contemporary learning models of the development of phobias and other anxiety disorders (e.g., Mineka & Zinbarg, 2006).

Conditioned responses can manifest in various ways including *physiological* changes, such as those seen by Pavlov in the salivation volume of laboratory animals or in the magnitude of skin conductance responses and changes in heart rate of humans (e.g., Neumann & Waters, 2006). *Emotional* changes may also occur, such as increased euphoria or increased fear levels. While the emotional changes can be reflected in physiological responses, they may also be measured in human participants.
by subjective ratings. Cognitive changes can occur in which there are increased attentional demands and a higher expectation of the US during the CS presentation. The cognitive changes can be measured through secondary task reaction time slowing and ratings of the expectancy of the US, among others. Finally, behavioural changes may also take place, such as avoidance behaviour in humans and other animals (Davey, 1992; Dawson & Schell, 1985; Öhman, Hamm & Hugdahl, 2000).

Pavlovian conditioning protocols have typically been designed in one of two ways. During simple or single cue conditioning, a neutral CS is paired repeatedly with the salient US and within-subject conditioned responses are recorded over consecutive trials (see Lissek et al., 2005 for review). The single cue conditioning procedure requires the use of a control group that receives random pairings of the CS and US in order to establish that the development of conditioned responses in the conditioning group reflects associative processes. In discrimination or differential conditioning, two CSs are presented. One CS is repeatedly paired with the salient US (i.e., CS+ trials) while the other CS is consistently presented alone (CS-). The development of conditioned responses in the differential conditioning procedure can be indexed through a within-subjects comparison of the difference in magnitude of responses to the CS+ and to the CS-. The differential conditioning procedure can permit the examination of both excitatory processes (i.e., conditioned responding on CS+ trials) and inhibitory processes (i.e., capacity to inhibit conditioned responding to the safety cue heralded by the CS- and during extinction) (see Lissek et al., 2005).

Pavlovian conditioning protocols involve two key components. The first described above, in which a neutral CS is repeatedly paired with a salient US, is referred to as acquisition. The CS acquires the ability to elicit a CR. The second important component of Pavlovian conditioning is the demonstration that acquired
conditioned responses can be extinguished. *Extinction* of the CR occurs when the CS is no longer paired with the salient US event, but is presented on its own. The magnitude of CRs gradually diminishes over repeated presentations of the CS alone until it is extinguished all together. Extinction is used as the cornerstone for behavioural treatments of a range of psychological disorders. For instance, in exposure therapy for simple phobia, the patient is repeatedly exposed to the feared object until the fear response has diminished.

It is now widely accepted that the extinction of CRs does not result in a “destruction” of the CS-US association formed during acquisition (see Bouton, 2004, 2004). Rather, extinction reflects new learning whereby the CS essentially has two meanings – one that is associated with the US (i.e., a CS-US association) and one that is not (i.e., a CS-noUS association). The fact that the CS-US association remains intact means that there is always the potential that a return of conditioned behaviour can occur following extinction. All that is required is that there is retrieval of the original CS-US association (Bouton, 2002).

**THE RETURN OF EXTINGUISHED CONDITIONED BEHAVIOUR**

An extensive body of research on extinction has shown that there are four mechanisms by which extinguished conditioned behaviour can return. All four mechanisms are also potential explanations for why relapse can occur after successful extinction in clinical treatments (i.e., exposure treatments). These mechanisms are (a) renewal, (b) reinstatement, (c) spontaneous recovery, and (d) reacquisition. Each highlights that extinction does not destroy the original learning about the CS-US association (Bouton, 2002, 2004; Bouton et al., 2006). Moreover, they indicate that the ambiguity that surrounds the CS after extinction is resolved by reference to other
cues that are present. For instance, if a concurrent cue promotes the retrieval of the CS-US association learnt during acquisition, conditioned behaviour will result. On the other hand, if the cue promotes retrieval of the CS-noUS association learnt during extinction, the extinction of conditioned responses will persist.

Cues that are present in the context in which the CS is encountered may be particularly important in whether conditioned behaviour is observed (Bouton, 2002, 2004; Bouton et al., 2006). Contextual stimuli can be wide and varied and may include aspects of the physical environment in which conditioning and extinction takes place, the passage of time following extinction, or factors related to the organism itself during and after extinction. A useful distinction is between those contexts that are exteroceptive and those that are interoceptive (Bouton, 2002). Exteroceptive contexts are those that are external to the organism and may include sights, sounds, smells, drug paraphernalia, and billboard advertisements, to name a few. Interoceptive contexts are those that are internal to the organism and may include drug states, emotions, physiological changes, cognitions, and the passage of time (e.g., Bouton & Schwartzentruber, 1991; Bouton, Mineka, & Barlow, 2001; Bradizza, Stasiewicz, & Maisto, 1994; Collins & Brandon, 2002).

The mechanism of renewal suggests that the reduction of conditioned behaviour that occurs during extinction depends on the degree of learning that takes place about the extinction context itself. In the typical renewal effect, conditioning takes place in context A (e.g., laboratory chamber A), extinction training takes place in context B (e.g., a different laboratory chamber B), and once the conditioned behaviour has been extinguished, the CS is presented alone but this time in Context A. The return to the original conditioning context (i.e., context A) typically ‘renews’ responding to the CS (e.g., Bouton & Bolles, 1979; Bouton & King, 1983; Bouton &
Peck, 1989; Harris, Jones, Bailey & Westbrook, 2000; Rauhut, Thomas & Ayres, 2001). Although ABA renewal (i.e., conditioning in Context A, extinction in Context B, and retesting in Context A) is the most widely studied renewal procedure, renewal can also occur when retesting is conducted in a third, different context (i.e., Context C; ABC renewal) (e.g., Bouton & Bolles, 1979; Bouton & Brooks, 1993; Gunther, Denniston & Miller, 1998; Harris et al., 2000). Although not as strong as ABA renewal (Harris et al., 2000), ABC renewal highlights that the mere removal of the CS from the extinction context can cause a return of the conditioned behaviour. Both ABA and ABC renewal effects are stronger than those observed during an AAB paradigm in which conditioning and extinction occur in context A and retesting occurs in context B (see Bouton, 2002).

Overall, renewal effects are strong and robust, with the original learning that takes place during conditioning impermeable to extensive extinction training (e.g., even after as many as 160 extinction trials) (Gunther et al., 1998; Rauhut et al., 2001). Renewal has also been demonstrated in relation to a wide range of behavioural phenomena, including fear conditioning (e.g., CS associated with a shock), appetitive conditioning (e.g., CS associated with food) (e.g., Brooks & Bouton, 1994), and taste aversion conditioning (e.g., food CS associated with illness) (e.g., Rosas & Bouton, 1998) and in a variety of animal species.

**Reinstatement** refers to the return of conditioned behaviour that occurs with re-exposure to the US alone after extinction has taken place. The typical reinstatement procedure involves a conditioning session in which the CS (e.g., a light) is repeatedly paired with the US (e.g., a shock), and then extinction of the conditioned behaviour is achieved by multiple exposures to the light CS alone. In another session, the shock US is presented several times on its own, followed by a separate test session often 24
hours later or longer, in which the light CS is presented alone. During this final test phase, the conditioned behaviour that was previously extinguished is observed to recur to the light CS.

Bouton and others have shown repeatedly that reinstatement is strongest when the test trials (i.e., when the CS is represented after the US alone presentations) are given in the same context in which re-exposure to the US takes place (e.g., see Bouton, 2002 for review). For example, in fear conditioning experiments with rats, the context is typically the laboratory chamber in which re-exposure to the shock US occurs. During re-exposure to the shock US, the rat associates the shock with the re-exposure context (i.e., the laboratory chamber). This contextual conditioning or formation of a new association is what triggers reinstatement of conditioned fear responses when the light CS is subsequently presented again during the test trials. This might occur if the context-US association promotes retrieval of a CS-US association when the CS is encountered in that context.

Bouton and colleagues have also demonstrated that the extent of reinstatement depends on the strength of the subjects “knowledge” about the context formed during conditioning (e.g., Bouton, 1985; Bouton & King, 1983); the stronger the association, the greater the likelihood that reinstatement will occur. He also points out that conditioned fear associated with the original conditioning context is unlikely to potentiate a fear response to a different CS that has not been extinguished (e.g., Bouton, 1984; Bouton & King, 1983). Thus, Bouton argues that extinguished CSs are particularly vulnerable to reinstatement, possibly because their meaning has become ambiguous.

More recent research (e.g., Westbrook, Iordana, McNalley, Richardson & Harris, 2002) suggests that reinstatement can also occur due to another context-
learning effect, this time, between the CS and the context in which extinction took place. When the shock US is presented in the same context in which extinction occurred, competing associations of tone-context and shock-context are formed. These findings suggest that if a particular context has become associated with an aversive event for whatever reason, conditioned fear responses can be reinstated. Thus, whereas Bouton’s earlier work suggested that the test trials (i.e., re-exposure to the CS) must occur in the same context as where the shock US was presented for reinstatement to occur, this more recent work suggests that reinstatement can occur in any context providing that the context in which extinction took place is subsequently associated with an aversive event.

*Spontaneous Recovery* is the most well-known process to occur after extinction with observations of this behavioural phenomena dating back to the seminal work of Pavlov with laboratory dogs (e.g., Pavlov, 1927). This effect reflects that if time elapses after extinction training (e.g., the elimination of salivation by laboratory dogs to a tone CS presented repeatedly without the meat US), the extinguished salivation response can reoccur spontaneously when the tone CS is presented again some time later. Moreover, initial responding to the CS during the test trials can be as strong as that observed at the end of conditioning (e.g., Brooks & Bouton, 1993).

Although there are numerous explanations of spontaneous recovery (e.g., Davenport, Hill, Wilson, & Ogden, 1997; Robbins, 1990), Bouton (2002, 2004) proposes that as the passage of time represents a gradually changing context, extinction may be specific to the physical context in which it occurs as well as to the context of time. Thus, Bouton (2004) likened spontaneous recovery to the renewal effect that occurs when the CS is tested in a new *temporal* context. Moreover, in both
spontaneous recovery and renewal paradigms, if a retrieval cue that reminds the subject of extinction (through brief presentations of a retrieval cue during the extinction session), is presented just before the test trials, return of the conditioned behaviour is reduced (see Brooks, 2000). These results suggest that spontaneous recovery and renewal represent a failure to retrieve extinction information in contexts (whether physical or temporal) that are outside the original extinction context (Bouton, 2002).

Reacquisition refers to the pairing of the CS and the US again after extinction has taken place. Reacquisition after extinction may occur either rapidly, almost as if extinction never occurred (Napier, Macrae & Kehoe, 1992) or slowly after numerous re-pairings of the CS and US after extinction (Bouton and Schwartzentruber, 1989; Calton, Mitchell, & Schachtman, 1996; Ricker & Bouton, 1996). Bouton (2002) explains that variation in the rate of reacquisition depends on whether context cues present during the test trials lead to the retrieval of conditioning or extinction associations; the former resulting in rapid reacquisition, the latter resulting in slow reacquisition. Thus, the rate and strength of reacquired conditioned responses depends on the unique interaction of various types of contextual cues.

Our understanding of renewal, reinstatement, spontaneous recovery, and reacquisition has been built up through extensive research with non-human animal subjects. From this research, the notion of ambiguity and the important role of exteroceptive, interoceptive, and temporal contexts on mediating the return of extinguished conditioned behaviour has been established (Bouton, 2002, 2004). Given the generality of Pavlovian conditioning processes across all organisms, including humans, the investigation of renewal, reinstatement, and related phenomena in humans has the potential to increase our understanding further. Moreover, the
relevance of the various phenomena as a potential explanation for relapse following extinction-based behavioural treatments provides a practical justification for research to be conducted in the human laboratory and in the clinical treatment context.

PROCEDURES USED TO STUDY RETURN OF EXTINGUISHED CONDITIONED BEHAVIOUR IN THE HUMAN LABORATORY

Laboratory research has investigated renewal, reinstatement, and spontaneous recovery in humans using three main experimental procedures: a fear conditioning procedure, a conditioned suppression procedure, and a causal learning procedure. The distinction between these different procedures is important because they may use different types of stimuli as the CS and US, different modes of stimulus presentation, and measure conditioned responses in different ways. The different procedures also offer different levels of parallels to the methods by which conditioning is studied in the laboratory with non-human animals or in the clinic to study fears and dependencies in humans. It is essential that the various return of conditioned behaviour phenomena be examined with more than one paradigm to ensure that the results obtained are not overly specific to the particular methods in the learning paradigm used.

The fear conditioning procedure (e.g., Alvarez, Ruben, Johnson & Grillon, 2007; Dirikx, Hermans, Vansteenwegen, Baeyens & Eelen, 2007; Neumann, Lipp & Siddle, 1997; Neumann et al., 2007), sometimes also referred to as an aversive conditioning procedure (e.g., Neumann & Waters, 2006), uses an aversive and biologically salient stimulus as the US. The stimulus most commonly employed is a mild electric shock presented to the participant’s arm or hand at an intensity that is
subjectively defined by the participant as “unpleasant, but not painful”. A loud tone may also be used (LaBar & Phelps, 2005). It is common that fear conditioning procedures employ a differential conditioning protocol (Öhman et al., 2000). The differential conditioning procedure provides a within-subjects control to measure the strength of conditioning. Only the CS+ should be expected to elicit conditioned responses and a subsequent recovery of extinguished conditioned responses because this stimulus and not the CS- was associated with the aversive US.

The fear conditioning procedure provides a strong procedural parallel to fear conditioning procedures used in non-human animal experiments. This is particularly the case with the use of an electric shock US in both applications. However, the measurements of conditioned responses are different in the human studies. The skin conductance response (e.g., Neumann, Lipp, & Siddle, 1997, 2002), which reflects the activity of the eccrine sweat glands that are under the control of the sympathetic nervous system, provides a key measure of the increases in arousal that are associated with the conditioned response. In addition, potentiation of the startle blink reflex during CSs associated with an aversive stimulus (e.g., Alvarez et al., 2007) provides a second psychophysiological measure related to emotion (Lipp, Neumann, & Mason, 2001; Lipp, Neumann, Siddle, & Dall, 2001) that has been employed in research. Although the startle reflex is sensitive to attentional processes (Lipp & Neumann, 2004; Lipp, Neumann, & McHugh, 2002; Lipp, Neumann, & Pretorius, 2003; Neumann, 2002; Neumann, Lipp, & McHugh, 2004; Neumann & Lipp, 2003; Neumann, Lipp, & Pretorius, 2004) it can provide a direct measure of fear because of the involvement of the amygdala in the startle fear circuit (Angrilli et al., 1996; Hitchcock & Davis, 1986). Startle potentiation is a commonly employed measure of fear in non-human animal research and provides a promising means for cross-species
comparisons to be made. Self-reported expectancy of the US, either given on-line (e.g., Neumann et al., 2007) or after a block of trials (e.g., Hermans et al., 2005), ratings of fear (e.g., Dirikx et al., 2004), and performance on a secondary reaction time task (e.g., Dirikx et al., 2004), provide additional measures to supplement the physiological measures. While it is assumed that all these measures will show similar effects in the return of conditioned fear, dissociations among them have also been found (e.g., Hermans et al., 2005), suggesting that they may be differentially sensitive to the various psychological processes that underlie conditioned fear.

The *conditioned suppression task* differs from the fear conditioning procedure by measuring conditioned responses through a behavioural procedure. The task was originally developed with the aim of providing a procedural parallel to the measurement of conditioned suppression in non-human animal studies. In these studies, animals are first trained through operant conditioning methods to depress a lever to obtain a food or drink reward. Conditioning trials are next given in which a CS is paired with an aversive US (e.g., shock). The aversive US presentations produce the UR of suppressing the operant bar pressing. Following conditioning, presentations of the CS on its own will elicit the suppression of the bar pressing and extinction of the suppression can also be produced by presenting the CS on its own. A return of extinguished conditioned suppression has been observed in animal subjects with this procedure (Bouton, 1984; Bouton & Bolles, 1979; Johnson, Baker, & Azorlosa, 2000; Wilson, Brooks, & Bouton, 1995).

To provide a human analogue to the measurement of conditioned suppression in humans, Arcediano, Ortega, and Matute (1996) developed a task that used a game format presented on a computer. The game involves the steady presentation of “Martians” in rows across the computer screen. Participants are trained to press a
button, which in the context of the game fires a “laser gun”, at a steady rate to destroy each Martian. However, the Martians are said to have a “laser shield”. If participants fire the laser gun when the shield is activated, as indicated by the screen flashing on and off intermittently, it has the consequence of allowing a large number of Martians to appear on the screen. In the context of the game, the laser shield functions as the US and participants can learn to predict when the shield is about to occur by CSs that appear on the screen immediately before the shield. If participants withhold firing the laser gun during the CS presentations, they will avoid firing when the shield is activated and so prevent a flood of Martians appearing on the screen. The conditioned suppression during the CS thus occurs due to the anticipated punishment within the context of the task, rather than due to fear of an impending aversive US (Havermans, Keuker, Lataster & Jansen, 2005). Nevertheless, the conditioned suppression task provides a non-verbal behavioural measure of conditioning that has been applied to study renewal and reinstatement in humans (Havermans et al., 2005; Neumann, 2006, 2007).

The final task that has been used in laboratory research is a causal learning task (e.g., García-Gutiérrez & Rosas, 2003; Vila & Rosas, 2001). In this task, participants are presented with a fictitious scenario in which events or stimuli are followed by positive consequences, negative consequences, or no consequence. Participants are asked to make judgments on the likelihood that certain consequences will follow the stimuli. In one task used to investigate reinstatement, for example, participants assumed the role of a healthcare inspector to investigate a problem in which people developed a stomach ache after ingesting medicines bought at importation pharmacies (Villa & Rosas, 2001). There are good reasons to assume that the acquisition of causal judgments based on hypothetical situations and fictitious
stimuli reflects Pavlovian conditioning processes (see Dickson, 2001). The causal learning task thus has the potential to contribute to our understanding of the return of extinguished conditioned behaviour in humans.

LABORATORY RESEARCH FINDINGS ON THE RETURN OF EXTINGUISHED CONDITIONED BEHAVIOUR IN HUMANS

Laboratory research on the return of extinguished conditioned behaviour has largely focussed on renewal, reinstatement, or spontaneous recovery in humans. Few studies in the human laboratory have investigated these phenomena in combination, such as question of whether renewal and reinstatement have an additive effect (Garcia-Gutierrez & Rosas, 2003). Such research would be enlightening given the suggestion that the various phenomena have been suggested to reflect a similar underlying mechanism of the highly context-dependent nature of extinction learning (Bouton, 2002; 2004). Due to the fact that renewal, reinstatement, and spontaneous recovery have largely been examined in isolation, the review below will address each of these phenomena in turn.

Renewal

The renewal of extinguished conditioned behaviour in humans has been reliably demonstrated with a variety of conditioning procedures. ABA renewal has been observed in a causal learning task (Garcia-Gutierrez et al., 2005; Paredes-Olay & Rosas, 1999; Rosas & Callejas, 2006). ABA renewal has also been observed with the conditioned suppression task with two different context manipulations (Havermans et al., 2005; Neumann, 2006, 2007). The fear-conditioning procedure has also yielded reliable evidence of renewal in several measures of conditioned responding, including skin conductance responses (e.g., Alvarez et al., 2007; Effting & Kindt, 2007;
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Neumann & Longbottom, submitted; Vansteenwegen et al., 2005; Vervliet et al., 2005), startle blink reflexes (Alvarez et al., 2007), ratings of the expectancy of the US (e.g., Neumann et al., 2007; Neumann & Longbottom, submitted; Vansteenwegen et al., 2005), and fear-ratings of the CS (e.g., Alvarez et al., 2007). The majority of demonstrations of renewal have used within-session manipulations of context. However, renewal may also be found when testing sessions are separated by a longer period of time. Renewal of skin conductance responses has been found during a renewal test when participants were tested 24 hours after the acquisition and extinction phases (Milad, Orr, Pitman, & Rauch, 2005). The various demonstrations across the different tasks and measures indicate that a context change after extinction can result in the return of extinguished conditioned behaviour in humans.

Effects of Nature of CSs and Contexts on Renewal

In addition to the various conditioning procedures and measures that have yielded renewal in humans are the various types of CSs and contexts. Most demonstrations of renewal have used neutral CSs as stimuli, such as geometric shapes (Neumann, 2006; Neumann et al., 2007), line drawings of faces (Vansteenwegen et al., 2005), or a tone (Havermans et al., 2005). The context changes have also been varied. Changing the perceptual features of the CS from a tall and thin parallelogram to a short and thick parallelogram has produced a renewal type effect (Vervliet et al., 2005). Renewal has also been found when the background colour and the direction at which the stimuli appear on a computer screen are varied in the conditioned suppression task (Havermans et al., 2005). However, contextual stimuli in the laboratory environment is often conceptualised to be broader in scope to include the background milieu of stimuli, such as the sights, sounds, and smells present in the laboratory. Context changes that are consistent with this broader notion have also
produced renewal in humans. For instance, changing the illumination of the room from dark to light (Vansteenwegen et al., 2005) and using different coloured lights (Effting & Kindt, 2007) and combinations of colours lights and background sounds (Neumann, 2006, 2007; Neumann et al., 2007) has resulted in renewal. A particularly novel way to manipulate context is to use a virtual reality environment. Using this technology, a renewal of extinguished conditioned responses has been observed (Alvarez et al., 2007).

While research with humans has largely focussed on changes in the exteroceptive context that may accompany acquisition and extinction, context may also be conceived as broader still, by encompassing the states associated with the organism itself. The return of extinguished conditioned behaviour has been demonstrated in animal subjects by using interoceptive contexts (Bouton, 2002) such as deprivation state (e.g., Davidson, 1993), hormonal state (e.g., Ahlers & Richardson, 1985), and drug state (e.g., Bouton, Kenney & Rosengard, 1990; Cunningham, 1979). Drug state associated with caffeine ingestion has been reported to function as a contextual cue that can produce the renewal of spider fear in a clinical fear-reduction procedure (Mystkowski, Mineka, Vernon, & Zinbarg, 2003). However, the effects of interoceptive contexts in producing renewal in the human laboratory remains to be explored. Related research has shown that mood state can influence memory in human participants (Eich, 1995). Taking the findings together, it would be expected that changes in interoceptive contexts would produce renewal effects in human laboratory studies of conditioning.

As noted earlier, research on renewal in humans has tended to use CSs and contexts that are neutral in nature (e.g., geometric shapes and different coloured lights, respectively). In a departure from this methodology, Neumann and
Longbottom (submitted) compared fear-relevant and fear-irrelevant CSs presented as images upon natural or artificial contexts in a fear conditioning procedure with an ABA renewal design. Fear-relevant stimuli are those stimuli that show a bias to be associated with an aversive outcome and include predatory and poisonous animals (Öhman & Mineka, 2001). Such stimuli may have been more likely to have endangered our ancestors and may explain why phobias to threatening organisms, such as spiders and snakes, are more common than are phobias to modern stimuli, such as cars and electrical outlets (Hugdahl & Johnsen, 1989). In their first experiment, a renewal of skin conductance responses and expectancy of the US was found when images of spiders and snakes were used as the CSs. Renewal was also found in a group that received flowers and mushrooms, which are examples of fear-irrelevant stimuli, as the CSs. The results showed that a renewal effect can be found for fear-relevant stimuli in an experimental procedure that also produces renewal with neutral fear-irrelevant stimuli.

A second important empirical question is whether the magnitude of the renewal effect differs between fear-relevant and fear-irrelevant CSs. Fear-relevant stimuli have previously shown resistance to extinction, that is, a slower rate of extinction of conditioned fear than fear-irrelevant stimuli (Fredrikson, Hugdahl, & Öhman, 1976; Hugdahl, Fredrikson, & Öhman, 1977; Öhman, Fredrikson, Hugdahl, & Rimmo, 1976). Although fear-relevant stimuli will extinguish provided that a sufficient number of extinction trials are given, the different rates of extinction imply that there may be different processes that underlie extinction in fear-relevant and fear-irrelevant stimuli and that these may influence the amount of renewal observed. In their second experiment, Neumann and Longbottom (submitted) did find a difference in the size of renewal between fear-relevant and fear-irrelevant stimuli. Intriguingly,
this difference depended on the nature of the context that was used in the different phases of the renewal procedure. Renewal was larger for fear-relevant stimuli when acquisition used an indoor office context, extinction an outdoor bush context, and test used an indoor office context. In contrast, renewal was larger for fear-irrelevant stimuli when acquisition used an outdoor bush context, extinction an indoor office context, and test used an outdoor bush context.

The results from Neumann and Longbottom’s (submitted) study do not appear to support the idea that there is an overall effect of larger or smaller renewal with fear-relevant stimuli compared to fear-irrelevant stimuli. Instead, the authors suggested that the results reflect the degree to which the participant’s expectancies were violated during the different phases of the experiment. For instance, fear-relevant stimuli presented in an outdoor bush context may represent a congruent context. An outdoor bush context may be one in which people would be more likely to encounter fear-relevant stimuli and for such encounters to be associated with a negative outcome (e.g., “snakes in the grass”). However, this expectation was violated in participants that received extinction training with fear-relevant stimuli in the outdoor bush context. This may have resulted in an ambiguity surrounding the fear-relevant stimuli and increased attention to contextual cues that accompanied the CS presentation. The increased salience of the contextual cues resulted in a larger renewal effect during the test phase when the fear-relevant CS was presented in an indoor office context. In contrast, acquisition trials of fear-relevant stimuli in an outdoor bush context and extinction trials in an indoor office context may have made “sense” to participants and produced less of a violation of expectancies and by consequence less attention to contextual cues during extinction. This produced a relatively smaller renewal effect in the test phase. While this explanation is speculative and requires
further investigation, their results do highlight that a complex interaction may occur
between the nature of the CS and context in producing the renewal effect. Moreover,
the renewal effect may also be influenced by the participants pre-existing biases or
expectations in relation to the stimuli that are used.

*Effects of instructions on renewal*

One way in which the participant’s expectations can be manipulated directly is
through explicit instructions regarding the contextual changes that are experienced
during the renewal procedure. Using a conditioned suppression task within an ABA
renewal design, Neumann (2007) gave participants instructions that aimed to devalue
the role of the context in the different phases of the experiment. Based on the notion
that the renewal effect reflects the context-specific nature of learning, particularly that
of extinction learning, it was hypothesised that using instructions that devalued the
role of contextual cues would attenuate renewal. However, instructing participants
prior to experiment that any changes in the meaning of the CS (i.e., whether it predicts
the US or not) are not related to changes in the context had no effect on renewal. In
addition, instructing participants in between the extinction and test phases that any
changes in the context they may have experienced are unrelated to whether the CS
predicts the US or not also did not attenuate renewal. The latter result also did not
appear to depend on whether a differential conditioning or a single cue conditioning
design was used. It could not also be attributed to the suggestion that participants did
not remember or believe in the instructions that they were given. The apparent
ineffectiveness of the instructions may be related to other factors yet to be determined.

Nevertheless, the results reported by Neumann (2007) suggest that contextual
cues are not easily ignored in a renewal procedure. This may be because after
extinction, the CS has become ambiguous and the only means by which to resolve the
ambiguity is by reference to contextual cues. If there are no other means by which to resolve the ambiguity (e.g., alternative retrieval cues), renewal will result. Alternatively, the results may suggest that non-cognitive processes may influence renewal in humans. Such a non-cognitive explanation may be particularly relevant to the conditioned suppression task given that the CS duration is short (1 – 3 s) and the participants attention is partly distracted by the need to maintain a steady rate of responding in order to destroy the Martians that appear at a rapid rate on the screen. The instructions may be ineffective in such a situation, suggesting that replication of this result to another conditioning procedure is required.

Comparisons among the various renewal designs

According to Bouton’s (Bouton, 1993, 2002, 2004) explanation of renewal, it is the highly context specific nature of extinction learning that is the major factor in producing renewal. Whenever the CS is encountered outside of the extinction context, renewal can occur. This idea provides a parsimonious explanation for the observation of renewal in the various ABA, ABC, and AAB procedures. All these procedures are common in that test trials are conducted outside of the extinction context. Based on these observations, it would be expected that given ABA renewal has been reliably observed in human research, ABC and AAB renewal should also be found. However, using a conditioned suppression task that reliably produced ABA renewal, no evidence for ABC (Havermans et al., 2005; Neumann, 2006) or AAB renewal (Neumann, 2004) has been found. In addition, no evidence for ABC renewal was found in US expectancy ratings or skin conductance responses in a fear conditioning procedure (Effting & Kindt, 2007). The finding of ABA renewal, but not ABC or AAB renewal, suggests that that it is acquisition learning that is context specific such that only a return to the original learning context will renew conditioned responding
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(Havermans et al., 2005; Effting & Kindt, 2007). Furthermore, a configural
CS+context stimulus may become associated with the US during acquisition and the
loss of responding observed during extinction reflects a generalisation decrement
(Havermans et al., 2005). The suggestion of the context specific nature of acquisition
may be seen as being at variance with the proposition that it is extinction learning that
is context specific.

The difficulty of finding evidence for ABC renewal to date may not be
surprising for two reasons. First, smaller ABC renewal than ABA renewal has been
reported in research with non-human animals (Harris et al., 2000). If renewal in an
ABC design is difficult to detect, stronger contextual manipulations or more sensitive
measures of conditioned behaviour may be required to observe renewal in humans.
Second, in the differential conditioning procedures that have been used to investigate
ABC renewal (Effting & Kindt, 2007; Neumann, 2006) a consistent finding has
emerged in that during the test phase an increase in conditioned responses during the
CS+ has been observed relative to the level of conditioned responding on the last
extinction trial. One might be tempted to take this finding as evidence of ABC
renewal. However, an increase in conditioned responses was also found for the CS-
on the first test trial relative to the last extinction trial. As a result, conditioned
responses to the CS+ has not been significantly higher than during the CS- during test,
although both have increased relative to that present at the end of extinction. The
ABC renewal design thus appears to produce a non-specific renewal of conditioned
responses to any CS that is presented during the test phase. Whether the increase can
also be found for a novel CS or if it is specific only to the CS+ and CS- for the test
phase will require further experimental research. Nevertheless, the ABC renewal
design may produce some non-specific renewal of conditioned responses in the test
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The apparent renewal of conditioned responses to the CS- during the test phase in an ABC design may be an example of a more general phenomenon when context switches are made with a differential conditioning procedure. A similar, though smaller, increase in responses to the CS- has also been found on the first extinction trial after a change from the acquisition context (Effting & Kindt, 2007; Neumann, 2006, 2007; Neumann & Longbottom, submitted) and on the first test trial in an ABA renewal design (Effting & Kindt, 2007; Neumann, 2006; Neumann & Longbottom, submitted). Basic associative learning models of conditioning would not expect an increase in conditioned responding to the CS- to occur because this stimulus had not been associated with the US during any phase of the experiment and as such its associative strength should not change. One explanation could be that it reflects the effects of US omission (Neumann, 2006). If the first trial of extinction or test is a CS+ trial, participants may expect that the US will follow. However, as no US is presented during extinction or test the US omission may change the participant’s expectations with regards to the CS-. For instance, if the participant has adopted a rule that “one CS is followed by the US”, the participant may expect that the CS- will now be followed by the US after the presentation of the CS+ alone. Consistent with this interpretation, participants that receive the CS+ first in the test phase show a greater increase in conditioned responding to the CS- when it is presented on the second trial than participants that receive the CS- presentation on the first test trial (Neumann, 2006). An alternative explanation could be that it reflects a generalisation decrement due to participants forming a configural CS-context stimulus during each phase. Removal from the acquisition context results in a new CS-context combination that produces an increase in responding to the CS- up to a level similar to that observed at
the start of acquisition. Likewise, removal from the acquisition context results in a new CS-context combination in the ABC design to again increase responding to the CS-up to a similar level as that observed at the start of the other phases of the experiment.

Enhancing renewal

Due to the apparent difficulty in unequivocally demonstrating ABC renewal in humans, it is worthwhile to consider what experimental manipulations might enhance the renewal effect in either an ABA, ABC, or even an AAB design. Although there are no published parametric studies in humans, it is likely that using contexts that have sharp differences in the components of the context will produce stronger renewal than using contexts that are more similar. In addition to the components of the context, the overall number of shared or dissimilar contextual cues might also impact on renewal (Thomas, Larsen, & Ayres, 2003). In a test of ABA renewal using a variation of the conditioned suppression task, Havermans et al. (2005) found that using a change in the background colour of the screen in which the stimuli were presented between blue and red showed a modest, although non-significant renewal of conditioned suppression. In a subsequent experiment, using a combination of changes in the background colour of the screen and changes in the colour of the Martian stimuli produced a stronger and statistically significant renewal of suppression. The results are thus consistent with the notion that the size of renewal is dependent on the extent to which the extinction and text context are perceptually different.

If renewal reflects the retrieval of the CS-US association, it might be expected that experimental manipulations that encourage this retrieval will serve to enhance renewal. Indeed, participants that are presented with a retrieval cue during the test phase showed stronger renewal of skin conductance responses and expectancy ratings
if the cue was also presented during acquisition than if the cue was also presented
during extinction (Vansteenwegen, Vervliet, Hermans, Beckers, Baeyens, & Eelen,
2006). Although the design this study cannot determine whether it was necessarily the
presence of the cue during acquisition or extinction that was the major contributor to
the difference in the renewal effects, the results are consistent with the idea that
retrieval cues can modulate the renewal effect. Subsequent research might more
directly examine the presence or absence of retrieval cues during the acquisition and
test phases of a renewal procedure.

Attenuating renewal

While the majority of research with human participants has been concerned
with producing the renewal effect, the question of how to prevent renewal is an
important one for theoretical and practical reasons. Experimental procedures that
serve to attenuate renewal can be suggestive of the psychological processes that
underlie the effect. For instance, the relative ineffectiveness of instructions that
devalue the role of contextual cues to attenuate renewal during a conditioned
suppression task noted earlier (Neumann, 2007) suggests that non-cognitive processes
may play a role in renewal, at least in certain situations. Instructions might also be
employed in other ways in an attempt to reduce renewal. For example, instructions
might be used to draw attention away from the contextual cues that are present or to
increase the transfer of learning from extinction to test.

An alternative approach to reducing renewal is to increase the generalisation
of extinction to contexts outside of that experienced during extinction training. One
way in which this might be done is to present extinction trials across a number of
different contexts. This might increase the chance that similar contextual cues are
shared among the test and extinction contexts. Findings from non-human animal
research have shown that presenting extinction across multiple contexts can attenuate renewal in an ABA design (Chelonis, Calton, Hart & Schactman, 1999) and an ABC design (Gunther et al., 1998). Consistent with these findings, presenting extinction trials across three different contexts abolished the renewal of conditioned suppression in an ABA design (Neumann, 2006). The use of three extinction contexts also attenuated the increase in conditioned suppression to the CS+ and CS- during test in an ABC design (Neumann, 2006). Taken together, the results are consistent with the animal studies of Chelonis et al. (1999) and Gunther et al. (1998) in suggesting that the use of multiple extinction contexts will abolish the renewal effect.

In contrast to the above studies, two recent reports suggest that the use of multiple extinction contexts does not necessarily attenuate renewal. Bouton, García-Gutiérreza, Zilskia, and Moody (2006) was unable to replicate the attenuation of renewal in a fear conditioning procedure with rats. In line with these findings, Neumann et al. (2007) also did not find strong evidence for an attenuation of ABA renewal when extinction trials were given across three or five contexts in a fear conditioning procedure with humans. The different results among the studies may reflect that one or more variables will mediate whether or not multiple extinction contexts attenuates renewal. The exact nature of the contextual cues that are present may be one important factor. For instance, renewal is larger when extinction and test differ on a larger number of distinct contextual cues (Thomas et al., 2003). Conversely, the greater the similarity in the cues between the extinction contexts and a subsequent test phase, the greater will be the attenuation of renewal. Although both the studies by Neumann (2006) and Neumann et al. (2007) used a combination of a coloured light and sound as the context, the two studies differed in exactly what combinations were used. A future parametric study may be required that
systematically manipulates the number and/or type of contexts used in the different phases of the experiment. For instance, using multiple extinction contexts of a blue light plus and bell sound and a red light plus a drum sound would produce a smaller renewal effect if test is conducted in a context that used a combination of these features, such as a blue light plus drum sound, than if test was conducted in a completely novel context, such as a yellow light plus cymbal sound (Neumann et al., 2007).

Reinstatement

Reinstatement in humans has been demonstrated with a causal learning task (García-Gutiérrez & Rosas, 2003; Vila & Rosas, 2001), a fear conditioning task (Dirikx et al., 2004; Dirikx et al., 2007; Hermans et al., 2005; La Bar & Phelps, 2005; Van Damme, Crombez, Hermans, Koster, & Eccleston, 2006), and a conditioned suppression task (Neumann, in press). In the conditioned suppression task, six presentations of the laser shield US on its own were made after extinction training. The unwarned US presentations had the effect of increasing conditioned suppression to the CS+ and no effect on the CS-. A control group that did not receive the US presentations after extinction, but received a similar time delay prior to the test trials, did not show any change in responding during the CS+ and CS- (Neumann, in press).

Research conducted by Hermans, Dirikx and colleagues (Dirikx, Hermans, Vanstevenegen, Baeyens, & Eelen, 2004; Dirikx, Hermans, Vanstevenegen, Baeyens, & Eelen, 2007; Hermans, Dirikx, Vanstevenegen, Baeyens, Van den Bergh, & Eelen, 2005; Van Damme, Crombez, Hermans, Koster, & Eccleston, 2006) has investigated reinstatement in a fear conditioning procedure. Across the series of the experiments, the presence of a reinstatement effect has been tested with a variety of measures of conditioned behaviour. For example, one experiment employed a
spatial cueing paradigm (Van Damme et al., 2006). The reaction times during the paradigm were suggested to reflect attentional biases that can accompany conditioned fear. Consistent with a reinstatement effect, attentional biases were greater when the cueing task involved CS+ presentations than when it involved CS- presentations following a reinstatement procedure. The two earlier experiments, reported by Dirikx et al. (2004) and Hermans et al. (2005), measured conditioned responses with US expectancy ratings, subjective fear ratings, and secondary task reaction time to auditory probes presented during the visual CSs. The most consistent evidence for reinstatement was observed for fear ratings. Fear ratings of the CS+ increased from extinction to the reinstatement test trial when unwarned presentations of the US were given after extinction. In addition, rated fear during test was higher for the CS+ than for the CS-. Ratings of US expectancy showed a similar pattern as the fear ratings during test trials (i.e., higher expectancy of US for CS+ than CS-) in one experiment (Hermans et al., 2005), but not in the other experiment (Dirikx et al., 2004). Likewise, evidence of reinstatement in secondary task reaction time (i.e., slower reaction time during CS+ than during CS- during test trials) was found in one experiment (Dirikx et al., 2004), but not in the other experiment (Hermans et al., 2005).

The experiments reported by Dirikx and colleagues (Dirikx et al., 2004, 2007; Hermans et al., 2005) also examined the relationship between the measures of conditioned responding and subjective ratings of the affective meaning of the CS+ taken immediately after extinction. Valence was measured on a rating scale with the anchors of very unpleasant and very pleasant. Results showed that more negative valence ratings of the CS+ was associated with higher reinstatement in fear ratings (Hermans et al., 2005), and secondary reaction time slowing (Dirikx et al., 2004, 2007) during test. No association was found between valence ratings and ratings of
the expectancy of the US in two studies (Dirikx et al., 2007; Hermans et al., 2005). The associations between the measures indicate that the amount of reinstatement found in some measures of conditioned responding is related to the evaluated valence of the CSs immediately after extinction (Dirikx et al., 2004).

In one of the first demonstrations of reinstatement in humans, a causal learning task was used that required participants to assume the role of a healthcare inspector that was investigating stomach aches in people who ingested medicines bought at importation pharmacies (Villa & Rosas, 2001). Ingestion of one medicine brand (CS+) was followed by a stomach ache (US) and ingestion of another medicine brand (CS-) had no consequence. In extinction, ingestion of both medicines were presented without any consequence. At the end of extinction, participants rated the probability that the illness followed either the CS+ or CS- as low. However, after extinction some participants were presented with trials in which the illness occurred when people merely visited a pharmacy. This phase thus represented a reinstatement procedure as the US (stomach ache) was presented on its own. After this phase, participants in both groups judged the probability that the stomach ache would follow ingestion of the CS+ medicine as higher than participants who did not receive a reinstatement phase of US only presentations, consistent with a reinstatement effect. A reinstatement effect has also been found in a causal learning task that used a different scenario in which eating different foods were followed by illness (García-Gutiérrez and Rosas, 2003)

Context changes and reinstatement

Animal research has suggested that reinstatement is dependent on the context in which the unwarned US presentations are made. For example, reinstatement has been found when exposure to the US alone is given in the same context as a
subsequent test phase, but not when exposure is given outside of the test context or when the test context only is presented before test (e.g., Bouton & King, 1986). Reinstatement also occurs when exposure to the US and the subsequent test phase is in a different context to that used during acquisition and extinction (Westbrook et al., 2002). These findings are consistent with the notion that reinstatement represents another instance of context dependent learning (Bouton, 1993; 2002; 2004). Presentations of the US after extinction will result in the organism associating it with the context and this promotes subsequent retrieval of the US when presentations of the CS are given in the same context. Extinction may result in the CS being under a contextually modulated form of inhibition (Bouton, 1993) such that the presence of the extinction context will promote the retrieval of a CS-noUS association. As research on renewal has suggested that ABC renewal has been difficult to demonstrate in humans, and by implication questioning the notion that it is merely the context specific nature of extinction learning that is of importance, the question of whether reinstatement shows context specificity in humans is of theoretical importance.

The results from a series of experiments employing a fear conditioning procedure appear to be consistent with context specific nature of reinstatement (LaBar & Phelps, 2005). In the first experiment, a single cue conditioning procedure was used in which a CS was paired with a loud noise US. Participants received four reinstating US presentations in either the same or a different experimental room to that in which the preceding acquisition and extinction phases were given. Test was always conducted in the same context as acquisition and extinction. Participants that received the reinstating US presentations in the same context as the subsequent test phase showed larger skin conductance responses to the CS during test relative to the last extinction trial. In contrast, participants that received the reinstating US presentations
in a different context did not show a return of conditioned responses. These results were replicated in a subsequent study that used a differential conditioning procedure and an electric shock as the US. Moreover, a final experiment failed to find any reinstatement in two amnesic patients despite these patients showing a reliable acquisition of fear. Taken together, these results support the notion that reinstatement is context dependent and may reflect context conditioning during the US exposure phases.

A similar conclusion was reached in earlier studies that used a causal learning task to investigate reinstatement (García-Gutiérrez & Rosas, 2003). In these studies, a causal learning task that was based on the scenario that people received illnesses after eating certain foods at a particular location. Thus, the CSs were ingestion of foods (e.g., garlic), the USs were gastric illnesses (e.g., diarrhea, constipation), and the contexts were names of restaurants (e.g., “The Swiss Cow”) or eating locations (“going on a picnic”). After an acquisition phase, a retroactive interference phase was introduced in which one food that was followed by one outcome (e.g., diarrhea) in acquisition, was followed by a different outcome in the retroactive interference phase. In the reinstatement phase, the contexts (eating locations) were presented with the outcomes. Using these methods, reinstatement was also observed and it was shown to be influenced by contextual changes. For instance, no reinstatement was observed when presentations of the outcome only were made in a different context to that in which the test trials were presented in.

However, not all results have been consistent with the view that reinstatement is specific to the context in which US exposure takes place. A casual learning task in which participants were required to rate the probability that illnesses followed the ingestion of certain medicines showed that reinstatement was larger when the US
outcome (illness) was presented in either the same context (the name of the pharmacy at which the medications were purchased) as the subsequent test phase than when the outcome was presented in a different context (Vila & Rosas, 2001). However, a significant reinstatement effect was still present in those participants that received different contexts for the US outcome and test phases. In the only study to investigate reinstatement with the conditioned suppression task, a reliable reinstatement effect was found when the US outcome (presentation of the laser shield) was given after extinction (Neumann, in press). Moreover, the reinstatement of conditioned suppression persisted even when the US presentations were made in a different context to the subsequent test phase. An additional experiment indicated that this persistence of a reinstatement effect did not depend on the differential exposure to the test context across the different groups.

The contradictory findings that have emerged in some studies on the context dependency of reinstatement places doubt on the notion that extinction learning is context dependent in humans. One possible explanation for the discrepancies may be that the contextual changes that were used in some studies were not salient or distinct enough to produce a strong context dependency effect. Vila and Rosas (2001) raised this possibility in their causal learning experiment by suggesting that the contexts they used may have been considered to be similar by the participants and that this promoted generalization of judgments between contexts. The designation of the pharmacy names as either “Yellow Pharmacy” or “Red Pharmacy” appears to be consistent with this explanation. Distinctive names were employed in the studies by García-Gutiérrez and Rosas (2003) that did find context dependent reinstatement effects. A similar explanation, however, does not seem to apply to the results of the conditioned suppression task by Neumann (in press). The context manipulations used
in this study were illuminating the experimental room with different coloured lights and playing different background sounds. These context manipulations have been shown to produce reliable renewal effects in prior research (Neumann, 2006; Neumann et al., 2007). Instead, the conditioned suppression task may contain unique features that tend to promote the transfer of learning across different contexts. For instance, the procession of experimental phases without any interruption from the experimenter, the short presentations of the CS, and the continuous nature of the task in which the stimuli appear at a steady rate across the entire experimental session, are all present in the conditioned suppression task and may make the contextual presentations during the US exposure and test phases less salient.

An alternative explanation for the discrepant findings could be that there are additional processes that mediate reinstatement in humans. The different processes may either complement each other or may be either present or absent in a given situation. Garcia-Gutierrez and Rosas (2003) tested the parsimonious explanation that reinstatement results from confusion on the part of the participants that is caused by the presentation of the US after extinction. However, the investigators ruled out this possibility by showing that reinstatement and renewal had an additive effect after extinction. Such an additive effect would not be expected if either or both the reinstatement and renewal procedures produced confusion in the participants.

Other associative learning explanations for reinstatement have been suggested. For instance, Rescorla and Heth (1975) initially proposed that reinstatement reflected the US representation weakens during extinction and that this weakening is counteracted by the presentation of the US before test. Such a process does not depend on the context in which the US is presented and may promote reinstatement across contexts and account for the results of Vila and Rosas (2001) and Neumann (in
press). This explanation may be particularly applicable to the conditioned suppression task used by Neumann (in press). Research on the renewal effect with this task has yielded results suggesting that participants may develop a configural context-CS stimulus and that this is associated with the US during acquisition (Havermans et al., 2005). The reinstating presentations of the US may have had the effect of promoting retrieval of the CS-US association during the test phase, particularly because the test phase was conducted in the same context as that used during acquisition (Neumann, in press).

**Spontaneous Recovery**

Spontaneous recovery has long been known as a mechanism for the return of extinguished conditioned responses (e.g., Pavlov, 1927) and has been observed in a wide variety of animal conditioning studies (see Rescorla, 2004 for a review). However, its examination in laboratory-based research using human participants has been surprisingly limited. This may reflect that there was one very early and apparently clear demonstration of spontaneous recovery of the galvanic skin response in a human fear conditioning procedure (Ellson, 1939; see also Hovland, 1937). In this study, spontaneous recovery was tested after intervals of 5 min, 20 min, 60 min, and 180 min. A trend emerged across time with greater spontaneous recovery of the galvanic skin response with longer delay intervals. The trend was curvilinear, reflecting that the increase in spontaneous recovery from one time interval to the next became progressively smaller as the time interval was increased. The curvilinear pattern replicated that found in comparable non-human animal research (e.g., Ellson, 1938) to suggest similar interval effects across species. Although there has been little further research on spontaneous recovery in a human fear conditioning procedure since this initial study (but see Beeman & Grant, 1961; and Franks, 1963 for studies
that used human eyelid conditioning), there is at least one report showing that spontaneous recovery of extinguished fear can be observed using modern laboratory materials and procedures (Guastella, Lovibond, Dadds, Mitchell & Richardson, 2007). Spontaneous recovery has also been observed in research that has used the causal learning task (Vila & Rosas, 2001; Vila, Romero, & Rosas, 2002). The research which has demonstrated spontaneous recovery suggests that this phenomenon is a reliable effect in human participants. Further research should be encouraged in order to better understand the mechanisms that underlie it and those variables that influence its magnitude in humans.

Summary and conclusion of human laboratory studies

It has been evident from the explosion of research on renewal and reinstatement in recent times that considerable progress is being made in understanding these phenomena in humans. Additional research efforts to examine spontaneous recovery and even reacquisition will help to maintain some degree of balance between the four phenomena that can produce a return of conditioned behaviour in the laboratory. The several demonstrations of renewal and reinstatement that have been reported show that they are reliable effects and can be observed with a variety of CSs, contexts, and learning paradigms. Now that the basic methodologies in producing the effects have been established, the time appears right to further our knowledge in a systematic manner. Some fundamental parametric studies appear to be needed in order to understand what exteroceptive and interoceptive contextual cues can produce powerful renewal effects. The extent to which many prior findings from non-human animal research apply to humans remains to be determined. There is also a need to elaborate on the theoretical basis of the return of extinguished conditioned behaviour in humans. The well developed theoretical models that have been based on
non-human animal research can be applied and tested in human studies. Moreover, research can investigate the role of those “human” aspects of learning, such as cognitive processes in the recovery from extinction. Finally, the means by which renewal, reinstatement, and spontaneous recovery can be prevented needs further investigation. While it may be unreasonable to expect that a total abolishment of these effects can be achieved, their attenuation would provide significant practical applications to the return of extinguished conditioned behaviour in clinical psychology.

APPLICATIONS OF THE RETURN OF EXTINGUISHED CONDITIONED BEHAVIOUR IN CLINICAL PSYCHOLOGY

One key reason for ongoing interest in the return of extinguished conditioned behaviour is its implications within clinical psychology. Behavioural models of psychopathology have previously used conditioning research to help explain the etiology and maintenance of symptoms in conditions such as specific phobia (Davey, 2002; Rachman, 1991), post-traumatic stress disorder (Pitman, Shalev & Orr, 2000), and depression (Lewinsohn, 1974), among others. Behavioural and cognitive-behavioural treatments of many clinical conditions involve exposure tasks, which have been proposed to exert their clinical effect (at least in part) through extinction processes (e.g., Tryon, 2005; Waters, McDonald, & Koresco, 1972; Emmelkamp, 1994). Despite successful treatment, relapse is a frequent observation in clinical practice (e.g., Yonkers, Bruce, Dyck, & Keller, 2003). One potential explanation that has been offered for such relapse is the return of extinguished conditioned responses through mechanisms such as renewal, reinstatement, and spontaneous recovery. Research conducted on anxiety disorders has tended to support this interpretation.
Moreover, other research that has examined substance dependence highlights the generality of the return of conditioned responses in the clinic.

*Anxiety Disorders*

Anxiety disorders are prevalent psychological conditions which can result in significant impairment of functioning (e.g., Kroenke, Spitzer, Williams, Monahan & Rowe, 2007) and quality of life (Lochner, Mogotski, du Toit, Kaminer, Niehaus & Stein, 2003; Olatunji, Cisler & Tolin, 2007; Rapaport, Clary, Fayyad, & Endicott, 2005). Previous research has supported behavioural and cognitive behavioural therapies as the treatments of choice (Barlow, Raffa & Cohen, 2002; Franklin & Foa, 2002) and as the most cost-effective interventions (e.g., RANZCP Clinical Practice Guidelines Team for Panic Disorder and Agoraphobia, 2003) for these conditions. Exposure treatments have been conceptualised as the repeated presentations of a CS in the absence of the US and underlies the incorporation of behavioural concepts into the understanding of these interventions as important.

Despite effective treatments, evidence has consistently emerged since the late 1960s that there are a proportion of individuals who experience a recurrence in anxiety symptoms following treatment (e.g., Rachman, 1966). Such recurrence in fear responses after successful treatment is a phenomenon often referred to as the return of fear (ROF; Rachman, 1979; 1989). The ROF is reported in as many as 33-50% of successfully treated individuals (Craske & Rachman 1987; Rachman, 1966; Rose & McGlynn, 1997). The typical clinical observation of ROF is the successful reduction in fear through exposure-based treatment, followed by a period in which the individual does not come into contact with their formerly feared object or situation. After such a hiatus, re-exposure to the feared stimulus results in the individual showing subjective experience and objective measures that indicate that the fear has
grown from its immediate post-treatment levels. Such ROF does not usually lead to a fear response at the same strength as pre-treatment, but nevertheless can present a significant clinical problem for patient and therapist (Rachman, 1989). It is also possible that small lapses may recur with increasing strength to result in a full-blown relapse. The phenomena of renewal, reinstatement, and spontaneous recovery provide a organisational framework with which to understand the ROF and in turn, may suggest means by which to attenuate the ROF following treatment.

Renewal as Return of Fear

In renewal of fear responses, differences in the context for which the original acquisition, extinction, and follow-up testing occur are thought to influence the degree of ROF observed. Support for this notion has been obtained in research that used spider-fearful individuals. Mineka, Mystkowski, Hladek, and Rodriguez (1999) required spider-fearful participant to undergo a two-hour exposure/modelling session in which their fear was reduced. Treatment-responders were followed up after one week, with a reassessment that included a self-report questionnaire of spider phobia symptoms and subjective fear ratings during a behavioural approach test. Half the participants conducted their reassessment in the same location as their treatment procedure, while the other half was placed in a novel location. For the group retested in a different context, the authors reported a moderate renewal of fear relative to that observed in the control group. Similar results were reported by Rodriguez, Craske, Mineka, & Hladek (1999) also using spider-fearful individuals retested after a two-week period. In this study, the presence/absence of a particular therapist and salient visual cues within the test rooms were manipulated in addition to the setting itself. Although self-reported fear did not show renewal in a different context, other measures such as heart-rate and behavioural avoidance provided support for the
context of ROF through renewal.

Contextual variables which influence ROF via renewal may also be occur
through manipulations of the interoceptive contexts. In a counterbalanced design,
Mystkowski et al. (2003) administered either caffeine or a placebo solution to
individuals undergoing an extinction process for spider fear responses. At follow-up,
half the participants received the same solution, while the other half received the
placebo. For those participants who conducted their reassessment in a different state
as the extinction procedure, there was significant renewal of fear at the closest
approach to the spider stimulus. The implications of these results are relevant for
therapeutic approaches that combine medications with exposure treatment. The ROF
via renewal may remain as a potential danger if the individual discontinues their
medications after exposure treatment has concluded. At the very least, the exposure
treatment should be continued well beyond the cessation of all medications.

It is noteworthy that one recent study has failed to find the renewal effect after
a three month period in participants whose spider phobia had been extinguished
(Vansteenwegen, Vervliet, Hermans, Thewissen, and Eelen, 2007). At the three
month follow-up, those tested in a different room and building to the one in which
their exposure treatment was conducted showed no greater return of fear than those
assessed in the same location, despite assessment including self-report, behavioural
and physiological measures. Interestingly, at one-year follow-up, those tested in a
different location showed significantly less ROF on their self-report measure of spider
anxiety. The authors suggested that this reduction in the ROF as reflecting that the
participants were exposed to multiple contexts prior to the one-year follow-up testing
session. This exposure may have increased the generalisation of extinction learning to
the follow-up testing session. Although requiring further direct experimental support,
this interpretation suggests that there are means by which the ROF via a renewal effect may be attenuated.

A direct attempt to attenuate the renewal of fear was reported by Mystkowski, Craske, Echiverri, and Labus (2006). Spider-fearful participants underwent exposure treatment to extinguish their fear responses. The treatment session was given in a distinctive room. During a subsequent renewal test phase, half of those re-tested were asked to mentally reinstate the conditions of the treatment room, while the other half were asked to think of events from an unrelated time. Those participants who used the mental reinstatement of the treatment context showed significantly less renewal of fear than those participants who did not. The results are encouraging in suggesting that there may be cognitive strategies that could be used by individuals post-treatment in order to reduce the ROF through a renewal effect.

Reinstatement as Return of Fear

There has been comparatively little research on the reinstatement of anxiety and fear in a clinical context. Perhaps one reason for this is that it is difficult to test for reinstatement effects in an ethical and experimentally controlled manner. By definition, reinstatement results from the re-experiencing of the UR of fear following successful exposure treatment. As such, it can be difficult to experimentally induce such a fear reaction in patients. An early study using snake and spider phobic individuals explored one means by which a fear response may be induced (Rachman & Whittal, 1989a). Fear responses were assessed using heart rate and subjective report of fear. After successful extinction of their fear response, participants were asked to return two weeks later for a reassessment. When participants returned for their retest session, half were presented with an electric shock to their forearm during their behavioural approach test, while the other half did not receive such a shock, acting as
a control group. In this study, despite the increase in anxiety and nervousness reported by the participants in the shock group, there was no significant difference in subjective fear rating or heart rate between the experimental and control conditions. The authors attributed the absence of a significant reinstatement of fear to the weakness of their aversive shock event. Evidence supporting this conclusion was the fact that the shock did not significantly elevate heart rate in the experimental group. As such, the shock may have been insufficiently aversive to elicit a reinstatement effect. Notwithstanding these methodological concerns, results from human laboratory investigations (e.g., Dirikx et al., 2004, 2007; Hermans et al., 2005; Neumann, in press) suggest that reinstatement in humans can be observed. Further tests for reinstatement in a clinical context might use more intense or alternative means by which to induce fear, such as a higher intensity shock stimulus or a threat of shock condition. Alternatively, reinstatement of fear might be tested in a naturalistic design that correlates the experience of fear or major periods of illness or anxiety in patients following exposure therapy.

Spontaneous Recovery as Return of Fear

ROF can occur in successfully treated individuals, despite no clear evidence that they have been re-exposed to pairings of the feared stimulus and an aversive event. In such cases, the spontaneous recovery may provide a viable explanation for the return of fear. Spontaneous recovery of fear was documented by Rachman in a seminal paper in 1979 and it has been observed in clinical and research settings in numerous studies since. Spontaneous recovery of fear responses has been documented to occur after both short-term and long-term time delays. Philips (1985) treated a small group of patients with emetophobia (fear of vomiting) and found that just under half of patients showed significant spontaneous recovery of their anxiety responses,
necessitating an extended number of exposure sessions for therapy to be successful. Comparable findings have been reported in claustrophobia (Wood & McGlynn, 2000), and phobias of spiders (e.g., de Jong, van den Hout, & Merckelbach, 1995) and snakes (e.g., Rose & McGlynn, 1997).

Factors Influencing Return of Fear

Factors that influence the development of ROF have been divided into (a) training factors and variables during the exposure process, (b) post-training factors that occur after the successful extinguishing of the fear response, and (c) state-related factors of the individual (Rachman, 1989). In terms of training factors, variables such as the level of difficulty (“demand”; Grey, Sartory, & Rachman, 1979), number of exposures (Craske & Rachman, 1987), use of distraction (Rose & McGlynn, 1997), and speed of fear reduction (Rachman & Whittal, 1989a; 1989b) have all been assessed for their relationship to ROF, often with inconsistent results across studies. The post-training factors that may influence return of fear can include reinstatement and related phenomena. As noted earlier, research into reinstatement of fear in humans has been scarce. Finally, numerous state-related factors have been investigated in studies examining ROF. Several of these factors have been demonstrated to influence ROF, although the most consistent finding is arguably the lack of consistency across different research studies. Factors such as initial fear levels, cognitive content and process, and mood state during exposure have all being investigated.

One example of inconsistent findings regarding state-related factors in predicting ROF is that of original levels of fear when exposed to the feared stimulus. Using clinical patients, several studies have demonstrated that ROF is correlated with initial fear levels in individuals with panic disorder (Rachman & Levitt, 1985), and
performance anxiety (Craske & Rachman, 1987). In a sample of patients with
claustrophobia, subjective fear ratings did not predict ROF, while heart rate during
initial exposure did (Wood & McGlynn, 2000). In contrast, Rose and McGlynn
(1997) reported that initial fear level was not predictive of ROF in a small sample of
snake-phobic patients.

One finding which has emerged with some consistency is the ability of
cognitive variables to predict ROF. There is some support from a small number of
studies that both cognitive content and cognitive processes are associated with ROF.
High levels of anxiety-related cognitions have been associated with ROF in anxious
musical performers (Craske & Rachman, 1987). Covariation biases, the tendency to
associate aversive outcomes with phobic stimuli, have also been associated with ROF
in spider phobics (de Jong, van den Hout, & Merckelbach, 1995). Individuals who
experience a sudden and subjectively important reduction in fear responses have also
demonstrated reduced levels of ROF (Rachman & Whittal, 1989b).

The mood state of individuals during exposure tasks may have important
effects on ROF. At least three studies have demonstrated that ROF is greater in
subjects who undergo exposure treatment in a dysphoric mood state, than for those
subjects in a positive mood state. This increased ROF has been observed when
participants are tested 30 minutes (Salkovskis & Mills, 1994), 1 week (Philips, 1985),
or 1 month (Samsom & Rachman, 1989) after exposure. This difference is observed
even when all participants are retested when in a neutral mood state at the follow-up
(Salkovskis & Mills, 1994). It has been suggested that this effect may result from both
a more elaborate encoding of negative material and a less elaborate encoding of
positive material when the participant undergoes exposure in a dysphoric state.

_Treatment Approaches Aimed at Reducing Return of Fear_
Research has aimed to elucidate the treatment approaches which may assist in reducing the possibility of relapse from ROF. Clinicians conducting behavioural or cognitive behavioural interventions for the anxiety disorders should be mindful of this literature when planning their treatment approach, and informing their patients of this relapse risk. Factors which have been shown to reduce the probability of ROF after successful extinguishing of fear responses include extended duration exposure sessions, increased numbers of exposure sessions, increased hiatus between exposure sessions, reducing use of distraction, use of multiple exposure stimuli, use of diverse contexts, and rehearsal out-of-session.

Exposure treatments for anxiety typically last until such a time as habituation has occurred (i.e., that anxiety has reduced despite continued exposure to the feared stimulus). Although evidence in clinical studies is scarce, Craske, Lopatka & Rachman (as cited in Rachman, 1989) reported that extending the duration of exposure sessions may assist in reducing ROF. In this study, individuals were exposed to their feared stimulus for a further ten minutes beyond the point at which anxiety had abated. Although detailed results are not available, Rachman (1989) reported that such a procedure produced some suppression of ROF.

In addition to extending the duration of exposure sessions, some authors have suggested that increasing the overall number of exposure sessions may assist in preventing ROF. As early as 1965, Agras reported that repeated exposure was effective in reducing spontaneous recovery of fear in a group of six individuals with specific phobias. In a similarly small group of individuals with emetophobia, Philips (1985) used an extended number of sessions to treat participants who showed significant between-session ROF. In this study, a larger number (13 compared to 8) of exposure sessions resulted in the elimination of ROF in the short-term, as well as at
six-month follow-up. Although human clinical studies are few in number, there is also evidence from animal fear studies that repeated ‘massive’ extinction procedures can reduce the renewal of extinguished fear responses that are otherwise difficult to reduce by ‘standard’ extended extinction treatments (Dennitson, Chang & Miller, 2003).

Procedures for exposure therapy have varied the period between successive exposures. Although there is some indication that massed or even single session exposure can be effective (e.g., Ost, 1989), there is also evidence that increasing durations between successful exposure may attenuate ROF. Rowe and Craske (1998a) compared massed exposure procedures to an exposure schedule with increasing durations between exposure sessions in a sample of spider phobic individuals. A group receiving massed exposure sessions showed more complete habituation during treatment than the expanding-spaced exposure groups. Despite this, those participants on the expanding-spaced exposure schedule showed significantly less ROF when presented with either the same spider used for exposure treatment, or a different, novel spider. Interestingly, these results were not replicated when Lang and Craske (2000) used expanding-spaced exposure sessions in treatment of height phobia. In this study, there were no significant differences in ROF, although the authors questioned whether their one-month follow-up period was a sufficiently long enough time for differences in ROF to be observed.

Behavioural theory on which some explanations of exposure therapy are based suggests that the use of distraction during the exposure process may serve to prevent full engagement with, and habituation to, the feared stimuli. Few studies have examined the impact of distraction during exposure on ROF. Rose and McGlynn (1997) reported on an experimental study in which snake-fearful participants were
asked to either focus on the snake-stimuli, or monitor an irrelevant audiotape for certain key phrases. Although both experiments in this paper showed that ROF was observed more frequently in the group who utilised distraction, these results did not reach statistical significance. Although the authors interpreted their findings as being suggestive that distraction may increase the likelihood of ROF being observed, replication with a larger sample is required to more fully answer questions around the role of distraction in ROF.

Renewal effects following successfully extinguished fear responses may be reduced through conducting exposure therapy with multiple different stimuli and in multiple different contexts. Two studies examining the use of varied stimuli have returned different findings. Using 28 spider-phobic undergraduates Rowe and Craske (1998b) investigated the impact of using varied stimuli on ROF. Half of their participants were exposed to a single tarantula over four exposure trials, while the other half was exposed to a different tarantula in each of the four trials. When the groups were reassessed after a three-week period, the group which had only seen the single spider showed greater ROF than those who had undergone exposure to a series of different spiders. Lang and Craske (2000) attempted to replicate the earlier work of Rowe and Craske (1998a) using participants who had a fear of heights. Similarly to the earlier study, half of the participants were exposed to the same situation across exposure trials, while the other half was exposed to a series of different situations. Unlike Rowe and Craske (1998a), however, there was no significant difference in ROF between the two groups as measured by subjective, behavioural or physiological measures. The effect of varied exposure stimuli on eventual ROF remains unclear, and further work using longer-term follow-up is also needed.

The early findings that ROF is observed more often when exposure tasks are
demanding suggests an avenue to reduce the likelihood of ROF. As discussed earlier, exposure therapy sessions which result in dramatic increases in subjective anxiety have been associated with increased likelihood of ROF. This suggests that the level of difficulty for exposure treatment sessions needs to be carefully planned. It would appear that a balance needs to be struck between exposure to significant stimuli to allow meaningful extinguishing of fear responses, and not placing unnecessarily high demand on the individual and increasing the probability of significant ROF.

Individuals who engage in behavioural or cognitive-behavioural treatment for anxiety disorders are usually requested to undertake between-session ‘homework’ tasks to assist in therapy. One such task, imaginal exposure, may assist in reducing ROF.

Sartory, Rachman and Grey (1982) assessed the impact of a brief 30 minute imaginal exposure session immediately following a successful in-vivo exposure session in a group of 28 individuals with animal phobias. Half of the participants spent 30 minutes after exposure conducting imaginal exposure, while the other half were asked to distract themselves by reading unrelated magazine articles. Contrary to the authors’ expectations, when participants were reassessed one week later, the group who used distraction immediately following exposure showed increased ROF as measured by subjective fear ratings. These findings give tentative support to the importance of rehearsal and imaginal exposure after successful treatment to reduce ROF.

Recent research has investigated the ability of the NMDA agonist, d-cycloserine (DCS) as an adjunct to the treatment of phobic anxiety. While DCS has been demonstrated to be effective in enhancing exposure therapy in a virtual-reality environment and social anxiety (Hofmann et al., 2006; Ressler et al., 2004), there is less evidence of its ability to prevent ROF. In a large group of undergraduates, DCS did not, however, lead to significant differences in ROF when participants were tested
with a more methodologically sophisticated differential conditioning paradigm (Guastella, Lovibond, Dadds, Mitchell & Richardson, 2007). The role of DCS in exposure and ROF attenuation remains unclear, and requires further research to replicate the recent findings of Guastella et al. (2007) using clinical participants.

**Substance Use Disorders**

Despite that the majority of clinical research into the return of extinguished conditioned responses in humans has been conducted in relation to anxiety disorders, there exists a smaller body of research into other conditions such as substance use disorders. One such example is the renewal of craving responses in alcohol use following successful extinguishing of craving. Drawing on the Pavlovian conditioning literature and the success of exposure treatments for anxiety, behavioural treatments for substance use problems have incorporated cue exposure components in which the individual is gradually exposed to increasingly more salient cues previously associated with their substance use. Similar to the phenomenon of ROF, however, such treatments may often be associated with a renewal effect, in which the same cues in a different context produce the same craving response, and hence, relapse occurs.

Pavlovian conditioning models of substance use suggest that exteroceptive and interoceptive cues (i.e., CSs) of drug use (e.g., drug paraphernalia, negative affect) become paired or associated with the unconditioned, pharmacological effects of the drug (e.g., tachycardia, euphoria). Over time, the previously neutral CSs develop the capacity to elicit physiological conditioned responses (CRs) in the absence of drug ingestion. A number of studies have shown these conditioning effects in alcoholics, opiate addicts, and smokers (e.g., Brandon, Piasecki, Quinn, & Baker, 1995; Childress, McLellan, Natale, & O’Brien, 1987). Consequently, extinction-based treatment studies of substance use that have been based on Pavlovian conditioning
models have shown post-treatment decreases in substance cravings and consumption (e.g., Drummond & Glautier, 1994; Stasiewicz et al., 1997). However, long-term outcomes have been relatively poor and the effectiveness of cue exposure interventions that are based on Pavlovian conditioning models relative to cognitive-behavioural relapse prevention has been questioned (e.g., Niaura et al., 1999). Some have argued that this may be due to a lack of attention paid to context effects in cue exposure treatments (e.g., Brandon et al., 1995; Childress et al., 1986; Rodriguez, Craske, Mineka, & Hladek, 1999).

Collins and Brandon (2002) recently addressed this problem experimentally in a sample of 78 nonalcoholic social drinkers. Because extinction effects (upon which cue exposure treatments are based) are unstable and do not generalise well to other contexts (Bouton, 2002), extinguished conditioned behaviour (i.e., the urge to drink) may “renew” with a change of context (i.e., a renewal effect). Moreover, based on animal research evidence that the renewal effect can be attenuated if a memory retrieval cue that was present during extinction is also presented during the renewal test trials (e.g., Brooks & Bouton, 1994), Collins and Brandon conducted a treatment-analogue study to test the role of context in renewal and the effects of a potential strategy to attenuate renewal.

After completing a cue exposure phase in an experimental room in which all participants were exposed repeatedly to alcohol (i.e., a beer can and a beer-filled cup) (context A), an extinction phase was completed in another room (context B) in which participants were repeatedly exposed to the same alcohol cues until their self-reported urge to drink returned to baseline levels. An extinction retrieval cue was present throughout the extinction phase (i.e., a novel coloured pencil participants used to record their urge ratings). This phase was followed some 25 min later by a renewal
test phase in which participants were randomly assigned to either the same context as extinction (i.e., the same room the extinction phase was completed in), a different context to extinction (i.e., a different experimental room), or to a different context as extinction but with the memory retrieval cue present. Self-reported urge to drink on visual analogue scales and saliva volume via the insertion of dental rolls into the mouth during each trial were sampled throughout each phase. As expected, the different context to extinction produced greater renewal effects, as indexed by both self-reported urge to drink and saliva volume than the same context as extinction. Moreover, renewal was attenuated when the memory retrieval cue was present. These findings were interpreted as highlighting the important role of context effects that may contribute to relapse following alcohol-cue exposure therapy, and the importance of strategies such as extinction context memory retrieval cues for attenuating renewal. In clinical terms, these findings translate to the likelihood that individuals with alcohol use problems will relapse following successful cue exposure therapy when they are subsequently exposed to drinking cues (whether internal or external) in situations other than those included during treatment. These findings also suggest that if these individuals can be instructed in the use of strategies (whether behavioural or cognitive) that remind them of their extinguished behaviour during treatment, the chance that they will relapse may be reduced.

However, a subsequent study by Stasiewicz, Brandon and Bradizza (2007) did not replicate these findings in a large sample of 143 alcohol-dependent outpatients. These authors used a similar procedure as Collins and Brandon (2002) in which participants completed extinction trials to reduce the craving and salivation responses to alcohol cues after repeated exposure to their preferred alcoholic beverage during the cue exposure phase. Each phase was completed in a different experimental room
within the same building. Moreover, there was an extinction context memory retrieval cue present throughout extinction for all participants (i.e., a novel coloured pencil). Participants were then randomised to renewal tests in either (a) the same context as extinction (i.e., the same experimental room), (b) a different context to extinction (i.e., a different experimental room), (c) a different context to extinction plus the extinction retrieval cue (i.e., a different context plus the novel coloured pencil), or (d) a different context to extinction plus a manipulation to increase the salience of the retrieval cue (i.e., a different experimental room plus specific instruction to associate the novel coloured pencil with the context). Contrary to expectations and the previous results, the different context did not produce the expected renewal effect. Instead, self-reported craving continued to decrease between extinction and renewal retest, regardless of the renewal test condition.

The authors offered numerous explanations for the results that highlight both the subtleties of potential contextual cues that may operate during extinction and renewal retest as well as the participant characteristics. They suggested that even though cue exposure and extinction took place in different experimental rooms, these rooms may not have been sufficiently discriminable because both were located in the same building. Thus, the building itself may have represented the context of extinction for all participants (Bouton, 2002). Similarly, the presence of the experimenter in the room during extinction and the renewal test may have inadvertently served as a salient extinction context cue that attenuated renewal. The mean of 1.1 days elapsed time between extinction and the renewal test also was suggested to be too short in this alcohol dependent population and/or demand effects and social desirability may have influenced reporting of low craving in this group. Another suggestion was that because the extinction criteria was reached by only 69%
of the sample, there may not have been sufficient extinction achieved prior to the renewal test. The authors also suggested that the utilisation of an ABC design may have prevented renewal effects from being observed based research which indicates that ABA renewal tends to be stronger than ABC renewal (Bouton, 2002). Finally, since the major difference between Stasiewicz et al.’s (2007) study and that of Collins and Brandon (2002) was the use of a clinical versus non-selected sample, the authors concluded that sample differences may be the most likely explanation for the different renewal effects between studies.

A recent study on the renewal of cue-elicited urge to smoke cigarettes has also been investigated using Pavlovian conditioning models. Thewissen, Snijders, Havermans, van den Hout, & Jansen (2007) exposed 37 participants who smoked five or more cigarettes per day for at least 2 years to a cue predicting smoking availability (CS+; either a blue or yellow ashtray) and a cue predicting smoking unavailability (CS-; the other coloured ashtray) in the acquisition context (context A; either an office or a therapy room located in different buildings). Following extinction in the other of these two rooms (context B) in which participants were not allowed to smoke, a renewal test took place in the original acquisition context A (i.e., ABA renewal). The dependent variable was urges to smoke as measured using a visual analogue scale. Results indicated that renewal of differentially conditioned urge responding occurred when participants were tested in the acquisition context, whereas differential urge responding remained extinguished when tested in the extinction context. The authors concluded that the extinguished cue-elicited urge to smoke was context-dependent. Moreover, that the cue-elicited urge to smoke was renewed when individuals find themselves outside the context where extinction treatment took place.

A strength of Thewissen et al.’s (2007) study compared with the renewal
studies involving alcohol dependence (e.g., Brandon & Collins, 2002; Stasiewicz et al., 2007) is the experimental control that was established over the acquisition of cue reactivity by the use of a differential conditioning paradigm involving both CS+ and CS- trials. Renewal might also have been more reliably demonstrated in Thewissen et al.’s study than in Stasiewicz et al.’s study by use of an ABA design, because the experimental contexts may have been more clearly discriminable due to the experimental rooms being located in different buildings, and because the experimenter was absent from all experimental contexts, hence avoiding a potential extinction retrieval cue confound. On the other hand, the acquisition and extinction conditions in Thewissen et al.’s study were highly discriminable because participants engaged in the smoking behaviour in the CS+ condition during acquisition and did not engage in this behaviour during extinction. This contrasts with Stasiewicz et al.’s study in which participants were instructed only to look at and smell the alcoholic beverage during both cue-exposure and extinction. The sharper distinction between explicit conditioned responding during acquisition (i.e., smoking) and complete abstinence from the behaviour during extinction may have contributed to the stronger rates of extinction that were reported in Thewissen et al.’s study compared Stasiewicz et al.’s study. This in turn, may have allowed for the emergence of stronger renewal effects. Nevertheless, as participants in Thewissen et al.’s study were mainly smokers with a low level of smoking dependence and who had no intention of quitting, similar to the unselected social drinkers studied in Collins and Brandon’s (2002) study, the difference in renewal results between these two studies and Stasiewicz et al.’s study may reflect on the severity of alcohol dependence in their outpatient sample.

Summary and conclusion on clinical research

The return of extinguished conditioned behaviour has been most extensively
investigated in the context of anxiety disorders and substance dependence disorders. This is not surprising given that exposure therapy has had wide application in the treatment of these conditions. The return of extinguished conditioned behaviour in clinical investigations has been found for the renewal of fear responses, urge to drink, and urge to smoke, and for the spontaneous recovery of fear responses. Although there are discrepancies among the results reported so far, these may reflect the influence of a range of variables that remain to be specified. Such variables can be particularly difficult to control in treatment-based clinical studies. Nevertheless, the demonstration that fears or dependencies can return following apparently successful exposure therapy underpins the need for therapists to consider relapse via renewal, spontaneous recovery, or related effects as a significant challenge. Future research that aims to investigate the means by which relapse can be attenuated will have significant benefits for the long-term treatment of individuals who engage in exposure therapy.

CONCLUSION

The increasing number of researchers that are investigating the return of extinguished conditioned behaviour in humans bodes well for our future understanding of the theoretical basis and practical applications of this phenomenon. The current research questions are now moving beyond asking whether renewal, reinstatement, and spontaneous recovery can occur in human conditioning procedures to more pertinent issues in relation to the psychological basis of the phenomena. A more detailed understanding will enable researchers to explain the apparent discrepancies that exist in the current literature, such as by specifying the conditions under which exposure to multiple extinction contexts does and does not attenuate
renewal in laboratory-based studies. Moreover, closer links between the laboratory-based research and clinical-based studies will be forged. It is known that there are differences between these two methodologies in fear acquisition with some cognitive phenomena such as implicit associations being observed in naturally occurring phobias, but not in newly conditioned fear responses (Boschen, Parker & Neumann, 2007). Likewise, there may be differences in the return of extinguished conditioned behaviour that may suggest limits on the generalisability of laboratory-created anxiety responses to a clinical context. As an example, Hermans et al. (2005) reported the reinstatement of an artificially-induced fear reaction to a relatively fear-irrelevant stimulus, but similar reinstatement effects have not yet been reliably found in clinically-based studies (Rachman & Whittal, 1989a). Progressive research that bridges the gap between the laboratory and the clinic will be needed. For instance, the testing of reinstatement in the laboratory with fear-relevant stimuli (cf. Neumann & Longbottom, submitted, who used a renewal procedure) may represent one step in this process.

Due to the particular relevance that the return of extinguished conditioned behaviour has for relapse in a clinical context, a particular exciting avenue for future research is in delineating the conditions under which renewal, reinstatement, and spontaneous recovery can be attenuated. However, there also remains an important need for basic parametric studies to determine what fundamental variables influence these phenomena in both increasing and decreasing the magnitude of their effects. Likewise, theoretical explanations for the return of extinguished conditioned behaviour in humans remain to be elaborated upon by using human studies. The explanations regarding the importance of ambiguity following extinction and the use of contextual cues to resolve this ambiguity as proposed by Bouton (2002, 2004;
Bouton et al., 2006) will provide the starting point for such research. The relationship that such concepts have to existing theoretical approaches to conditioning and extinction in humans, and in particular the role of cognitive processes in learning (e.g., Davey 1987; Lovibond, 2004), promises to be an exciting future area of theoretical development.

Finally, the return of extinguished conditioned behaviour remains to be explored in children in either the laboratory or clinic. Such research has the potential to increase the generality of phenomena such as renewal and reinstatement across the lifespan. Moreover, further information on how return of extinguished behaviour phenomena are implicated in relapse following exposure therapy also has relevance for the treatment of children with anxiety disorders. Further research is warranted given that childhood-onset anxiety affects up to 20% of children and is linked as a risk factor for adult anxiety (McGee et al., 1992), depression (Pine et al., 1998), and substance use disorders (Merikangas et al., 1999). Childhood anxiety disorders are also associated with debilitating academic and vocational functioning (Kessler et al., 1995) and impaired social competence (Spence, Donovan, & Brechmann-Touissant, 1999). The ethical difficulties in using noxious stimuli like electric shock and loud tones as USs in fear conditioning procedures does limit further research. The adoption of other unpleasant, but not painful or intense, stimuli as USs (Neumann & Waters, 2006; Neumann, Waters, & Westbury, in press) or the use of other associative learning tasks (e.g., conditioned suppression task; Arcediano et al., 1996), may provide a solution to this problem.
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