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RESISTANCE TO EXTINCTION IN HUMAN FEAR LEARNING.

AN ERP INVESTIGATION OF PROCEDURAL AND FEAR RELEVANCE EFFECTS

ON CONDITIONED RESPONDING.

By

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RESISTANCE TO EXTINCTION IN HUMAN FEAR LEARNING. AN ERP INVESTIGATION OF PROCEDURAL AND FEAR RELEVANCE EFFECTS ON CONDITIONED RESPONDING.

Summary

In human fear conditioning 'resistance to extinction' occurs when the removal of the aversive outcome fails to produce a reduction in conditioned responding. This phenomenon is important to understanding the persistence of anxiety disorders such as phobias. The research presented in this thesis examines factors that promote the acquisition and maintenance of learned fear response and attempts to differentiate between different explanations of the resistance to extinction phenomenon.

To investigate the impact of different conditioning procedures (evaluative or classical conditioning) on the durability of the conditioned response (CR), event-related potential (ERP) methodology was employed. In addition, the role of the fear-relevance of the conditioned stimulus (CS), in supporting the acquisition and resistance to extinction of the CR, was explored.

Evidence suggested that extinction effects are likely to reflect procedural differences in conditioning rather than different underlying learning processes. Extinction effects were dissociable across procedures, supporting the role of the type of unconditioned stimulus (US) in explaining past demonstrations of extinction when responses were indexed by physiological measures. Verbally transmitted, threat information heightened aversive US-expectancies and fear beliefs without the need for conditioning. Additionally, fear-beliefs were reduced without the need for extinction training when positive information was provided. Contrary to Davey's (1997) expectancy bias model, the results do not support

the hypothesis that verbal information interacts with direct contingency experience to create fear responses; instead, information appears to be a direct pathway to fear.

ERP measures of fear responses did not echo the effects of verbal information and contingency on fear-beliefs. However, the comparability of our ERP data, to other research using physiological measures of response, is discussed regarding the number of trials required to calculate the average ERP response. Due to averaging over a large number of trials the ERP measure may not be sensitive to fluctuations in response that may be dependent on information or contingency manipulations. In conclusion our data suggest the importance of verbal information as a pathway to fear and the role of cognitive factors in the prevention and treatment of fears.

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1.1 Overview of the applied and theoretical importance of extinction

1.1.1 The practical importance of extinction

Conditioning models of affective learning suggest that if a conditioned stimulus (CS) is paired with an unconditioned stimulus (US), which already evokes an emotional/physiological response, the response towards the CS will change in anticipation of the US. As an explanation of fear acquisition, the conditioning model took shape from Watson and Rayner's (1920) demonstration that fear and behavioural avoidance could be learned towards a previously neutral stimulus through its pairing with an aversive stimulus. In their study, Watson and Rayner first established that a 9 month-old child, Albert B, was fearful of a loud banging noise (made by banging a hammer against an iron bar) but showed no fear towards a white rat. To explore whether fear could be learned through experiencing a stimulus in temporal proximity to a traumatic event, each presentation of the rat (when it approached Albert or he tried to touch it) was then followed by the loud noise. As a result of these presentations, Albert began showing signs of fear towards the rat alone.

Conditioning models (Pavlov, 1927; Rescorla & Wagner, 1972) explain such accounts of fear acquisition in terms of an association that is formed between the CS (rat) and the US (loud noise) in memory. As the US already evokes a naturally unconditioned response (UR), the CS comes to evoke a conditioned response (CR) through its association with the

US. Further presentation of the CS in absence of the US should additionally reduce the CS-US association and therefore reduce the CR. This process is known as extinction.

Observation of reduced CR through extinction training, along with evidence that the CR is a function of beliefs/expectancies of the aversive outcome, has formed the scientific basis of most fear intervention strategies (Wolpe, 1961; Zinbarg, 1993), such as exposure therapy and cognitive behavioural therapy (CBT). However, exposure therapy does not always result in long term benefits of anxiety reduction (Barlow, 1988). Likewise, in conditioning studies, removal of the US in extinction training does not always result in reduction of conditioned responding towards the CS. This phenomenon is known as resistance to extinction.

Factors that support resistance to extinction can inform us a great deal about why fear persists in anxiety disorders, such as phobias (Field, 2006c), posttraumatic stress disorder (Blechert, Michael, Vriends, Margraf, & Wilhelm, 2007) and panic disorder (Michael, Blechert, Vriends, Margraf, & Wilhelm, 2007). Additionally, factors that support the persistence of CRs through extinction training could help our understanding of relapse after exposure therapy (Bouton, 2002). A review of the evidence for factors that maintain the CR, and the implications these factors hold for theories of fear acquisition and persistence can be found in Section 1.3 of this chapter.

1.1.2 The theoretical importance of extinction

As discussed in the previous section, resistance to extinction is particularly interesting in terms of understanding fear maintenance in anxiety disorders. However, differences in the circumstances under which extinction occurs are also important for our understanding of the mechanisms that underlie associative learning.

Classical conditioning (CC) has been dissociated from another form of learning, evaluative conditioning (EC), based on their seemingly different functional characteristics. These characteristics include: the extent to which learning appears reliant on awareness of the CS-US contingency; the nature of the response that is acquired (expectancy vs. affective responses) and the extent to which the CR is resistant to extinction (for a review see De Houwer, Thomas, & Baeyens, 2001).

Procedurally in CC, the CS generally signals the onset of a motivationally relevant US, such as a loud noise or electric shock (see De Houwer et al., 2001; Lovibond, 2004). In such procedures removal of the US, during extinction, usually diminishes US expectancy along with the CR and thus learning appears to be driven by expectancy of the US (Lovibond, 2004). Consequently, prototypical CC paradigms also tend to use physiological measures, such as galvanic skin conductance response (SCR) to index anticipation of the aversive US, or verbal measures of US-expectancy (e.g., Hermans, Crombez, Vansteenwegen, Baeyens, & Eelen, 2002).

EC, on the other hand, is a form of learning by which a formerly neutral stimulus (CS) gains valence through its contiguous pairing with an affective stimulus (US). Although procedurally similar to CC (both involve CS-US pairings), prototypical EC paradigms do not use overtly aversive/motivationally relevant USs, because it is argued that such USs heighten contingency awareness (encouraging participants to 'search' for predictive cues), and encourage expectancy learning (Lovibond & Shanks, 2002). Rather, EC paradigms tend to pair CSs with previously 'liked'/'disliked' stimuli (USs) and learned *affective* response

towards the CS is usually measured by explicit verbal ratings or implicit measures such as the affective priming task.

Affective CRs in EC seem to be independent of contingency awareness and resistant to extinction (removal of the contingent affective US). These characteristics provide support for a simpler learning system to that underpinning CC, which does not rely on expectancy of the US. The dissociation in extinction effects between these two procedures is intriguing because it provides indication that learning might rely on qualitatively different underlying processes. Dual-process models of learning propose that, whereas CC represents a form of expectancy learning, dependant on the contingencies between stimuli, EC represents a referential form of learning (Baeyens, Eelen, & Crombez, 1995; Baeyens, Eelen, Crombez, & Van den Bergh, 1992). The referential account of affective learning outlines a distinct learning mechanism that differs from expectancy learning, because it is affected by CS-US contiguity but not knowledge of their contingency. Thus affective learning is assumed to be based on referential associations between stimuli that are not affected by changes in the CS-US contingency in extinction.

1.1.3 Chapter overview

This chapter begins with a review of the evidence for dual-process models of associative learning. Evidence for learning in the absence of awareness is presented along with alternative, artefactual explanations for these effects, which criticise some of the methodologies used (for reviews see Field, 2000; Lovibond & Shanks, 2002). In addition, evidence for a single-process propositional model (De Houwer, 2009; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010; Mitchell, De Houwer, & Lovibond, 2009) is discussed, bringing the debate on underlying processes of fear learning up to date. In spite of evidence for artefactual accounts of learning in the absence of awareness, recent evidence has supported that resistance to extinction is a genuine functional characteristic of EC (De Houwer, Baeyens, Vansteenwegen, & Eelen, 2000; Diaz, Ruiz, & Baeyens, 2005; Field, 2006a). The persistence of conditioned responding after US removal during extinction in EC implies that the CR does not depend on expectancy of the US. Thus EC seems to differ from CC in reliance on CS-US contingency knowledge. However, the distinction between EC and CC based on underlying processes still remains controversial and alternative accounts for EC's functional characteristics are presented, which render the dual-process account unnecessary (Lipp, Oughton, & LeLievre, 2003; Lipp & Purkis, 2006; Lovibond & Shanks, 2002).

The second part of this chapter focuses on the contribution of conditioning models to our understanding of the aetiology and maintenance of fear (for reviews see Field, 2006b; Mineka & Zinbarg, 2006). Factors that support resistance to extinction within the CC paradigm, such as CS fear relevance, are explored with regard to models of selective associations in phobias (Davey, 1997; Öhman & Mineka, 2001). The implications of these factors for treatments of phobias and other anxiety disorders are also discussed.

Finally, the use of the event-related brain potential (ERP) technique as a physiological index of affective response is discussed. The use of ERP measures in the research of stimulus affect and the potential benefits for applying this measure in conditioning

paradigms are explored. The implications of implementing ERP indices of response for experimental design within the differential conditioning paradigm are also discussed.

Summary of aims

This thesis aims to compare resistance to extinction of conditioned ERP response between EC and CC on a procedural level. In doing so it should be possible to differentiate between procedural and process level explanations for previous findings of the extinction of physiological response using measures such as SCR (e.g. Blechert, Michael, Williams, Purkis, & Wilhelm, 2008). ERP indices are employed to enable the comparison across paradigms of affective response acquisition and most notably, extinction, in the physiological domain.

Additionally, this thesis explores the impact of fear-relevance manipulations on acquisition and extinction of the conditioned ERP response. In particular the role of verbal threat information in maintaining the CR is explored as a cognitive explanation for selective associations. This thesis also aims to investigate whether positive information enhances rates of extinction on measures of cognitive (fear beliefs) and physiological (ERP) response, thus supporting the role of cognition in the reduction of fear.

1.2 Explanations of the resistance to extinction phenomenon.

1.2.1 Cognitive vs. Associative models of associative learning

Dual process vs. Single process models of associative learning

In human conditioning there are two indicators of learning. First is the demonstration of a CR to the CS, and second is the ability to report the CS-US contingency. Models of conditioning attempt to represent the nature of the relationship between contingency awareness and the demonstration of a CR. Lovibond & Shanks (2002) distinguish between two classes of model which describe the role of awareness in conditioning.

Single process models: These models assume that learning occurs through propositional reasoning processes (an approach that has recently been supported by (De Houwer, 2009; Mitchell et al., 2009). A "strong" single process model, as described by Lovibond & Shanks (2002), posits a causal relationship between contingency awareness and the CR. Exposure to the CS-US contingency results in propositional learning of the relationship between these stimuli. In turn, the propositional knowledge of the contingency between the stimuli results in production of a CR. A "weak" single process model is also proposed by Lovibond & Shanks (2002). Like the strong model, learning is deemed propositional, however this model suggests that the learning process can result in contingency awareness and the production of a CR independently. Though both contingency awareness and the CR are based on propositional knowledge, the relationship between them is not causal.

Dual process models: In dual process models of learning (e.g., Baeyens et al., 1995; Baeyens et al., 1992), although propositional learning is necessary for contingency awareness, an independent, non-propositional learning system can produce the CR. This non-propositional system elicits a CR through an automatic referential system in which

representation of the CS elicits a representation of the US and thus produces the CR. Hence conditioning is seen as a low-level, unconscious process through which associations between stimuli can be formed automatically.

However, evidence for the automaticity of learning in CC has proved hard to obtain. Lovibond and Shanks (2002) outline that, whereas evidence for a propositional learning system primarily comes from participant reports of contingency knowledge, evidence for a dual-process account of learning should be demonstrated by CRs in the absence of contingency awareness. Lovibond & Shanks also propose that to fully support the notion of conditioning in the absence of awareness two tests must be met. First, conditioned responding must be compared between participants that are classed as aware and those that are unaware. A null result in this case would indicate that the relationship between conditioning and awareness is unnecessary. Second, CR performance in unaware participants must be accounted for.

Evidence for conditioning without awareness

Examples of conditioning in the absence of awareness have been provided by studies of autonomic classical conditioning (CC) using supraliminal and subliminal stimuli; eyeblink conditioning in normal participants; conditioning in amnesic patients and evaluative conditioning (EC). However, reviews of such evidence (e.g. Field, 2000; Lovibond & Shanks, 2002) highlight limitations regarding the reliability, validity and sensitivity of methodologies and measurements used, which may provide alternative explanations for the lack of awareness demonstrated in these studies. Examples of such limitations will be provided in turn.

The reliability of measures, used to index the theoretical constructs of contingency awareness and CR, is open to influence by unrelated factors that add uncontrolled variance to the measures. As a result, dissociation between awareness and CR may be due to an artefact of measurement rather than a real dissociation between these two

constructs. Consequently, correlational evidence for this dissociation, such as presented by Baeyens, Hermans & Eelen (1993), is also flawed. Lovibond and Shanks (2002) propose that single process models can also explain low correlations between awareness and conditioning, because the relationship between them might be non-linear. Performance on either measure could also be at floor or ceiling level, or otherwise restricted in range, resulting in low correlation between the measures. It is because of such considerations that Lovibond and Shanks (2002) stress the statistical importance of first comparing CR between aware and unaware participants, and second testing whether a differential CR is demonstrated in unaware participants, as evidence of unaware conditioning.

The validity of awareness measures depends on factors such as measurement relevance, immediacy, and sensitivity. Lovibond and Shanks (2002) highlight the need for a measure that taps "all conscious knowledge that is *relevant* to production of the CR" (p.06). Also measures should be recorded with minimal time lapse (immediacy) from the event of interest to reduce 'room for forgetting' and interference (Shanks & St. John, 1994).

In terms of the relevance of an awareness measure some studies, using subliminal presentations of the CS, have been criticised for expecting explicit CS recognition as evidence of awareness (Öhman & Soares, 1993). Lovibond and Shanks (2002) explain that a lack of recognition does not mean participants were not aware of certain discriminative features of the stimuli during conditioning. This possibility was subsequently acknowledged by Ohman, Esteves and Soares (1995), thus undermining the claim that CR expressed towards such masked stimuli occurred in the absence of awareness.

In terms of immediacy, many examples of conditioning without awareness used measures of awareness post-hoc the conditioning phase, or even post-extinction, thus failing to meet this principle of measure validity. Such studies include examples from autonomic conditioning (e.g. Hamm & Vaitl, (1996); conditioning in amnesic patients (e.g. Woodruff-Pak, 1993) and eyeblink conditioning in 'normal' participants (e.g. Clark and Squire, 1998).

Hamm & Vaitl (1996) provided evidence, within an autonomic conditioning study, that differential SCRs and heart rate response were dependant on awareness but blink startle modulation was not. From this observation they concluded that, unlike SCR and heart rate, differential startle modulation might not depend on conscious knowledge of the CS-US contingencies. However, Lovibond and Shanks (2002) argue that the method used to determine contingency awareness, a post-extinction interview, was not sensitive enough to discount the possibility of interference in contingency knowledge through extinction, or whether such knowledge had been forgotten since conditioning took place. Additionally no analysis assessed whether differential startle modulation was observed in unaware participants.

On the other hand, a study by Purkis and Lipp (2001) demonstrated a strong relationship between startle modulation and contingency awareness. During a visual masking task participants were presented sets of 4 pictures for which they had to report the sequence. Participants received 16 trials in which a particular picture (CS+) was followed consistently by a shock US, and another 16 trials in which a control stimulus (CS-) was consistently presented without the US. By using an expectancy dial Pukis and Lipp were able to track contingency awareness online. This method allowed a much more sensitive measure of awareness in comparison to that used by Hamm & Vaitl (1996). The results showed that differential SCR and startle response were successfully conditioned towards the CS+, but only when participants were contingency aware. Unaware participants showed no differential response between the CS+ and the CS-, and additionally conditioned responding was only observed at the point in time when participants became aware of contingencies (as indexed by the online expectancy dial). Thus modulation of the startle response, like SCR and heart rate, appears to be reliant on contingency awareness.

Equally an important factor of measure validity is sensitivity to the construct in question. Sensitivity is linked to the issue of immediacy: to be sensitive, a measure should occur at the point in time when the construct is of interest. However, if this is not possible (i.e. post hoc measures) measures that enable ease of recollection should be used (e.g.,

recognition rather than free recall tests). For example, a post hoc measure of awareness used by Baeyens, Eelen and Van den Bergh (1990) required explicit knowledge, of which US each CS was paired with, through a recall test. Scrutinised in a review by Field (2000), it has been shown that the explicit recall task misclassified 18.5% of contingencies when compared to a more sensitive concurrent measure, which only required knowledge of the valence of the contingent USs. This resulted in a probability of 37% that an aware participant would be misclassified as unaware, which could have contributed to the finding of conditioning in absence of contingency awareness. Explicit measures of awareness are supported by Baeyens, De Houwer and Eelen (1994), who claim that awareness should be linked to some subjective, phenomenological experience. Shanks and St. John (1994), on the other hand, believe verbalised, explicit measures to be insensitive to awareness and could be limited by participants being reluctant to report knowledge of which they are unsure.

One of the largest bodies of evidence for conditioning in the absence of awareness comes from the EC literature. EC is proposed to be characteristically different from CC, on the basis that it is not dependant on contingency awareness (De Houwer et al., 2001). To date, findings of EC in the absence of contingency awareness have been inconsistent and many studies that seem to have demonstrated this type of learning have been critically flawed in their measures of contingency awareness. Additionally a recent meta-analysis by Hofmann et al. (2010) showed contingency awareness to be the most important moderator of EC, with EC rarely occurring in its absence. Explanations for the questionable evidence of EC in the absence of awareness include limitations described in this section, such as the use of explicit verbal reports; measures of awareness taken at different points in time to the CR; measures which seem to index *demand* rather than contingency awareness (Field, 2000).

One of the earliest systematic demonstrations of EC in the absence of contingency awareness, Baeyens et al. (1990), also used a concurrent measure of awareness, as an important step to improving immediacy between measure and construct. However, the

CR was still measured post-conditioning. In contrast, when measuring the CR at the same time as awareness, Purkis and Lipp (2001) showed conditioning only when participants were aware of contingencies between stimuli. One explanation of this failure to find conditioning in the absence of awareness could be that the paradigm used by Purkis and Lipp (2001) is more typical of CC studies (using loud tones to elicit a startle response), which is widely considered to be dependant on contingency knowledge. However, due to the discrepancy in findings between Baeyens et al. (1990) and Purkis and Lipp (2001), concurrent measures of both awareness and CR would need to be employed to rule out the possibility of an artefact in time of measurement.

As well as the above flaws due to measurement issues of awareness, studies have been criticised for not counterbalancing stimuli pairings or using a control condition with which to compare experimental manipulation (Field and Davey, 1998, 1999). Control conditions and counterbalancing is essential in determining that conditioned responses are the result of EC and not artefacts of stimuli assignment, as if this were the case it would be understandable finding EC does not depend on contingency awareness (Davey, 1994). The importance of controls and stimuli counterbalancing in associative learning studies is discussed in further detail in due course.

In spite of conflicting and questionable evidence for EC in the absence of contingency awareness, Field and Moore (2005) have provided support for the phenomenon. This study dissociated the effects of contingency awareness from attention using counterbalancing and control conditions to exclude any possibility that conditioning effects may be artefacts of stimuli pairings. The findings showed that when attention was not inhibited CRs occurred for both normally and subliminally presented stimuli. These findings imply that EC occurred both with and *without* contingency awareness, as participants could not be aware of contingencies when USs were presented subliminally. However, Field and Moore stress that, as awareness was measured after the conditioned evaluative responses, it is unclear whether the sensitivity of their awareness measure was

comparable to the measure of conditioning. Therefore they advise caution with interpretation of these results as an example of conditioning in the absence of awareness.

In terms of evidence for whether EC is a qualitatively distinct form of learning from CC, there is also evidence of conditioning in the absence of awareness within CC paradigms, especially when the nature of the CS is fear-relevant (Öhman & Soares, 1993). However, the majority of evidence for differential dependency on contingency knowledge, between fear-relevant (FR) and fear-irrelevant (FI) stimuli, has come from observations of improved resistance to extinction for FR CSs (for reviews see McNally, 1987; Öhman & Mineka, 2001).

In summary, though evidence for an automatic referential system, as part of a dual process model of learning, is presented in the form of conditioning in the absence of contingency awareness, such evidence has frequently been criticised for inadequate measures of awareness and other limitations in experimental methodologies. Methods for improving the validity and sensitivity of measures have been suggested (Lovibond & Shanks, 2002), and when implemented there is evidence that conditioning does not occur unless participants are aware of the CS-US contingencies (e.g. Purkis & Lipp, 2001). By all accounts conditioning seems to rely on a propositional system associated with conscious reasoning processes, and the existence of a separate referential system is questionable.

A propositional account of associative learning

The propositional account of associative learning is based on the idea that all learning can be explained in terms of reasoning processes (De Houwer, 2009; Mitchell et al., 2009). In keeping with single process models, as described by Lovibond and Shanks (2002), this approach suggests that we learn about the relationships between stimuli rather than simply forming associative 'links' between stimuli. De Houwer (2009) differentiates between associative learning as an effect (the observable CR as a result of a contiguous CS-US pairing) and as the underlying process which determines the CR. De Houwer states

that this separation allows freedom for theoretical investigation of the processes, which underlie associative learning as an observable effect. Additionally, two main assumptions of the propositional account are outlined. Firstly, associative learning effects depend on the formation and evaluation of propositions. Secondly, the formation and evaluation of propositional knowledge is mediated by non-automatic processes.

De Houwer (2009) and Mitchell et al. (2009) support the first assumption of the propositional explanation of associative learning effects by providing evidence of factors that influence both the formation and evaluation of propositions and learning effects. They propose that factors, such as prior knowledge, instruction, and deductive reasoning, in addition to direct contingency experience, drive the effects of associative learning. Much of the evidence for the impact of these factors stems from research into 'blocking' effects in conditioning studies.

The term 'blocking' refers to the observation that a CS (B) will not evoke a CR on pairing with the US, if it is paired in composite with another CS (A), which has previously been paired with the US on its own. In other words, after experience of A+ trials (+ represents presence of the US), AB+ trials will not result in a CR towards B because the associative strength of B is undermined by the presence of an existing US predictor (A). The blocking phenomenon is particularly important in support of the propositional account of associative learning as it provides evidence for the impact of factors, such as prior knowledge, instruction, and reasoning, on associative learning effects.

Waldmann (2000) demonstrated that prior knowledge, as to whether stimuli were a potential cause or effect of the outcome, dissociated the prominence of blocking effects. Propositional knowledge of causal relations allows participants to reason that if A+ trials result in a particular outcome, and there is no additive outcome in AB+ trials, then these observations are inconsistent with the proposition 'B is the cause of the outcome'. Thus blocking effects towards stimulus B were more pronounced when A and B were classed as the *cause* of the outcome. In contrast, when A and B were classed as *effects* of the outcome, A+ trials do not undermine the relationship between stimulus B and the

outcome. The extent that A and B are effects of the outcome is independent. Thus blocking effects are less likely with prior knowledge that the stimuli are effects of the outcome. A review by Lopez, Cobos & Caño (2005) provides evidence from several studies supporting this prediction.

Additionally evidence exists that instructions, regarding un-experienced events, can also influence associative learning effects. Verbal warning that a shock US will follow a particular CS has been demonstrated to produce SCRs towards the CS in absence of actual CS-US experience (Epstein & Roupenian, 1970; Olsson & Phelps, 2004). Colgan (1970) also demonstrated that reduction in SCR, conditioned through direct experience of CS-US trials, could be achieved through instruction that the CS would no longer be followed by the US. Such findings support the notion that, not only can instructions about a causal relationship lead to similar learned responses as direct experience, but also that propositional knowledge derived from such experience can interact with propositional knowledge derived through verbal information.

The impact of instruction on propositional beliefs has also been demonstrated for more complex learning phenomena. In a 'release from overshadowing' study Lovibond (2003) demonstrated that information mirrors the impact of direct contingency experience. When a stimulus compound was trained to signal a shock (AT+), further A- trials (no shock) led to the development of a CR towards the T cue alone. Lovibond then showed the same 'release from overshadowing' effect when learning trials (AT+ and A-) were described verbally, or when AT+ trials were experienced directly, but verbal information was substituted for A- trials.

All of the above examples also provide evidence for the role of deductive reasoning in associative learning, as reasoning is the mechanism that allows the consistency between propositions to be assessed in determining a 'truth' concept, and consequently the associative learning effects observed. However, De Houwer (2009) also provides evidence that deductive reasoning can also provide the input for truth evaluation in learning. De Houwer and Beckers (2002a, 2002b) demonstrated the role of deductive reasoning in

associative learning by presenting participants with AB+ and AX+ trials, followed either B+ or B- trials. Not only were ratings of the A-US relation influenced by the further presentation of B+ or B- trials, but also ratings of the X-US relation. Causal status of the X-US relation cannot be directly assessed because no trials were presented of A alone.

When participants were presented with a combination of AB+ and B- trials they demonstrated the ability to infer that A is the cause of the outcome for both AB+ and AX+ trials. Thus X does not hold much predictive ability. In contrast when AB+ trials were presented in combination with B+ trials, participants were able to infer that A was not the cause of the outcome. Thus X holds more predictive ability in the AX+ trials.

The second main assumption of the propositional approach holds that propositions are generated and evaluated through non-automatic processes. Reviews of studies demonstrating automatic conditioning in the absence of awareness (Field, 2000; Lovibond & Shanks, 2002) convincingly contest the evidence for such learning. In addition there is much evidence that the effects of associative learning depend on non-automatic processes, such as awareness of events/relationships and the availability of cognitive resource.

Most studies of associative learning focus on the relationship between conditioned responding and contingency awareness. Such awareness of the relationship between stimuli is characterised as propositional knowledge. Thus the propositional approach predicts that learning depends on awareness of the output (propositional knowledge of the relation between stimuli) of the process that generates the propositional knowledge (De Houwer, 2009). This account also predicts that propositional knowledge can be evaluated only if one is aware of it, thus associative learning effects would depend on this awareness. Little convincing evidence has been reported for associative learning in the absence of contingency awareness, whereas evidence of the dependency of learning on such awareness is ubiquitous (see the previous section); therefore, De Houwer (2009) argues that there is strong support for the propositional approach.

Additionally De Houwer (2009) explains that awareness as a feature can refer, not only to the output of the process (contingency awareness), but also on the effect of the process on behaviour. Particularly awareness of the influence that propositional knowledge has on the elicitation of behavioural responses is not so clear when considering responses that are inherently implicit, such as physiological responses. The automaticity of a CR represented through implicit measures does suggest an associative link between stimuli that is not mediated by propositional reasoning. However, De Houwer (2009) and Mitchell et al. (2009) argue that this does not mean the learning process itself is automatic. "Weak" single process models of learning, as described by Lovibond and Shanks (2002), posit that elicitation of a CR can occur through propositional reasoning which then generates a response that is automatic. Thus the propositional account of associative learning can also account for examples where there is some dissociation between CR and awareness.

Regarding the impact of cognitive demand on associative learning effects, studies by Dawson and colleagues have shown that the impact of demanding secondary tasks reduces associative learning effects (Dawson, 1970; Dawson & Biferno, 1973). However, such findings are limited in distinguishing between associative and propositional accounts of learning, as even association formation processes can be deemed effortful. De Houwer and Beckers (2003) provide more selective evidence for a propositional explanation of such findings. In a forward blocking paradigm, when participants experience A+ and AX+ trials, it is likely that evaluating the X-US relationship requires a more effortful process that is required for the A-US relationship, as the latter only requires knowledge that the outcome is predicted by A. To evaluate the X-US relationship one must evaluate not only A+ and AX+ trials, but also take into consideration whether any additive outcome was predicted by the AX composite. Thus the propositional account predicts that cognitive demand should have a bigger impact on causal ratings for X, reducing the blocking effect, than it does for A. De Houwer and Beckers not only found evidence for this prediction, but actually found that causal ratings for X increased. This effect was interpreted in terms of the increased mental load interfering with the ability to infer that X was not the cause of

the outcome, thus causal ratings for X increased. In his review, De Houwer (2009) emphasises the difficulty in explaining this observation, that an increase in cognitive demand can increase the CR towards one cue but leave another unaffected, on the basis of association formation models.

Although the focus of this thesis is not to dissociate between link formation and propositional accounts of associative learning, it is an interesting concept to keep in mind when considering evidence for the resistance to extinction phenomenon and the factors that mediate it. Resistance to extinction is one phenomenon that supports dual-process models of associative learning because a lack of reduction in CR, once the predicted US is removed, suggests that the CR does not wholly depend on US expectancy/contingency awareness. As will be discussed in the next section, evidence for the prevalence of resistance to extinction within evaluative conditioning (EC) paradigms has led to a debate of whether EC represents an automatic form of learning that is qualitatively distinct from classical conditioning (CC).

1.2.2 Evidence of resistance to extinction in evaluative conditioning

In a review by Lovibond (2004) it was suggested that the majority of research in CC support the idea that the extinction process is reliant on changes in contingency beliefs. Little un-refuted evidence has been found for a separate, automatic learning mechanism, as is proposed by dual-process models. However, studies of EC suggest that associations can be learned through a 'simpler' system, which simply forms an associative link between representations of stimuli or events that have been paired in temporal contiguity. It is argued that EC qualitatively differs from CC, in three main characteristics:

1. EC can occur in absence of contingency awareness (see above).

2. Rather than expectancy or anticipatory responses (CC), EC results in learned affective response (i.e. like and dislike).

3. Once a CR is established in EC, that response is resistant to extinction training.

Based on these functional characteristics of EC, it has been proposed that EC and CC represent qualitatively different learning mechanisms.

Earlier, I suggested that evidence for learning in the absence of contingency awareness in EC is refuted based on limitations revealed in the reviews by Field (2000) and Lovibond and Shanks (2002). This section will review the evidence of resistance to extinction from the EC literature and will then be followed by a discussion of other possible explanations for the existence of this phenomenon. The implications this has on our understanding of the processes underlying associative learning are also discussed.

In a review by De Houwer, Baeyens and Field (2005) the importance of defining EC in terms of either an effect, a procedure, or a process is highlighted. Whether EC and CC represent two qualitatively distinct forms of learning is largely dependent on whether differences in their functional characteristics, such as extinction of the CR, are the result of different underlying learning processes or artefact of procedural differences. Although

procedurally similar to CC (they both involve CS-US pairings), EC paradigms typically differ in the type of US employed. USs in EC tend to be positive or negative in valence, but not motivationally relevant. In other words, unlike a shock stimulus typically used in CC, USs in EC studies are unlikely to provoke a motivational UR, such as anxiety or avoidance. The argument for use of less salient USs in EC studies has mainly been that such stimuli are less likely to heighten participant's awareness of the contingencies, thus allowing observations of 'true' EC.

Although EC is not considered to provoke motivational responses (such as anxiety or avoidance) EC paradigms are still important in terms of our understanding of fear learning, as fear itself can be conceptualised as an affective response. However, more important is the prevalence of resistance to extinction reported for evaluative/affective conditioned responses as opposed to the anticipatory responses acquired through traditional CC paradigms. Fear, disgust and dislike are all negatively valenced emotions that can provoke withdrawal/avoidance. If these affective responses are indeed resistant to extinction, or simply have a slower rate of extinction than anticipatory responses (e.g., de Jong, Vorage, & van den Hout, 2000; Hofmann et al., 2010), such responses might be linked to relapse of clinical fear/phobia following exposure treatment (Hermans et al., 2002; Olatunji, Forsyth, & Cherian, 2007).

Evidence of resistance to extinction

Levey and Martin (1987) proposed that "the evaluative response, once it is conditioned to a neutral stimulus, cannot thereafter be extinguished though nonreinforcement". This largely led to early investigations by Baeyens and colleagues, as to whether affective-evaluative responses were indeed resistant to extinction. Such findings then would support the idea that EC effects do not rely on US-expectancy, as in CC. A study by Baeyens, Crombez, Van den Bergh and Eelen (1988) used a EC picture-picture paradigm to explore whether previously neutral pictures can gain affective valence through contingent

pairings with liked/disliked pictures, and whether this affective valence would hold post extinction training. Evaluative self-report responses were taken at a baseline phase, which also enabled the researchers to determine which images would be used for the neutral (N) CSs, and the liked (L)/disliked (D) USs. The researchers then paired the N stimuli with either L or D stimuli, based on their perceptual similarity. The rational for this stimuli assignment method was based on Martin and Levey's (1978) demonstration that "similarity in form, content and colour palette" facilitates evaluative conditioning. During an acquisition phase the N-L, N-D and N-N pairings were each presented 10 times, in a random order that varied across participants. Post acquisition, a second block of affective-evaluative self-report scores were taken for each CS. Baeyens et al. were able to demonstrate the basic effects of EC through significant evaluation score changes, towards the CSs, in the direction of the affective stimuli with which they were paired. An extinction phase then followed in which the N CSs were presented again, for either 5 or 10 trials, in the absence of the affective USs. Affective-evaluative ratings were recorded again post extinction and no significant changes in affective ratings were observed regardless of whether 5 or 10 trials were implemented. Concerned as to whether this demonstration of resistance to extinction might have been due to demand awareness, Baeyens et al. conducted a follow-up study 2 months later in which affective ratings of the CSs were measured again. No significant change in affective ratings was found in the follow-up study either, enabling the assumption that resistance to extinction effects did not depend on demand awareness from the recency of the post-acquisition ratings.

Baeyens, Eelen, Van den Bergh and Crombez (1989) replicated the resistance to extinction effect in a similar EC picture-picture paradigm. Again stimuli pairings were matched based on perceptual similarity post baseline ratings. However, a possible artefact in this method of stimuli assignment was identified by Field and Davey (1997, 1999).

Field and Davey (1997, 1999) argued that the observed changes in liking shown in these experiments may have been artefact of pairing stimuli based on their perceptual similarity. Also, as participants selected their own CSs (through the baseline rating phase)

stimulus assignment was not counterbalanced across participants. Counterbalancing of the CS-US assignments is important to determine whether differential changes in response are due to the association that the CS has entered into and not simply artefact of properties intrinsic to a particular CS. Without between-subject controls, Field and Davey (1997, 1999) argued that it was not possible to demonstrate that the learning was associative.

Previous evidence had already supported this assessment. Shanks and Dickinson (1990) compared N-L and N-D pairings to a control procedure in which the pairings were not implemented. Instead the control included 10 presentations of the N slide alone followed by 10 successive presentations of it's 'paired' L or D slide. Shanks and Dickinson replicated the basic EC effect through the stimuli pairings condition, however they also found identical changes in response towards the N stimuli in the 'non-paired' control. The study by Field and Davey (1999) however, provides more convincing evidence of such artifactual EC effects. Considering that the control condition used by Shanks and Dickinson (1990) did not completely eliminate the possibility that participants could learn an association across 10 sequential CS presentations followed by 10 presentations of the US stimulus, Field and Davey (1999) used an improved control condition.

Field and Davey (1999) used a block/subblock control (BSB control) proposed by Field (1997). In this procedure CSs and USs were selected and assigned to a CS-US pair as in Baeyens et al.'s (1988) study. However, during the acquisition phase the stimuli were not presented in any contiguous or contingent pattern in the BSB control condition. Rather the stimuli are paired with themselves in half the number of trials, so that each appears the same number of times as in the conditioning condition. This method, along with use of the same inter-stimuli intervals and inter-trial intervals enabled exposure effects to be controlled for. For half the participants CS blocks (CS paired with itself) are presented first in a random order followed by random presentation of the US blocks (US paired with itself). For the remaining participants US blocks are presented before the CS blocks. Separating the CS and US blocks in this manner ensured that participants never

encountered a CS in contingency with the corresponding US, and randomising the order of the blocks ensured that participants would not be able to detect which CS and US were 'matched' together before presentation.

This BSB control met the criterion of an adequate control for association, proposed by Field and Davey (1998). However, additionally Field and Davey (1999) used a third, no-treatment condition, recommended by Field (1997). The no-treatment condition provided a comparison where all associations were eliminated, and the possibility that that effects are due to the selection procedure was controlled for by not exposing the participants to any stimuli during the conditioning stage. In combination these control conditions allow the researcher to dissociate effects that are due to exposure to the stimuli (BSB control), and effects that are due to the stimulus selection procedure and participant expectancies (no-treatment condition).

At the analysis stage Field and Davey (1999) also split CS-US pairings into those that were rated as perceptually similar and those that were rated as dissimilar, based on the judgments of independent raters. Having done this they found that the basic EC effects, demonstrated by Baeyens et al. (1988) were only replicated for perceptually similar CS-US pairs. Furthermore, conditioning-like effects were also found in the non-paired and no-treatment control groups. These findings strongly imply that, in the picture-picture paradigm used by Baeyens et al. (1988; 1989), perceptual similarity seems necessary to establish differential responding towards CSs in the N-L and N-D pairs. More importantly the observation of EC effects in both of the control conditions demonstrated that differential responding can be found even when participants receive no presentations of the stimuli. This finding implies that when images are matched on their perceptual similarity, differential responding may result not from associative processes or even the re-exposure to perceptually similar CSs and USs that are not related in a contiguous or contingent fashion. Differential responding may simply be artifact of the stimulus selection process itself.

Field & Davey (1999) suggested that a possible explanation for this finding is that, when making their initial evaluative ratings of the stimuli, participants would need to see many images before being able to form 'anchor points' as to what is most liked and what is most disliked. By the time they have created their anchor points, participants may have already rated some images as neutral that were actually closer to representing what they like or dislike. Thus on a subsequent rating phase participants might shift their original stimuli ratings to fall in line with these anchor points, regardless of any manipulations in stimuli pairings that occurred in the meantime. Consequently Field and Davey highlighted the importance of using BSB or no-treatment controls to ascertain whether EC effects are associative in nature, and thus cast doubt over the early findings of EC in the visual domain. Not only do their findings refute much early evidence of demonstrations of EC in the absence of awareness but they also explain why EC was found to be resistant to extinction. If changes in evaluation stem from the similarity between stimuli viewed in the stimulus selection process, rather than the contiguous CS-US pairing, then it is not surprising that removal of the US from the pairing in extinction training does not result in a further change in response.

However, since Baeyens and colleagues' early studies, there have been successful demonstrations of resistance to extinction in the EC picture-picture paradigm, using randomly assigned/fully counterbalanced stimuli pairings and/or between-subject controls, which rule out Field and Davey's criticisms. For example, De Houwer et al. (2000) demonstrated resistance to extinction in the visual paradigm using a within-subjects design and random assignment of CSs to USs. As in previous picture-picture paradigms participants first gave evaluative ratings from which CSs and USs were selected. However to avoid participants changing their affective ratings based on changes in anchor points during the initial rating phase, participants were presented with all the images prior to starting their evaluative ratings so that their judgements could be based on previously informed anchor points. Participants were then assigned to either a standard conditioning group or an extinction group. In the conditioning group participants were presented with seven presentations of eight CS-US pairs. Those in the extinction group experienced the

same acquisition procedure, however the CS-US pairs were immediately followed by five presentations of each CS on its own. An overall significant effect of EC was found. Additionally a comparison between the two groups showed no significant difference in EC effects, thus demonstrating resistance of the evaluative response to the extinction trials.

Although De Houwer et al. (2000) did not use the between-subjects non-paired control proposed by Field and Davey (1998), De Houwer et al. argued that a well designed within-subject experiment, using random or counterbalanced stimuli assignment, is equally sufficient in demonstrating the associative nature of the learnt CR. The within-subjects design also allows for more powerful comparison of effects whilst requiring fewer participants and is, therefore, more economical in terms of time and the number of participants required. However, De Houwer et al.'s study used only five extinction trials, which was less than the number of acquisition trials. It is perhaps no surprise then that resistance to extinction was found: perhaps there were simply too few extinction trials to extinguish the CR. In spite of this limitation, further support for resistance to extinction has come from studies using a between-subjects, BSB control (as recommended by Field & Davey, 1997) and larger numbers of extinction trials. Diaz et al. (2005) used Japanese letters as CSs and affectively liked/disliked words, selected from a study by Hermans and De Houwer (1994), as USs. CS-US pairs were assigned on a random basis and the CSs (Japanese letters) were counterbalanced across participants to control for affective differences, which might arise from the Japanese letters themselves. Along with the affective US pairs, a set of neutral words were also paired with Japanese letters to form the within-subjects N-N control. Most importantly to control for exposure and other non-associative effects, Diaz et al. used the BSB control group as outlined by Field and Davey (1998).

During acquisition, in the paired condition, each CS-US pair was presented 10 times with the addition of 4 CS-only trials. This reduction of the CS-US contingency to 71% was implemented to reduce contingency awareness. In the BSB control group each CS and US was paired with itself, 7 times for CSs and 5 times for USs, to control for exposure effects.

CSs and USs blocks were separated and pairs of stimuli presented in a random order. Half of the participants received the US block first whereas the other half received the CS block first. Affective ratings were taken pre-acquisition, post-acquisition and after an extinction phase. During this extinction phase CSs were presented in isolation for the same number of trials experienced during acquisition. Diaz et al. found significant EC effects post-acquisition, but only for the group that received the CS-US pairs, indicating that changes in response were indeed associative. They also demonstrated that using the same number of extinction trials, as presented during acquisition, did not result in a reduction in the acquired valence of the stimuli. Thus their data support the position that EC is resistant to extinction training.

In Experiment 2, Diaz et al. adapted their procedure by increasing the number of extinction trials and adding a post-extinction affective priming task, to account for two possible explanations of the resistance to extinction effect found in Experiment 1. The former adaptation was used to account for the possibility that extinction was not previously successful due to the partial reinforcement schedule used during acquisition. This was based on previous reports that larger numbers of extinction trials are needed to 'disconfirm' US-expectancy acquired through partial reinforcement (Rescorla, 1999). The latter adaptation was implemented to account for the possibility that the resistance to extinction effect was a result of demand awareness. As well as replicating the EC effects of Experiment 1, verbal ratings in Experiment 2 showed that increasing the number of extinction trials to 24 (10 more than acquisition) was not enough to cause significant reduction in acquired affect. Furthermore, significant differences in reaction times between congruent and incongruent trials in the affective priming task provided an implicit measure of stimulus affect, which was present post-extinction. All together this study provided a strong account of resistance to extinction in EC and supports that EC is a qualitatively distinct form of learning.

Field (2006b) also demonstrated EC of preferences in children, using neutral/novel cartoon characters as CSs and images of liked(ice cream)/disliked(Brussels sprouts) food

types as USs. Like Diaz et al. (2005), Field (2006b) also implemented the BSB control condition, and counterbalanced the CS-US pairings, so that non-associative explanations of EC effects could be ruled out. Additionally Field used a more rigorous extinction phase than De Houwer et al. (2000) by including as many CS-only trials in extinction as there were CS-US trials during extinction. This study provided additional support for resistance to extinction in EC by also demonstrating maintained affective ratings post-extinction in Experiment 1: after extinction trials the children still held higher positive ratings for the character that had been paired with the ice cream US, and negative ratings for the character that had been paired with Brussels sprouts. Like Diaz et al. (2005) the resistance to extinction effect was replicated in a second experiment, using affective priming as an implicit measure of awareness that is not subject to experimental demand (Field, 2006b).

Thus, using both verbal and implicit measures of affective ratings, there is un-refuted evidence that EC can be genuinely resistant to extinction. However, the meta analysis by Hofmann et al. (2010) demonstrated that unpaired CS presentations, during extinction, reduce the magnitude of EC. Thus it is still not clear whether one can assume that EC represents a distinct learning process to CC, on the basis of this evidence. It is possible that the rate of extinction is simply slower for EC than it is for CC. Referring back to the issue raised by De Houwer et al. (2005): that EC can be defined as a procedure, a process, or as an effect; evidence has been provided that explains the resistance to extinction phenomenon in terms of the type/time of measurement used. In other words there is argument to suggest that further procedural aspects of EC might be responsible for the resistance to extinction phenomenon rather than it representing a distinct form of learning (EC as a process).

1.2.3 Alternative explanations of the resistance to extinction phenomenon

As an effect, EC is typically measured using explicit self-report indices and implicit indices (e.g., affective priming) of stimulus affect. Primarily such measures of CR are used as EC is defined as a change in affective response. On the other hand, explicit measures of US expectancy, and implicit physiological measures of response (e.g., SCR), are typically implemented to account for CC effects. These measures are used because CC is defined as a form of expectancy learning, and CC paradigms tend to use USs that are motivationally relevant (i.e. they produce a motivational UR). Thus acquisition of a similar physiological response (CR) towards the CS implies associative learning (the CS acquires similar motivational relevance to the US), as does increased expectancy of the US.

Whether or not these different measures are deemed representative of qualitatively distinct learning mechanisms has largely been based on whether or not extinction of the CR is observed. In this section evidence will be reviewed that implies a distinction, between measures representative of expectancy learning and measures representative of affective learning, on the basis of their extinction effects. Observations that the former measures demonstrate extinction, whereas the latter types of measure do not, has led to the assumption that they reflect different learning processes which underlie expectancy and affective learning.

Across two similar experiments Hermans et al. (2002) demonstrated that effects of expectancy and affective learning could be measured concurrently in a differential CC paradigm using an electrocutaneous US. Differential conditioning, between a CS+ (100% US contingency) and CS- (no US contingency), was found for self-report measures taken post-conditioning of both US-expectancy and CS-affect. Additionally changes in affective ratings towards the CS+ (negative valence) and CS- (positive valence) were confirmed by an affective priming measure, thus supporting that changes in affective rating were not based on demand awareness.

However, the main aim of these experiments by Hermans et al. (2002) was to investigate whether extinction training would have a differential effect on indices of US-expectancy and acquired affect. After 8 extinction trials (the same number of acquisition trials were used), in which the CS+ and CS- were presented alone, further measures of US-expectancy and CS-affect were taken. In support of the co-occurrence of expectancy and affective learning, differential extinction effects were demonstrated across learning type.

The observed extinction of US-expectancy was unsurprising considering the CC nature of the paradigm, and that extinction effects are well documented in such paradigms. However, additional measures of CS-affect (evaluative ratings and affective priming) showed resistance to extinction: characteristic of EC. The differential extinction effects found, using different measures, were interpreted by Hermans et al. as indicative of the aforementioned separate learning mechanisms: expectancy learning being sensitive to extinction whereas affective learning is not. In addition, support was claimed for the concept that, although the CR is reduced through the extinction procedure in expectancy learning, the underlying association between stimuli remains (Rescorla, 1996). However, the authors did not assume that their results were evidence of qualitatively different learning processes. Instead, their observations are discussed at the effect level. It was suggested that differential extinction effects between such measures result from the way in which a learnt association is expressed, rather than how it is formed.

Other studies using a CC paradigm also suggest that the way in which differential conditioning is measured determines whether extinction is observed. To address the possibility that differential extinction is an effect of the paradigm used (EC vs. CC), as opposed to the underlying learning process, such studies concurrently measure indirect physiological responses (typical of the CC paradigm) and overt self-report indices of affect (typical of EC paradigms) within the same paradigm. However, as the USs used in EC are typically not salient enough to elicit a physiological response (such as SCR), the concurrent measure of physiological response (typically used to index CR in CC) is difficult within EC paradigms (Blechert et al., 2008; Vansteenwegen, Francken, Vervliet, De Clercq, & Eelen,

2006). Therefore, to date concurrent measurement of affective and expectancy learning have inclined to use the differential CC paradigm, as implemented by Hermans et al. (2002). Examples of such studies include those by Vansteenwegen and colleagues (Vansteenwegen, Crombez, Baeyens, & Eelen, 1998; Vansteenwegen et al., 2006).

In a first attempt to reconcile some of the criticisms regarding early evidence of resistance to extinction in EC, Vantseenwegen et al (1998) concurrently measured affective learning and expectancy learning in a differential conditioning procedure. However, due to concerns of the effect of demand awareness on verbal ratings in an expectancy learning paradigm, Vansteenwegen et al. (1998) attempted to find a non-verbal index for evaluative learning which could be measured alongside the typical non-verbal SCR measure of expectancy learning. Based on evidence from Vrana, Lang and colleagues (Vrana & Lang, 1990; Vrana, Spence, & Lang, 1988) the startle reflex was used to measure stimulus affect. Lang, Bradley and Cuthbert (1990) postulated that the startle reflex augments when the disposition of the organism matches the affective conditions of the reflex. Thus the startle reflex should diminish in the context of a positive stimulus because the activated disposition of the organism (participant) does not match the defensive nature of the reflex.

Vansteenwegen et al. (1998), observed the expected extinction of SCR and self-report measures of CS valence taken post-extinction indicated resistance to extinction (differential conditioned responding was still evident). However, against the predictions of the authors, extinction of the startle response was also observed. As more recent evidence suggests that the nature of the startle response is also dependant on the arousal generated by the stimulus (Cuthbert, Bradley, & Lang, 1996), the decreased arousal evidenced by the SCR measure during extinction may explain why no startle reflex was found at this point. As a result of this study the viability of startle response, as a comparable non-verbal measure of affective learning to SCR, is questionable. Measures of ERP however, often implemented in affective picture-processing research, could represent

a suitable alternative physiological measure of affective response that is not so dependant on arousal (a discussion of the advantages of ERP measures will follow).

Vansteenwegen and colleagues (Vansteenwegen, Francken, Vervliet, De Clercq, & Eelen, 2006) continued their investigation for evidence of differential extinction effects within the CC paradigm with an attempt to improve on both the studies by Vansteenwegen et al. (1998) and Hermans et al. (2002). Across two experiments Vantseenwegen et al. (2006) compared the effects of extinction on implicit measures of affective learning (affective priming) and expectancy learning (SCR). Improving on the account of resistance to extinction from affective priming measures provided by Hermans et al. (2002) in Experiment 1, an additional measure of affective priming was taken post-acquisition (for comparison with the post-extinction measure). Again evidence for extinction was observed from the SCR measure, but resistance to extinction was evidenced by faster reaction times to congruent (vs. incongruent) trials both after acquisition and extinction. Concerned that practice effects, as a result of participants performing the affective priming task twice, could have compromised the resistance to extinction effect, affective priming was measured only once in Experiment 2. A between-subjects design was employed with groups differing as to whether they experienced a prolonged acquisition phase (further reinforced trials), a control extinction phase (unreinforced new CSs), or a normal extinction phase (unreinforced CSs).

Crucially Vansteenwegen et al. (2006) demonstrated resistance to extinction as participants were faster to respond to congruent rather than incongruent trials, and this effect did not significantly differ with regard to group. Unexpectedly however, the prolonged acquisition group did not show evidence of affective learning from the affective priming measure: a possible result of habituation towards the US through the prolonged acquisition phase. Additionally there was some evidence of recovery of differential SCRs at the end of conditioning for the extinction group and, although differential US-expectancy was reduced post-extinction, in both studies differential US-expectancy was not completely extinguished. Therefore, even though these studies do provide some support

for resistance to extinction of EC within the same paradigm as CC, the results are uncertain.

Interpretation of these findings is largely in line with the premise that the different measures represent different learning processes. Indirect physiological measures represent expectancy learning whereas the self-report and affective priming measures represent affective learning. However, this conclusion is based largely on the fact that these measures are prototypical of the separate paradigms that have traditionally been used to investigate EC and CC, and on the differential extinction effects observed from these measures. But differences in the nature of these indices could also be responsible for the differential extinction effects observed.

Lipp et al. (2003) suggested that resistance to extinction in some cases can be the result of renewal effects due to contextual changes after extinction training. Renewal is the re-emergence of a CR, post-extinction, which can occur if the CS is presented in a different context to the extinction training (Bouton & Swartzentruber, 1991). Evidence that extinction is specific to the context under which it occurs (Bouton, 1994) implies that differential responding post-extinction training may represent renewal, due to a change in context, rather than resistance to extinction.

Additionally differences in the time of measurement (online vs. post-extinction) between indices of response could itself be responsible for differential extinction effects. Comparing verbal affective measures and SCR, within a differential CC procedure, Lipp et al. (2003) found extinction of affective ratings measured online during extinction training, which mirror the extinction effect observed for SCRs. Lipp et al. (2003) provide an alternative interpretation for extinction of affective ratings, when measured online, based on evidence from causal learning studies. In a series of experiments by Collins & Shanks (2002) time of measurement was demonstrated as a crucial factor in determining the development of causal judgements. In a contingency reversal paradigm, participants were exposed to 80 trials in which the causal relationships were reversed halfway through training. Cue contingency with the outcome was either inverted from .8 to -.8, or from -.8

to .8 halfway through the trials. Thus, over all the trials, the average contingency between the cue and the outcome was essentially zero. Participants were either asked to only make a causal judgment at the end of the training sequence, or after every 10 trials during training. Evidence from these experiments demonstrated that when asked to make a contingency judgement only once at the end of training, participants reported zero contingency. In other words their causal judgement seemed to reflect the average contingency across all experimental trials. However, if judgements were required on a frequent basis (i.e. every 10 trials) participants' causal judgements seemed to reflect the most recent experienced contingency. Lipp et al. (2003) suggest that participants asked to provide affective ratings post-extinction training, in their differential conditioning procedure, may have been performing in a similar manner. Rather than basing their ratings on their knowledge of the current contingency, participants base their post-hoc rating on an average assessment of stimulus valence, which is integrated over all contingency experiences throughout the experiment.

Lipp and Purkis (2006) provided further evidence that the same judgment strategies, which are dependant on time of measurement in causal learning studies (Collins & Shanks, 2002), are also reflected in both contingency judgements and affective ratings after contingency reversal and extinction training alike. In Experiment 1, Lipp and Purkis (2006) demonstrated the same effects of measurement frequency on contingency judgements, in a contingency reversal paradigm similar to Collins and Shanks (2002), whilst using stimuli more typical of an EC paradigm (USs were happy and angry faces). The pattern of results for valence ratings resembled those for contingency ratings: when ratings were only provided once post-training, valence ratings did not differ between the CS which was last contingent with the happy face and the CS which was last contingent with the angry face. Thus the authors conclude that this single judgement again reflects integration across contingencies. On the other hand, participants that provided frequent judgments throughout training rated the CS, which was contingent with the happy face in the first half, more positively than the CS contingent with the angry face, and visa versa when the

contingencies were reversed in the second half. Thus online ratings seemed to reflect the current CS-US contingency.

To determine whether the effects found in contingency reversal studies are relevant to explaining dissociations in extinction effects, Lipp and Purkis (2006) replaced the contingency reversal stage with extinction training in Experiment 2. The results confirmed the findings of Experiment 1 in an extinction procedure. Both affective ratings and contingency judgements were significantly different during acquisition, but differential responding vanished during extinction when measures were taken frequently. In the final test session, participants who had rated the CSs frequently during the experiment gave ratings and contingency judgements that reflected the last contingency. However, participants who had not rated the stimuli during the procedure, and for whom this was their only rating stage, integrated their judgements (contingency and affective ratings) in account of the entire experiment (evaluations reflected the acquisition phase).

A further interesting finding by Lipp and Purkis (2006) was that, across both experiments, participants were much faster to change their contingency judgements in response to either contingency reversal or extinction, than they were to change their affective ratings. Thus the authors conclude that although they provided evidence of extinction in affective learning, their findings are not altogether inconsistent with evaluative learning theory. In its strongest form theories of evaluative learning suggest that EC does not extinguish (Baeyens, Eelen, & Crombez, 1995) because it is driven by a referential system that does not rely on propositional knowledge that a US will follow a particular CS. Therefore, the difference between EC and CC is framed as qualitative not quantitative, forming a basis for dual-process models of associative learning (see earlier). The results provided by Lipp and Purkis (2006) clearly refute a qualitative difference between types of learning based on strong evidence that dissociations in extinction effects are the result of measurement time, as opposed to measurement type. Yet a weaker approach to evaluative learning theory, which posits that evaluative learning can extinguish but at a slower rate than

expectancy learning, would be consistent with these findings but does not suggest a necessary dissociation of the underlying learning processes.

In conclusion, Lipp and Purkis (2006) suggest that their results provide an alternative explanation for previous failures in finding extinction of evaluative learning, which relies on measurement time rather than dual-process models of human fear learning. However, Blechert et al. (2008) propose that extinction of affective learning found in studies by Lipp and colleagues (Lipp et al., 2003; Lipp & Purkis, 2006), may have been facilitated by the use of simple geometrical shapes as CSs. Referring to an account from De Houwer et al. (2005), that EC is more robust when using "stimuli that participants feel they can evaluate in an intuitive, spontaneous manner" (p.167), Blechert et al. claim that EC effects may not be observed when using very simple CSs. In support of this claim the authors draw attention to evidence of resistance to extinction in EC when faces are used as CSs (Hermans et al., 2002) as opposed to extinction of EC when simple shapes were used as CSs (Purkis, 2004). From such evidence Blechert et al. suggest that simple stimuli, which are familiar to the participant, might not be salient enough to promote 'true' evaluative learning. Therefore, using a similar differential CC paradigm to Lipp et al. (2003), Blechert et al. (2008) investigated whether online measures of stimulus valence would similarly extinguish when CSs comprised of complex stimuli (Rorschach pictures: images of symmetrical coloured inkblots). Additionally, similar to Lipp and Purkis (2006), Blechert et al. implemented both online, verbal measures of stimulus affect (EC) and US-expectancy (CC) whilst stressing the importance of comparing responses within the same domain (Lipp et al., 2003, compared a verbal measure of EC and a physiological measure of CC).

A physiological measure of CR (SCR) confirmed the acquisition and extinction of an expectancy response. However, the main interest of the study was whether online affective ratings would extinguish, and whether the rate of extinction would differ to the verbal measure of US-expectancy (taken post-extinction). Blechert et al. (2008) found resistance to extinction of online affective ratings. This finding contrasts the online extinction of affective ratings reported by Lipp et al. (2003). Thus Blechert et al. suggest

that their finding may represent 'true' EC, as a result of using more complex/salient CSs. Additional interest was provided by the post-hoc verbal measure of US-expectancy. Like the affective ratings, there was also evidence of resistance to extinction for the verbal measure of US-expectancy. This finding contrasts with Hermans et al. (2002) who found extinction of differential US-expectancy post-extinction training. Blechert et al. suggest this dissociation may have been due to differential use of instructed extinction. Hermans et al. (2002) explicitly informed participants that no more shocks would follow, before their extinction phase. Blechert et al. suggest that instructions might compete with participants' intuitive US-expectancy and thus heighten demand awareness, therefore they did not include instructions in their extinction phase. They conclude that without such instructions verbal affective and US-expectancy ratings follow a similar time course.

Overall the findings of Blechert et al. (2008) suggest dissociation in extinction effects between verbal and non-verbal measures of response. However, the demonstration of resistance to extinction in online affective ratings might be misleading. Blechert et al. (2008) draw attention towards conditioning of affective response within each CS type. The CS+ was rated more negative during acquisition but its valence returned to neutral after the extinction phase. The differential ratings during and after extinction actually seem to arise from an increase in positivity towards the CS- (the safety signal). Thus, differential affective response did not follow predictions of evaluative learning theory and the pattern of extinction for online affective ratings seemed to be more similar to those found by Lipp et al. (2003).

Blechert et al. (2008) highlight two main problems faced by most of the studies in this section, which have aimed to investigate the dissociation between EC and CC in terms of extinction. First, comparing measures along different domains (physiological and verbal) may result in differential extinction effects due to different time courses of extinction across these domains. Blechert et al. (2008) suggest that comparing EC by verbal indices and CC by physiological measures may be problematic because the electrodermal system may reflect a number of factors other than the predictive ability of a CS. The second

problem involves comparing verbal indices of EC and CC within a differential CC paradigm. De Houwer et al. (2005) refer to the possibility that different processes might underlie the associative learning effects obtained under the different conditioning paradigms. Thus in CC paradigms affective ratings might also reflect US-expectancies, whereas in EC paradigms ratings might represent automatic valence changes. Blechert et al. (2008) suggest that this last premise might explain why they did not find differential extinction rates between verbal measures of affect and expectancy.

To date, there is no evidence as to whether the effects of extinction, as indexed by a physiological measure, differ across visual EC and differential CC paradigms. This is in part due to problems in eliciting startle or SCRs within EC paradigms which do not employ overtly aversive/motivationally relevant USs. **The first aim of this thesis is to implement measures of the event-related brain potential (ERP), used in affective picture processing studies (see Olofsson, Nordin, Sequeira, & Polich, 2008, for a review), as an index of physiological affective response that could be implemented equally in EC and CC paradigms.** Recording ERP responses provides a temporally fine online index of CS processing both with and without contingent US pairings. The advantage of ERP measures over behavioural and cognitive (self-report) measures of CR is that it allows for 'covert' monitoring of online CS processing. Additionally, based on research within the affective picture processing literature, ERP is considered to be a suitable alternative to other physiological measures of affective response, such as SCR, and thus can be applied within EC paradigms (Wong, Bernat, Bunce, & Shevrin, 1997; Wong, Bernat, Snodgrass, & Shevrin, 2004). Comparison of acquisition and extinction of conditioned ERP response, across EC and CC paradigms would allow us to control for the effects of online measurement (e.g., Lipp et al., 2003; Lipp & Purkis, 2006); the time course of extinction in the physiological domain (e.g., Blechert et al., 2008) and indicate whether extinction of physiological responses (such as SCRs), in the previously mentioned CC studies, can be explained in terms of the procedural differences between EC and CC. A more detailed discussion of the advantages of ERP measures and their application in conditioning research is provided in Section 1.4 of this chapter.

1.3 The aetiology and maintenance of fear.

It is important to consider what we mean by 'fear' and 'anxiety' when considering how anxiety disorders, such as phobias, develop. Fear can be characterised as a response to a specific stimulus or threat, which in turn can result in avoidance behaviours and anxiety emotions that are directly orientated to those cues. Anxiety on the other hand can be characterised as an emotional state, which is related to a larger, more generalised set of cues and in turn leads to less functionally organised behaviours (Lang, Davis, & Ohman, 2000). This thesis focuses on models of 'fear' acquisition and extinction and as such the implications of findings within this thesis contribute more towards our understanding of specific fears and phobias, as opposed to the more generalised anxiety disorders.

Conditioning models have contributed a lot to our understanding of the aetiology and maintenance of fears and anxiety (Davey, 1997; Field, 2006b; Mineka & Zinbarg, 2006). Consequently these models inform the modes of intervention that are widely used in the treatment of anxiety disorders to this day (Öst, Svensson, Hellstrom, & Lindwall, 2001). As discussed in the overview of this chapter, observations of reduced CR through extinction training, along with evidence that the CR is a function of aversive outcome expectancies, have formed the basis for fear and anxiety interventions, such as exposure therapy and CBT (Wolpe, 1961). Thus factors that support resistance of the CR to extinction training, in human laboratory studies, may inform a great deal as to why fear persists in anxiety disorders, such as phobias (Field, 2006c); posttraumatic stress disorder (Blechert, Michael, Vriends, Margraf, & Wilhelm, 2007); panic disorder (Michael et al., 2007).

During this section I will discuss the ability of contemporary learning models to account for the development and maintenance of fear. Furthermore, factors that support the resistance to extinction phenomenon are explored with regards to their implications for models of selective associations. Finally the implications for treatment of phobias and other anxiety disorders are discussed.

1.3.1 Contemporary learning models of fear acquisition

Early conditioning models of fear acquisition have been criticised on the basis that not all traumatic experiences result in the development of an anxious response and that some phobic individuals cannot remember an aversive experience as the onset of their fear (Rachman, 1977). Additionally, Rachman (Rachman, 1968, 1977) observed that fears can be acquired indirectly (i.e. without experience of a direct conditioning episode) through verbal information and vicarious learning.

Evidence from retrospective recall studies has not only identified that some phobic individuals do not recall traumatic events in account of their fears (Davey, 1992a; Menzies & Clarke, 1993a, 1993b) but also that not all individuals who experience a traumatic event go on to develop a fear/phobia (Poulton & Menzies, 2002). Much of the early evidence for the aetiology of specific fears/phobias is retrospective in nature and as a result limited by possibilities of memory bias and forgetting (King, Eleonora, & Ollendick, 1998). However, this evidence still poses a problem for simple conditioning models of fear learning, which rely on direct traumatic experience.

Rachman's three-pathway theory of phobia onset (Rachman, 1968, 1977) suggests that, in addition to direct conditioning, fears can be learned through non-traumatic learning experience such as observational (vicarious) and instructional (information) learning. Early evidence for the role of modelling (observing another's fearful response) and information in the aetiology of fears and phobias largely came from retrospective studies where children or adults were required to assign their learning experience to one of Rachman's 3 pathways (King et al., 1998; Merckelbach, De Jong, Muris, & Van den Hout, 1996; Muris & Merckelbach, 2001; Öst & Hugdahl, 1981). In addition to identifying that not all fears are based on a direct learning experience, these studies also found reports of fear onset through verbal instruction and observational (vicarious) learning. Such studies are criticised for providing only retrospective accounts of fear onset, which might be prone to memory bias and forgetting (Field, Argyris, & Knowles, 2001; King et al., 1998). Additionally these retrospective reports tend to rely on questionnaires such as the Phobic

Origin Questionnaire (Öst & Hugdahl, 1981), which have been criticised for misattribution of the causal pathway by failing to identify components of the conditioning process (Menzies & Clarke, 1994). In combination, criticisms that not all traumatic experiences result in acquisition of a fear/phobia and that fears can develop through pathways other than a direct traumatic experience imply that conditioning models alone may be insufficient to explain the aetiology and maintenance of phobias.

However, contemporary models of fear learning, based on up to-date research, address many of the criticisms faced by earlier models (Davey, 1997; Field, 2006b; Mineka & Zinbarg, 2006). For example, the onset of fear without direct traumatic experience, and traumatic experiences that do not result in a fear response, can be explained through the concept of US revaluation (Davey, 1997; Field & Davey, 2001). Firstly, a CS-US association may be formed when evaluation of the US is not yet traumatic, but subsequent traumatic revaluation of that US could lead to a CR towards the original CS. Secondly, experience of a traumatic event might not lead to development of a fear response if the traumatic event is devalued post CS-US association. Field (2006b) also presents a conditioning framework that explains learning in the absence of a direct conditioning episode, such as through threat information (instruction) or vicarious learning. Experiencing another person's fearful reaction to a stimulus, or receiving threat information regarding that stimulus, can be conceptualised in conditioning terms in which the focus stimulus is the CS and either the fearful information, or the other person's reaction, is the US.

Evidence that another's fear response can act as a US has been provided in a series of experiments by Mineka & Cook (Mineka & Cook, 1993; Mineka, Davidson, Cook, & Keir, 1984) who demonstrated unconditioned fear responses (UR) in Monkeys when observing another Monkey's distress. Additionally, evidence of fear acquisition in the observer Monkeys, towards the target of the model Monkey's attention (snake), also suggests that observational conditioning follows similar mechanisms to CC. Olsson and Phelps (2004) directly compared fear acquisition through aversive conditioning, observation and information, in a human differential conditioning experiment. Participants in the

Pavlovian-learning group experienced the CS+ (one of two angry face images) paired with a shock stimulus, whereas the CS- was always presented alone (no information was given about the stimuli contingencies). Participants in the vicarious learning group received no shocks during the conditioning, however, having viewed a short video of the experiment in which another participant received a shock contingent with the CS+, participants were warned that they would receive a minimum of 1, maximum of 3, shocks following the same stimulus when they took part in the experiment. Participants in the instructed-learning group also received no contingent pairings of the CS+-US, but were shown the stimuli pre-conditioning and warned that minimum of 1, maximum of 3, shocks would follow the CS+ and no shocks would follow the CS- (stimuli were counterbalanced across participants). Comparable and significantly differential SCRs (between CS+ and CS-) were observed across all 3 types of learning. This comparable nature of the CRs suggests that both vicarious and instructional learning do indeed follow a similar framework to direct conditioning. The direct-conditioning and observational groups also showed significant differential SCRs on masked trials (CSs subliminally presented). However, the same differential response pattern was not observed towards masked stimuli in the instruction-only group. Olsson and Phelps (Olsson & Phelps, 2004, 2007) suggest that instructional learning may rely on a partially dissociated system to direct-conditioning and vicarious learning, which has evolved along with the emergence of language in humans and relies on initial representations in higher cortical areas that support conscious processes.

Additional non-retrospective studies support the proposition that fear can be evoked in children through verbal instruction and storytelling, contributing to the evidence for a direct pathway to fear through information (see Muris & Field, 2010, for a review). Studies by Field and colleagues demonstrated behavioural avoidance and increased fear beliefs, with both direct and indirect measures, when threat information was provided regarding either novel toy characters or animals (Field et al., 2001; Field & Lawson, 2003; Field, Lawson, & Banerjee, 2008). Physiological indices have also successfully been used to demonstrate an increase in fear response towards the CS following verbal information/instruction. Field & Schorah (2007) demonstrated increased heart rate

responses in children when approaching a box which they believed to contain an animal about which they had received threat information . The same effect was not seen when the children approached a box said to contain an animal about which they had received no information. In summary, there is a strong body of evidence supporting that threat information, can not only change fear beliefs, it can induce an implicit physiological fear response similar to that observed in direct conditioning and vicarious learning. Thus threat information itself can be conceptualised as the US of instructed learning, in a similar manner to another person's fear reaction in vicarious learning (Field, 2006b; also see Askew & Field, 2008 and Muris & Field, 2010 for respective reviews of the roles of modelling and verbal threat information in fear acquisition).

One potential problem with framing instructional learning in conditioning terms is that the fear information might not always provoke an UR itself. Without a fear provoking US one could argue that instructed fear learning cannot be explained in conditioning terms. Field (2006c) suggests that, because conditioning models can explain causal learning in which USs are not biologically relevant, it is plausible that a person can continuously learn through causal experiences in which a stimulus (CS) predicts threat information (US). Procedurally, such learning experiences are conditioning, because a stimulus is paired with an outcome. If these experiences result in the acquisition of beliefs/behaviours then this can be described as conditioning at the effect level too.

A further issue that early conditioning models struggled to explain is *the uneven distribution of fears*. The premise of equipotentiality (Pavlov, 1927; Thorndike, 1898) suggests that any predictor (CS) should be equally able to enter into an association with any particular outcome. Therefore one should be able to develop a fear/phobia of any stimulus depending on its association with a traumatic experience. However, the observation that the majority of clinical phobias are orientated towards a selective group of stimuli led to the concept of selective associations (LoLordo, 1979; LoLordo & Droungas, 1989), which challenged the equipotentiality premise of early conditioning models and drove forward Seligman's preparedness theory of phobias (Seligman, 1970, 1971).

Seligman made the connection between preparedness (the readiness of a stimulus to enter into an association with an aversive outcome) and an evolutionary aetiology based on the observation that most common phobias are directed towards objects of ecological importance to survival, such as dangerous animals (e.g., snakes and spiders), heights and water. The theory of biological preparedness was developed further by Öhman and Mineka (2001) who proposed an evolutionary module of fear learning in which fear is *selectively* and *automatically* activated by stimuli that are phylogenetically FR; elicitation of fear originates in an amygdala-centred, neural circuitry; such fear responses are impenetrable to cognitive control.

Evidence from a series of human CC studies, by Öhman and colleagues, has supported the idea that not only do phylogenetic FR stimuli (such as snakes and spiders) enter more rapidly into an aversive association with aversive USs than ontogenetic FR stimuli (such as guns and electrical outlets), but also such aversive associations are formed more readily under conditions of reduced awareness (subliminal presentations) when phylogenetic FR CSs are used (Öhman & Soares, 1993). However, the majority of support for the concept of preparedness has come from robust findings of resistance to extinction when CSs are classed as phylogenetically FR stimuli, rather than FI or ontogenetically FR (see McNally, 1987, for a review).

1.3.2 Resistance to extinction in human classical conditioning with fear-relevant stimuli

The biological preparedness explanation of selective associations

Observations that differential physiological responses can be acquired under conditions of reduced awareness (i.e. using backward masked CS presentation) towards phylogentic FR stimuli, and that such differential CRs are resistant to extinction, supports the concept of an automatic fear learning module, which less susceptible to cognitive control (Öhman & Mineka, 2001).

Using a between-subjects control procedure to control for sensitisation, Öhman, Eriksson and Olofsson, (1975) demonstrated that differential SCRs towards FR CSs were resistant to extinction after only a single conditioning trial. Alternatively, 5 conditioning trials were insufficient to support the same resistance to extinction effect for FI stimuli. Similarly, using a within-subject control procedure, Öhman, Fredrikson, Hugdahl and Rimmö (1976) demonstrated differential SCRs between the FR CS+ and CS-, which exceeded the differential responses for FI stimuli during extinction, though not during conditioning. Öhman et al. (1976) propose that similar rapid rates of conditioning for both FR and FI stimuli may be due to ceiling effects that obscure potential group differences. On the other hand, the differential rates of extinction between FR and FI stimuli were supported by a series of experiments by Öhman and colleagues (e.g. Fredrikson & Öhman, 1979; Hugdahl, Fredrikson, & Öhman, 1977; Öhman, Fredrikson, & Hugdahl, 1978). These findings do offer support for dual-process models of associative learning (described earlier), because differential CRs after extinction training for FR stimuli suggest that associations in this context are not reliant on expectancy of the aversive outcome.

The second aim of this thesis will explore the effect of phylogenetic fear relevance on the inhibition of extinction within both CC and EC paradigms. This thesis will explore

whether, similar to the findings of Öhman and colleagues, phylogenetic fear relevance supports resistance to extinction in CC when indexed by ERP measures of response. In addition, if EC represents a functionally different form of learning that does not rely on US-expectancy, resistance to extinction is expected irrespective of phylogenetic fear-relevance (see earlier discussion).

However, research by Dawson, Shell and colleagues (Dawson, Schell, & Banis, 1986; Schell, Dawson, & Marinkovic, 1991) has also found greater resistance to extinction for FR CSs on measures of US-expectancy (i.e., self-report), in addition to SCR, when employing a similar experimental design to Öhman and colleagues. Davey (1992b) also reports concurrent findings differential SCR and US-expectancies for FR stimuli after extinction training. Based on these findings Davey (1992b) proposed a generalised expectancy-based model of selective associations, which does not rely on explanations of evolutionary preparedness. Together, these findings suggest that the resistance to extinction phenomenon is not exclusive to EC paradigms or verbal measures of response (see earlier).

An expectancy bias model of selective associations

Davey (1995) argued that cognitive bias models of fear conditioning can explain most phenomena normally associated with biological preparedness. Although there is compelling evidence from both human (Mineka, 1985; Öhman & Mineka, 2001) and primate studies (M. Cook & Mineka, 1989, 1990) for selective aversive associations with phylogenetically FR stimuli, Davey presents evidence for how the evolutionary predisposition explanation could misrepresent what might simply be explained in terms of information processing biases.

Some of the best human lab evidence for biological preparedness comes from studies that demonstrate superior resistance to extinction for FR phylogenetic over ontogenetic stimuli (E. W. Cook, Hodes, & Lang, 1986; Hugdahl & Karker, 1981). However, Davey

(1992b) points out that lacking comparison between the FI (control) and ontogenetic FR stimuli (E. W. Cook, Hodes, & Lang, 1986) or comparisons of extinction rates between the groups (Hugdahl & Karker, 1981), it is not possible to test whether the differences in resistance to extinction are the result of selection pressures, as the preparedness theory would predict. Other explanations for superior resistance to extinction include that the orientation of the CS, and the type of aversive outcome with which it is paired, accentuate resistance to extinction of the CR. Hugdahl and Johnsen (1989) demonstrated superior resistance to extinction when either a gun pointing towards the participant (CS1) was followed by a loud noise (US1), or a snake facing the participant (CS2) was followed by an electric shock (US2). Different combinations of these stimuli, or presentation of the CSs orientated away from the participant, resulted in higher extinction rates. Hamm, Vaitl & Lang (1989) made similar findings of differential resistance to extinction based on the 'belongingness' of CS-US pairs. Using CS-US pairs that had been independently rated as high (e.g., angry face-human scream) or low (e.g., landscape-scream) in perceived belongingness, participants demonstrated superior acquisition and resistance to extinction of conditioned finger-pulse response towards the 'high belongingness' slide. Additionally, the presence of the high belongingness slide in a compound stimulus, in which a coloured background was the discriminant predictor of the US, inhibited differential finger-pulse and skin conductance responding. Thus Hamm, et al. (1989) provide an explanation for selective associations in terms of the semiotic similarity between the CS and US, as opposed to a genetic predisposition to fear a particular CS.

Davey's (1997) conditioning model of phobias explains selective associations and the uneven distribution of fears by incorporating inferred processes, thus advancing on traditional behavioural contiguity models. It is inferred that the learnt association between the CS and US mediates the observed CR (Rescorla, 1980). Thus Davey suggests that processes that influence the strength of that association also would influence the strength of the CR. Other than just experiencing contingent CS-US pairings, other factors influence the strength of the CS-US association. These factors include: verbally and culturally transmitted information regarding the contingency between the CS and US

(Dawson & Grings, 1968); prior existing beliefs/expectancies about the possible consequences associated with the CS (Davey, 1992a; Honeybourne, Matchett, & Davey, 1993) and current emotional reactions elicited by the CS (Davey & Dixon, 1996; Diamond, Matchett, & Davey, 1995). In Davey's (1997) model these factors are referred to as 'Expectancy Evaluations'. Such information processing-factors are also described in a contemporary learning model proposed by Mineka and Zinbarg (2006), additionally Field (2006c) describes how verbal information alone can lead to the acquisition of a CS-US association as opposed to simply aiding acquisition through direct experience of a CS-US contingency.

Davey (1995) outlines evidence that an a priori expectancy bias, mediated by such 'expectancy evaluations', can lead to a covariation bias that is evidently important in determining selective associations. Tomarken, Mineka & Cook (1989) demonstrated overestimation of the contingencies between FR stimuli and aversive outcomes, in a randomly reinforced paradigm. Although this covariation bias seemed only to occur for phylogenetically FR stimuli, it was reported that initial fear towards the stimulus was an important factor in determining the covariation bias when the aversive outcome contingency was low. Diamond, et al. (1995) also found a covariation bias for phylogenetic stimuli but only when prior fear was high. These findings suggest that prior fear is the important factor in maintaining expectancy bias, not simply that the CS is phylogenetically FR. Davey proposes that if prior fear is important in determining the covariation bias, then the reason why it is exhibited only for phylogenetic stimuli may result from such stimuli (e.g., snakes and spiders) being highly feared in Western cultures. This explanation still poses the question as to why these phylogenetic FR stimuli are more generally feared than ontogenetic stimuli.

As described above, evidence for a main effect of learning fear through information rules out the need for experiencing trauma, and in this sense represents an adaptive, low risk, form of learning (Olsson & Phelps, 2007). However, the development of specific and persistent phobias may still be reliant on an interaction between negative information and

a direct traumatic experience. It is possible that culturally and verbally transmitted information, defined as an expectancy evaluation factor in Davey's (1997) conditioning model of phobias, may contribute to high fear towards specific stimuli within specific cultures. Consequently, fear that stems from culturally shared information regarding certain stimuli may help to determine a covariation bias, which could explain selective aversive associations towards that group of stimuli. Thus Davey's expectancy bias model (1995) would predict selective associations, in the form of superior conditioning and resistance to extinction, towards both stimuli that are already commonly feared in a specific culture and novel/neutral stimuli for which threat information is provided.

Evidence for an interaction between threat information and direct conditioning experience on enhanced avoidance behaviour in children has been demonstrated by Field and Storksen-Coulson (2007). Children developed comparative fear beliefs and avoidance response as a result of either threat information or a direct negative experience alone; yet in combination these pathways led to significantly higher avoidance responses. Most important, the fear beliefs created by the verbal information moderated the change in behaviour created by the negative experience. This moderation effect supports Davey's expectancy model (Davey, 1995; 1997): that verbal threat information can create aversive outcome expectancies, which interact with direct conditioning experience to accentuate the fear response. This observation does not rule out the possibility that a CR can be learnt through information alone, but does provide an alternative explanation to biological preparedness for why certain stimuli may be resistant to extinction training.

The third aim of this thesis is to investigate whether verbal threat information and direct aversive conditioning experiences also interact to heighten fear beliefs and physiological responses (EPR) and produce resistance to extinction. Of particular interest is whether fear-relevancy effects can be manipulated through verbal threat information to induce heightened fear-beliefs, and in turn whether verbal information and conditioning would interact to maintain the physiological ERP response through extinction in support of Davey's expectancy-bias model (Davey, 1995, 1997).

1.3.3 Implications for prevention and intervention in clinical fear/phobia

Prevention

Research that investigates pathways to fear is important for understanding fear prevention strategies (Field, 2006c). If fear can be acquired through simply observing the fear of others (Askew & Field, 2008) or through threat information about particular stimuli/situations (Muris & Field, 2010), then there is potential for prevention of unnecessary fear acquisition through controlled verbal information and modelling, especially in the parent-child context. By reducing the amount of negative/threat information provided to children about particular stimuli/situations, and controlling the amount of personally expressed fear in response to particular stimuli, parents may be able to reduce the number of aversive learning experiences their child encounters and potentially prevent specific anxieties from developing. Additionally, expectancy-bias models of fear acquisition (Davey, 1995) suggest that verbally/culturally shared information can heighten outcome expectancies, which are evidently important in maintaining CRs acquired through further conditioning experience. As such, positive expectancies (e.g., those induced by verbal information) should inhibit the CS-US association formed during a directly negative conditioning experience. Such observations highlight the importance of implementing positive learning experiences (such as positive information) as a prevention of aversive outcome expectancies, which may heighten the chance of developing a persistent phobia (that is resistant to extinction/exposure therapy).

Interventions

Behavioural treatments for anxiety disorders have largely been based on learning theory, with the extinction process in classical conditioning studies offering a 'mini-model' of exposure therapy (Zinbarg, 1993). Therefore, research that investigates the mechanisms

underlying extinction in classical conditioning can offer further understanding of the mechanisms that underlie exposure therapy. The scientific basis of exposure therapy is praised as one of it's strengths, whereas early cognitive therapies have been criticised for focusing on therapy targets (e.g., negative images and thought patterns) rather than therapy procedures based on an experimental background (Clark, 2004). Consequently Clark (2004) stresses the need for research that constructs a theoretical account of maintaining factors in anxiety disorders; tests these factors empirically; develops and tests the efficacy of treatments designed to reverse these maintenance factors. The success of this research strategy, in the development of effective cognitive therapy (CT) programmes, is evident from studies which have shown superior efficacy of the CT programmes in comparison to longer established behavioural and pharmacological treatments (Clark et al., 2006; Clark et al., 2003). Evidently, cognitive factors that promote the maintenance of CRs through extinction training may further inform cognitive-behavioural treatment strategies aimed at reversing these maintenance factors and improve on existing exposure therapies.

The propositional account of associative learning discussed earlier in this chapter (De Houwer, 2009; Mitchell et al., 2009) suggests that all associations formed through direct conditioning experiences are propositional in nature. If this is the case, it is perhaps predictable that cognitive interventions might have as much, or even more, effect than behavioural interventions in reducing fear responses. Zinbarg (1993) explains how information processing models of classical conditioning, such as the standard operating procedures (SOP) model proposed by Wagner (Wagner, 1976, 1978, 1981), blur the boundaries between traditional behaviour therapy based on conditioning paradigms, and the techniques/principles associated with cognitive therapies.

The SOP model emphasises mechanisms of memory and rehearsal in associative learning, and was partly developed to account for blocking effects (see propositional account of associative learning, described earlier). However, in Zinbarg's (1993) review empirical support for several of the SOP model predictions is presented. In particular, learning of a

new CS-US association during extinction should depend on capacity for rehearsal of the stimuli pairing in the short-term memory. In a differential conditioning study, Merckelbach, Van Hout, De Jong and Van den Hout (1990) explored the allocation of limited-capacity cognitive processing during extinction training. Merckelbach et al. (1990) found that performance on a secondary reaction time (RT) task, in addition to CS+ and CS- presentations during extinction, was significantly impaired on CS+ trials. These results suggest that omission of an expected US (on CS+ extinction trials) makes a greater demand on limited-capacity processing resources than the expected omission of the US (on CS- trials). Thus the prediction of the SOP model is supported. Additional learning after a differential conditioning episode seems to require the resource of limited-capacity processing, such as rehearsal in the working memory. This implies that behaviour therapy, such as exposure, may not be distinguishable from cognitive therapies in terms of underlying associative mechanisms. Instead, behavioural changes observed as a result of conditioning based procedures may be the result of changes in the cognitive representations of affective stimuli and their relationships. It is perhaps unsurprising then that Clark and colleagues have found evidence for the efficacy of cognitive therapies for several anxiety disorders including panic, hypochondriasis, social phobia and posttraumatic stress disorder (Clark, 2004). Additionally, on comparison to some behavioural and pharmacological interventions, cognitive interventions have demonstrated greater impact on measures of anxiety disorders, such as social phobia (Clark et al., 2006; Clark et al., 2003). The efficacy of information alone in reducing fear beliefs (Kelly, Barker, Field, Wilson, & Reynolds, 2010), and the efficacy of cognitive therapies for anxiety, support a propositional explanation of associative fear learning (De Houwer, 2009; Mitchell, et al., 2009) and imply that reasoning processes are involved in the reduction of the fear response.

As discussed earlier, there is substantial evidence that fear acquisition can follow three pathways: direct conditioning experience, vicarious learning, verbal threat information (Rachman, 1977). Field & Storksen-Coulson (2007) demonstrated that that these pathways can interact (specifically verbal information and experience) to heighten avoidance

behaviour, one of the response systems (subjective/cognitive, behavioural, physiological) identified in Lang's (1978) tripartite model of fear. Kelly, Barker, Field, Wilson & Reynolds (2010) stress the importance of research investigating whether fear can be *un-learned* through the same pathways through which it is learnt.

Kelly et al. (2010) provide evidence that a CR can be acquired and extinguished through separate pathways. In this study Kelly et al. demonstrated heightened fear beliefs and behavioural avoidance towards a novel animal (the CS) that had been paired with threat information (also see Field & Lawson, 2003). However, through subsequent positive information about the CS, provided either verbally (instructional learning) or by modelling (vicarious learning), behavioural avoidance of the CS was significantly reduced. However, verbal information was more efficient than modelling in reducing fear beliefs. One possible explanation for the reduced efficacy of the modelling intervention was the difference between the pathway to fear (the threat information) and the intervention pathway (observational). Kelly et al. suggest that reduction of fear beliefs learnt along a particular pathway might be more efficient when fear is unlearnt along a similar pathway. Thus they highlight the importance of investigating other pathways to fear, and the combination of these pathways in reducing fear responses. Another possible explanation of the differential efficacy in reducing fear-beliefs, between verbal information and modelling interventions, is simply that positive verbal information is a more efficient method for reducing the subjective/cognitive module of the fear response. Evidently, the efficacy of these pathways in reducing fear along all three response systems: cognitive, behavioural and physiological (Lang, 1978), needs further investigation. If positive information/instruction alone, or in combination with the other pathways, is superior in reducing fear response, this would have important implications for the role of information in counteracting associations formed through direct negative experience.

As such, research investigating which pathways successfully reduce fear, and what components of the fear response are reduced, is important in understanding modes of intervention (Davis & Ollendick, 2005). Models of associative learning (Rescorla & Wagner,

1972) suggest that fear is reduced by weakening the association between the stimulus (CS) and the aversive outcome (US). Typically in extinction training this is achieved by reducing the contingency between the CS and the US. Bouton (2002) stresses that extinction training does not cause 'un-learning' of the original CS-US association, but that new learning occurs. A new association is formed between the CS and no aversive outcome, which weakens the *overall* association between the CS and the US. However, Bouton also describes how the second learning experience can lead to ambiguity of the CS signal (the CS can predict either the occurrence, or lack, of the US). As a result contextual cues may be used to predict which outcome is more likely: occurrence or no-occurrence of the US. Either presence of contextual cues experienced during conditioning, or lack of contextual cues experienced during extinction, could potentially lead to a relapse in conditioned responding. Although this account of extinction presents a pretty grim outlook for therapies based on extinction training, Bouton (2002) suggests that the concept of CS signal ambiguity calls for treatment methods that promote ubiquitous retrieval of the 'no US' signal. One possibility, suggested by Field (2006c), predicts that 'quick intervention' (i.e. following up bad experiences with good ones) would be important in weakening the original association between the stimulus and the bad outcome, to reduce anxiety. Field (2006c) also suggests that information (in instructional learning) and another's reaction (in vicarious learning) can act as USs (see earlier). It is plausible that, following a direct CS-US experience, a new CS-positive information association could potentially reduce a fear response by weakening the previous association that had been learnt. Equally, if combined threat information and direct experience magnify a fear response in comparison to either pathway alone (e.g., Field & Storksen-Coulson, 2007), potentially this combination of pathways might have a superior effect in *reducing* the fear response.

The fourth aim of this thesis is, therefore, to investigate whether positive verbal information, presented post aversive conditioning, has an equal or superior effect in reducing CRs to extinction training alone. Effects of positive verbal information and

extinction training will be indexed for both measures of fear-beliefs and ERP, to account for both cognitive and physiological modules of the fear-response.

1.4 Event-related brain potential (ERP) indices of conditioned response

1.4.1 Introduction to the ERP technique

One of the aims of this thesis is the use of event-related potentials (ERP) taken from the electroencephalogram (EEG) as a methodological tool for identifying changes in affective response within the conditioning paradigm. This technique, widely used in the fields of cognitive neuroscience and neuropsychology, involves recording continuous EEG activity from electrodes placed on the participants scalp during a cognitive task; amplifying the signal and plotting changes in voltage across time (Handy, 2005; Luck, 2005). The EEG signal represents a combination of many exogenous and endogenous sources of activity making it difficult to isolate individual neuro-cognitive processes (Luck, 2005). However, ERP waveforms represent 'time-locked' neural responses based on sensory, cognitive or motor events, which can be extracted from the EEG signal using a simple averaging technique. These waveforms consist of a sequence of voltage deflections that are generally labelled according to their polarity (P for positive and N for negative) and latency (approximate time of occurrence in milliseconds) or temporal order (P1: first positive peak, N1: first negative peak, P2: second positive peak).

ERPs have successfully been used to study both aspects of response to external and internal events, and though ERP does not allow the amount of spatial resolution achieved with MRI and PET, its main advantage is a high temporal resolution, which reveals momentary changes in patterns of brain activation often on a millisecond-by-millisecond basis (Key, Dove, & Maguire, 2005).

Additional advantages of the ERP technique over behavioural measures include:

1. The implicit and continuous measurement of the cognitive process, between a stimulus and a response, allows for the investigation of all putative stages of processing that are affected by an experimental manipulation. Overt behavioural measures, on the other hand, can only reflect the summation of several individual cognitive processes (from early perceptual processing to decision making), making it difficult to attribute variations in reaction time (RT) and accuracy to specific cognitive processes.

2. The online measure of stimuli processing in the absence of a behavioural response allows 'covert' monitoring of the online processing of information (Luck, 2005).

However, some disadvantages of ERP in comparison to behavioural measures are that it is harder to ascertain the functional significance of an ERP response, and a large number of trials (often 50 to 100) is required to gain an accurate measurement for a particular event due to the large amount of variance across single trials. This in itself is restricting to study design because experiments can become 'long winded' resulting in factors such as habituation to the stimuli and fatigue. Additionally, the cost of averaging response across trials meaning that any longitudinal variance in ERP latency or amplitude is traditionally lost (Hu, Mouraux, Hu, & Iannetti, 2010).

1.4.2 Stimulus affect modulations of the ERP response

Over the next two sections I will discuss component modulation of the ERP response within the domains of affective picture processing and affective learning research.

ERP in the affective picture processing domain

Affective picture processing research has shown that the physiological measure of the ERP response is influenced by the affective stimulus properties of valence and arousal (see Olofsson et al., 2008, for a review). Factors of stimulus affect generally seem to modulate ERP component amplitude, with inconsistent observations of peak latency modulation. Modulations of waveform amplitude have been observed, as early as 100ms post stimulus onset for stimulus valence and there is some evidence for larger P1 (first positive deflection, dominant at posterior sites) amplitudes towards unpleasant images as opposed to images of pleasant and neutral valence (e.g. Carretie, Hinojosa, Martin-Loeches, Mercado, & Tapia, 2004; Carretie, Mercado, Hinojosa, Martin-Loeches, & Sotillo, 2004; Smith, Cacioppo, Larsen, & Chartrand, 2003). Larger P1 responses for unpleasant valence images are consistent with the premise of a processing system that is sensitive towards unpleasant/fear-relevant stimuli (LeDoux, 1995; Öhman & Mineka, 2001).

An 'early posterior negativity' (EPN) is also reported for arousing as opposed to neutral stimuli. The EPN is characterised by N1 and N2 components (150-350 ms post stimulus onset) in the posterior occipitotemporal region (Astikainen & Hietanen, 2009), which has been related to early encoding of affectively and motivationally significant, visual stimuli (Schupp et al., 2007). Superior effects of high-arousing unpleasant images have been demonstrated by resistance to habituation of the N1 component, by Carretie, Hinojosa and Mercado (2003), in comparison to high-arousing pleasant or low-arousing neutral images. Additionally overall effects of arousal (high arousing-positive and high arousing-negative images > low arousing-neutral images) modulate both N1 and N2 amplitude

(Schupp, Junghofer, Weike, & Hamm, 2003) indicating that the EPN indexes a bias in 'natural selective attention' towards affectively arousing stimuli.

Later components, including the P2, P3 components and the late positive potential (LP), show bilateral differences between unpleasant and pleasant affective stimuli (e.g. Bernat, Bunce, & Shevrin, 2001) but effects within (or beyond) the P300 range of waveforms are more likely to vary according to task relevance (Olofsson et al., 2008). In summary, the exogenous or stimulus-driven responses resulting from factors of stimulus valence are mainly documented during the range of ERP response approximately 100-300 ms post stimulus onset. These valence effects seem to be associated with selective attention processes that are influenced by a 'negativity bias'. Arousal effects on the other hand seem to elicit consistent modulation of waveforms from 200 ms onwards (Olofsson et al., 2008).

ERP in the affective learning domain

Based on modulations of the ERP response observed in affective picture processing research, ERP seems a suitable index of change in stimulus affect/arousal through associative learning. ERP has been used as a measure of non-conscious CR in studies by Wong and colleagues (Wong, Bernat, Bunce, & Shevrin, 1997; Wong, Bernat, Snodgrass, & Shevrin, 2004). In a differential conditioning paradigm, ERP response was measured towards subthreshold CS+/CS- presentations during conditioning and suprathreshold CS+/CS- presentations during pre-conditioning and post-conditioning phases. Differential CS response was compared within phase (with the exception of a pre-post conditioning phase comparison: Wong et al., 1997). These studies focused on modulation of the P3 component, as an index of stimulus salience (e.g. Begleiter, Porjesz, Chou, & Aunon, 1983) in the supraliminal pre/post conditioning phases. Additionally earlier components, such as the N1 and P2 components, were selected on the basis that differences in activity on such components have been demonstrated in relation to attentional processes towards suprathreshold stimuli (e.g. Naatanen, 1990). N1 and P2 component activity was also

investigated within the subthreshold conditioning phase, as differential activity have previously been observed on these components towards subthreshold stimuli (Shevrin, 1973).

Wong et al. (1997) found a significant reduction in P3 amplitude activity associated with the CS-, from pre-conditioning to post-conditioning, whereas no change was observed towards the CS+. This finding supports the modulation of P3 amplitude as a function of the subthreshold conditioning manipulation. Significant differential amplitude responses were also observed, post-conditioning, for the N1 component (CS+ < CS-) and the P2 component (CS+ > CS-), but not during pre-conditioning. Wong et al. thus concluded that the subthreshold conditioning phase successfully manipulated differential responding between the CS+ and CS- so that differences in P3, N1 and P2 amplitudes could be observed in the post-conditioning phase. Effects were strongest at Pz (posterior/parietal) and Cz (central) sites and no effects on ERP component peak latency were observed, consistent with observations that stimulus affect generally modulates component amplitude (Olofsson et al., 2008).

Analysis of ERP component amplitudes within the subthreshold conditioning phase (Wong et al., 1997) revealed significantly higher N1 negativity and higher P2 positivity towards the CS+ in comparison to the CS- (CS+ > CS-). A similar trend of differential P3 modulation was also observed, during conditioning, but this effect was not significant. Though different levels of CS presentation did not allow for cross-phase comparison including the conditioning phase, these results do support the efficacy of ERP measures of affect modulation within a differential conditioning paradigm. However, Wong et al. (1997) did not counterbalance their stimuli assignments, and using an un-pleasant face as the CS+ in comparison to a pleasant face as the CS-, the effects observed may be the result of a salience/fear-relevance effect rather than CS-US contingency.

A more stringent study by Wong et al. (2004), using a fully factorial design and only negatively valenced words for CSs, factored out stimulus valence/assignment as possible explanations of differential response. Based on findings by Bernat et al. (2001), that larger

amplitude positivity towards unpleasant affective words is demonstrated across P1, N1, P2, P3 and LP components (thus N1 amplitude was in fact smaller towards unpleasant words), Wong et al. 2004 included measures of all these components within conditioning and post-conditioning phases. Focussing mainly on activity recorded from posterior/parietal electrodes they found differential modulation of early (P1 and P2) and late (P3 and LP) components, between the CS+ and CS-, within the post-conditioning phase. In line with observations of valence effects reported by Bernat et al. (2001), these findings suggest that stimulus affect, acquired through differential conditioning, reliably mediates amplitude response of the P1, P2, P3 and LP components. Similar to Wong et al. (1997), no cross phase analysis was conducted due to differences in CS presentation thresholds between conditioning and pre/post conditioning phases. Although the authors argue that (due to their fully-factorial design) differential CS+/CS- response within the post-conditioning phase was sufficient evidence of associative learning, cross-phase analysis is desirable as it allows one to account for separate effects of CR acquisition and extinction.

Advantages of ERP indices of conditioned response

Based on research within the affective picture processing and associative learning domains, ERP is deemed a suitable and interesting alternative to other physiological measures of response (e.g., SCR) commonly used in differential conditioning paradigms. Not only can the measure be taken online, during the experimental training phases, but evidence also suggests ERP can be used as physiological measure of implicit affect, making it a suitable alternative to implicit behavioural measures of affect (e.g., affective priming tasks). In this thesis ERP indices allow for an online physiological measure of response within both EC and CC paradigms. Thus we can control for the effects of online measurement (see Lipp et al., 2003; Lipp & Purkis, 2006) and the time course of extinction in the physiological domain (see Blechert et al., 2008; Lipp et al., 2003), as possible explanations of extinction found using other physiological measures (e.g., SCR) in CC

paradigms (see earlier). However a potential draw back of the ERP index of response in the current context may come from the need to aggregate across a large number of EEG trials when calculating the average ERP response (Luck, 2005). The averaging process may have a similar effect to using single, post-hoc measures on affect and contingency judgments (cf. Collins & Shanks, 2002; Lipp et al., 2003). As discussed earlier, differential extinction effects can be explained in terms of the contingency judgement strategies used when measurements are taken frequently, during contingency training, as opposed to once, post-hoc training. An averaged ERP response would also reflect an average of implicit judgements across all trials within each experimental phase. However, one would still expect to observe a differential average response, depending on conditions of US contingency and fear-relevance, within experimental phase as demonstrated by Wong et al. (1997; 2004).

ERP also represents an interesting alternative to other physiological measures of response, such as SCR and startle modulation, which seem to be associated with the expectancy of a salient event, i.e., the US (Vansteenwegen et al., 1998). However, unlike measures of SCR, it is not possible to track changes in response across trials with standard ERP data treatment, simply due to the variability within single trials. However the analysis of single trial data in ERP research is an emerging field with new analytical techniques arising from the need to access information concerning across-trial variability of ERP latencies and amplitudes (Blankertz, Lemm, Treder, Haufe, & Muller, 2010; Hu et al., 2010). The development of such methods is promising for future applications of the ERP technique in associative learning research, as it would open the possibility for tracking rates of acquisition and extinction within the learning paradigm.

1.4.3 Design, analysis and interpretation of ERP effects within this thesis

General issues regarding experimental design

As discussed earlier, 50 to 100 trials are normally required to gain an accurate measurement of ERP response for a particular event, due to the large amount of variance across single trials (Luck, 2005). Therefore, to reduce participant fatigue within experimental phase, we deemed it important to keep CS presentation times relatively short (500 ms) during baseline (pre-conditioning), conditioning and extinction (post-conditioning) phases, thus reducing the duration of the experimental procedure. Additionally each phase was broken down into blocks of trials allowing participants rest time within the experimental procedure.

100 trials, for each CS, were deemed sufficient for calculating the average ERP response within each phase. This created an allowance of up to 50 trials to be rejected based on various artefacts within the EEG recording. Participants with large amounts of artefact noise within their EEG recording, resulting in the rejection of more than 50 trials for any particular CS, were excluded from the analysis.

Component analysis

Similar to the experimental design used by Wong and colleagues (1997; 2004) initial studies within this thesis implemented three ERP recording phases: baseline, conditioning and extinction. An online measure of contingency awareness is included during conditioning, by means of a US prediction task, based on the recommendations of Lovibond and Shanks (2002; also see Purkis & Lipp, 2001) regarding measure sensitivity (see earlier). To extend the analyses of Wong et al. (1997; 2004) ERP responses will be compared both within- and across-phase, to dissociate between effects of acquisition and extinction of the CR, and designs are fully-factorial (stimuli assignment was fully counterbalanced across participants) to avoid modulations of the ERP response that are

stimulus specific. However, including a prediction task between CS and US presentations, during conditioning, has implications for comparison of component response across phase that will be discussed later.

Only early latency components (P1, N1 and P2) are selected for analysis. These components are selected as potential indices of CR based on observations of their amplitude modulation associated with stimulus affect and differential conditioning (see above). Early latency components may be more suitable for cross-phase comparisons between active and passive viewing tasks, as later ERP components are deemed endogenous (self-generated) and are less likely to present within passive viewing tasks (in the current design, pre- and post-conditioning phases) as opposed to active tasks (in the current design, conditioning phase). As previously stated, arousal effects within the P300 (e.g., P3a and P3b) range have been reported as inconsistent based on task relevance (Olofsson et al., 2008). Thus early exogenous components of the ERP response, such as the P1, N1 and P2 seem more suitable for comparison across phases which vary regarding task relevance, as these components are considered to be "obligatory cortical potentials" (see Key et al., 2005, p.189) produced as a basic function of stimulus processing.

Finally, although we record activity from an array of sites over the entire scalp, analysis of the ERP response is limited to the posterior scalp areas. This is mainly because early components in the visual domain, such as the P1, N1 and P2, are more pronounced in these areas (Bernat et al., 2001; Key et al., 2005).

Potential component modulation effects

Based on ERP findings within the affective picture processing and associative learning domains (see earlier), we predict amplitude modulations of the P1, N1 and P2 components as a result of fear-relevance and CS-US contingency manipulations. In particular modulation of P1 amplitude may be associated with changes in early attentional processes mediated by stimulus valence. Negative CS valence, mediated through fear-

relevance and/or aversive conditioning, is expected to increase the P1 amplitude response in comparison to neutral/fear-irrelevant stimuli, which are not contingent with an aversive outcome. Modulation of N1 and P2 amplitudes, on the other hand, may be associated with changes in arousal, and/or stimulus valence, mediated by manipulations of US contingency and fear-relevance. Additionally we predict that response amplitude, on all three components, will attenuate as a result of US removal, during the extinction phase, if extinction of the affective/arousal response occurs.

Overall effects of experimental phase are also predicted to modulate amplitudes and latencies of the P1, N1, and P2 components across stimuli. Levels of attention are likely to be mediated by the inclusion of an active prediction task, during conditioning, compared to responding within the passive baseline and extinction phases. Evidence of differential P1 amplitude between active and passive response phases has been demonstrated by Parkinson, Dyson and Khurana (2010). Investigating perceptual letter recognition based on stroke presentation sequence, Parkinson et al. (2010) found significantly larger P1 amplitudes during active (task-engaged) viewing in comparison to a passive viewing phase. This global effect of task-engagement on amplitude may be due to increased attentional processes. However other factors, such as habituation towards the stimuli, and participant fatigue, might also mediate both amplitude and latency of component response across phase. General arousal and fatigue effects should present across the entire stimulus set. Interactions between phase and CS-US contingency, on the other hand, would indicate changes in response across experimental phase, which are dependent on contingency manipulation. Such an interaction is crucial for the demonstration of CR acquisition and extinction.

Finally hemispheric specialisations are predicted in ERP responses during fear learning. Bernat et al. (2001) demonstrated differences in amplitude response, of the P1 and N1 components, between pleasant and unpleasant words within the left hemisphere only. The authors suggest that this hemispheric bias may be due to a tendency for semantic stimuli to produce left-hemisphere activation. However, a right hemispheric bias, for the

acquisition of a conditioned fear response, has been supported in studies by Hugdahl and colleagues (Hugdahl, Franzon, Andersson, & Walldebo, 1983; Hugdahl & Johnsen, 1991). Therefore, effects of stimulus valence may dissociate within the left hemisphere, but we might also expect right hemisphere dissociation based on CS-US contingency.

1.5 Summary of aims

To sum up, this thesis has 4 aims:

1. **To implement measures of the event-related brain potential (ERP), used in affective picture processing studies (see Olofsson et al., 2008, for a review), as an index of physiological affective response that could be implemented equally in EC and CC paradigms.** Do EC and CC differ regarding resistance to extinction when compared procedurally, through the online physiological measure of ERP response? If resistance to extinction of an ERP CR were demonstrated in an EC paradigm, but not in CC, this would indicate a functional dissociation between EC and CC, which is attributable to procedural differences. If resistance to extinction were found in both EC and CC paradigms then this would imply that affective learning is captured by ERP, whereas expectancy learning is captured by measures of SCR and startle response within the physiological domain.

2. **To explore the effect of phylogenetic fear relevance on the inhibition of extinction within both CC and EC.** Does phylogentic fear relevance support resistance to extinction in CC, indexed by measures of ERP? Additionally, if EC represents a functionally different form of learning that does not rely on US-expectancy, does phylogenetic fear-relevance make any difference to extinction effects in EC?

3. **To investigate whether verbal threat information and direct aversive conditioning experiences interact to heighten fear beliefs and physiological responses (EPR) and produce resistance to extinction.** If fear-relevancy effects can be manipulated through verbal threat information to induce heightened fear-beliefs, will this effect in turn interact with aversive conditioning to maintain the conditioned ERP response through extinction?

4. **To investigate whether positive verbal information, presented post aversive conditioning, has an equal or superior effect in reducing CRs to extinction training alone.**

CHAPTER 2: Procedural and fear-relevance effects on the demonstration of extinction: Event-related potential indices of conditioned response within the *Evaluative Conditioning* paradigm.

2.1 Introduction

2.1.1 Mediators of Extinction

Procedural and Measurement Effects

In traditional Classical Pavlovian conditioning (CC), extinction is the process by which conditioned response (CR) towards the conditioned stimulus (CS) is reduced or eliminated by the removal of the affective unconditioned stimulus (US) following further (post-acquisition) trials of the CS. However the phenomenon of resistance to extinction, when the removal of the US fails to produce a reduction in conditioned responding, is of great importance to understanding the persistence of anxiety disorders, such as phobias (Field, 2006c), and relapse after treatment (Bouton, 2002).

Although resistance to extinction has been demonstrated in traditional CC studies, especially in cases in which the CS is phylogentically fear relevant (McNally, 1987; Öhman, 1979) these demonstrations are few and far between. However, the phenomenon has been much more prevalent in evaluative conditioning (EC) studies. As described in Chapter 1, EC is a change in liking of a stimulus due its contiguous pairing with another affective stimulus. Differences in the functional characteristics of EC, such as resistance to extinction, have led to a qualitative distinction between EC and CC as different learning processes (see De Houwer et al., 2001, for a review). Dual process accounts of learning suggest that if, in EC, the CR does not extinguish following unreinforced presentations of

the US (extinction training) then, unlike CC, the learning process must not rely on the US expectancy but some other non-propositional system (Baeyens et al., 1995; Baeyens, Eelen, Crombez, & Van den Bergh, 1992).

Early evidence for resistance to extinction in EC was provided by Baeyens and colleagues (Baeyens et al., 1988; Baeyens et al., 1989) using a EC picture-picture paradigm and self-report measures of CS valence. However, Field and Davey (1997, 1999) argued that the observed changes in liking shown in these experiments may have been an artifact caused by creating stimuli pairings on the basis of perceptual similarity; without between-subject controls, they argued that it was not possible to demonstrate that the learning was associative. Since Baeyens and colleagues' early studies, however, there have been successful demonstrations of resistance to extinction in the EC picture-picture paradigm, using randomly assigned/fully counterbalanced stimuli pairings and/or between-subject controls, which rule out Field and Davey's criticisms. For example, De Houwer et al., (2000) were able to demonstrate resistance to extinction in the visual paradigm using a within-subjects design with random assignment of CSs to USs. De Houwer et al. argued that a well designed within-subject experiments, using random or counterbalanced stimuli assignment, is equally sufficient in demonstrating the associative nature of the learnt CR, as using a between-subjects non-paired control. The within-subjects design also allows for more powerful comparison of effects whilst requiring fewer participants and is, therefore, more economical in terms of time and the number of participants required. However, De Houwer et al.'s study used only five extinction trials, which was less than the number of acquisition trials. It is perhaps no surprise then that resistance to extinction was found: perhaps there were simply too few extinction trials to extinguish the CR. In spite of this limitation, further support for resistance to extinction has come from studies such as that by Diaz, et al. (2005) and Field (2006b) which have used a between-subjects, block/sub-block control (as recommended by Field & Davey, 1997) and larger numbers of extinction trials.

Although the studies described so far provide evidence for resistance to extinction in picture-picture EC paradigms, and presents a case for EC being functionally distinct from CC, there is evidence that the different types of measures typically used in EC and CC paradigms may be responsible for the lack of extinction. Hermans, et al. (2002) demonstrated extinction of US expectancy ratings in a CC paradigm using an electrocutaneous US. This observed extinction effect was unsurprising considering the nature of the paradigm, however, additional measures of CS affect (evaluative ratings and affective priming) showed resistance to extinction characteristic of EC. The differential extinction effects found using different measures was interpreted by Hermans et al. as indicative of the aforementioned separate learning mechanisms: expectancy learning being sensitive to extinction whereas affective learning is not. However, the authors do not assume that their results were evidence of qualitatively different learning processes(they note that although the CR is reduced through the extinction procedure in expectancy learning, the underlying association between stimuli remains, Rescorla, 1996); instead, they suppose that the observed dissociation in extinction between different measures result from the way a learnt association is expressed, rather than the way that association is formed.

Other studies using a CC paradigm also suggest that the way in which CRs are measured can determine whether extinction is observed. Indirect physiological measures, typical of the CC paradigm, such as skin conductance and startle modulation, consistently demonstrate extinction of the CR whereas overt self-report measures such as CS valence ratings, measured concurrently in the same paradigm, are resistant to extinction (e.g., Blechert et al., 2008; Vansteenwegen et al., 1998; Vansteenwegen et al., 2006). Interpretation of these findings is largely in line with the premise that the different measures represent different learning processes: indirect physiological measures represent expectancy learning whereas the self-report and affective priming measures represent affective learning. This conclusion is theory driven in that, because the contingency between the CS and the US is removed during extinction, if a type of response

is resistant to this training it must represent something other than expectancy learning, and likewise if a response extinguishes it must be reliant on expectancy of the US.

However, other aspects of the conditioning paradigm have been shown to influence the demonstration of extinction: Lipp et al. (2003) found extinction of affective/valence ratings when measured online during extinction training, a result corroborated by Lipp and Purkis (2006). Both of these studies suggest that the time of measurement, online during extinction as opposed to post hoc, is responsible for the observation of extinction effects, rather than the type of measurement used. This alternative explanation is based on evidence from causal learning studies (e.g. Collins & Shanks, 2002). In a series of experiments, Collins and Shanks (2002) demonstrated that time of measurement was as a crucial factor in determining the development of causal judgements. Evidence from these experiments demonstrated that when asked to make a contingency judgement only once at the end of training, participants' causal judgements reflected the average contingency across all experimental trials. However, if judgements were required on a frequent basis (i.e. every 10 trials) participants' judgements seemed to reflect the most recent experienced contingency. Lipp et al. (2003) suggest that participants asked to provide affective ratings post-extinction training, in their differential conditioning procedure, may have been performing in a similar manner. Rather than basing their ratings on their knowledge of the current contingency, participants base their post-hoc rating on an average assessment of stimulus valence, which is integrated over all contingency experiences throughout the experiment. Thus, the observation of resistance to extinction when measures are taken post-extinction training may simply be the result of measurement time. In addition, Lipp & Purkis (2006) demonstrated that both affective ratings and contingency judgments responded in a similar manner to the time of measurement (online versus post hoc). The results provided by Lipp and Purkis (2006) clearly refute a qualitative difference between types of learning based on strong evidence that dissociations in extinction effects are the result of measurement time, as opposed to measurement type. In conclusion, Lipp and Purkis (2006) suggest that their results provide an alternative explanation for previous failures in finding extinction of evaluative learning,

which relies on measurement time rather than dual-process models of human fear learning.

At the level of measurement, within predominantly CC paradigms, it seems that extinction of the CR (whether a measure of stimulus affect or US expectancy) may result from frequent updates in CS assessment as the contingencies change through the experimental procedure. However, once no more contingency information is being made available, these changes are no longer reflected in the overall post hoc judgement and judgements instead reflect an integration of the overall experimental contingencies. Therefore, the extinction effects observed for physiological measures, such as SCR and startle response, are likely to result from the measurement being taken online and not from a distinction between expectancy learning and affective learning. Also, the use of the CC paradigm in studies that have differentiated between physiological and self-report measures of CRs after extinction training is pertinent because the typical physiological measurements used in CC designs (e.g. SCR and startle response) require a startle stimulus (e.g. loud noise or shock) to demonstrate response. The drawback of these procedures is that it is unclear whether the extinction effects observed from these physiological measures result from a representation of expectancy learning, or whether the extinction effects are simply a result of the type of paradigm being used. To date, no one has explored whether the online extinction effects found using physiological measures in CC paradigms are also found using a visual EC paradigm. The main reason for such lack of evidence is because procedurally EC does not lend itself to the physiological measures used in CC paradigms: CC designs typically use USs that elicit SCR or startle responses (e.g., electric shock) whereas visual EC procedures use less motivationally relevant USs (e.g affective pictures). The importance of identifying 'the procedural elements that determine the nature of the processes that are responsible for the observed effects' is highlighted by De Houwer et al. (2005). Thus, to allow comparison between EC and CC at the procedural level using an online physiological measure, this study investigated resistance to extinction using event-related brain potential (ERP) as an intrinsic physiological measure of affective response in a visual EC paradigm. As such, we can see whether the extinction effects found for

physiological measures in the aforementioned studies can be explained in terms of procedural differences between typical EC and CC paradigms (Chapter 3 describes a complimentary study, Experiment 2, which uses a CC paradigm).

Fear Relevancy Effects

A second variable that mediates whether extinction of the CR occurs is the nature of the CS. Various studies have shown that resistance to extinction is more common when CSs are phylogenetically fear relevant (for reviews see McNally, 1987; Öhman & Mineka, 2001). If physiological measures do represent expectancy learning, then this resistance to extinction of CRs could represent either a biological preparedness (Öhman & Mineka, 2001; Seligman, 1971) or a cognitive bias (Davey, 1995; 1997) that allows sustained expectation of a negative outcome, even when contingencies between the CS and aversive US are reduced. As such, the present study also includes a manipulation of phylogenetic CS fear relevance to explore whether resistance to extinction of the CR (as indexed by measures of ERP) will occur in the typical EC paradigm, irrespective of CS fear relevance. We hypothesise that, if EC represents a functionally different form of learning that does not rely on US-expectancy, resistance to extinction should not be mediated by increased US-expectancy modulated through phylogenetic fear-relevance of the CS.

2.1.2 Why use ERP as a physiological Measure?

Affective picture processing research has shown that the physiological measure of event-related brain potential (ERP) is influenced by the affective stimulus properties of valence and arousal (see Olofsson et al., 2008, for a review). Modulations of waveform amplitude have been observed, as early as 100 ms post stimulus onset, for stimulus valence and there is some evidence for larger P1 (first positive potential component) and N1 (first negative potential component) amplitude responses towards unpleasant images as

opposed to images of pleasant and neutral valence (e.g., Carretie, Hinojosa, Martin-Loeches, Mercado, & Tapia, 2004; Carretie, Mercado, Hinojosa, Martin-Loeches, & Sotillo, 2004; Smith, Cacioppo, Larsen, & Chartrand, 2003). Additionally, consistent amplitude modulations of the posterior P2 component (200-300 ms after stimulus onset) by stimulus arousal have been observed across various types of experimental designs and using different picture stimuli (e.g., Bernat et al. 2001; also see Olofsson et al., 2008, for a review). Based on this research, ERP is deemed a suitable and interesting alternative to the commonly used physiological measures of response (e.g., SCR). Not only can the measure be taken online, during the experimental training phases, but it has also been demonstrated as representative of stimulus affect, whereas SCR and startle modulation, are claimed to be more representative of the expectancy of a salient event, i.e., the US (Vansteenwegen et al., 1998).

2.1.3 Summary of Aims

1. The first aim of this experiment is to determine the rate at which participants learn the CS-US contingencies and whether this rate is affected by the manipulation of fear-relevance. In line with the biological preparedness account of selective associations (Seligman, 1971), a behavioural measure of US-expectancy learning is expected to reveal faster learning of the aversive US contingency during conditioning when CSs are fear-relevant as opposed to fear-irrelevant.

2. Secondly this study aims to explore whether resistance to extinction, observed from verbal/affective priming measures within visual EC paradigms (e.g. Baeyens et al., 1988; 1989; Diaz et al., 2005; & Field, 2006a), can be found when using an online measure of physiological response (ERP) in a visual EC paradigm. If previous demonstrations of resistance to extinction in EC studies are the result of procedural factors (specifically the use of unpleasant visual USs, as opposed to affective sounds/shock stimuli typical of CC paradigms) then we would expect ERP measures to also indicate resistance to extinction irrespective of CS fear-relevance.

2.2 Method

2.2.1 Participants

Seventeen adult participants were recruited from the University of Sussex course credit mailing list and taught/research postgraduate mailing lists. After artefact rejection, a minimum of 50% of trials per stimulus per phase was used as a general rule for participant data inclusion. One participant's data were excluded by this criterion. The final sample of 16 participants consisted of 6 men and 10 women with an age range from 18 to 33 (M = 23.94, SD = 3.43). Based on the sample size of nine, used by Wong et al. (1997), our sample size of 16 was deemed sufficient for this study. Sixteen participants enabled full counterbalancing of the stimuli across participants (see following section). However, as significance tests can be largely affected by sample size, effect sizes are also reported and considered carefully in the case of statistical trends where statistical power might otherwise be called into question. Participants were paid for their participation.

2.2.2 Stimuli and Materials

Conditioned stimuli (CS) consisted of four neutral images of a white pill with different imprints of animals on them, created using Adobe Photoshop (see Appendix 2A for CS images). Although the white pill had been used, as a neutral CS, in a previous study by Ugland and Field (2006) the images of animals were incorporated onto the pill image as a manipulation of fear-relevance. Two pills displayed fear relevant imagery of either an outline of a spider or a snake, in keeping with the types of phylogenetic fear relevant stimuli used frequently by Öhman and colleagues (see Öhman & Mineka, 2001, for a review). The other two pills displayed fear irrelevant imagery of either an outline of a rabbit or a squirrel, thus controlling for the use of animals as CSs but manipulating the typical fear-relevance. A pilot study of subjective ratings towards these stimuli showed no difference between type of CS within each fear-relevance condition (i.e. no difference in

ratings were found between the spider and snake CS or between the rabbit and squirrel CS) on measures of 'unpleasantness', 'anxiety' and 'startle' ($p > .05$). However, collapsing across type of animal, the fear relevant CSs were rated as significantly more 'anxiety evoking' than the fear-irrelevant CSs ($F (1, 8) = 6.60$, $p = .03$, $\eta^2_p = .45$). This effect was expected considering the fear-relevance manipulation.

The unconditioned stimuli (US) were the same size as the CS and presented in the same central position on the screen. These stimuli consisted of four aversive images of faces with the skin disease, Lupus vulgaris, and two neutral images of healthy faces (one male, one female)[1]. Out of the fear relevant (FR) and irrelevant (FI) CSs, one of each was paired in 100% contingency with an aversive US (CS+) and the other two (CS-) were paired in 50% contingency with an aversive US, whereas in 50% of trials they were paired with a neutral US based on Rescorla's truly random control (Rescorla, 1967). As such there were four types of pairing: FR-CS+, FR-CS-, FI-CS+, FI-CS-. CS-US pairings were fully counterbalanced across participants to ensure that any effects observed would be due to associative learning and not an artefact of stimuli pairings (Field and Davey, 1998). Stimuli were presented using 'Presentation' experiment building software.

2.2.3 Design

The experiment used a repeated measures design, consisting of 3 phases: baseline, conditioning (acquisition), and extinction, similar to designs used by Wong et al. (1997; 2004). The baseline phase consisted of 100 trials each of the FR and FI CS+ and CS- (400 trials in total presented in a random order). This phase was followed by conditioning, which consisted of 100 presentations of each of the four different types of pairing described above in random order (400 trials in total). Finally, the extinction phase

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[1] The current USs were also used in a previous study by Ugland and Field (2006), in which the aversive USs were found to be rated significantly more unpleasant than the neutral images ($F (1, 38) = 173.39$, $p < .001$).

replicated the baseline phase with a further 100 presentations of each the four CSs (400 trials in total).

Baseline & Extinction Trial Sequence							
CS	⟶	Blink dot	⟶	CS			
500	500	500	1000				Time in ms.
Acquisition Trial Sequence							
CS	⟶	Awareness Measure	⟶	US	⟶	Blink dot	⟶
500		1500		500	500	500	1000	Time in ms.
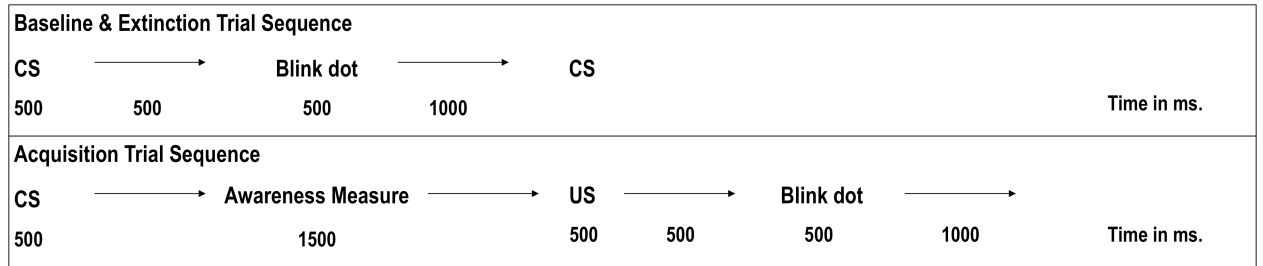
Figure 2.1 : Individual trial sequences for baseline, conditioning and extinction phases.

Figure 2.1 shows the timeline for each trial. On each trial the CS and US were presented individually for 500 ms. Baseline and extinction phases had an inter-trial interval (ITI) of 2000 ms, which included a fixation dot presentation, which was a cue for participants to blink. Trials in the conditioning phase were longer due to the additional presentation of the US. Standard presentation of the CS for 500 ms was followed by a measure of contingency awareness/US expectancy lasting 1500ms (described in 'procedure' below). Every trial in the conditioning phase was completed with the presentation of the appropriate US for 500ms, followed by the ITI and blink prompt lasting 2000 ms before the next trial began.

2.2.4 Measures

ERP

ERP indices of learning were obtained from continuous EEG activity recorded across each experimental phase (see 2.2.6).

US-expectancy learning

During the conditioning phase an online contingency awareness measure was also included in order to track rates of US-expectancy learning. A context between the images of the pills (CSs), and, the images of skin diseased and non-diseased faces (USs) was created. Consequently, participants were informed that some of the pills would be followed by aversive images representing side-effects of those pills observed in medical trials, but that in some trials there would be no side-effects and the pill images would be followed by an image of a healthy person. They were informed that they would be asked to predict whether a pill produced a 'side-effect' or 'no side-effect' in each trial. This formed the measure of contingency awareness by a 1500ms prompt, presented after each CS, asking what outcome they expected to follow the CS. Participants were told that this was not a test and they should base their responses on their gut instinct. If participants were not sure about their responses, they were asked to refrain from responding in the same direction on each trial to reduce any responses bias. Participants responded by pressing '1' for 'side-effect' or '2' for 'no side-effect' on a key pad on which their preferred hand rested and, in the absence of a response within that timescale, a 'Miss' score was automatically recorded for that trial.

2.2.5 Procedure

Participants were given an information sheet to read about ERP and its measurement. Following this, participants completed an informed consent form, electrodes were attached and participants were seated in a sound proof booth. Having gelled all electrodes, the effects of participants' movement; blinking; eye movement; teeth grinding; and closing of eyes, was demonstrated and participants were instructed to avoid these behaviours and to regulate eye blinks as much as possible when prompted by the dot.

Baseline and Extinction Phases

For the baseline and extinction phases participants were informed that they would see 400 randomly ordered trials (100 presentations of each CS) that would be split into 2 blocks of 200 trials lasting roughly 8 minutes. This blocked presentation ensured that participants had a good chance to rest, thus reducing blinking/movement in the next block. Instructions were given that participants should pay attention to the images on the PC monitor whilst remaining as still as possible and regulating their blinking.

Conditioning Phase including Contingency Awareness Measure

The Conditioning phase also incuded 400 randomly ordered trials (100 presentations of each CS), however each CS presentation was followed by the awareness measure and it's associated US. This phase was split into 5 blocks lasting roughly 6 minutes each, again to reduce tiredness by increasing the number of breaks for participants. Participants then experienced the extinction phase (described above) at the end of which the electrodes were removed, participants were given the opportunity to wash/dry their hair, were debriefed and paid for their participation.

2.2.6 ERP measures

Electrical brain activity was digitized continuously (band-pass 0.05-100 Hz; 500-Hz sampling rate) from an array of 64 electrodes using NeuroScan Quik-Caps and SynAmps2. Recordings were stored for offline analysis. Vertical and horizontal eye movements were recorded using independent bipolar channels and all recordings were referenced on-line to an independent electrode situated on the midline in-between Cz and CPz. Impedances were kept below 10 KΩ.

During data preparation, the contribution of eye blinks to the ERP signal was reduced by modelling eye blinks from each condition (and for each participant) and applied as a spatial filter to continuous recordings. ERPs for the CS from each phase were included in the analysis with the analysis epoch representing activity 100 ms pre-stimulus and 500 ms post-stimulus. Trials contaminated by excessive peak-to-peak deflection (+/-100μV) at all channels were rejected before averaging. ERPs were then averaged separately for each electrode site and each of 12 conditions (FR/FI; CS+/CS-; and baseline/conditioning/extinction). ERPs were digitally low-pass filtered to attenuate frequencies above 30 Hz, rebase-lined relative to pre-stimulus activity and re referenced to an average reference of activity from all sites, excluding those related to eye movements. Exogenous responses were aggregated across 18 posterior electrode sites (for similar data treatment see Schaefer, Pottage, & Rickart, 2010): 9 left hemisphere (P1, P3, P5, P7, PO3, PO5, PO7, O1 and CB1) and 9 right hemisphere (P2, P4, P6, P8, PO4, PO6, PO8, O2, and CB2).

2.3 Results

2.3.1 Contingency Awareness

A 2(Fear-relevance: relevant vs. irrelevant) × 2(Contingency: CS+ vs. CS-) repeated measures ANOVA was run on a score of Contingency Awareness from the number of accurate CS outcome predictions made during Conditioning.

There was a significant main effect of contingency, $F (1, 11) = 383.05$, $p < .001$ ($\eta^2_p = .97$), in addition to a statistical trend of fear-relevance $F (1, 11) = 3.83$, $p = .08$ ($\eta^2_p = .26$) for contingency awareness, indicating that the number of correct predictions made during conditioning significantly may vary depending on whether a CS was 100% contingent with the negative US (CS+) or 50% contingent (CS-). As would be expected, Figure 2.2 reveals that participants performed with almost perfect accuracy for both the CS+ and CS- and were therefore contingency aware in both conditions. Participants showed near 50% accuracy for the CS-, consistent with the knowledge that there is essentially no contingency between the stimuli in the CS- condition (thus participants only have 50% chance of guessing the right outcome of a trial); and participants showed accuracy nearing 100% for the CS+ condition in which stimuli were 100% contingent. The number of accurate predictions was marginally higher for fear-relevant stimuli than for fear-irrelevant which can only be due to a higher expectancy of negative outcomes for fear-relevant stimuli resulting in higher correct responses in this condition than for the fear-irrelevant stimuli, when collapsing across CS type. However there was no significant interaction between fear-relevance × contingency to demonstrate a higher accuracy rate for fear-relevant stimuli in the CS+ condition as opposed to the CS- condition (where higher negative outcome expectancy would be unable to affect accuracy), $F (1, 11) = .98$, $p < .34$ ($\eta^2_p = .08$).
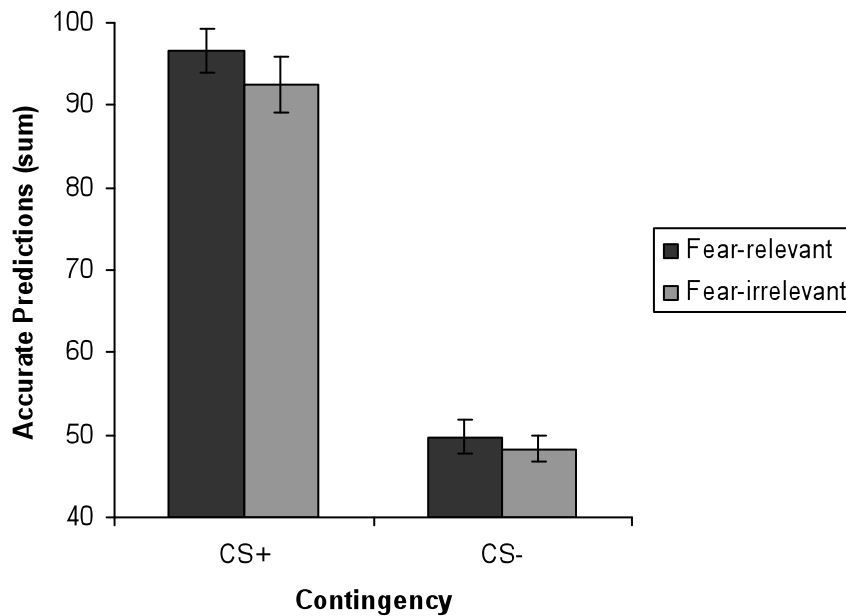
Figure 2.2: Mean number of correct outcome predictions, for fear-relevant and irrelevant CS, depending on contingency of negative US (error bars represent standard error of the mean).

To explore whether the effects of fear-relevance and contingency on contingency awareness was consistent throughout the conditioning phase, a further 2(Fear-relevance: relevant vs. irrelevant) × 2(Contingency: CS+ vs. CS-) × 10(Epoch: 1st 10 trials vs. 2nd 10 trials vs. 3rd etc.) repeated measures ANOVA was run on accuracy scores calculated from 10 time epochs, from consecutive groups of 10 trials.

The assumption of sphericity was violated for the main effect of epoch (time), χ^2 (44), 92.46, $p < .001$, $\varepsilon = .27$, and the interaction between Contingency × Epoch, χ^2 (44), 66.46, $p = .04$, $\varepsilon = .43$. Therefore degrees of freedom were corrected using the Greenhouse-Geisser estimate of sphericity.

There was a statistical trend effect of epoch, F (2.42, 26.62) = 2.53, $p = .09$ ($\eta^2_p = .19$). This finding suggests that accuracy in prediction varies across these time epochs and therefore

that participants might not have learnt the contingency between CS and US from the start of conditioning.

There was a statistical trend interaction between epoch × contingency, F (3.90, 42.99) = 2.49, p = .06 (η^2_p = .18), indicating that differences in awareness between CS+ and CS- were dependant on the epoch of trials (partial eta^2 indicated that epoch × contingency interaction accounted for 18% of the overall variance in the epoch × contingency interaction effect and it's associated error, thus seeming sufficient for further follow-up analysis). Figure 2 suggests that participants are performing at chance for the CS- across all 10 epochs. However, accuracy seems lower during the first 10 trials for the CS+, than for the 2nd 10 trials and thereafter. One-sample t-tests, comparing the number of accurate predictions for the CS+ to 50% chance performance, show that in all epochs participants perform significantly better than chance ($p \leq .001$), including the 1st 10 trials, but a paired-sample test between accuracy from the 1st epoch to the 2nd epoch shows accuracy to be significantly lower in the 1st, t (11) = -2.82, p = .02, r = -.41 (*See Figure 2.3). These findings indicate that, although participants are contingency aware (performing significantly better than chance) within the 1st 10 trials, uncertainty mostly likely occurring for the first few trials (when participants have no previous contingency knowledge to base their predictions on) is dragging the mean down for this epoch.
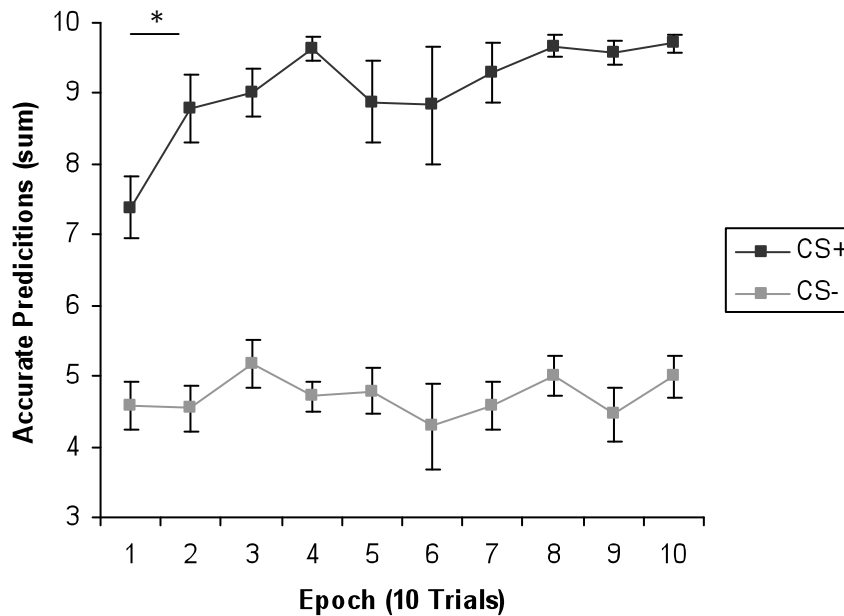
Figure 2.3: Mean number of accurate predictions (contingency awareness), per 10 trial epoch, for CS+ and CS- collapsed across fear-relevance (error bars represent standard error around the mean).

Also there was a significant interaction between epoch and fear-relevance, F (9, 99) = 2.05, p = .04, η^2_p = 0.16, indicating that accuracy differences, between fear-relevant and irrelevant stimuli irrespective of contingency, were dependant on epoch. Accuracy seemed rather constant between FR and FI stimuli (when collapsing across contingency) across all epochs, except the 1st where error bars do not overlap (see Figure 2.4). Because of this observation at epoch 1 a paired-sample t-test, between FR and FI conditions, was carried out for the first epoch only. This test showed significantly higher accuracy for FR than FI stimuli in this 1st epoch, t(11) = 2.72, p = .02, r = .49 (*see Figure 2.4). Again this result may be due to higher expectancy of negative outcomes for fear-relevant stimuli, resulting in higher accuracy predicting the negative outcomes in the first epoch.
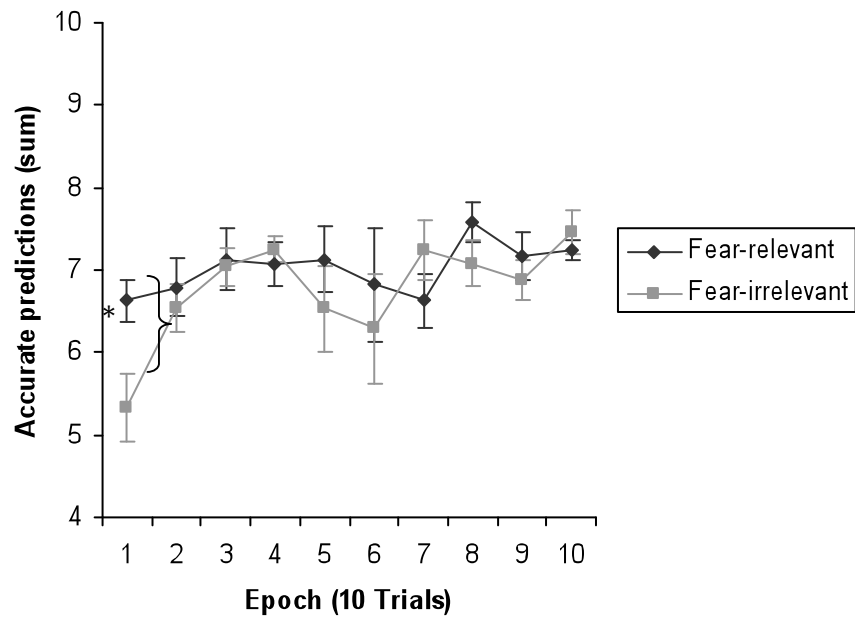
Figure 2.4. Mean number of accurate predictions (contingency awareness), per 10 trial epoch, for fear-relevant and irrelevant CSs, collapsed across contingency (error bars represent standard error of the mean).

2.3.2 ERP Results

Baseline

Left

Right

Conditioning

Extinction

Fear relevant CS+
Fear relevant CS-

Fear irrelevant CS+
Fear irrelevant CS-
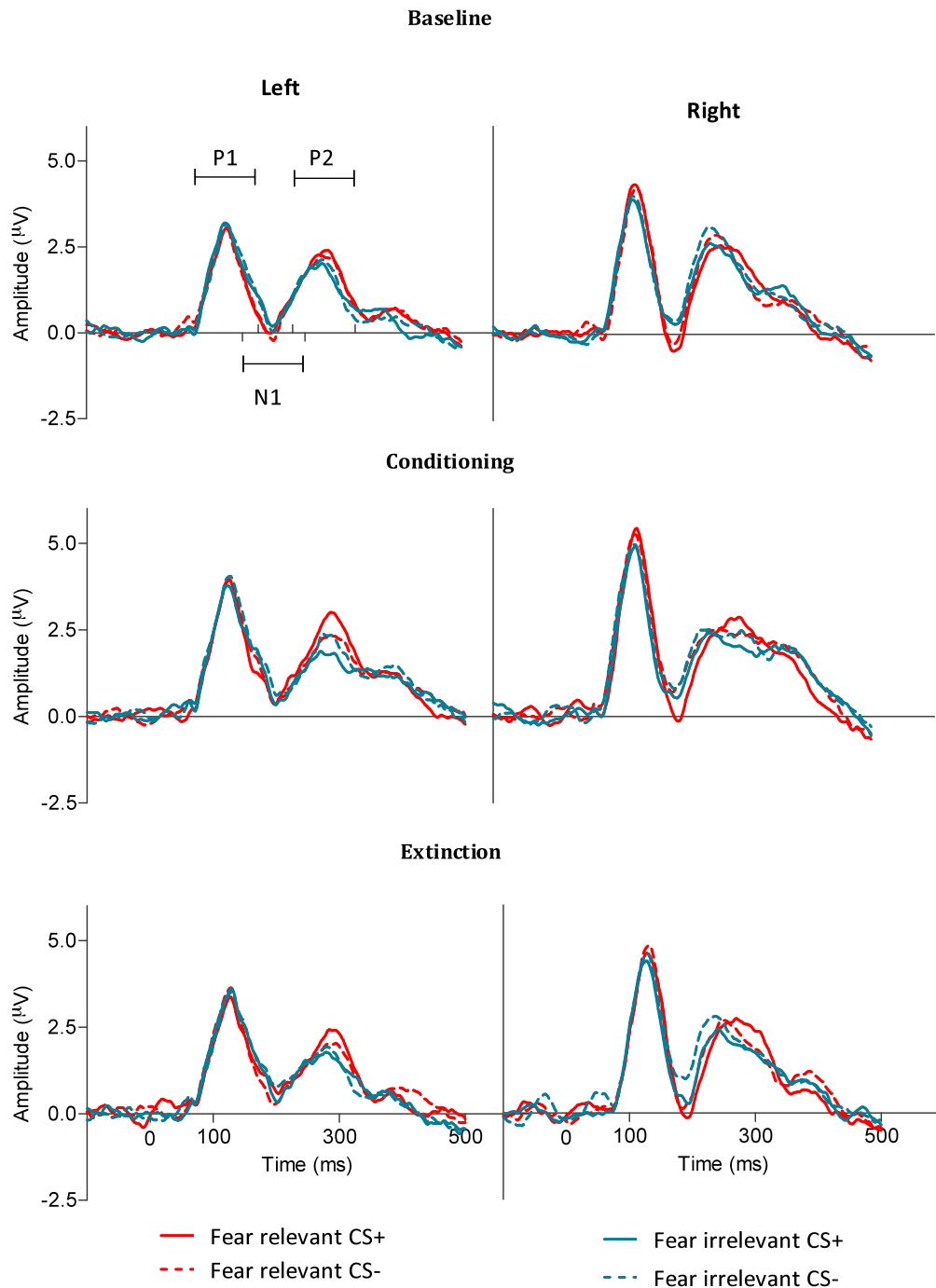
Figure 2.5: ERP grand average at each experimental phase, split by hemisphere. Collapsed across all analyzed parietal and occipital electrode sites, for the four conditions of interest: fear (relevant, irrelevant) and contingency (CS+, CS-).

Graphical representation of the grand average ERP waveforms (Figure 2.5), in response to the four stimuli, suggest overall larger N1 response to fear relevant CSs at baseline in the right hemisphere. During conditioning, the FR CS+ produced larger N1 (right hemisphere) and P2 (bilateral) amplitudes, which seem to persist post-conditioning/extinction. Therefore, during baseline, there seems to be a main effect of fear relevance, whereas during conditioning and extinction there seems an interaction between fear relevance and contingency, such that the FR CS+ showed larger N1 responses at conditioning (right hemisphere), and larger P2 responses at conditioning and extinction (bilateral). Modulation of the P1 response is not analysed as there seems to be little modulation of this component by contingency or fear-relevance manipulations.

N1 Peak Latency

A 4-way, 3(Phase: baseline vs. conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Fear relevance: FR vs. FI) × 2(Hemisphere: left vs. right), repeated measures ANOVA was conducted on the peak latency of the N1 component (150-250 ms after stimulus onset), collapsed across 9 left (P1, P3, P5, P7, PO3, PO5, PO7, O1 and CB1) and 9 right (P2, P4, P6, P8, PO4, PO6, PO8, O2, and CB2) hemisphere electrodes from Parietal, Occipital and Cerebellum sites.

Main effects of hemisphere, $F(1, 15) = 4.72$, $p = .05$ ($\eta^2_p = .24$), and phase, $F(2, 30) = 3.69$, $p = .04$ ($\eta^2_p = .20$), demonstrated overall faster N1 Latencies in the right hemisphere ($M = 187$, $SE = 3.90$) compared to the left ($M = 197$, $SE = 4.11$); and overall faster baseline N1 latencies ($M = 189$, $SE = 3.45$) than conditioning ($M = 194$, $SE = 3.73$) or extinction ($M = 192$, $SE = 3.36$)[2].

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[2] NB: within-subjects contrasts showed that N1 was significantly faster at baseline than conditioning ($p = .03$, $\eta^2_p = .28$), however conditioning did not significantly differ in N1 latency to extinction ($p = .31$, $\eta^2_p = .07$).

N1 Mean Amplitude

Mean Amplitude time windows were calculated 25 ms either side of Peak Latency results (based on recommendations from Luck, 2005) and the Mean Peak Latency was adjusted for the main effects of phase and hemisphere.

An initial 4-way, 3(Phase: baseline vs. conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Fear relevance: FR vs. FI) × 2(Hemisphere: left vs. right), repeated measures ANOVA was conducted on the mean amplitude of the N1 component, collapsed across the same Parietal, Occipital and Cerebellum electrode sites.

There was a significant main effect of phase, $F(2, 30) = 3.79$, $p = .03$ ($\eta^2_p = .20$), and a trend effect of fear-relevance, $F(1, 15) = 2.92$, $p = .11$ ($\eta^2_p = .16$) on N1 mean amplitude. Bonferroni contrasts showed significantly larger N1 mean amplitude at baseline ($M = .42$, $SE = .32$) than during conditioning ($M = .84$, $SE = .38$) ($p = .06$, $\eta^2_p = .21$) but not between conditioning and extinction ($M = .81$, $SE = .29$) ($p = .86$, $\eta^2_p = .002$). The fear-relevance trend indicated larger N1 response for fear-relevant stimuli ($M = .55$, $SE = .35$) than fear-irrelevant stimuli ($M = .83$, $SE = .30$) when collapsed across phase, contingency and hemisphere.

Critically, to demonstrate an effect of conditioning, an interaction between phase and contingency needs to be shown. A statistical trend for the phase × contingency interaction effect: $F(2, 30) = 3.02$, $p = .06$ ($\eta^2_p = .17$) demonstrated that for N1 mean amplitude, regardless of fear-relevance and hemisphere, the difference in response between experimental phase was dependant on reinforcement of the CS (CS+ vs. CS-). Contrasts between baseline and conditioning phases suggested the overall acquisition of a conditioned response ($p = .05$, $\eta^2_p = .23$), with a smaller N1 response for CS- relative to CS+ (less habituation to the CS+). However there did not seem to be extinction of this general conditioned response effect between conditioning and extinction phases: $p = .45$, $\eta^2_p = .04$, (see Figure 2.6).

Paired sample t-tests showed that, when collapsed across fear-relevance and hemisphere, the response to the CS+ did not significantly change between baseline and conditioning phases ($t(15) = -1.50$, $p = .15$, $r = .09$), whereas the CS- significantly decreased (habituated) at conditioning: $t(15) = -2.33$, $p = .03$, $r = .19$, (see Figure 3.). Neither CS+ nor CS- differed significantly between conditioning and extinction [CS+ ($t(15) = -.91$, $p = .93$, $r = .003$); CS- ($t(15) = .38$, $p = .71$, $r = .02$)].
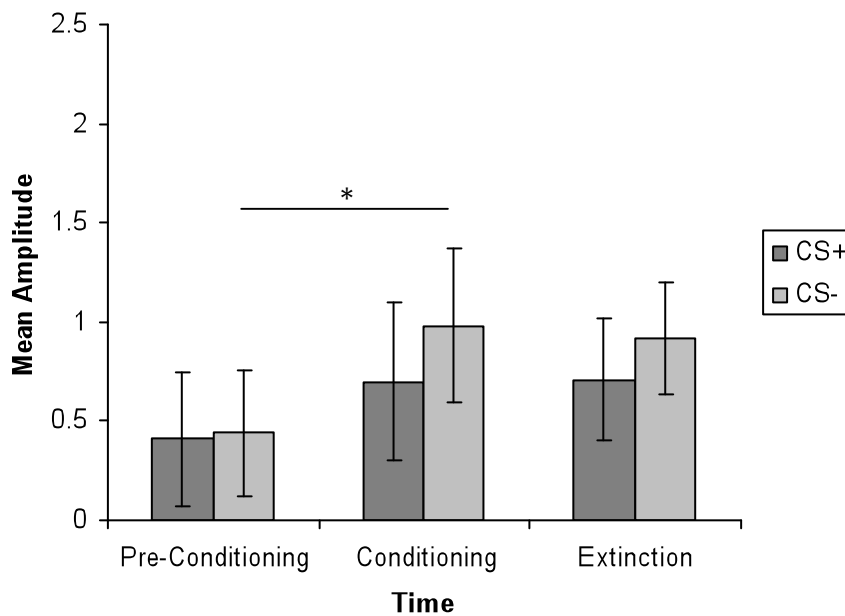
Figure 2.6. Mean N1 mean amplitude in response to the CS+ and CS- across baseline, conditioning and extinction phases (error bars represent standard error of the mean).

The second major hypothesis, predicting heightened conditioning and resistance to extinction to the fear relevant CS+ in comparison to the fear irrelevant CS+, was partially supported by a statistical trend in the three-way interaction between phase, contingency and fear-relevance, $F(2, 30) = 2.81$, $p = .08$ ($\eta^2_p = .16$). Bonferroni contrasts showed a fear-relevance × contingency interaction for extinction ($p = .04$, $\eta^2_p = .25$) but not for

conditioning (p = .86, η^2_p= .002). This result does not support any impact of fear-relevance on conditioning but does indicate an influence for extinction. Furthermore there was a statistical trend between phase, contingency, fear-relevance and hemisphere, $F(2, 30)$ = 3.03, p = .06 (η^2_p= .17), indicating hemispheric difference in fear-relevance effects on conditioning. Bonferroni contrasts point to some effect of hemisphere and fear-relevance on acquisition (baseline to conditioning): $F(1, 15)$ = 3.75, p = .07 (η^2_p= .20), and extinction (conditioning to extinction), $F(1, 15)$ = 4.70, p = .05 (η^2_p= .24).

To break down this 4-way interaction, two separate 3-way, 3(Phase: baseline vs. conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Fear-relevance: FR vs. FI) repeated measures ANOVAs were run (one for each hemisphere).

In the left hemisphere the interaction between phase, contingency, and fear-relevance was non-significant $F(2, 30)$ = 2.08, p = .14 (η^2_p= .12). In the right hemisphere this interaction was significant $F(2, 30)$ = 3.34, p = .05 (η^2_p= .18) and Bonferroni contrasts show a significant interaction between phase × contingency × fear-relevance from conditioning to extinction, $F(1, 15)$ = 7.46, p = .02, η^2_p= .33, but not from baseline to conditioning, $F(1, 15)$ = .48, p = .50, η^2_p= .03. Paired samples t-tests showed that, whereas N1 mean amplitude remained stable from conditioning to extinction for the fear irrelevant CS+ and CS- along with the fear relevant CS+ (p >.05), there was a significant increase between these phases for the fear relevant CS-: $t(15)$ = 2.40, p = .03, r = .14.

The significant increase in N1 negativity in the right hemisphere, from conditioning to extinction, towards the fear relevant CS- contradicts expectations that fear relevance would heighten resistance to extinction for the CS+. Instead what we seem to find is resistance to extinction for the CS+ regardless of fear relevance and an unexpected heightened response at extinction towards the fear relevant CS- (see Figure 2.7).

Right Hemisphere
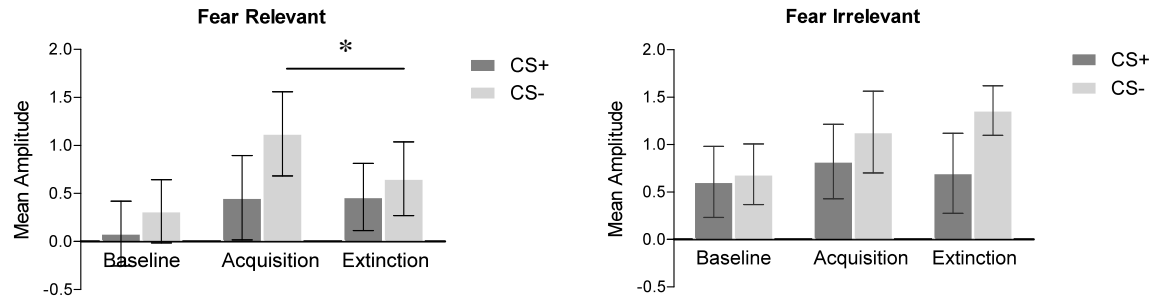
Left Hemisphere
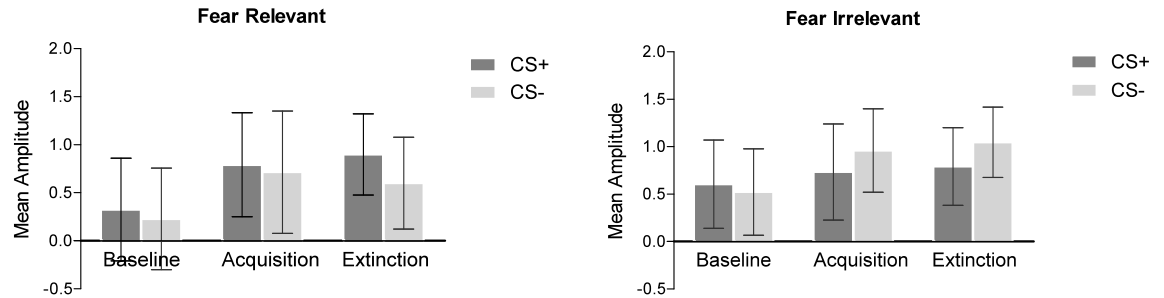
Figure 2.7: Mean N1 mean amplitude in response to the CS+ and CS- across baseline, conditioning and extinction phases, split by fear-relevance and hemisphere (Error bars represent standard error of the mean).

P2 Peak Latency

A 4-way, 3(Phase: baseline vs. conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Fear relevance: FR vs. FI) × 2(Hemisphere: left vs. right), repeated measures ANOVA was conducted on the peak latency of the P2 component (250-350 ms after stimulus onset), collapsed across the same Parietal, Occipital and Cerebellum electrode sites as for N1.

A significant main effect of phase, using a Greenhouse-Geisser correction (ε = .68), F (1.36, 20.46) = 6.59, p = .01 (η^2_p = .31) again showed significantly faster P2 latencies (p = .009, η^2_p = .38) at baseline (M = 279, SE = 3.16) than at conditioning (M = 291, SE = 4.42) and a

statistical trend of slower P2 latencies ($p = .06$, $\eta^2_p = .21$) at conditioning than at extinction ($M = 283$, $SE = 3.23$).

There was also a statistical trend interaction between phase x fear-relevance x hemisphere, $F (2, 30) = 2.83$, $p = .08$ ($\eta^2_p = .16$)[3]. Due to these effects on P2 peak latency, P2 mean amplitude time windows were calculated 25 ms either side of average P2 Peak Latency with the Mean Peak Latency adjusted for the effects of phase, fear-relevance and hemisphere.

P2 Mean Amplitude

A 4-way, 3(Phase: baseline vs. conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Fear relevance: FR vs. FI) × 2(Hemisphere: left vs. right), repeated measures ANOVA was conducted on the mean amplitude of the P2 component, collapsed across the same Parietal, Occipital and Cerebellum electrode sites as for N1.

A significant main effect of fear-relevance, $F (1, 15) = 21.54$, $p < .001$ ($\eta^2_p = .59$), demonstrated larger P2 response for FR stimuli ($M = 2.31$, $SE = .29$) than for FI ($M = 1.95$, $SE = .29$).

There was a significant interaction between fear-relevance and contingency $F (1, 15) = 5.89$, $p = .03$ ($\eta^2_p = .28$) which, collapsing across effects of hemisphere and phase, in the FR condition, showed larger P2 response for the CS+ ($M = 2.45$, $SE = .32$) than for the CS- ($M = 2.16$, $SE = .26$). Whereas, for the FI condition, the P2 response was smaller for the CS+ ($M = 1.84$, $SE = .28$) than for the CS- ($M = 2.07$, $SE = .33$).

---

[3] Multivariate tests show phase x fear-relevance x hemisphere interaction to be significant: $F (2, 14) = 4.06$, $p = .04$ ($\eta^2_p = .37$)

There was a significant interaction between fear-relevance and phase F (1, 15) = 3.72, p = .04 (η^2_p = .20) for which Bonferroni contrasts showed the interaction to be significant between baseline and conditioning only (p = .03, η^2_p = .29). Controlling for effects of contingency and hemisphere, estimated marginal means show an increase in P2 mean amplitude from baseline (M = 2.23, SE = .28) to conditioning (M = 2.48, SE = .40) for FR stimuli only. For FI stimuli, the P2 response remains almost constant from baseline (M = 2.06, SE = .34) to conditioning (M = 2.01, SE = .39).

Critically there was no further significant interaction here between contingency and phase that would indicate conditioned response at the P2 component (contingency × phase: F (2, 30) = .70, p = .51, η^2_p = .04). In addition there was no significant higher order interaction involving contingency and phase that might indicate conditioning dependant on fear-relevance or hemisphere (fear-relevance × contingency × phase, F (2, 30) = 1.53, p = .23, η^2_p = .09; hemisphere × fear-relevance × contingency × phase, F (2, 30) = .55, p = .58, η^2_p = .04) (see Figure 2.8).
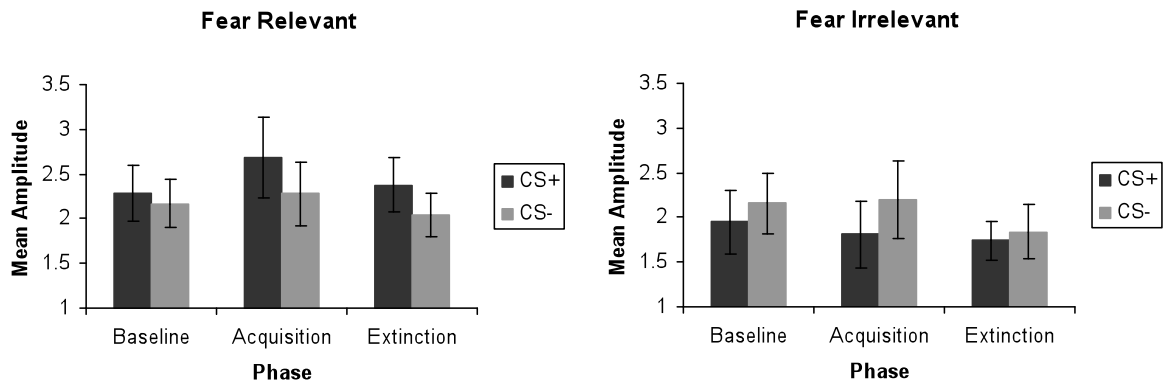
Figure 2.8: Mean P2 mean amplitude in response to CS+ and CS- across baseline, conditioning and extinction phases, split by fear-relevance. Error bars represent standard error of the mean.

2.4 Discussion

2.4.1 Fear-relevance aids faster US-expectancy learning

In the present study participants learnt the contingencies between CSs and the US within the first 10 trials of conditioning, with accuracy scores in predicting the US from the CS+ significantly greater than chance. A learning trend in US expectancy was apparent because the mean accuracy score for the CS+ from the first 10 trials was significantly lower in comparison to the second 10 trials: most likely the result of early uncertainty, within the first 10 trials, which brought down the accuracy score at the very start of conditioning trials. The rapid rate of learning observed is not surprising considering the 100% contingency condition for the CS+ with the aversive US.

Fear-relevance did seem to impact on US expectancy learning to some degree, with significantly higher mean accuracy in the first 10 trials for FR as opposed to FI stimuli. Although there was not a significant interaction between fear-relevance, contingency and epoch, it ought to be noted that participants could perform only at chance accuracy for the CS-, regardless of fear-relevance; therefore the higher accuracy in the first 10 trials for FR stimuli must be a result of greater expectancy for the aversive US following the FR CS+. Faster US expectancy learning for the phylogenetically FR CS+ does support a biological preparedness account for selective association formation between aversive outcomes and stimuli which may have posed some threat to pre-technological man (Seligman, 1971; Öhman & Mineka, 2001): if participants learn to expect the aversive US faster when encountering such FR stimuli, they will be more likely to develop an aversive association between that stimulus and the aversive outcome. However an alternative explanation, to biological preparedness, may be the cognitive bias account of selective associations (Davey, 1995; 1997). Davey argues that bias in US expectancy towards phylogenetic FR stimuli may be a result of cultural factors, as opposed to selection pressures.

However in spite of faster demonstration of US expectancy learning for FR CSs from the contingency awareness data, a superior learning/resistance to extinction effect for the FR CS+ was not observed from ERP indices of CR.

2.4.2 ERP indices of differential conditioning and resistance to extinction within the EC paradigm

A significant main effect of fear-relevance was found for the mean amplitude of N1 and P2 component response. These components indicated larger amplitude response for the FR stimuli as opposed to FI and thus correspond with the affective picture processing literature which has largely demonstrated larger amplitude responses when images are unpleasant, as opposed to pleasant (see Olofsson et al., 2008, for a review). This effect also gives strong support for the notion that early/mid latency amplitude modulation is linked to the processing of affect and arousal properties of visual stimuli (Olofsson et al., 2008) and that unpleasant stimulus valence demands greater attention early during information processing.

Experimental phase also had a significant impact on latency and mean amplitude measures of the N1 and P2 component responses. The N1 component was slower to peak and smaller in mean amplitude response in the conditioning and extinction phases, as opposed to baseline, which may represent a generalised habituation effect. However, although the P2 component showed faster mean peak latency response at baseline than during conditioning, response was also significantly faster during extinction. As both 'passive' experimental phases demonstrate faster peak latency response than the conditioning phase, and thus there was not a linear trend of increase in peak latency, it is difficult to assume that in all cases an increase in peak latency is representative of habituation. Later peak latency may instead result from a reduction in processing/attention resource due to the addition of the USs and prediction task during the conditioning phase, whereas in baseline and extinction phases participants are only

required to passively view the CSs. In spite of generalised later peak latency during conditioning there was a *larger* P2 amplitude response specifically towards FR stimuli during conditioning as opposed to during the baseline phase. This increase in response amplitude also does not support a habituation explanation for effects of phase on mean amplitude measures, but as it is specific to FR stimuli it may represent an increase in attention directed towards such stimuli when aversive outcomes are incorporated into the experimental procedure. However, this effect was not dependant on contingency, therefore it seems to indicate a generalised increase in attention towards FR stimuli as a result of aversive US introduction, as opposed to a specific increase in attention towards the FR CS+ as a result of this FR stimulus predicting the aversive US.

As there seems to be a general consensus within the affective picture processing literature that the amplitude of ERP components is more consistently modulated by affective stimulus factors than is the latency of components (Olofsson et al., 2008), it is perhaps not surprising that the only indication of a CR came from the mean amplitude measure for the N1 component. The interaction between contingency and phase demonstrated that although there was a significant reduction in negativity of the N1 response, from baseline to conditioning, when the CS was randomly reinforced (CS-), N1 was maintained when the CS was 100% reinforced with the aversive US (CS+). As general reduction in mean amplitude response was observed from baseline to conditioning phase for the N1 component, the maintenance of a larger mean amplitude response for CS+ is indicative of this stimulus type acquiring an unpleasant affect and may indicate the focus of attentional resources on the stimuli which are predictive of the aversive outcome.

Interestingly this effect of conditioning, which does not seem to be dependant on fear-relevance of the CS, did not show an effect of extinction. Unlike other online physiological measures of CR (such as SCR and startle response), which have been consistently shown to demonstrate the effects of extinction (e.g. Blechert et al., 2008; Lipp et al., 2003; Vansteenwegen et al., 1998 & 2006), there was no significant change in N1 mean amplitude response from the conditioning phase to the extinction phase for the CS+.

Additionally, though resistance to extinction has been demonstrated in CC, using SCR and startle response measures when the CS+ was phylogenetically fear relevant (e.g., Fredrikson & Öhman, 1979; Lipp & Edwards, 2002; Öhman et al., 1975; Öhman et al., 1976), resistance to extinction in this study occurred irrespective of fear-relevance.

This observation of general resistance to extinction not only corresponds with findings from the EC literature, in which verbal and affective priming measures tend to account for resistance to extinction of the CR (e.g. Baeyens et al., 1988; 1989; Diaz et al., 2005; & Field, 2006a) but it also provides a physiological account of resistance to extinction of the CR within the typical EC paradigm. Thus demonstrations of extinction of CR using physiological response measures from typical CC paradigm studies, (e.g. Blechert et al., 2008; Lipp et al., 2003; Vansteenwegen et al., 1998; 2006) could arguably be the result of the type of paradigm used. However, the dissociation between extinction effects observed for conditioned ERP response, in the present study, and extinction effects observed for SCR and startle response measures used in previous studies, could be attributed to the type of physiological measure employed. Conceivably, ERP measures may represent affective learning, whereas SCR and startle response (see aforementioned studies) may represent expectancy learning. To determine which explanation is more valid, a comparative CC paradigm study is reported in Chapter 3 using ERP as the indirect measure of CR. If resistance to extinction can be demonstrated regardless of paradigm it may indicate that ERP indices of CR represent a qualitatively different response to SCR or startle response measures. If extinction effects are observed in the CC paradigm however, this would indicate that previous reports of extinction from physiological indices of response may have resulted from the type of paradigm used as opposed to physiological and verbal indices of response representing qualitatively different forms of learnt response.

2.4.3 Additional fear-relevance effects

In addition to the general conditioning effect found from N1 mean amplitude response, although no effect of fear-relevance on CR for the CS+ was observed, there was an effect of heightened response at extinction towards the *FR CS-* (in the right hemisphere only). Whereas the N1 mean amplitude response remained constant from the conditioning to the extinction phase for the FR CS+, the FR CS- demonstrated an *increase* in N1 mean amplitude response. Evidence for increase in response towards the FR CS- at extinction has been demonstrated previously when using evaluative ratings (Lipp & Edwards, 2002). Lipp & Edwards found an increase in CS- pleasantness ratings for fear relevant stimuli post extinction (as opposed to pre-conditioning). If modulation of the N1 component is associated with stimulus *affect* (as opposed to outcome expectancy) this increase in CS- may have resulted from a more preferential evaluative response formed during extinction once affective outcomes have been removed.

An alternative explanation, as this CS- effect is fear relevant specific, could be conceived as generalization between the fear relevant CS+ and CS-, occurring once the superior predictive ability of the CS+ is removed. Blechert et al. (2008) report unpublished studies from their lab where very long extinction phases paradoxically increased US expectancy. The authors observed that participants expected 'something' to occur towards the end of lengthy procedure. Vansteenwegen et al. (2006) also report a similar effect where the SCR reappeared, after extinction of the CR had been observed, towards the end of their extinction training. Although speculative, such reports may give a clue as to why an increase in response was observed towards the FR CS- at extinction. If there is resistance to extinction for the CS+ in general (regardless of fear-relevance) the extreme length of the extinction phase in the present study may lead participants to expect 'something' is going to occur for the FR CS-. Participants might be safer to generalize across the two FR CSs, once the predictive nature of the CS+ has been removed, so that they are prepared should the aversive US suddenly be re-presented following one of the fear relevant stimuli.

2.4.3 Summary

The present study has shown ERP to be a viable measure of CR that is suitable for use in typical EC study designs. Apart from an unexpected increase in response towards the FR CS- at extinction, no effects of fear-relevance on acquisition or extinction of CR were observed, when strictly looking for changes in response towards the CS+. Rather, a general effect of conditioning was observed regardless of fear-relevance, which remained resistant to extinction also regardless of fear-relevance. One may argue that this is not surprising, as the present study made use of a typical EC picture-picture paradigm similar to those used in EC studies where resistance to extinction has been observed for FI stimuli before (e.g. Diaz et al., 2005; & Field, 2006a). However, to explore whether resistance to extinction was the result of the paradigm used or an artifact of type/time of measurement, results from the present study will be compared to results from a study using a CC procedure (Experiment 2) in Chapter 3.

CHAPTER 3: Procedural and fear-relevance effects on the demonstration of extinction: Event-related potential indices of conditioned response within the *Classical Conditioning* paradigm.

3.1 Introduction

Whether Evaluative conditioning (EC) and Classical conditioning (CC) represent two qualitatively distinct forms of learning is largely dependent on whether differences in their functional characteristics, such as extinction of the CR, are the result of different underlying learning processes or artefact of procedural differences (De Houwer et al., 2005). A substantial amount of evidence has demonstrated that the type of measurement, and the time at which measure of response is taken, can determine whether extinction of the CR is observed (e.g. Blechert et al., 2008; Hermans et al., 2002; Lipp et al., 2003; Lipp & Purkis, 2006; Vansteenwegen et al., 1998; 2006). Generally this evidence supports a split between the physiological measures (SCR and startle response) giving rise to extinction whereas verbal measures demonstrate resistance to extinction. The 'split' between these types of measure might explain why typically resistance to extinction has been observed in EC but not CC studies: in CC, CRs tend to be measured with physiological measures; whereas early EC studies typically used verbal measures.

Verbal measures of stimulus affect have demonstrated resistance to extinction regardless of the type of paradigm used (EC vs. CC); however, Lipp & Purkis (2006) demonstrated that if such measures are recorded online during the extinction training they do show evidence of extinction, leading to the premise that effects of extinction could be reliant on the time of measurement rather than the *type* of measurement. This suggestion could explain why online physiological measures, such as SCR and startle response, consistently

demonstrate extinction effects and, as a result, why conflicting data with regards to resistance to extinction have been found between CC and EC paradigms.

To date, all studies exploring the effects of measurement type on extinction, have used a CC paradigm because a biologically relevant US (such as shock or startle noise) is necessary to elicit the physiological SCR or startle response. These measures contrast with early EC paradigms in which affective pictures tended to be used as USs.

To investigate whether extinction effects observed from physiological indices are the result of these measures representing some form of expectancy learning (as opposed to affective learning), or simply the type of paradigm used, Experiment 1 (Chapter 2) used ERP as an online physiological measure of response in a typical EC paradigm that could be compared directly on a procedural level to the CC paradigm. ERP has successfully been used for measure of affective picture processing (Olofsson et al., 2008) with consistent modulation of P1, N1 and P2 and amplitude depending on the affective nature of the images. Thus ERP seemed a suitable alternative physiological measure, to SCR and startle response, for use in an EC paradigm using unpleasant affective pictures as USs. Through use of ERP as an index of CR it would be possible to compare EC and CC at the procedural level to determine whether extinction effects found for physiological measures in previous studies were the result of the use of CC paradigms.

Experiment 1 showed ERP to be a viable measure of CR that is suitable for use in typical EC study designs. Early modulation of amplitude response was demonstrated for the N1 component dependant on experimental phase and contingency of the CS with the US. Alongside main effects of CS fear-relevance and experimental phase, which supported larger amplitude response at N1 and P2 components for FR stimuli (as opposed to FI) and a general decrease in negativity of the N1 component from baseline to conditioning, the interaction between experimental phase and contingency on N1 mean amplitude supports a CR, with significant reduction in response towards the CS- at conditioning, whereas higher negativity in response towards the CS+ was maintained. Apart from an unexpected increase in response towards the FR CS- at extinction, no effects of fear-relevance on

acquisition or extinction of CR were observed, when strictly looking for changes in response towards the CS+. As only a general effect of conditioning was observed, regardless of fear-relevance, and the CR was resistant to extinction, these results support the case for resistance to extinction within the typical EC paradigm with the use of an implicit physiological measure. This result contrasts with those from other physiological measures used within CC paradigms (e.g. Blechert et al., 2008; Lipp et al., 2003; Vansteenwegen et al., 1998 & 2006). However, to explore whether resistance to extinction was the result of the paradigm used or an artefact of type/time of measurement, the present study uses a CC paradigm, similar in nature to those used in studies by Blechert et al. (2008), Lipp et al. (2003), & Vansteenwegen et al. (1998; 2006). In this procedure a biologically relevant US (loud noise) was substituted for the affective pictures used for US in Experiment 1. ERP indices of response from this procedure were then compared to the results observed in Experiment 1 to determine whether resistance to extinction occurs only in EC paradigms using affective picture stimuli as USs. If extinction is indexed by ERP response in this CC paradigm then this would indicate that the type of procedure is responsible for previous extinction effects found using SCR/startle response. However, if resistance to extinction is found for conditioned ERP response in the current study, as it was in Experiment 1, this would indicate that apparent differences in resistance to extinction between EC and CC are actually attributable to the measure of response. If resistance to extinction were found in both EC and CC paradigms then this would imply that affective learning is captured by ERP, whereas expectancy learning is captured by measures of SCR and startle response within the physiological domain.

Additionally, the present study also includes the same manipulation of CS fear-relevance used in Experiment 1, in order to investigate whether phylogentic fear relevance supports resistance to extinction in CC, indexed by measures of ERP. Based on reports of differential extinction effects, between FR and FI CSs, using physiological indices such as SCR (e.g. Fredrikson & Öhman, 1979; Lipp & Edwards, 2002; Öhman et al., 1975; Öhman et al., 1976), one would also expect superior resistance to extinction for FR over FI stimuli with ERP indices. However, if ERP indexes a functionally different form of learning to

expectancy (i.e. affective learning) then one might expect resistance to extinction regardless of CS fear-relevance.

In summary the aims of this experiment include:

1. To investigate whether the rate at which participants learn the CS-US contingencies increases for fear-relevant CSs (in line with the biological preparedness/cognitive bias accounts of selective associations).

2. To provide an ERP index of conditioned responding, as opposed to other online physiological measures of response (such as SCR) commonly used in CC paradigms, which would enable cross paradigm comparisons between EC (Experiment 1) and CC.

3. To investigate whether extinction effects indexed online using ERP differ from EC (Experiment 1). An overall extinction effect is hypothesised (collapsing across fear-relevance), indicating that procedural differences in the type of US employed within EC and CC paradigms may be responsible for previous failures to find resistance to extinction with physiological measures such as SCR and startle response (e.g. Blechert et al., 2008; Lipp et al., 2003; Vansteenwegen et al., 1998 & 2006).

4. To explore whether resistance to extinction of the ERP response will be observed for fear-relevant stimuli only, as observed consistently with other physiological measures of response (e.g., SCR) in CC paradigms (see Öhman & Mineka, 2001 for a review). Based on such findings by Öhman and colleagues, resistance to extinction is expected for the FR CS+, in support of either a biological preparedness (Öhman & Mineka, 2001; Seligman, 1971) or cognitive bias (Davey, 1995; 1997) account of selective associations.

3.2 Method

3.2.1 Participants

A total of 21 adult participants were recruited from the University of Sussex paid participant pool and taught /research postgraduate mailing lists. However 5 participants' data were withdrawn from analysis, using the data inclusion rule from Experiment 1. The remaining sample of 16 participants consisted of 4 men and 12 women with an age range from 18 to 33 (M = 22.94, SD = 5.25) and participants were paid for their participation.

3.2.2 Materials, Measures and Procedure

The stimulus materials, design, procedure and ERP recording parameters of Experiment 2 were identical to Experiment 1, apart from the replacement of visual USs with auditory USs. In Experiment 2, the CSs consisted of the same four neutral images of white pills, with either fear relevant or fear irrelevant animal imprints, as used in Experiment 1. In contrast to the previous study, the unconditioned stimuli (US) were 500 ms auditory sounds calibrated to 82dB peak amplitude[4]. The aversive US was a shortened version of a sound created by Neumann and Waters (2006) of metal scraping on slate, and the neutral US was a sound of water running. Various 500 ms sound clips from Neumann and Waters'

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[4] The purpose for using the 82dB aversive sound developed by Neumann and waters (2006), instead of a more common 100dB single frequency tone often used in CC studies, was for ethical consideration as the aversive US would be presented at a rate of 10 trials per minute. It was considered that an aversive sound played at lower dB would be considerably less damaging/uncomfortable for participants when played at such a frequent rate, and as Neumann and Waters found on several measures the 82dB aversive sound to be equally if not more aversive than the 100dB single frequency tone, a shortened (500 ms) version of their sound seemed preferable.

original sound were piloted along with various neutral sound clips, and two sound clips were selected as being the highest and lowest in ratings of 'startle', 'anxiety evoking', and 'unpleasantness'. Therefore, during the conditioning phase participants were now asked to predict if the CS would be followed by a 'pleasant' or 'unpleasant' sound.

3.3 Results

3.3.1 Contingency Awareness

The same 2-way ANOVA that was used in Experiment 1 was run for the contingency awareness score from the number of accurate CS outcome predictions made during conditioning.

Significant main effects of fear-relevance: F (1,14) = 5.48, p = .04 (η^2_p= .28), contingency, F (1,14) = 320.05, $p <$ .001 (η^2_p= .96), and their interaction F (1,14) = 15.10, p = .002 (η^2_p= .52) echo the results of Experiment 1 in that participants performed close to 100% accuracy for the CS+ and around 40-50% accuracy (chance) for the CS-, demonstrating expected contingency awareness for these conditions. Using paired samples t-tests, the interaction showed significant higher levels of accuracy for FR CS+ in comparison to FI CS+, t (15) = 3.62, p = .003, r = .23 (see Figure 3.1), but no significant impact of fear-relevance for the CS- condition, t (15) = -.73, p = .48, r = -.07. However, one-sample t-tests showed significantly higher accuracy than chance for CS+ in both fear-relevance conditions, $p <$ .001 (test value = 50), Therefore we can assume participants were contingency aware regardless of fear-relevance but perhaps less certain of the 100% negative outcomes in the fear-irrelevant condition.
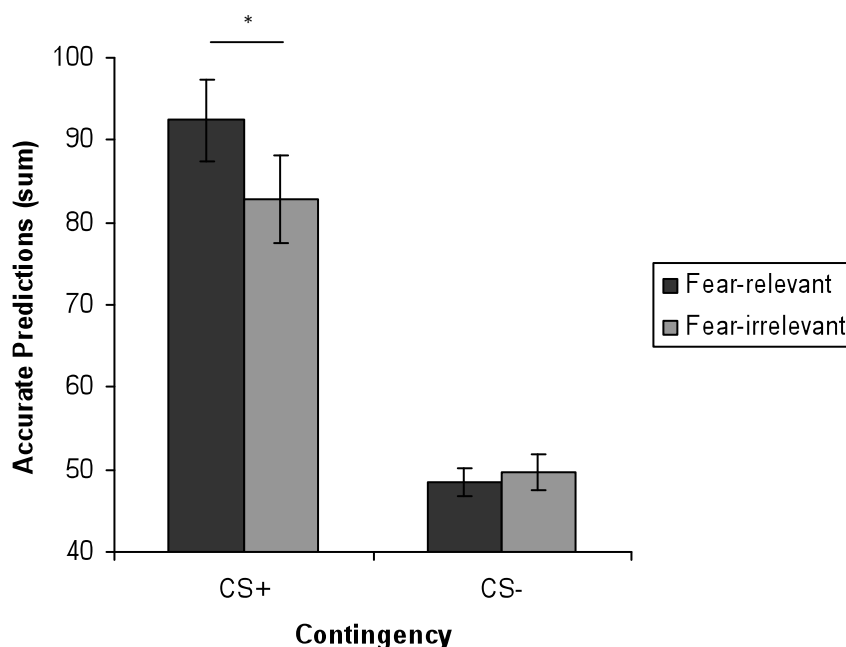
Figure 3.1. Mean number of correct outcome predictions, for fear-relevant and irrelevant CS, depending on contingency of negative US (error bars represent standard error of the mean).

As in Experiment 1, to explore whether the effects of fear-relevance and contingency were consistent over time in the conditioning phase, a 2(Fear-relevance: FR vs. FI) × 2(Contingency: CS+ vs. CS-) × 10(Epoch: 1st 10 trials vs. 2nd 10 trials vs. 3rd etc.) repeated measures ANOVA was run on accuracy scores calculated from 10 time epochs, from consecutive groups of 10 trials.

The assumption of sphericity was violated for the main effect of epoch (time), χ^2 (44), 77.67, p = .002 and the interaction between contingency × epoch, χ^2 (44), 83.88, p = .001. Therefore degrees of freedom were corrected using the Greenhouse-Geisser estimate of sphericity (ε = .38 and ε = .49 respectively).

Similar to Experiment 1 there was a significant main effect of epoch, F (3.45, 51.68) = 5.57, p = .001 (η^2_p= .27), suggesting that accuracy in prediction varies across these time epochs and therefore participants may not be contingency aware from the start of conditioning.

There was a significant interaction between contingency × epoch, F (4.44, 66.53) = 5.14, p = .001 (η^2_p= .26), indicating that differences between CS+ and CS- on awareness were dependant on the epoch of trials. There was also a further statistical trend interaction between fear-relevance × contingency × epoch, F (9, 135) = 1.77, p = .08 (η^2_p= .11), suggesting that differences between CS+ and CS-, dependant on epoch, showed a different pattern of results for fear-relevant stimuli than for fear-irrelevant. This contrasts to Experiment 1 where there was only a significant interaction between fear-relevance × epoch, this was not further dependant on contingency as would be expected. Here fear-relevance × epoch was not significant, F (9, 135) = 1.38, p = .20 (η^2_p= .08).

Figure 3.2 demonstrate the interaction between fear-relevance × contingency × epoch. These figures suggest that, although the pattern of awareness is similar for FR CS- and FI CS-, across all 10 Epochs (c. 50% accurate predictions), participants reach almost perfect accuracy much faster for the FR CS+ than they seem to for the FI CS+ (error bars for the CS+ and CS- overlap for the 1st epoch in FI condition only).

To explore differences in accuracy between CS+ and CS-, in the 1st epoch of 10 trials, depending on fear-relevance of the CS a 2(Fear-relevance: FR vs. FI) × 2(Contingency: CS+ vs. CS-) repeated measures ANOVA was run on a score of accuracy for the 1st epoch only. A significant interaction between fear-relevance × contingency, F (1, 15) = 20.93, p < .001 (η^2_p= .58) confirms differential accuracy between CS+ and CS-, dependant on fear-relevance, for the first 10 trials. Bonferroni corrected contrasts showed significantly higher accuracy for the fear-relevant CS+ than the fear-relevant CS- in the 1st 10 trials, t (15) = 4.98, p < .001, r = .61, whereas for the fear-irrelevant CS+ participants are slower to reach almost perfect accuracy and their accuracy is not significantly different to the fear-irrelevant CS- in the 1st 10 trials, t (15) = -.21, p = .84, r = .03. This finding indicates a higher

expectancy for negative outcome when a CS is FR, which permits contingency awareness within the 1st 10 trials of conditioning.
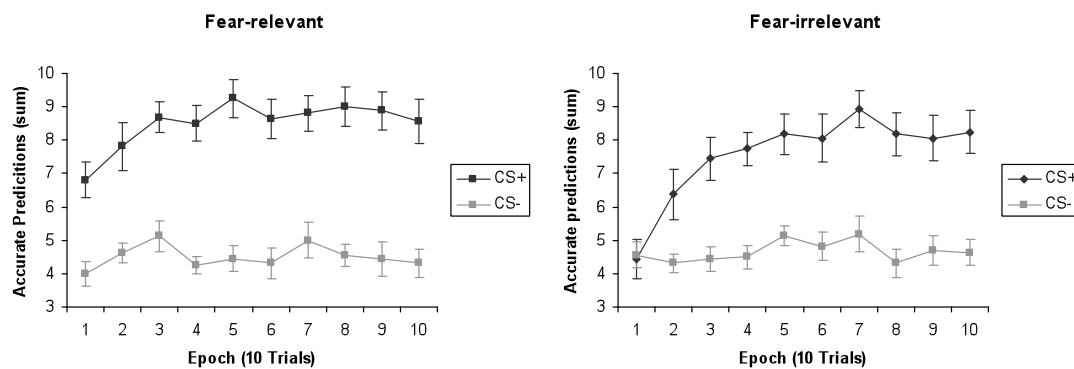
Figure 3.2: Mean number of accurate predictions (contingency awareness), per 10 trial epoch, for CS+ and CS-, split by fear-relevance (error bars represent standard error of the mean).

3.3.2 ERP Results
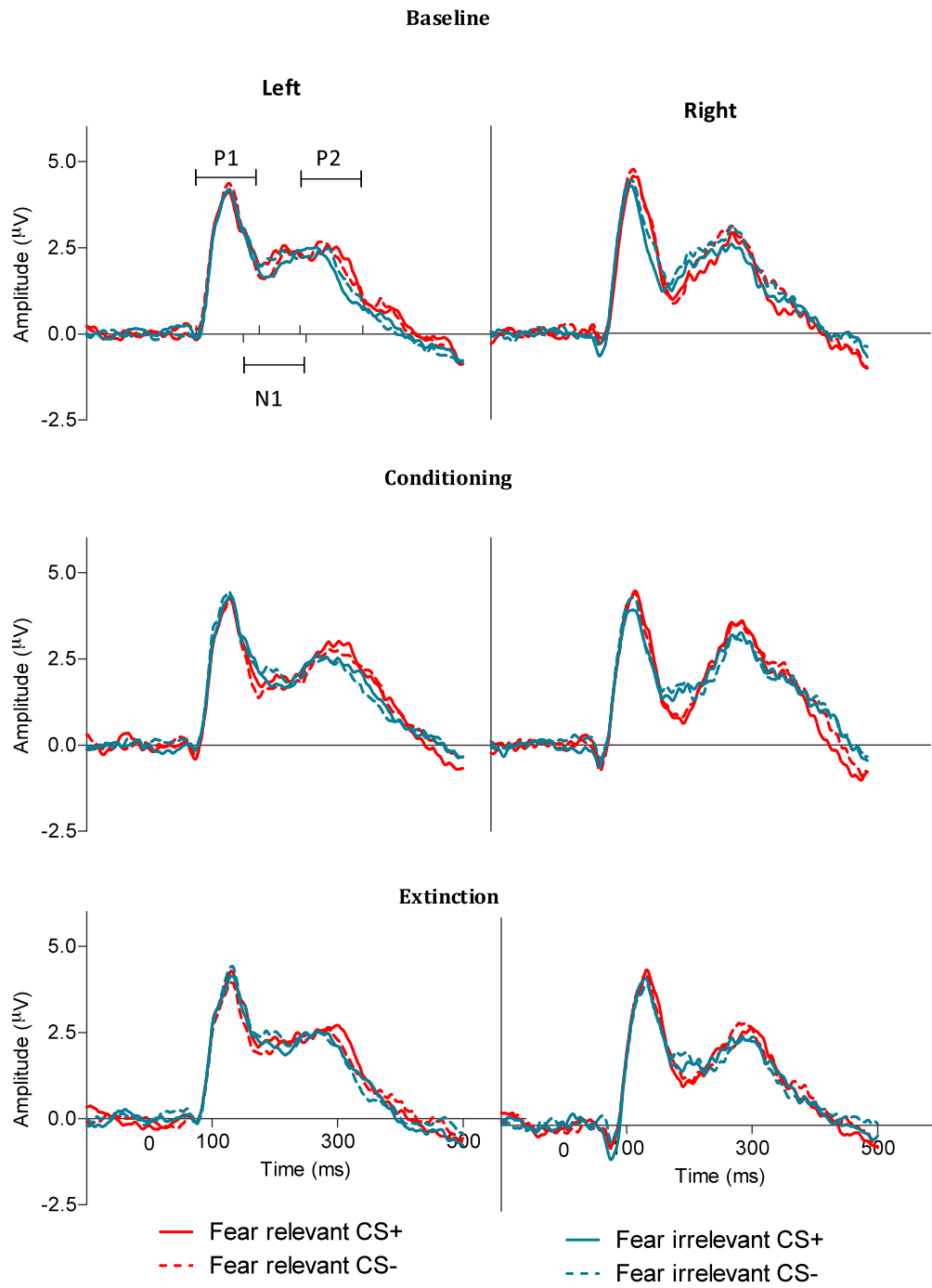
Figure 3.3: Experiment 2 ERP grand average for 500ms poststimulus interval, split by hemisphere. Collapsed across all recorded parietal and occipital electrode sites.

Graphical representation of the grand average ERP waveforms (Figure 3.3), in response to the four stimuli, suggests N1 differences in response to fear-relevant and fear-irrelevant stimuli at baseline conditioning and extinction (right hemisphere). Contingency of the CS, mainly seems to affect the fear irrelevant stimuli during conditioning and extinction phases (bilateral). The P2 component also indicates larger response to fear-relevant over fear-irrelevant CSs during conditioning and extinction (bilateral), with a slightly larger response to the FR CS+ in the left hemisphere during conditioning. As in Experiment 1 (Chapter 2) little modulation of the P1 component is apparent thus analysis is only reported for N1 and P2 components.

N1 Peak Latency

The same procedure of analysis, used in Experiment 1, was conducted for Experiment 2. In analysis of the N1 peak latency, a statistical trend effect of phase [F (2, 30) = 2.88, p = .07, η^2_p = .16] was observed which further interacted significantly with fear-relevance: fear-relevance × phase [F (2, 30) = 4.16, p = .03, η^2_p = .22]. Bonferroni Contrasts show a statistical trend effect of fear-relevance between baseline and conditioning phases (p = .09, η^2_p = .18) but not between conditioning and extinction (p = .50, η^2_p = .03). Whereas FI stimuli had a faster N1 peak latency than FR, at baseline, they seem to slow to a similar latency at conditioning (see Figure 3.4).
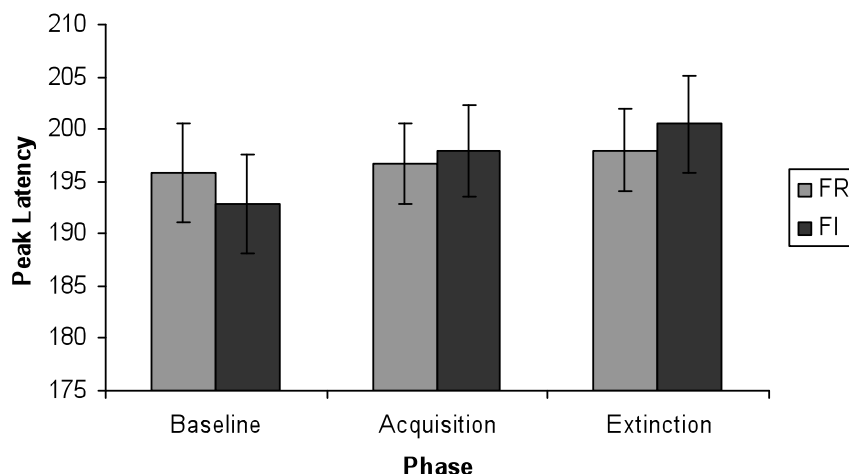
Figure 3.4: Mean N1 peak latency towards FR and FI stimuli across experimental phase, collapsed across contingency and hemisphere. Error bars represent standard error of the mean.

N1 Mean amplitude time windows were calculated 25 ms either side of average N1 Peak Latency (as in Experiment 1) with Mean Peak Latency adjusted for the main effects of phase and fear-relevance.

N1 Mean Amplitude

N1 mean amplitude was analyzed in the same way as Experiment 1. Similar to Experiment 1 a statistical trend effect of fear-relevance, $F (1, 15) = 4.13$, $p = .06$, $\eta^2_p = .22$, indicated a larger N1 response for FR ($M = 1.61$, $SE = .54$) as opposed to FI ($M = 1.87$, $SE = .50$) stimuli.

In addition, fear-relevance significantly interacted separately with hemisphere (fear-relevance × hemisphere: $F (1, 15) = 4.70$, $p = .05$, $\eta^2_p = .24$), and contingency (fear-relevance × contingency: $F (1, 15) = 5.82$, $p = .03$, $\eta^2_p = .28$,). N1 mean amplitude response proved larger for FR ($M = 1.22$, $SE = .60$) than FI stimuli ($M = 1.69$, $SE = .59$) in the right

hemisphere, whereas mean amplitude response was similar between FR (*M* = 1.99, *SE* = .58) and FI (*M* = 2.05, *SE* = .50) in the left. Also N1 mean amplitude response was similar for CS+ in both the FR (*M* = 1.72, *SE* = .52) and FI (*M* = 1.74, *SE* = .50) conditions (collapsed across phase and hemisphere), but a larger response was seen for the FR CS- (*M* = 1.50, *SE* = .56) in comparison to the FI CS- (*M* = 2.00, *SE* = .52).

In contrast to Experiment 1 there was no evidence of conditioning for N1 mean amplitude: there was no significant interaction between contingency and phase, *F* (2, 30) = .07, *p* = .93, η^2_p = .005; and there was no further interaction between fear-relevance × contingency and phase, *F* (2, 30) = .70, *p* = .51, η^2_p = .05 (see Figure 3.5).
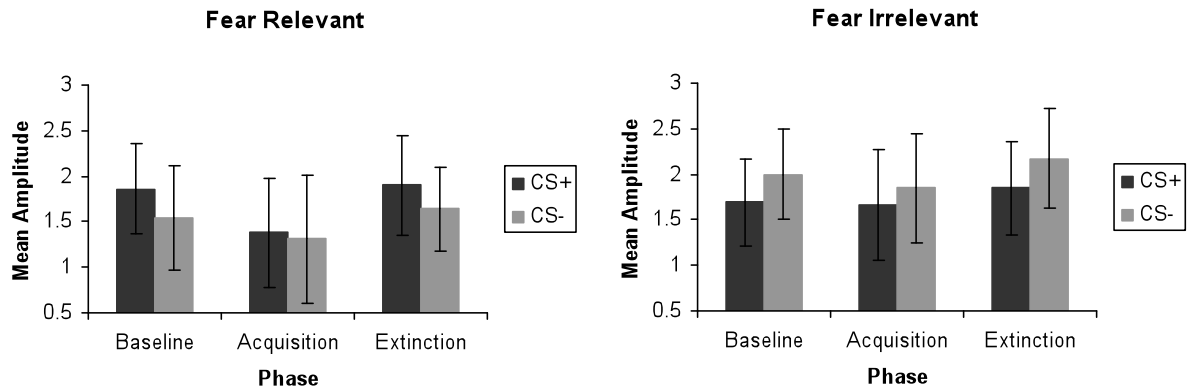
Figure 3.5: Mean N1 mean amplitude in response to CS+ and CS- across experimental phase, split by fear-relevance. Error bars represent standard error of the mean.

P2 Peak Latency

Analysis of P2 peak latency showed a statistical trend effect of fear-relevance *F* (1, 15) = 3.83, *p* = .07 (η^2_p= .20), with faster peak latency for the FI (*M* = 284, *SE* = 3.27) than the FR (*M* = 287, *SE* = 2.81). There was also a significant main effect of phase (sphericity violated), using the Greenhouse-Geisser correction (ε = .73), *F* (1.47, 21.98) = 13.09, *p* = .001 (η^2_p= .47). Bonferoni contrasts show peak latencies to be significantly faster (*p* = .001, η^2_p= .51)

at baseline (*M* = 281, *SE* = 2.84) compared to conditioning (*M* = 292, *SE* = 3.75) and significantly slower (*p* = .002, η^2_p= .50) at conditioning in comparison to extinction (*M* = 283, *SE* = 2.87).

P2 Mean amplitude time windows were calculated 25 ms either side of average P2 Peak Latency (as in Experiment 1) with mean peak latency adjusted for the main effects of phase and fear-relevance.

P2 Mean Amplitude

 P2 mean amplitude was analysed in the same way as Experiment 1. A statistical trend of fear relevance, *F* (1, 15) = 3.10, *p* = .10 (η^2_p= .17) indicated higher P2 mean amplitude for fear-relevant stimuli (*M* = 2.72, *SE* = .33) in comparison to fear-irrelevant stimuli (*M* = 2.48, *SE* = .26) collapsing across contingency, phase and hemisphere. There was also a statistical trend of phase*, F*(2, 30) = 2.35, *p* = .11 (η^2_p= .14), with Bonferoni comparisons indicating that the conditioning phase (*M* = 2.87, *SE* = .36) showed significantly larger P2 response (*p* = .05, η^2_p= . 23) compared to the baseline phase (*M* = 2.47, *SE* = .33), and also showed a trend of larger P2 response (*p* = .13, η^2_p= .15) compared to extinction (*M* = 2.46, *SE* = .25).

Contrary to Experiment 1 (where evidence of conditioning was shown from the N1 component but not P2) the critical contingency × phase interaction was significant, *F* (2, 30) = 3.21, *p* = .05 (η^2_p= .18), indicating conditioning on the measure of P2 mean amplitude for Experiment 2. Contrasts here, between baseline and conditioning phases, suggested an overall acquisition of conditioned response *F* (1, 15) = 7.44, *p* = .02 (η^2_p= .33) with amplitude of the P2 component increasing more for the CS+, from baseline to conditioning, than for CS- (see Figure 3.6). However, there did not seem to be extinction of conditioned responses. Between conditioning and extinction phases contrasts showed no significant difference in mean amplitude change between the CS+ and CS-, *F* (1, 15) = .94, *p* = .35, η^2_p= .06.

Paired samples *t*-tests for CS+ and CS-, between baseline and conditioning phases showed that P2 mean amplitude response to the CS+, significantly increased, from baseline to conditioning *t* (15) = -2.96, *p* = .01, *r* = .21 (two-tailed). Whereas increase in response from baseline to conditioning for the CS- was not significant, *t* (15) = -1.11, *p* = .28, *r* = .07. Interestingly, though contrasts did not distinguish a significant difference between CS+ and CS- from conditioning to extinction, the two-tailed, paired samples tests did show a statistical trend of decrease in P2 amplitude for the CS+ from conditioning to extinction, *t* (15) = 1.73, *p* = .11, *r* = .19 (two-tailed). Considering the effect size is almost as large as the conditioning effect for the CS+, this seems indicative of extinction (see Figure 3.6). Change in response towards the CS- from conditioning to extinction was not significant (*t* (15) = 1.32, *p* = .21, *r* = .13) but as this represents a similar decrease in response to the CS+ it is not surprising that contrasts did not show up a significant contingency × phase interaction between conditioning and baseline which would have indicated an extinction effect.
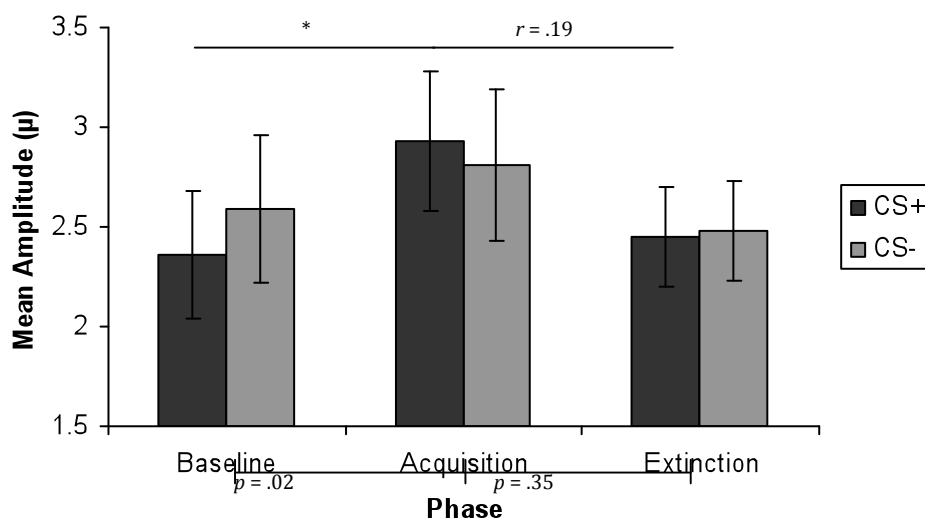
Figure 3.6: Mean P2 mean amplitude response towards CS+ and CS- across experimental phase. Error bars represent standard error of the mean.

There were no further significant interactions between our effect of conditioning and either fear-relevance and/or hemisphere suggesting that these variables may not have such impact in traditional expectancy learning paradigms as was expected (fear-relevance × contingency × phase, $F(2, 30) = .35$, $p = .71$, $\eta^2_p = .02$; hemisphere × fear-relevance × contingency × phase, $F(2, 30) = 1.46$, $p = .25$, $\eta^2_p = .09$).

3.4 Discussion

3.4.1 Fear relevance aids faster US-expectancy learning

The contingency awareness results of Experiment 1 were echoed in the present study, with participants demonstrating full awareness of the CS-US contingencies when averaged over all conditioning trials. However, although participants learnt to predict the aversive US outcome within the first 10 trials for the FR CS+, participants did not learn this contingency before the second 10 trials for the FI CS+: during the first 10 trials participants did not perform significantly better than chance when the CS+ was FI. This effect of fear-relevance on US expectancy learning, along with overall higher accuracy scores in predicting the aversive US when the CS+ was FR, supports a preparedness account (Seligman, 1971; Öhman & Mineka, 2001) or cognitive bias account (Davey, 1995 & 1997) for US expectancy learning: higher expectation of aversive outcomes for phylogenetic FR CSs permit contingency awareness within the first 10 trials of conditioning.

3.4.2 ERP indices of conditioning within the CC paradigm

Also, in a similar trend to Experiment 1, experimental phase modulated ERP peak latency and mean amplitude of the P2 component, demonstrating slower peak latency of response at conditioning in comparison to baseline and extinction, yet in addition there was indication of larger P2 amplitude in response during conditioning than during the baseline phase. Phase also modulated peak latency response for the N1 component like in Experiment 1, with faster response during baseline than conditioning or extinction phase. However the effect of phase on N1 mean amplitude seen in Experiment 1, with larger responses during baseline phase, was not observed in the present study.

The same effects of fear-relevance on N1 and P2 mean amplitude, were also observed for the present study, with larger amplitude response towards FR than FI stimuli, again

concurring with the premise that early to mid latency components of the Occipital region are sensitive to modulation by affective images, with consistently larger amplitude response if the image is found to be unpleasant (see Olofsson et al., 2008, for a review). The effects of phase in the present study also suggest a higher demand of attentional resources during the conditioning phase as peak latency is consistently slower in response to the CSs during this phase, than in baseline and extinction phases, as was the case in Experiment 1. However, the larger mean amplitude response during conditioning for the P2 component may perhaps be indicative of higher arousal/attention during that experimental phase. This goes against the explanation for the effect of phase on P2 peak latency, and it is also strange that the same effect was not seen for the conditioning phase in the EC paradigm of Experiment 1.

Interestingly there was no interaction between contingency and phase on N1 mean amplitude that would indicate acquisition of a conditioned response, as in Experiment 1. Neither was there any conditioning effect dependant on fear-relevance for the N1 mean amplitude response. For P2 mean amplitude however there was a significant interaction between contingency and phase, and contrasts demonstrated the contingency × phase interaction to be significant between the baseline and conditioning phases but not between conditioning and extinction. The results from the contrasts thus were indicative of a conditioning effect, but not of extinction. A significant increase in P2 amplitude response was demonstrated from baseline to conditioning for the CS+ in comparison to no significant change in response for the CS-, demonstrating acquisition of the conditioned response. Considering the evidence that P2 mean amplitude response increases in general towards fear-relevant stimuli it may be assumed that the direction of response shift, towards the CS+ as a result of the 100% contingency with the aversive US, is associated with a negative shift in stimulus affect.

It is particularly interesting that evidence of CR acquisition occurs from different components of the ERP response in Experiments 1 and 2. There is evidence to suggest that earlier components may represent responsiveness to stimulus affect, whereas ERP

components around 200-300 ms may represent arousal towards the stimulus (Olofsson et al., 2008, for a review), therefore one might argue that the presentation of CR on these different components does actually indicate some difference in the responses being formed as a result of the different paradigms used. Learning within the EC paradigm, in Experiment 1, may be observable through amplitude modulation of the N1 component because the learnt response towards the stimulus is affective, whereas learning within the CC paradigm in the present study may be observable at the later P2 component because the learnt response represents arousal due to anticipation of the startle noise US. Perhaps it is not surprising that the type of event that is anticipated by, or associated with, the CS will affect the type of response produced: a motivationally relevant stimulus such as that used in the present CC paradigm is likely to be anticipated in a different way to a visually affective stimulus which may be grotesque, but does not produce a physiological UR as such[5].

3.4.3 Comparison of Extinction in EC and CC Paradigms

Interesting as it is that CR is demonstrated on a later component in this CC paradigm, as opposed to Experiment 1 where the paradigm was typical of EC, the main point of interest is whether these paradigms demonstrated differences in terms of extinction. Although contrasts did not show a significant interaction between contingency and phase from conditioning to extinction phases, and this seemed indicative of resistance to extinction, bonferroni corrected paired samples t-tests suggest otherwise. Decrease in response towards both the CS+ and CS-, from conditioning to extinction, meant that no significant contingency × phase interaction was found between these phases; however the decrease in response for the CS+ neared significance. As the effect size for this decrease in response was almost as large as the effect size for the significant increase in response seen for the

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[5] Visually affective stimuli may produce a UR, however this is likely to be different in nature to the UR produced by shock/startle USs: perhaps a disgust response as opposed to fear.

CS+ from baseline to conditioning, and the same size as the effect size found for the significant decrease in N1 mean amplitude for the CS- in Experiment 1, there is evidence of extinction for the CR using a CC paradigm.

Evidence for extinction using ERP as an online physiological measure of response in a CC paradigm, when resistance to extinction was clearly demonstrated in a comparable EC paradigm, supports the possibility that previous failures to find resistance to extinction with physiological measures, such as SCR and startle response, may have been because these measures necessarily rely on using a CC paradigm. The indication that procedural differences, in the type of US employed by EC and CC paradigms, might be responsible for extinction effects previously found when using physiological measures of response opposes the premise that the type of measure used (physiological vs. self-report) distinguishes between expectancy learning and affective learning.

3.4.4 Fear-relevance effects on extinction

Another interesting aspect of this study was that extinction effects were not dependant on fear-relevance of the CS. Resistance to extinction has consistently been found through physiological measures of response, in CC paradigms, when using FR as opposed to FI CSs. Öhman and colleagues consistently demonstrated superior conditioning and resistance to extinction with SCR when using images of FR animals such as snakes and spiders, as opposed to FI images of stimuli such as flowers and mushrooms (e.g. Fredrikson et al., 1975; Öhman et al., 1975; Öhman et al., 1976; see McNally, 1987, and Öhman & Mineka, 2001 for reviews). The present study employed degraded FR images of a snake and a spider and FI images of a rabbit and a squirrel. Although clear effects of fear relevance were seen in measures of the ERP response there was no significant impact of fear relevance on the acquisition or extinction of CR in either Experiments 1 or 2. This finding may be a result of the animal images being degraded: animal outlines in the forms of imprints on white pills were used as opposed to vivid animal images in order that they

may be more neutral in affect before conditioning. Although fear-relevance did impact on measures of ERP response, perhaps the difference between FR and FI was not strong enough to impact on the CR.

Another explanation of the lack of fear-relevancy effects on the acquisition of CSs could be the extreme number of acquisition and extinction trials that needed to be used in the current studies to calculate a clear average ERP response. Preparedness theory of selective associations suggests that some stimuli are more likely to enter into associations with aversive outcomes based on their phylogenetic fear-relevance: i.e. depending on whether they posed a threat to the survival of pre-technological man (Seligman, 1971). Davey's (1997) cognitive bias model of selective associations proposes a similar trend but that fear-relevance may be determined by cultural factors as opposed to biologically pre-determined. Either way, evidence from human laboratory studies has shown that acquisition of CR can occur faster (within less trials) and will take longer (more trials) to extinguish if a CS is fear-relevant (e.g. Fredrikson et al., 1976; Fredrikson & Öhman, 1979; Öhman et al., 1975; Öhman et al., 1976). However, these studies typically employ 5-8 trials of conditioning and 8-10 trials of extinction, whereas the present study, and Experiment 1, employ 100 trials of each experimental phase. If the distinction between FR and FI stimuli largely depends on the speed/number of trials it takes for extinction of the CR to occur, then it is not surprising that fear relevancy did not moderate extinction: within 100 trials of extinction training the CR would surely have time to extinguish regardless of fear-relevance.

3.4.5 Comparison of ERP and other physiological measures

As discussed in Experiment 1, in spite of the difference in the number of trials employed in experimental phases for the present study, a main difference in the way ERP represents response, in comparison to the other more commonly used physiological measures of response, should also be noted. ERP is measured online, like SCR and startle response, but

an average of response is taken across all trials within the experimental phase in order to reduce the signal to noise ratio. Due to this averaging process the ERP response measured may be more representative of the integrative approach to CS judgements seen in causal learning studies, and similarly with affective CS ratings and US expectancy ratings demonstrated by Lipp & Purkis (2006), in which a single judgment taken post hoc extinction training seems more representative of an averaged response based on contingency changes over the whole experimental procedure. The average ERP response taken over such a large number of trials is likely to represent an average of the fluctuations in affective response throughout the conditioning and extinction phases. If this principle is correct it might explain why differences in acquisition and extinction of CR are not found between the FR and FI CS+. Due to this prospect it is seen as worth attempting an alternative method of handling the ERP data in order to track changes in response throughout the conditioning and extinction phases in a similar manner to SCR measures.

In Experiments 3 and 4 (Chapters 4 and 5), as well as the average ERP analysis over all trials, an attempt is made to epoch the raw EEG trials and take sequential 5 trial averages to model changes in the ERP response longitudinally throughout each experimental phase. As a number of trials are lost through the artefact rejection procedure (where artefacts in the EEG recording were identified), for some epochs no trials are available for averaging, therefore in order to handle these missing data points multi-level modelling is used as a more robust measure for handling such data (Field, 2009).

3.4.6 Summary

So far, Experiments 1 and 2 have demonstrated ERP to be a viable physiological measure of CR that can be employed within typical EC and CC paradigms alike. Evidence of differential extinction patterns between the two paradigms, with resistance to extinction in Experiment 1 (EC) and some evidence of extinction in the present experiment (CC),

indicates that procedural differences in the types of US used in typical EC and CC paradigms may be the cause for why many previous studies have consistently found extinction of CR when using physiological measures (SCR/startle response) of response. However, limitations in the need to average across such a large number of trials when measuring average ERP response during each experimental phase, may be contributing to the observation of resistance to extinction. The number of trials and averaging process may also be reason for why no impact of CS fear-relevance is observed on effects of conditioning or extinction.

Experiments 3 and 4 investigate further the role of fear-relevance within the CC paradigm with the aims of determining whether information manipulations of fear-relevance have similar effects on US-expectancy, as seen in the present study using phylogentically FR and FI animals. These studies take advantage of a more explicit fear-relevance manipulation considering that the downgraded images in Experiment 1 and the present study did not successfully impact on the CRs observed. These studies also explore evidence for information effects on the acquisition and extinction of CR, indexed again using measures of ERP response. The relevance of the information manipulations is discussed with regards to alternative routes to fear-learning (Rachman, 1977) and Davey's (1997) cognitive bias model of selective associations. Experiments 3 and 4 also implement the alternative epoched handling of the ERP data and analysis, in addition to the traditional methods of analysis employed in Experiments 1 and 2. The alternative analysis that is proposed will attempt longitudinal modelling of response change across the conditioning and extinction phases for evidence of differential rates of acquisition and/or extinction of conditioned response depending on fear-relevance manipulated through the information provided.

Chapter 4: The impact of negative information on fear beliefs, US expectancy, and ERP indices of conditioned response

4.1 Introduction

4.1.1 Cognitive vs. Biological explanations of selective associations and resistance to extinction

Resistance to extinction of the conditioned response (CR) can be explored in terms of both the procedural elements that support it and theoretical models of the process that underlies it. In Experiments 1 and 2, two comparative studies investigated whether differences in resistance to extinction of the CR could be found on the procedural level. ERP was used as an implicit physiological measure of CR in both a visual evaluative conditioning (EC) paradigm and a classical conditioning (CC) paradigm. At this procedural level little evidence was found for differences in acquisition of the CR, however differential extinction effects were observed: resistance to extinction was found when using the EC paradigm, whereas there was some evidence of extinction observed when using the CC paradigm. This dissociation in extinction effects implies that previous findings of extinction, using physiological measures of response (e.g. Blechert et al., 2008; Vansteenwegen et al., 2006), may have resulted from the reliance of these measures on a CC paradigm.

In the previous experiments, the phylogenetic fear-relevance of the CS was also manipulated to investigate whether fear-relevance supports superior acquisition, and resistance to extinction of the CR. Disparity in resistance to extinction between phylogenetically FR and FI stimuli (McNally, 1987), along with the uneven distribution of fears, has been explained in terms of a biological preparedness to form associations between aversive consequences and threatening stimuli (Seligman, 1971). As discussed

earlier (see Chapter 1) the theory of biological preparedness was developed further by Öhman and Mineka (2001) who emphasised the selective and automatic nature of an evolutionary module of fear learning, which is activated by stimuli that are phylogenetically FR.

In Experiments 1 and 2, although overall main effects of fear-relevance on ERP peak latency and mean amplitude were found, the ERP indices of response did not support superior acquisition or resistance to extinction of CR for the phylogenetic FR CS+. This result contradicts findings from studies using other physiological measures, such as SCR (Öhman et al., 1975; Öhman et al., 1976) and finger pulse volume (Fredrikson & Öhman, 1979), which have demonstrated the expected 'preparedness' effects of resistance to extinction for FR stimuli. However, due to the large number of trials needed to calculate an average ERP response, this index of CR might be insensitive to differential fluctuations in the rate of acquisition and extinction of CR towards FR and FI stimuli. The present study attempts to resolve this issue by incorporating an alternative analysis of ERP response, epoched across experimental phase. This analysis is discussed in due course.

Although no significant effects of phylogenetic fear-relevance were observed for ERP indices of CR in Experiments 1 and 2, there was evidence for improved/faster learning of contingencies for the FR CS+. This fear-relevance effect on acquisition supports the notion that biological preparedness promotes faster learning of the contingency between a phylogenetic FR stimulus and an aversive outcome.

However, as discussed earlier (see Chapter 1), Davey's (1995) cognitive bias model of fear conditioning provides an alternative explanation for selective associations. Though there is compelling evidence from both human (Mineka, 1985; Öhman & Mineka, 2001) and primate studies (M. Cook & Mineka, 1989, 1990) for selective aversive associations with phylogenetically FR stimuli, Davey presents evidence for how the evolutionary

predisposition explanation could misrepresent what might simply be explained in terms of information processing biases[6].

Davey's 1997 conditioning model of phobias explains the uneven distribution of fears by incorporating inferred processes, thus advancing on traditional behavioural contiguity models. As well as inferring that the learnt association between the CS and US mediates the observed CR (Rescorla, 1980), Davey suggests that the factors that influence the strength of that association also influence the strength of the CR. These factors are referred to as 'Expectancy Evaluations' (Davey 1997) and include: verbally and culturally transmitted information regarding the contingency between the CS and US; prior existing beliefs/expectancies about the possible consequences associated with the CS and current emotional reactions elicited by the CS.

Davey (1995) outlines evidence that *a priori* expectancy bias, mediated by such 'expectancy evaluations', can lead to a covariation bias that is evidently important in determining selective associations. Though a covariation bias is often found when stimuli are phylogentically fear relevant studies by Tomarken et al. (1989) and Diamond et al. (1995) suggest that prior fear is the important factor in maintaining expectancy bias. Davey proposes that if prior fear is important in determining the covariation bias, then the reason why it is exhibited only for phylogenetic stimuli may result from such stimuli (e.g. snakes and spiders) being highly feared in Western cultures. This explanation still poses the question as to why these phylogenetic FR stimuli are more generally feared than ontogenetic stimuli.

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[6] Examples of alternative explanations for selective associations with phylogenetically fear-relevant CSs include the semiotic similarity between a CS and its associated US (Hamm et al., 1989; Hugdahl & Johnson, 1989).

4.1.2 Information as a pathway to fear: a conditioning framework of social fear learning.

Rachman's (1968, 1977) three pathway theory of fear acquisition suggests that, in addition to direct conditioning, fears can be learned through non-traumatic learning experience such as observational (vicarious) and instructional (information) learning. Conditioning models of phobia development have been criticised on the basis that not all traumatic experiences result in the development of an anxious response and that some phobic individuals cannot remember an aversive experience as the onset of their fear. Additionally, Rachman (1968, 1977) observed that fears can be acquired indirectly (i.e. without experience of a direct conditioning episode) through verbal information and vicarious learning. These criticisms imply that conditioning models alone may be insufficient to explain the aetiology and maintenance of phobias.

In defence of conditioning models, Field (2006c) explains how some fears develop without direct traumatic experience, and how some traumatic experiences might not result in a fear response, through US revaluation (Davey, 1997; Field & Davey, 2001). Firstly, a CS-US association may be formed when evaluation of the US is not yet traumatic, but subsequent traumatic revaluation of that US could lead to a CR towards the CS. Secondly, experience of a traumatic event might not lead to development of a fear response if the traumatic event is devalued post CS-US association. Field (2006) also presents a conditioning framework, which explains learning in the absence of a direct conditioning episode, such as through threat information (instruction) or vicarious learning. Experiencing another person's fearful reaction to a stimulus, or receiving threat information regarding that stimulus, can be conceptualised in conditioning terms in which the focus stimulus is the CS and either the fearful information, or the other person's reaction, is the US.

Evidence that another's fear response can act as a US was provided by Mineka & Cook (1993), who demonstrated unconditioned fear responses (UR) in Monkeys when observing

another Monkey's distress. As reviewed in Chapter 1, a large amount of evidence for both instructional (verbal information) and observational (vicarious learning) pathways to fear has been provided from early retrospective studies (for a review see King et al., 1998) and importantly more recent non-retrospective studies by Field and colleagues, amongst others (for recent reviews see Askew & Field, 2008; Muris & Field, 2010).

Studies by Field and colleagues demonstrated behavioural avoidance and increased fear beliefs, with both direct and indirect measures, when threat information was provided regarding either novel toy characters or animals (e.g., Field, Argyris, & Knowles, 2001; Field & Lawson, 2003; Field, Lawson, & Banerjee, 2008). In further support of the information pathway to fear, physiological indices have successfully been used to demonstrate an increase in fear response towards the CS following verbal information/instruction (Field & Schorah, 2007). Additionally, Olsson & Phelps (2004) manipulated a fear learning procedure to directly compare the effects of conditioning, vicarious learning and verbal instruction. Significant differences in SCR were observed between the CS+ and CS- in all three learning conditions, for supraliminal CS presentation. In summary, there is a strong body of evidence supporting that threat information, can not only change fear beliefs, it can induce an implicit physiological fear response similar to that observed in direct conditioning and vicarious learning. Thus threat information itself can be conceptualised as the US of instructed learning, in a similar manner to another person's fear reaction in vicarious learning.

One potential problem with framing instructional learning in conditioning terms is that the fear information might not always provoke an UR itself. Without a fear provoking US one could argue that instructed fear learning cannot be explained in conditioning terms. Field (2006) suggests that, as conditioning models can explain causal learning where USs are not biologically relevant, it is plausible that a person can continuously learn through causal experiences where a stimulus (CS) predicts threat information (US). Procedurally, such learning experiences are conditioning, because a stimulus is paired with an outcome. If these experiences result in the acquisition of beliefs/behaviours then this can be

described as conditioning at the effect level too. Furthermore, US revaluation helps to explain how a CR towards the CS may occur through verbal information. Having formed an association between the CS and the information, if the information were then revalued through further salient experience, this could lead to a CR towards the original CS that was associated with it.

4.1.3 The role of information in fear learning: a main effect or interaction hypothesis?

The main effect of learning fear through information rules out the need for experiencing trauma, and in this sense represents an adaptive, low risk, form of learning (Olsson & Phelps, 2007). However, the development of specific and persistent phobias may still be reliant on an interaction between negative information and a direct traumatic experience, as suggested by expectancy bias models of associative learning (Davey, 1995). Evidence for an interaction hypothesis between verbal information and direct conditioning experience on enhanced avoidance behaviour in children is provided by Field & Storksen-Coulson (2007). Children developed comparative fear beliefs and avoidance response as a result of either threat information or a direct negative experience alone. Yet in combination these pathways led to significantly higher avoidance responses. This interaction effect supports Davey's expectancy model (Davey, 1995; 1997): that threat information creates expectancies that translate into a fear response through further reinforcement. The main effect hypothesis would predict a CR that is learnt through threat information alone, and would support the premise that information can act as an US (Field, 2006c). However these hypotheses are not mutually exclusive and, whereas a fear response could be learned through threat information alone, additional aversive experiences may simply serve to reinforce that fear belief leading to an association that is more resistant to extinction and thus perceived as selective.

4.1.4 Does the impact of information on fear learning support a propositional account of associative learning?

The propositional account of associative learning propose is based on the idea that all learning can be explained in terms of reasoning processes (De Houwer, 2009; Mitchell et al., 2009). This approach suggests that we learn about the relationships between stimuli rather than simply forming associative 'links' between stimuli, where the representation of the CS automatically evokes the representation of the US. Although the automaticity of a CR represented through implicit measures does suggest an associative link between stimuli that is not mediated by propositional reasoning, Mitchell et al. (2009) argue that this does not mean the learning process itself is automatic. Learning can occur through propositional reasoning and then generate a response that is automatic.

Support for the propositional nature of associative learning has been provided through observation of instructional learning. Verbal instruction (information) studies, such as those mentioned above; for example, Field and Schorah (2007) and Olsson and Phelps (2004), demonstrate that increase in heart rate and SCR can be produced through providing threat information alone without direct experience of an aversive outcome. Additionally, the impact of information on more complex learning phenomena, such as 'release from overshadowing' (Lovibond, 2003), emulates the impact of direct contingency experience. Lovibond (2003) demonstrated that when a stimulus compound was trained to signal a shock (AT+), further A- trials (+/- signs respectively signal the presence or absence of contingent shock) led to the development of a CR towards the T cue alone. Lovibond then showed the same 'release from overshadowing' effect when learning trials (AT+ and A-) were described verbally. Mitchell et al. (2009) interpret the similarity in effect as indicative that knowledge, acquired through direct experience, is propositional in nature.

Both hypotheses of the impact of verbal information on fear learning (fixed effect or interaction effect hypothesis) are compatible with both associative and propositional

accounts of learning. If information acts as an US then it is plausible that learning occurs through the formation of representative links between the CS and the information. However, evidence from Olsson & Phelps (2004) suggests that a CR can be learned only through verbal instruction when participants are aware of the CS (supraliminal presentation). Through direct conditioning and vicarious learning on the other hand, Olsson & Phelps additionally demonstrated learning when CSs were presented subliminally. Thus learning through information is dissociated from direct conditioning and vicarious learning by indication that higher awareness is required for this pathway to fear. If awareness is required for instructional learning this supports the idea that such learning may be based on propositional knowledge. Additionally, learning through verbal information, as demonstrated in Lovibond's (2003) release from overshadowing study, requires propositional knowledge of the relationship between stimuli to produce the same effects as direct contingency experience. Thus there is good evidence that instructional learning is based on reasoning processes. When contingency learning is involved however, it is harder to ascertain whether knowledge is gained through reasoning processes or representational links. Therefore an interaction hypothesis, where negative information increases expectancies and in turn leads to faster acquisition/slower extinction of the CR, could be explained by a combination of propositional and associative accounts. Expectancies could represent propositional connections that strengthen further through direct contingency experience, which itself is based on the formation of associative links.

4.1.5 Aims

The present study aimed to investigate the role of verbally transmitted information, which the expectancy model would predict to influence selective associations through expectancy bias, and social learning theory would suggest leads directly to the fear response itself. Although Field et al. (2001) were able to heighten fear beliefs in children directly through negative verbal information, this effect may have been linked with increased aversive outcome expectancy, and such an expectancy bias could have resulted

in a CR that was resistant to extinction. Additionally, though Field & Storksen-Coulson (2007) demonstrated heightened avoidance behaviour, as a result of the interaction between information and direct experience, this is only one component of the fear emotion proposed by Lang (Lang, 1968). Thus the present study aims to test for a similar effect using ERP indices of response as a physiological measure of fear.

Fear beliefs in the present study were manipulated towards novel and FI animal stimuli using negative verbal information in a similar manner to Field et al. (2001). The source of information was an important factor in this study: children's fear beliefs successfully changed only when the information came from a reliable source such as a teacher (as opposed to a same-age peer). Thus, due to the adult audience of the present study, the information was framed as a news bulletin in an attempt to make the source seem more reliable to an adult audience.

The same fear conditioning paradigm was employed as in Experiment 2, with 100% aversive outcome reinforcement of the CS+ and a partially (50%) reinforced random control (CS-). US prediction was measured online, as in Experiments 1 and 2, to track contingency awareness. Also animal fear beliefs were measured before and after each experimental phase using the animal fear beliefs questionnaire (FBQ, Field & Lawson, 2003). Based on the interaction hypothesis, if negative information was successful in heightening fear beliefs towards novel FI stimuli then higher accuracy in predicting the US for the 'FR' CS+ is predicted, as well as faster learning of the 100% contingency as seen for the phylogenetically FR CS+ in Experiments 1 and 2. Additionally, if verbally transmitted information regarding a CS can create fear beliefs that promote the same effects as seen for phylogenetically FR stimuli, we would expect to find resistance to extinction for the FR CS+. Based on the main effect hypothesis, however, a CR could be evident as a result of negative information alone (regardless of direct conditioning). However, the main effect of information is not considered to be mutually exclusive to the interaction hypothesis. A response formed after information may interact further with additional reinforcement to promote selective associations predicted by the expectancy model (Davey, 1997).

4.2 Method

4.2.1 Participants

A total of 30 adult participants were recruited from the University of Sussex paid participant pool and taught /research postgraduate mailing lists. Six participants' data were withdrawn from analysis, using the same data inclusion rule from Experiments 1 and 2. The remaining sample of 24 participants consisted of 9 men and 15 women with an age range from 17 to 57 (M = 25.38, SD = 9.15) and fulfilled a full counterbalancing order of stimuli across conditions. Participants were paid for their participation.

4.2.2 Stimuli and Materials

Conditioned stimuli (CS) consisted of four images of generically similar, 'fear irrelevant' animals. Three of the animals were Australian marsupials (the quoll, quokka and cuscus) which have been consistently used as novel animals to which information manipulations can be applied with the aim of investigating the effects of information on avoidance behaviour and fear cognitions (e.g. Field and Lawson, 2003; Field et al., 2008). As the design of this study was meant to be comparable to that of Experiment 2, four CSs were needed, therefore a fourth generically similar animal (the pizote) was used (see Appendix 4A for animal images). To ensure participants held no pre-existing fear beliefs about the animals before they took part in the study, the novelty of the animals was checked by showing each participant a picture of each animal and asking first whether they knew the name of the animal, and second, whether they had ever seen one before . Participants were unaware that being unfamiliar with the animals was a requirement of the experiment.

Out of the four CSs, two were presented with auditory negative information, at a comfortable listening level via headphones, which participants were told had been

recorded by media students for a local radio news bulletin. The negative information script can be found in Appendix 4B.

The same unconditioned stimuli (USs), as in Experiment 2, were used: 500 ms auditory sounds calibrated to 82dB peak amplitude (aversive US = sound of metal scraping on slate created by Neumann and Waters, 2006; neutral US = gurgling water sound).

4.2.3 Design

This experiment used a similar repeated measures design to that used in Experiments 1 and 2, however only 2 experimental phases were included: conditioning (acquisition), and extinction. The conditioning and extinction phases were exactly the same as in Experiments 1 and 2, with two of the CSs followed 100% of the time by the aversive auditory US (CS+) and the other two followed 50% of the time by the aversive auditory US, 50% of the time by the neutral auditory US (CS-). One CS+ and one CS- were presented, pre-conditioning phase, with the negative information about them. Assignment of animal to CS+ and CS-, and fear-relevance condition, was fully counterbalanced so that any response found could not be attributed to an artefact of which animal was used in each of the conditions.

4.2.4 Measures

US-expectancy learning

The same online measure of contingency awareness was employed during the conditioning phase, as in Experiments 1 and 2, to track US-expectancy learning.

Fear-beliefs

An animal fear beliefs questionnaire (FBQ) was adapted from Field and Lawson (2003) to make it more suitable for adults (see Appendix 4C). This questionnaire used 7 questions, about how one would feel in certain situations involving the animals, to which participants used a 5-point Likert scale to respond (1 = No, not at all; 2 = No, not really; 3 = Don't know/ Neither; 4 = Yes, probably; 5 = Yes, definitely). An additional item was added to the questionnaire asking whether the participant had received any information about each animal (to which participants could answer 'YES' or 'NO'). This question was included to track whether participants were aware of the animals about which they had received the negative information. In this version of the FBQ no names were attributed to the animals (in case this were to trigger familiarity) but animals were numbered 1-4 and the same set of questions was given for each animal image. Items on the questionnaire were scored 1-5, with a low score indicative of having a fear belief, and item scores were averaged for each animal to give a single fear belief score, which could range between 1 and 5. Some items were reverse scored (see those marked with an asterisk, Appendix 4C).

ERP

Electrical brain activity (EEG) was recorded continuously during both conditioning and extinction phases and parameters of ERP recording were identical to Experiments 1 and 2.

4.2.5 Procedure

The procedure for Experiment 3 followed closely that of Experiment 2, with exception of the baseline phase. However pre-conditioning phase, participants were presented with the negative information about two of the animals (one CS+ and one CS-) and these were then classed as the fear-relevant animals, based on the information that was given about them. The two animals without information were classed as the fear-irrelevant animals. The information was presented aurally, via headphones, whilst participants viewed the images of the 'fear-relevant' animals on the PC monitor.

Following the information stage, the first FBQ was administered so that a pre-conditioning fear belief score could be taken for each animal, and we could be sure that participants were aware of which animals had been paired with the negative information. This was followed by the conditioning phase, which followed the same procedure as Experiment 2.

After conditioning, a second FBQ was administered to monitor whether participants' fear beliefs had changed towards the animals as a result of the contingent pairings with the aversive US, and if this was dependant on whether negative information had been given about the animal pre-conditioning. An extinction phase followed which again used the same procedure as Experiment 2.

Post-extinction, a third FBQ was administered to monitor whether participants' fear beliefs reduced towards the CS+ as a result of the aversive US being taken away, and if this was dependant on whether negative information had been given about the CS+ pre-conditioning. Participants were then debriefed and either received payment or course-credit for their participation.

4.2.5 Across-phase data analysis strategy

Traditional ERP analysis, when ERPs are calculated from an average of trial responses across an experimental phase, makes it impossible to track any difference in *rates* of acquisition or extinction of the CR. Any systematic variance in ERP latency and amplitude across-trials is hidden through the averaging process. This dilemma is not specific to the application of ERP indices in fear-conditioning research. Hu et al. (2010) explain that "The cost of this across-trial averaging procedure is that all the information concerning across-trial variability of ERP latency and amplitude is lost. However, this variability may reflect important factors such as differences in stimulus parameters (duration, intensity, and location)...and, most importantly, fluctuations in vigilance, expectation, attentional focus, or task strategy" (p. 99).

However, the analysis of single trial data in ERP research is an emerging field with new analytical techniques arising from the need to access information concerning across-trial variability of ERP latencies and amplitudes (see Blankertz, Lemm, Treder, Haufe, & Muller, 2010; Hu et al., 2010). Blankertz et al. describe some of the data processing techniques that can be implemented prior to the classification of single-trial ERPs with the aim of increasing the signal to noise ratio (SNR). In particular various feature extraction methods have been applied, including temporal and spatial filters, to distinguish the signals of interest (ERP signals) from the interfering noise. Most prevalent techniques include bandpass, notch or Laplace filters, principle component analysis (PCA) and 'wavelet denoising'.

In the present study we decided to move slightly away from single trial analysis in our approach towards the across-trial variability analysis. To keep our data processing techniques similar to our standard ERP analysis (see Experiments 1 and 2), for reasons of cross-analysis comparisons, ERP response was calculated from consecutive epochs of 5 EEG trials. Thus, differences in longitudinal change of ERP response, based on the information manipulation, could be tracked across the conditioning and extinction phases, but similar data processing techniques were implemented as in the overall-trial analyses.

Although these 5-trial epoched ERP responses were still likely to have an extremely low SNR, averaging across 5 trials would help to improve the SNR relative to single trials. The added benefit of averaging across 5 trials was that it enabled us to use the standard artefact rejection procedures employed in our overall-trial average ERP analyses. Additionally, averaging across 9 posterior electrode sites (for each hemisphere response measurement) also provides some noise reduction, as ERP signals have relatively similar latency and potential deflections when recorded from sites that are close in proximity. Thus, for the purpose of piloting such an analysis within the constraints of this thesis, further feature extraction techniques (as listed above) were deemed unnecessary. Depending on the efficacy of the current approach, however, such feature extraction techniques do provide potential alternatives in the endeavour for across-trial analysis.

One withstanding problem was missing data points: data points for which all five EEG trials were rejected due to artefacts in the EEG recording. The ANOVA based analysis used previously does not deal well with missing data and rather than impute missing data (which can result in artificially small standard errors – see Tabachnick & Fidell, 2001), we decieed to use a multilevel modelling analysis which handles such missing data routinely (Field, 2009). This analysis provides a more sensitive data analysis than is achieved by collapsing across all trials.

A mixed model multilevel regression analysis was used to predict latency and amplitude measures of the ERP response with participants as level one predictors and trial-type factors (hemisphere, phase, contingency and threat information) as level two predictors. In the analysis, level two predictors (hemisphere, phase, US-contingency, and threat information) were entered as fixed factors and participants as a random factor. The analysis followed a hierarchical sequence, starting with the most basic regression model, which included only the intercept, which was random within participants. Next the fixed factors of hemisphere, phase, contingency and threat information were added to the model. Then the variance and covariance structure of the data were modelled: first, heteroscedasticity across hemisphere, phase, contingency and threat information was

modelled by weighting these variables by the group variances. If this model improved the fit it was retained, otherwise, the previous model was used. Next, the covariance structure of the epoch variable (5-trial averages) was modelled by including a first order autoregressive covariance structure (AR1), then a continuous autoregressive structure (CAR1), then a first order moving average correlation structure (CORARMA1) and finally a second order moving average correlation structure (CORARMA1). The fit of these four models was compared to the previous model, before the best (in terms of model fit) covariance structures was retained (if none of the models produced a significant improvement in the fit of the model then none of these covariance structures were retained in the model). Having determined a sensible covariance structure to use, the epoch variable was then added to the model along with its interaction with hemisphere, phase, contingency and threat information (as fixed factors). Finally, the slopes for hemisphere, phase, contingency and threat information were allowed to vary by participant, and if the random slopes produced a significant improvement to the fit of the model, this model was retained as the final model.

Both the overall-trial ERP analyses (as reported for Experiments 1 and 2) and comparable results from the multilevel modelling analyses of the 5-trial ERP data are reported for all three components of interest (the P1, N1 and P2).

4.3 Results

4.3.1 Contingency Awareness

A 2(Information: negative vs. none) × 2(Contingency: CS+ vs. CS-) repeated measures ANOVA was run on a score of contingency awareness from the number of accurate CS outcome predictions made during the conditioning phase.

There was a significant main effect of contingency, F (1, 22) = 89.66, $p < .001$ (η^2_p= .80) and a statistical trend for information, F (1, 22) = 3.25, $p = .08$ (η^2_p= .13), on contingency awareness, indicating that the number of correct predictions made during conditioning significantly varied depending on whether a CS was 100% contingent with the negative US (CS+) or 50% contingent (CS-), and to a degree whether negative information was provided about the CS prior to the conditioning phase. As predicted, Figure 4.1 reveals that participants performed with almost perfect accuracy for both the CS+ and CS- and were therefore contingency aware in both conditions: participants showed near 50% accuracy for the CS-, consistent with the knowledge that there is essentially no contingency between the stimuli in the CS- condition (thus participants only have 50% chance of guessing the right outcome of a trial); and participants showed accuracy nearing 100% for the CS+ condition in which stimuli were 100% contingent. The number of accurate predictions was marginally higher for stimuli when negative information had been provided, which can only be due to a higher expectancy of negative outcomes for these stimuli, resulting in higher correct responses in this condition than when no information was provided (when collapsing across CS type). A statistical trend for the fear-relevance × contingency interaction, F (1, 22) = 3.26, $p = .08$ (η^2_p= 0.13) suggests a higher accuracy rate for the CS+s when negative information was provided, but a similar effect cannot be seen for CS-s.
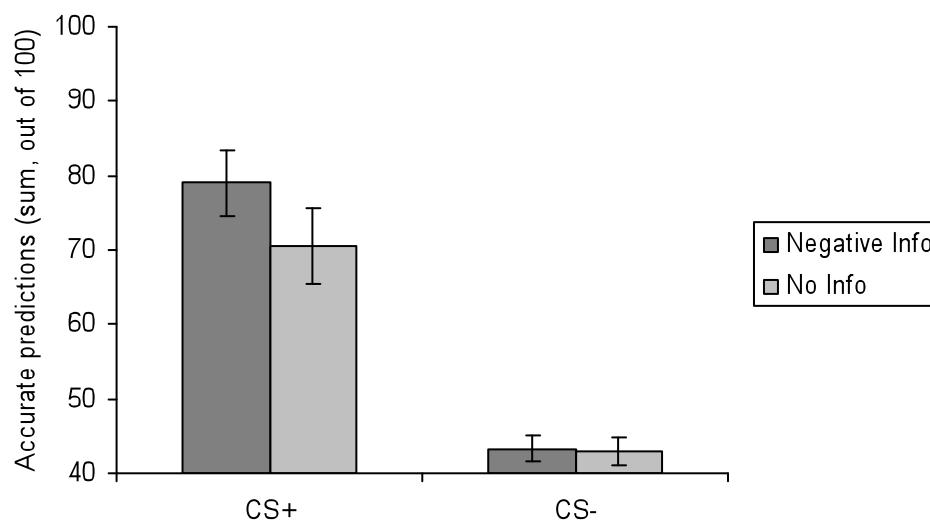
Figure 4.1: Mean number of correct outcome predictions, for negative and no information CSs, depending on contingency of negative US (error bars represent standard error of the mean).

To explore whether the effects of contingency and information on contingency awareness was consistent throughout the conditioning phase, a further 2(Information: negative vs. none) × 2(Contingency: CS+ vs. CS-) × 10(Epoch: 1st 10 trials, 2nd 10 trials, 3rd etc.) repeated measures ANOVA was run on accuracy scores calculated from 10 time epochs, from consecutive groups of 10 trials.

The assumption of sphericity was violated for the main effect of epoch (time), χ^2 (44), 70.67, p = .008, ε = .54, and the interaction between contingency × epoch, χ^2 (44), 73.66, p = .004, ε = .54. Therefore degrees of freedom were corrected using the Greenhouse-Geisser estimate of sphericity.

There was a significant main effect of epoch, F (4.81, 101.07) = 2.49, p = .04 (η^2_p= 0.11). This finding suggests that accuracy in prediction varied across time epochs and therefore that participants might not have learnt the contingency between CS and US from the start of conditioning.

There was a significant interaction between contingency × epoch, F (4.89, 102.62) = 3.87, p = .003 (η^2_p= 0.16), indicating that difference between CS+ and CS- on awareness was dependant on the epoch of trials. There was also a significant interaction between information × epoch, F (9, 189) = 2.97, p = .003 (η^2_p= 0.12) indicating differential accuracy across epochs depending on whether negative information was provided or not, and the 3-way interaction between information × contingency × epoch was also significant, F (9, 189) = 6.21, p < .001 (η^2_p= 0.23), indicating that difference between CS+ and CS-, across epoch, differed depending on whether negative information had been provided as opposed to no information regarding the CS.

Figure 4.2 demonstrates the interaction between information × contingency × epoch. These figures suggest that, although the pattern of awareness is similar across all 10 epochs for CS-, irrespective of whether negative information was provided before conditioning (c. 50% accurate predictions), participants seemed to reach almost perfect accuracy much faster for the CS+ when negative information was provided prior to conditioning than when it was not (error bars for the CS+ and CS- overlap for the 1st epoch in no information condition only).
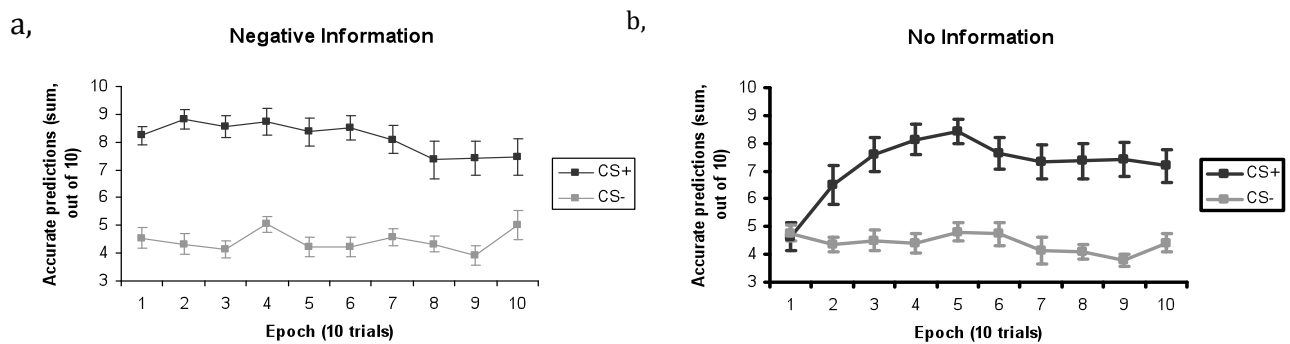
Figure 4.2: Mean number of accurate predictions, per 10 trial epoch, for CS+ and CS-, split by information (error bars represent standard error of the mean).

To explore differences in accuracy between CS+ and CS- in the 1st epoch of 10 trials, depending on whether negative information was provided regarding the CS, a 2(Information: negative vs. none) × 2(Contingency: CS+ vs. CS-) repeated measures ANOVA was run on a score of accuracy for the 1st epoch only. A significant interaction between information × contingency, $F (1, 22) = 30.58$, $p < .001$ ($\eta^2_p = 0.58$) confirms differential accuracy between CS+ and CS-, dependant on information, for the first 10 trials. Bonferroni corrected contrasts showed accurate and significantly higher contingency awareness for the negative information CS+ than CS- in the 1st 10 trials, $t (22) = 7.24$, $p < .001$, $r = .71$, whereas for the no information CS+ performance was not significantly different to the CS- in the 1st 10 trials, $t (22) = -.16$, $p = .87$, $r = .03$. This finding indicates a higher expectancy for negative outcome, when a CS is 'primed' with negative information, permitting contingency awareness within the 1st 10 trials of conditioning, similar to the effect seen for fear-relevant stimuli in Experiment 2.

4.3.2 Self Report Results: Animal Fear Beliefs Questionnaire (FBQ)

Figure 4.3 shows the mean fear beliefs score (higher score = higher fear beliefs) for the CS+ and CS- after information/pre-conditioning, post-conditioning and post-extinction phases, split by whether negative information was provided or not.
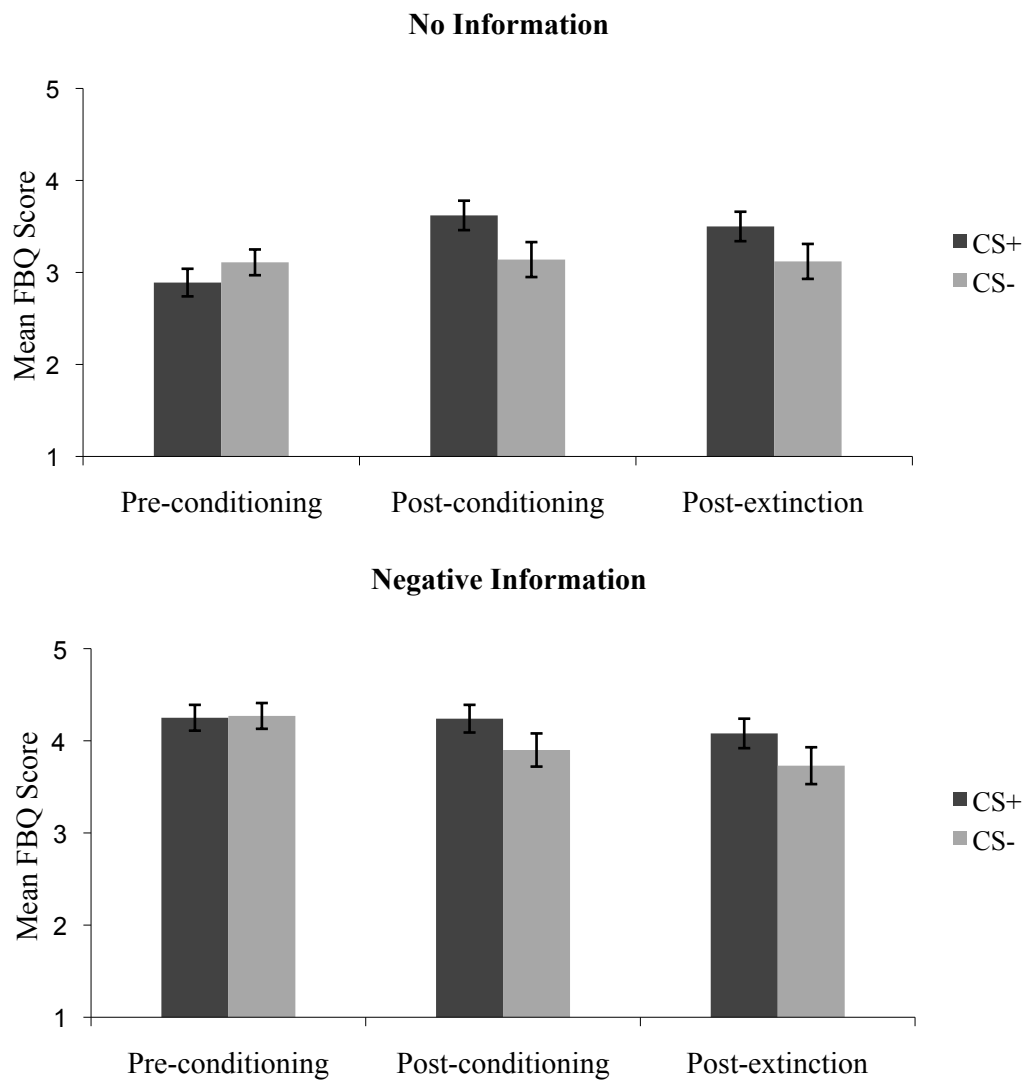
Figure 4.3: Mean fear belief scores after information/pre-conditioning, post conditioning and post-extinction, for CS+ and CS-, split by information condition. Error bars represent standard error of the mean.

In the 'No information' condition fear belief scores about the animals, pre-conditioning, were around mid-scale and so response towards the animals was neutral. In contrast the negative information condition showed fear belief scores to be between 4 and 5, pre-conditioning: indicating high negative beliefs as a result of the information.

Of the animals about which participants were not given information, fear beliefs increased post-conditioning for the CS+ but not the CS-, indicating an increase in fear beliefs as a result of aversive conditioning. However, for the animals about which participants were given negative information, response remained similarly negative post-conditioning towards the CS+ (no change) whereas fear beliefs towards the CS- decreased. This change in mean FBQ score from pre- to post-conditioning towards animals in the negative information condition indicates a ceiling effect in fear beliefs towards these animals pre-conditioning which was maintained through aversive conditioning for the CS+ but reduced for the CS-. There did not seem to be a reduction in fear beliefs post-extinction for the CS+ in either information condition, indicating resistance to extinction.

A 2 (Information: negative vs. none) × 3 (Time: pre-conditioning, post-conditioning, post extinction) × 2 (Contingency: CS+ vs. CS-) repeated measures ANOVA was conducted on mean FBQ scores. The assumption of sphericity was violated for the main effect of time ($W = .68$, $\chi^2 (2) = 8.01$, $p = .02$), the time × information interaction ($W = .58$, $\chi^2 (2) = 11.45$, $p = .003$), the time × contingency interaction ($W = .58$, $\chi^2 (2) = 11.44$, $p = .003$), and the time × information × contingency interaction ($W = .76$, $\chi^2 (2) = 5.91$, $p = .05$).

There were significant main effects of information ($F (1, 22) = 48.53$, $p < .001$, $\eta^2_p = .69$) and contingency ($F (1, 22) = 12.51$, $p = .002$, $\eta^2_p = .36$) on fear beliefs, and 2 way interactions between time × information, $F (1.41, 30.98) = 20.69$, $p < .001$, $\eta^2_p = .49$, indicating change in fear beliefs dependant on information (overall contingency conditions); and, more interesting in terms of aversive conditioning, between time × contingency ($F (1.41, 30.98) = 12.51$, $p < .001$, $\eta^2_p = .36$), indicating change in fear beliefs dependant on contingency of the CS with the aversive US (overall information conditions).

Bonferroni corrected contrasts showed that CS+ and CS- did not differ pre-conditioning ($CI_{.983}$ = -.07 (lower), .30 (upper), $t(22)$ = 1.65, p = .11, r = .33) when collapsing across levels of information. However, post-conditioning and post-extinction, fear beliefs were significantly higher for the CS+ than the CS- (post-conditioning: $CI_{.983}$ = -.67 (lower), -.14 (upper), $t(22)$ = -3.98, p = .001, r = .65; post-extinction: $CI_{.983}$ = -.61 (lower), -.11 (upper), $t(22)$ = -3.77, p = .001, r = .63) indicating that general aversive conditioning did occur and was resistant to extinction.

Of greater interest, however, was the significant interaction between time × information × contingency (F (1.61, 35.34) = 3.45, p = .05, η^2_p= .14) indicating that the effect of contingency on change in fear beliefs depended on whether negative information was provided. To interpret this interaction two 3 (time: pre-conditioning, post-conditioning, post-extinction) × 2 (contingency: CS+ vs. CS-) repeated measures ANOVAs were run for negative information and no information conditions separately.

There was a significant interaction between time × contingency for the negative information condition (F (1.59, 34.97) = 5.37, p = .01, η^2_p= .20), and the no information condition (F (1.40, 30.89) = 14.01, p < .001, η^2_p= .39), indicating that change in fear beliefs was dependant on contingency in both information conditions. Bonferroni corrected contrasts for the negative information condition showed that CS+ and CS- did not differ pre-conditioning ($CI_{.983}$ = -.19 (lower), .23 (upper), $t(22)$ = .23, p = .82, r = .05) but, post-conditioning and post-extinction, the fear beliefs were significantly higher for the CS+ than the CS- (post-conditioning: $CI_{.983}$ = -.58 (lower), -.08 (upper), $t(22)$ = -3.41, p = .003, r = .59; post-extinction: $CI_{.983}$ = -.61 (lower), -.09 (upper), $t(22)$ = -3.49, p = .002, r = .60). For the no information condition corrected contrasts also showed that CS+ and CS- did not differ pre-conditioning ($CI_{.983}$ = -.08 (lower), .52 (upper), $t(22)$ = 1.88, p = .07, r = .37) but, post-conditioning and post-extinction, the fear beliefs were significantly higher for the CS+ than the CS- (post-conditioning: $CI_{.983}$ = -.89 (lower), -.07 (upper), $t(22)$ = -3.06, p = .006, r = .55; post-extinction: $CI_{.983}$ = -.75 (lower), -.003 (upper), $t(22)$ = -2.61, p = .02, r = .49). These results indicate aversive conditioning and resistance to extinction for both the negative

information and no information animals as a result of 100% contingent pairings with the aversive US.

Further (Bonferroni corrected) paired sample tests showed that the conditioning effect in the no information condition occurred as a result of significant increase in fear beliefs, from pre-conditioning to post conditioning, towards the CS+ ($CI_{.988}$ = .28 (lower), 1.19 (upper), $t(22)$ = 4.37, $p < .001$, $r = .68$) whereas CS- did not significantly change between pre-conditioning and post-conditioning ($CI_{.988}$ = -.28 (lower), .34 (upper), $t(22)$ = -.27, $p =$ .79, $r = .06$). This supports the expected pattern of change in fear beliefs between CS+ and CS- through aversive conditioning. However, the conditioning effect in the negative information condition occurred as a result of significant decrease in fear beliefs, from pre-conditioning to post conditioning, towards the CS- ($CI_{.988}$ = -.72 (lower), -.004 (upper), $t(22)$ = -2.75, $p = .01$, $r = .51$) whereas CS+ did not change significantly between pre-conditioning and post-conditioning ($CI_{.988}$ = -.29 (lower), .27 (upper), $t(22)$ = -.12, $p = .91$, r = .03). This supports that fear beliefs were already as high as possible for CS+ and CS- after participants received the negative information, therefore there was no room for further increase in fear beliefs towards the CS+ through aversive conditioning, but rather fear beliefs were maintained at this high level whilst fear beliefs towards the CS- decreased.

4.3.3 Overall-trial, ERP results
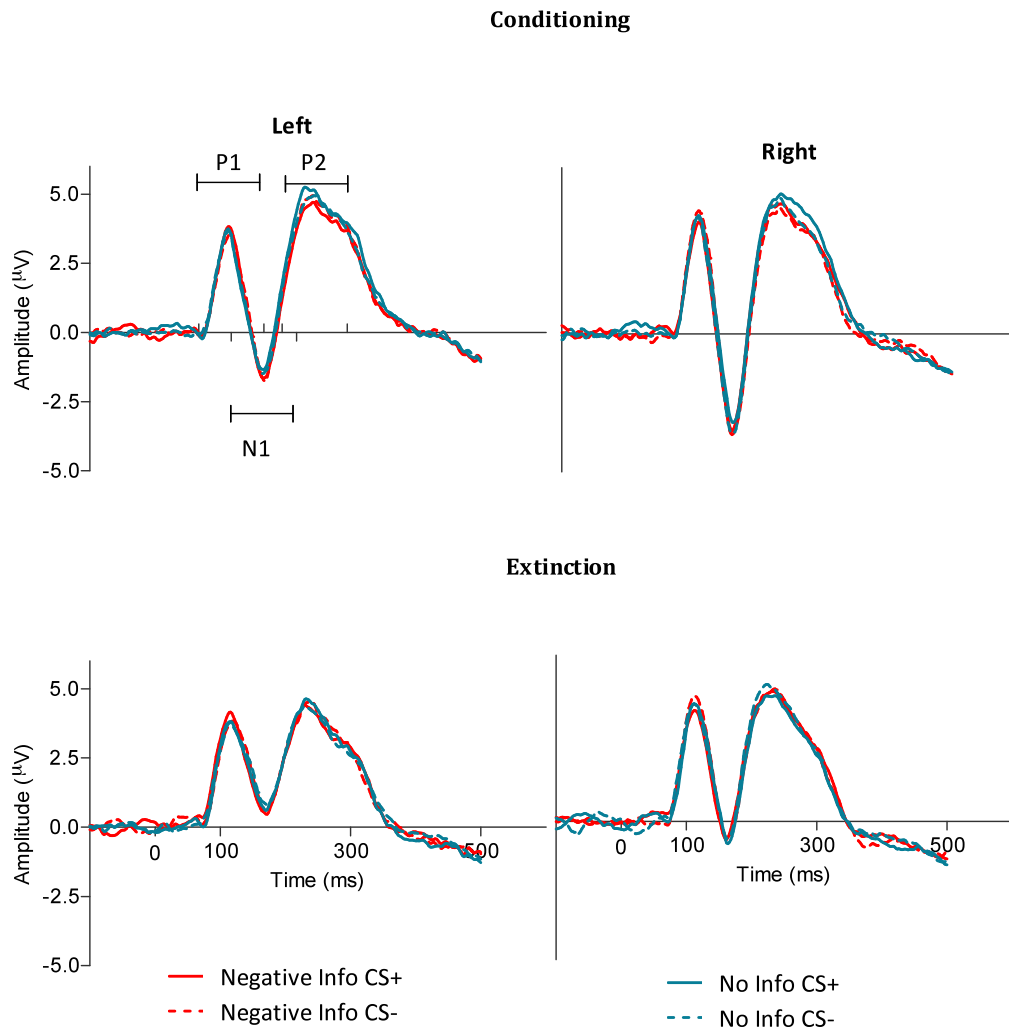
Figure 4.4: ERP grand average at conditioning and extinction, split by hemisphere. Collapsed across all analyzed parietal and occipital electrode sites, for the four conditions of interest: Information (negative/threat vs. none) and contingency (CS+, CS-).

P1 Peak Latency

A 4-way, 2(Phase: conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Information: negative vs. none) × 2(Hemisphere: left vs. right), repeated measures ANOVA was conducted on the peak latency of the P1 component (67-167 ms after stimulus onset), collapsed across 9 left (P1, P3, P5, P7, PO3, PO5, PO7, O1 and CB1) and 9 right (P2, P4, P6, P8, PO4, PO6, PO8, O2, and CB2) hemisphere electrodes from Parietal, Occipital and Cerebellum sites (as in experiments 1 and 2).

A significant main effect of Phase, $F(1, 23) = 28.76$, $p < .001$ ($\eta^2_p = .56$), demonstrated overall earlier P1 Latencies in conditioning ($M = 116$, $SE = 2.28$) than extinction ($M = 124$, $SE = 2.38$), perhaps indicating a general increased state of arousal/attention during the active vs. the passive viewing conditions. However there was also a significant 3 way interaction between phase × information × hemisphere $F(1, 23) = 5.17$, $p = .03$ ($\eta^2_p = .18$) indicating a hemispherical information effect on peak latency across phase. This was explored by two, 2 (Phase: conditioning vs. extinction) × 2(Hemisphere: left vs. right), separate repeated measures ANOVAs for negative information and no information conditions (collapsed across contingency). A significant interaction between phase × hemisphere in the no information condition, $F(1, 23) = 6.53$, $p = .02$ ($\eta^2_p = .22$), indicates that although there are similar peak latencies in the right and left hemispheres at conditioning, at extinction peak latency was later in the left than the right hemisphere. In contrast when negative information was provided pre-conditioning the phase × hemisphere interaction is no longer significant $F(1, 23) = .01$, $p = .91$ ($\eta^2_p = .001$), as the peak latency is earlier in the right hemisphere during conditioning as well as during extinction (see Figure 4.5) This may indicate a hemispheric bias, pre-empted by negative information so that it can be seen in the conditioning phase as opposed to only in extinction.
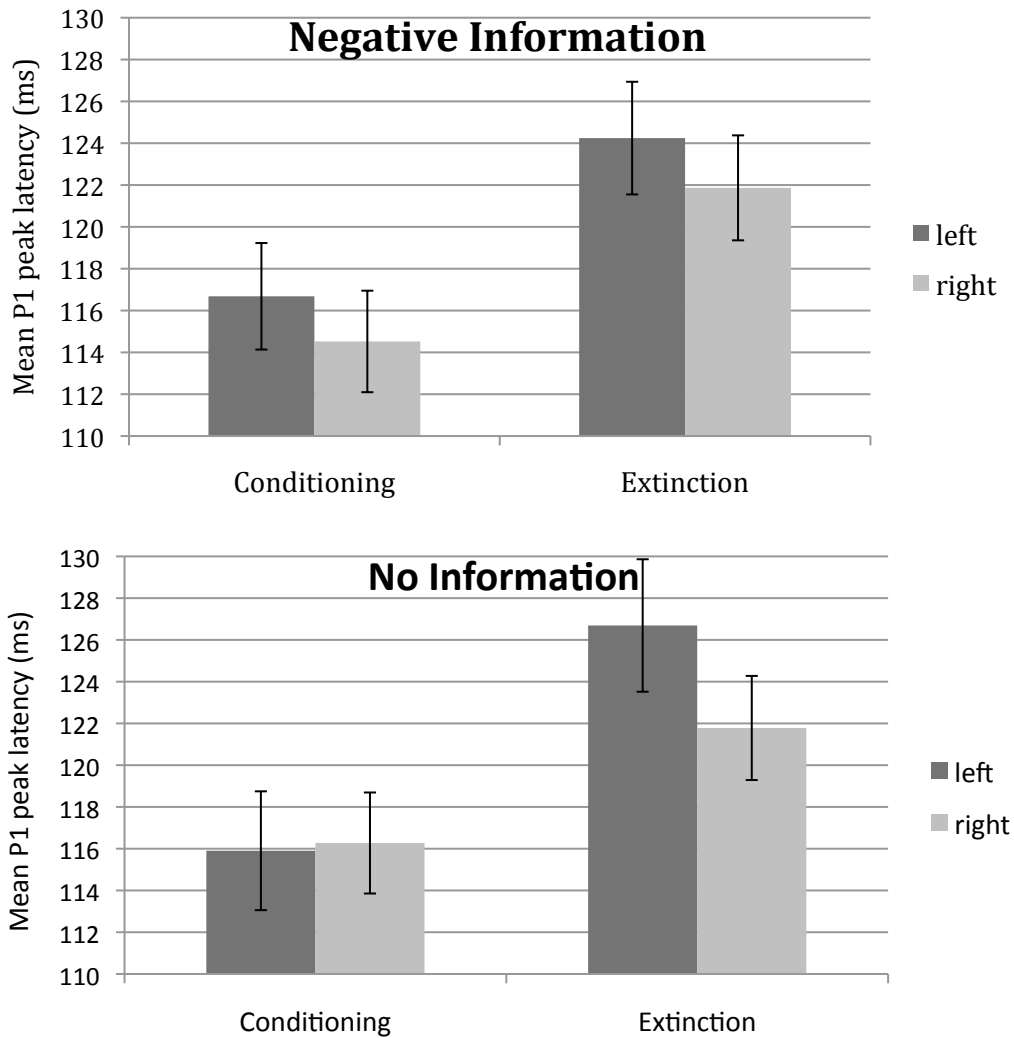
Figure 4.5: Mean Peak Latency of the overall 100 trials ERP, P1 component (67-167 ms after stimulus onset) from the left and right hemispheres during conditioning and extinction phases: split by negative and no information conditions (error bars show standard error of the mean).

An additional non-significant interaction, between contingency × information, on P1 peak latency was noted as it neared significance $F(1, 23) = 3.32$, $p = .08$ ($\eta^2_p = .13$). As for Experiments 1 and 2, the purpose of noting 'trend' effects on peak latency, as well as significant effects, was so that time windows for calculating mean amplitude could be corrected based on mean peak latencies which differed between conditions.

P1 Mean Amplitude

As for Experiments 1 and 2, mean amplitude time windows were calculated 25 ms either side of peak latency. Mean peak latency was adjusted for the effects of phase, contingency, information and hemisphere. Initial analysis of mean amplitude scores was conducted as per P1 peak latency scores.

A 2(Phase: conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Information: negative vs. none) × 2(Hemisphere: left vs. right), repeated measures ANOVA was conducted on the mean amplitude of the P1 component (collapsed across the same parietal, occipital and cerebellum electrode sites).

A significant main effect of phase, $F(1, 23) = 9.51$, $p = .005$ ($\eta^2_p = .29$), demonstrated larger P1 mean amplitude at extinction ($M = 3.08$, $SE = .50$), than at conditioning ($M = 2.63$, $SE = .50$).

There were no other significant effects of phase, contingency, information or hemisphere on P1 mean amplitude.

N1 Peak Latency

A 4-way, 2(Phase: conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Information: negative vs. none) × 2(Hemisphere: left vs. right), repeated measures ANOVA was conducted on the peak latency of the N1 component (sought 117-217 ms after stimulus onset), collapsed across the same parietal, occipital and cerebellum sites as for P1.

A significant main effect of hemisphere, $F(1, 23) = 6.19$, $p = .02$ ($\eta^2_p = .21$), demonstrated overall earlier N1 Latencies in the Right hemisphere ($M = 160$, $SE = 2.41$) compared to the Left ($M = 164$, $SE = 2.77$). A statistical trend of phase × hemisphere was also noted as it neared significance, $F(1, 23) = 3.62$, $p = .07$ ($\eta^2_p = .14$) indicating equivalent peak latency in

the right hemisphere across conditioning (M = 160, SE = 2.35) and extinction phases (M = 159, SE = 2.63), whereas peak latencies were later in the left hemisphere at conditioning (M = 163, SE = 2.62) and later still at extinction (M = 164, SE = 3.05). Effects of hemisphere and phase on peak latency were taken into consideration for mean amplitude time windows in the following analysis of N1 mean amplitude.

N1 Mean Amplitude

Mean amplitude time windows were calculated as per the P1 component and the mean peak latency was adjusted for the main effects of phase and hemisphere. Initial analysis of mean amplitude scores was conducted as per N1 peak latency scores.

Again there was a significant main effect of phase, $F(1, 23)$ = 82.49, $p < .001$ (η^2_p= .78), however N1 mean amplitude was larger at conditioning (M = -1.24, SE = .52), than at extinction (M = 0.89, SE = .45), and the trend of larger and earlier components in the right hemisphere as opposed to the left was again demonstrated by the significant main effect of hemisphere, $F(1, 23)$ = 6.90, $p = .02$ (η^2_p= .23) (Left: M = 0.38, SE = .43, Right: M = -0.72, SE = .59). More interesting again is the interaction between phase × contingency as to whether response changed differentially across phase depending on contingency with the aversive US. This interaction neared significance for N1 mean amplitude, $F(1, 23)$ = 3.75, p = .07 (η^2_p= .14), however Bonferroni corrected contrasts showed that there was no significant differences between CS+ and CS- at conditioning ($CI_{.975}$ = -.30 (lower), .56 (upper), $t(23)$ = .72, p = .48, r = .03) or extinction ($CI_{.975}$ = -.55 (lower), .30 (upper), $t(23)$ = -.70, p = .49, r = .03) therefore an overall conditioning or extinction effect cannot bee seen for N1 mean amplitude. Rather the statistical trend seen from this interaction seems to stem simply from a slightly larger mean amplitude towards the CS- at conditioning which becomes slightly smaller than the CS+ at extinction (see Figure 4.6).

Figure 4.6: Mean N1 Mean Amplitude in response to the CS+ and CS- across phases of conditioning and extinction (error bars represent standard error of the mean).

There was no further interaction between phase × contingency, with either information or hemisphere which may have indicated any effect of information on conditioning or extinction or any hemispheric bias in that respect.

P2 Peak Latency

A 4-way, 2(Phase: conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Information: negative vs. none) × 2(Hemisphere: left vs. right), repeated measures ANOVA was conducted on the peak latency of the P2 component (195-295 ms after stimulus onset), collapsed across the same parietal, occipital and cerebellum sites as for P1 and N1 components.

A significant main effect of Phase, $F(1, 23) = 18.20$, $p < .001$ ($\eta^2_p = .44$), demonstrated overall earlier P2 latencies in extinction ($M = 239$, $SE = 3.81$) than conditioning ($M = 248$, $SE = 3.57$) in contrast to the effect seen at the P1 component.

A statistical trend between contingency × hemisphere was also noted as it neared significance, $F(1, 23) = 3.31$, $p = .08$ ($\eta^2_p = .13$) indicating earlier peak latency towards the CS+ in both left ($M = 243$, $SE = 3.75$) and right hemisphere ($M = 242$, $SE = 4.46$), and towards the CS- in the right ($M = 242$, $SE = 3.91$) whereas peak latency was later towards the CS- in the left ($M = 247$, $SE = 3.54$). Effects of phase, contingency and hemisphere on P2 peak latency were taken into consideration for mean amplitude time windows in the following analysis of P2 mean amplitude.

P2 Mean Amplitude

Mean amplitude time windows were adjusted for the main effects of phase, contingency and hemisphere on P2 peak latency. Initial analysis of mean amplitude scores was conducted as per P2 peak latency scores.

A significant 3 way interaction between phase × contingency × hemisphere, $F(1, 23) = 7.90$, $p = .01$ ($\eta^2_p = .26$) indicated change across phase, in CS+ and CS- difference, depending on hemisphere.

In order to explore this 3 way interaction between phase × contingency × hemisphere, two 2(Phase: conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) repeated measures ANOVAs was run separately for left and right hemisphere, collapsing across information.

The interaction between phase × contingency was non-significant in the left hemisphere, $F(1, 23) = .006$, $p = .94$ ($\eta^2_p < .001$), with means indicating similar P2 mean amplitude between CS+ and CS- at both conditioning and extinction (see figure 4.7). In the right hemisphere the interaction between phase × contingency was significant, $F(1, 23) = 5.09$,

$p = .03$ ($\eta^2_p < .18$), indicating a right hemisphere distinction between CS+ and CS-, which varied across phase.

However, bonferroni corrected contrasts, for the right hemisphere, failed to find any significant difference between CS+ and CS- at conditioning or extinction, neither were there significant changes between conditioning and extinction demonstrated for either CS. Therefore the significant phase × contingency interaction in the right hemisphere seems to stem from a pattern of decrease in P2 mean amplitude, from conditioning to extinction, for the CS+, whereas an increase is observed for the CS- (see Figure 4.7).

There was no further interaction between phase × contingency × hemisphere, with information.
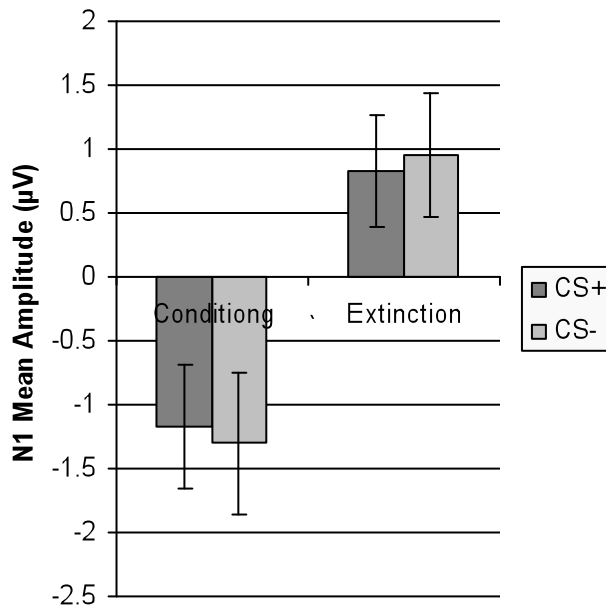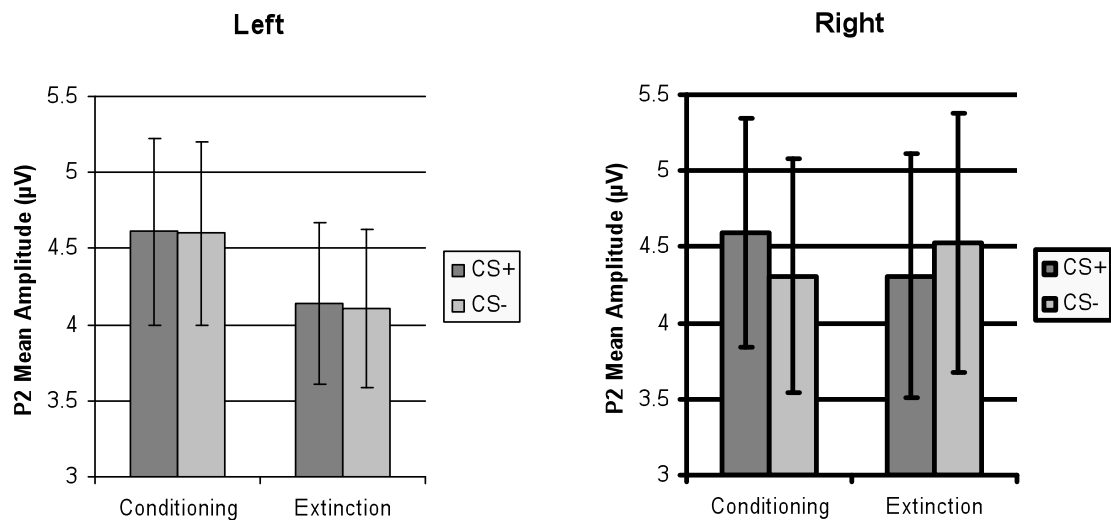

Figure 4.7: Mean P2 Mean Amplitude in response to the CS+ and CS- across phases of conditioning and extinction, split by hemisphere (error bars represent standard error of the mean).

4.3.4 5-trial Epoch multilevel regression analysis

Peak Latency effects

As described in the *data analysis strategy* (see earlier) a mixed model multilevel regression analysis was conducted on peak latency of the 5-trial average P1, N1 and P2 components. The effects of this analysis were additionally used to determine windows of measurement for mean amplitude calculations. To be concise, only the effects from the final models are reported in comparison to effects from the overall-trial ERP analyses.

Fixed factors of hemisphere, phase, contingency and threat information were added to the basic regression model, including only the intercept, which was random within participants. This significantly improved the model on all accounts of P1, N1 and P2 peak latency. Then the variance and covariance structure of the data were modelled: first, heteroscedasticity across hemisphere, phase, contingency and threat information was modelled by weighting these variables by the group variances. To be concise not all improvements are reported, but generally, for all three components heteroscedasticity modelled across hemisphere and phase significantly improved the model. For all components, modelling the covariance structure of the epoch variable, using the four methods described, did significantly improve the model fit. In all analyses reported the first order autoregressive covariance structure (AR1), was used, as the three other methods (see data analysis strategy) did not significantly improve on the AR1 model. Additionally the complexity of the three other covariance structures made it difficult to converge further models.

Having modelled the variance and the AR1 covariance structure in the data, epoch and the interactions between epoch, hemisphere, phase, contingency and threat information were added to the model as fixed effects. Although adding the fixed effect of epoch did, in most cases significantly improve the model, improvements based on adding the interactions between epoch and the other fixed effects were inconsistent. Inclusion of

random slopes for hemisphere, phase, contingency and threat information did, however, improve the fit of the model for all three peak latency measures. For all components the effects of epoch, hemisphere, phase, contingency and threat information on mean peak latency scores are reported from the final model.

P1

Similar to the overall-trial ERP analysis, a significant main effect of phase (t (7645) = 3.43, $p < .001$) and a significant interaction effect between phase × hemisphere (t (7645) = -2.22, $p = .02$) was found for epoched P1 peak latency scores. However the interaction between phase × hemisphere did not interact significantly with information (t (7645) = 1.73, $p = .08$), as in the overall-trial analysis. Thus mean amplitude windows were adjusted for the main effects of phase and hemisphere on P1 peak latency.

No significant effects of epoch, or its interaction, were found for P1 peak latency scores. This indicates that peak latency of the P1 component did not significantly differ across the time course of experimental phase.

N1

Although a significant main effect of hemisphere and a trend interaction between phase × hemisphere were found for overall-trial N1 peak latency scores, there were no significant effects of hemisphere, phase, contingency, information or epoch for epoched peak latency scores. Thus N1 mean amplitude windows were based on mean N1 peak latency, collapsed across all levels of epoch, hemisphere, phase, contingency and threat information.

P2

Similar to the overall-trial ERP analysis, a significant main effect of phase was found for epoched P2 peak latency scores, t (7645) = -3.81, $p < .001$. However the interaction between hemisphere × contingency was not significant (t (7645) = 0.76, $p = .44$), as in the overall-trial analysis. On the other hand, significant interactions between contingency × information (t (7645) = 2.47, $p = .01$) and information × phase (t (7645) = 2.15, $p = .03$) were apparent for the epoched P2 peak latency scores. Additionally the three-way interaction between contingency × information × phase neared significance, t (7645) = -1.89, $p = .06$. This interaction suggests differential changes in mean peak latency, between the CS+ and CS- across experimental phase, depending on whether threat information had been provided.

When no information was provided, mean peak latencies indicate an earlier response for the CS+ than for the CS-, during conditioning. During extinction however, mean peak latency is earlier for the CS- than for the CS+. On the other hand, when threat information was provided mean peak latencies indicate an earlier response for both the CS+ and CS- that is similar to the mean latency of response towards the CS+ in the 'no information' condition. In the threat information condition, mean peak latency was earlier for the CS+ than for the CS- during extinction (see Figure 4.8) [7]. This interaction suggests that earlier latency of the P2 component is modulated by US-contingency and threat information, during conditioning. Additionally, threat information seems to result in earlier P2 latency towards the CS+ during extinction, whereas without information response to the CS+ is later than for the CS- during extinction. Although modulation of peak latency, through differential conditioning and threat information, was not observed in the overall-trial ERP

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[7] Figures within this section are presented without error bars to represent standard deviations of the means, because heteroscedasticity was factored into the model. Thus error bars would misrepresent the remaining variance within levels of each variable.

analysis, the epoched-trial analysis perhaps provides a more sensitive approach, revealing otherwise un-observed effects.
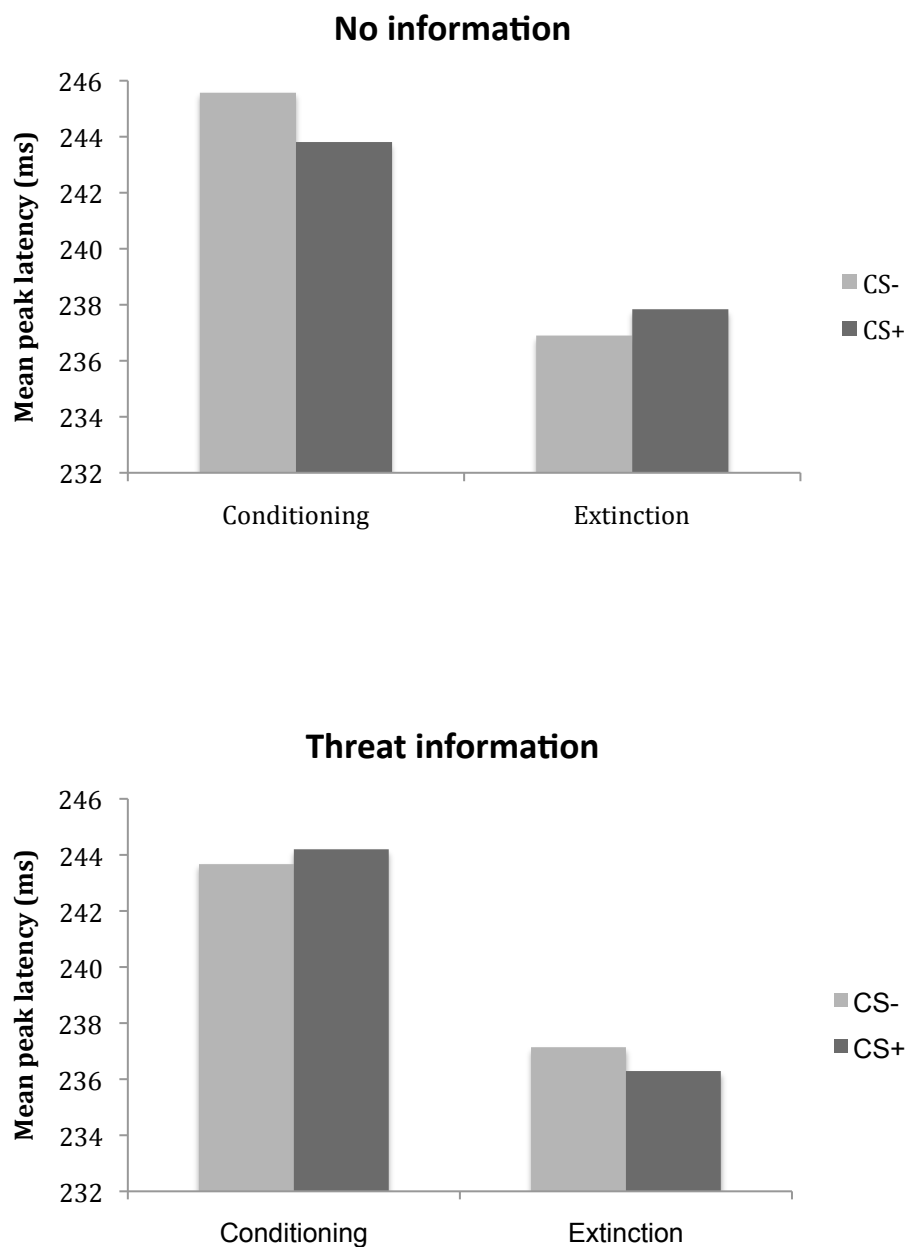
Figure 4.8: Mean P2 peak latency in response to the CS+ and CS- across phase, split by information.

As for P1 and N1 components, no significant effects of epoch, or its interaction, were found for P2 peak latency scores. This indicates that peak latency of the P2 component did not significantly differ due to the time course of the experimental phase. P2 mean amplitude windows were adjusted for the main effects of phase, contingency and information on P2 peak latency.

Mean amplitude effects

The same mixed model multilevel analysis conducted for epoched peak latency scores, was conducted on the epoched mean amplitude scores for the P1, N1 and P2 components. Similar general trends in model fit were observed and for all components the effects of epoch, hemisphere, phase, contingency and threat information on mean amplitude scores are reported from the final model.

Compared to the standard analyses conducted for overall-trial ERP amplitude (see earlier), a wider mean amplitude time window (60 ms as opposed to 50 ms in the overall-trial analysis) was implemented due to the increased variance found for 5-trial average ERP responses. Mean amplitude windows were adjusted based on the significant modulations of peak latency described above.

P1

Analysis of the P1 mean amplitude scores for the overall-trial ERP analysis showed a significant main effect of phase only. Although a similar trend effect of phase was found for epoched P1 mean amplitude scores, this effect was not significant, t (7645) = 1.67, p = .10. However, a significant interaction effect between contingency × information × hemisphere was found, t (7645) = -2.51, p = .01. This interaction effect seems to stem from differential hemisphere responses towards the CS+ and CS-, depending on threat information. Based on US-contingency alone, in the no-information condition, modulation

of P1 mean amplitude is observable in the right hemisphere only, with larger amplitude in response to the CS+ as opposed to the CS-. However, when threat information was provided opposite effects of contingency are seen across the hemispheres. In the left hemisphere mean amplitude response was larger towards the CS+ compared to CS-. In the right hemisphere by contrast, larger amplitude response was indicated for the CS- compared to the CS+ (see Figure 4.9).
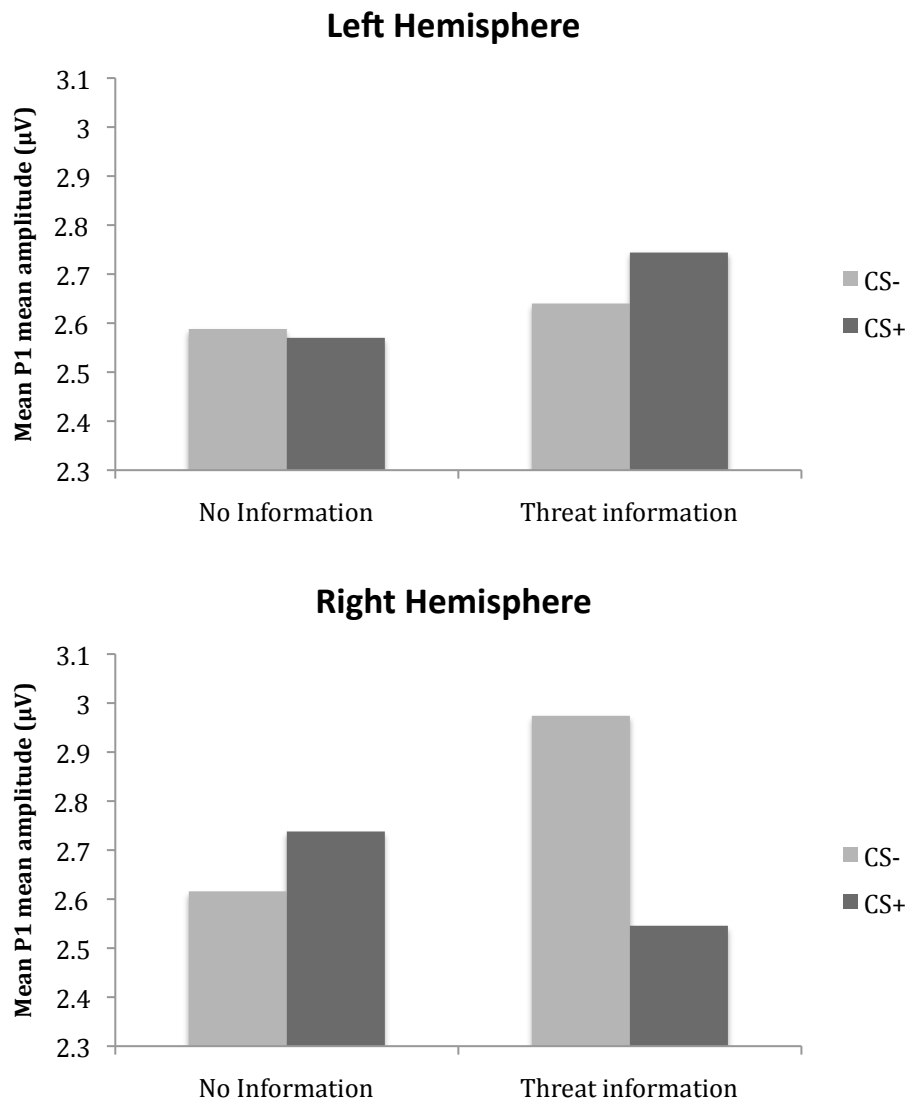
Figure 4.9: Mean P1 Mean Amplitude in response to the CS+ and CS- across information conditions, split by hemisphere.

One interpretation of this interaction effect may be that whereas differential conditioning alone is sufficient to increase attentional response towards the CS+ in the right hemisphere, additional threat information is required to produce the same modulation effect in the left. However, the combination of threat information and aversive conditioning seems to have a different impact on right hemisphere activity. The mismatch of information in the CS- condition, between the threat information and the lack of negative reinforcement, may be responsible for an increase in attentional response in the right hemisphere towards the CS- over the CS+.

No significant effects of epoch, or its interaction, were found for P1 mean amplitude scores. This indicates that mean amplitude of the P1 component did not significantly differ across experimental phase.

N1

Similar to the overall-trial ERP analysis, significant main effects of phase (t (7645) = 6.28, p < .001) and hemisphere (t (7645) = -3.16, p = .002) were found for the epoched N1 mean amplitude scores. Additionally the epoched data revealed that the interaction between information × epoch neared significance (t (7645) = 1.89, p = .06). This interaction indicates differential mean amplitude response towards CSs across phase epoch, depending on the verbal-threat information condition. However, without further interaction with phase it is unlikely that this trend represents differential extinction rates based on the threat-information manipulation.

The interaction between phase × contingency which neared significant for overall-trial N1 mean amplitude was not found to be significant for the epoched N1 mean amplitude scores, t (7645) = -.83, p = .41.

P2

Epoched analysis of P2 mean amplitude scores revealed significant interactions between phase × hemisphere (t (7645) = 2.13, p = .03) and phase × epoch (t (7645) = -2.84, p = .005). The phase × hemisphere interaction did not, however, interact further with contingency as was observed for P2 mean amplitude scores in the overall-trial analysis, t (7645) = -1.06, p = .29.

4.4 Discussion

4.4.1 A cognitive bias explanation for increased aversive outcome expectancy

When fear-relevance was shaped through threat information, participants were faster to learn the 100% contingency between the CS+ and aversive US, than when the CS+ remained fear irrelevant (no information). There was also a trend effect of higher overall accuracy in predicting the aversive US for the FR CS+ over the FI CS+. These results mirror those found in Experiment 2, where participants showed contingency awareness within the first 10 trials of conditioning when the CS+ was a typical phylogenetic FR stimulus (a snake or a spider). When the CS+ was typically FI (a rabbit or a squirrel) participants did not perform significantly better than chance until the second block of 10 trials. In the present study the same results are observed, however, an increased expectancy of aversive outcomes was achieved by priming a CS with threat information. This increased expectancy allowed participants to learn the CS+ contingency faster than when no information was provided[8]. The results support that increased expectancy bias, generally found for phylogenetic FR stimuli (e.g. Davey, 1992a; Davey & Craigie, 1997; Davey & Dixon, 1996; Honeybourne, et al., 1993), may equally result from prior fear originating in verbally and culturally transmitted information as from selective processes (Davey, 1995; 1997; Field & Davey, 2001).

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[8] It should be noted that, as contingency awareness was measured by accuracy in predicting the correct outcome of each conditioning trial, participants were unable to perform significantly better than chance for the CS- (random control), therefore any evidence of expectancy bias can be seen only for the CS+.

4.4.2 Increased fear beliefs may be learned through information alone

The results of the present study have shown that not only can fear beliefs, towards fear irrelevant novel animals, be inflated in adults through aversive conditioning: they can also be inflated by negative verbal information alone. This supports the view that verbally/culturally transmitted information regarding a CS is important in the development of prior fear beliefs towards a particular stimulus and that such fear beliefs do not need to be explained in terms of genetic transmission (Davey, 1995; 1997; Field et al., 2001).

In terms of conditioned response, the expectancy bias model of fear conditioning predicts a superior CR towards the FR CS+ that would be resistant to extinction (Davey, 1992a; 1997). Conditioned changes in fear beliefs were found for both information conditions, although the presentation of these conditioning effects did depend on whether negative information had been provided.

For the FI stimuli (no information) fear beliefs began rather neutral, pre-conditioning, and increased significantly post-conditioning for the CS+. Fear beliefs towards the CS- remained neutral. This finding demonstrated the predicted effects of aversive fear conditioning on fear beliefs. However, there seemed to be a ceiling effect in fear beliefs pre-conditioning for the FR stimuli when negative information was provided. Thus no increase in fear beliefs was observed as a result of the aversive conditioning. Alternatively a reduction in fear beliefs towards the CS- was observed, post-conditioning, as a result of the 50% contingency with the aversive US (essentially the CS- has no predictive ability for the aversive US). High fear beliefs towards the CS+ were maintained.

These findings replicated the effect of negative information in increasing fear-beliefs (e.g. Field, et al., 2001; Field & Lawson, 2003; Field & Storksen-Coulson, 2007; Field, et al., 2008). However, results did not support an interaction between information and fear conditioning, as Davey's (1997) conditioning model would predict. Rather than this interaction resulting in increased fear beliefs towards the CS+, fear beliefs decreased

towards the CS-. Negative information alone served to heighten fear beliefs, without the need for a direct conditioning experience, supporting the premise that information can act as an US (Field, 2006). Yet aversive conditioning served to maintain fear beliefs learnt through information. It ought to be noted that the ceiling effect in fear beliefs, measured post-information, may have restricted demonstration of further increase in fear beliefs post conditioning.

4.4.3 Resistance to extinction of fear beliefs

Contrary to predictions of the expectancy model of selective associations, fear beliefs towards the CS+ remained resistant to extinction for *both* FR and FI conditions when measured post-extinction phase. However, this resistance to extinction effect may have resulted from the way in which affect has been measured here (post-hoc, self-report). Studies by Blechert et al. (2008) and Vansteenwegen et al. (2006) demonstrated that when physiological measures, such as SCR or startle response, are used to measure CR, extinction of the response is generally found, whereas post-hoc self-report and affective priming measures generally show resistance to extinction of the CR. It is plausible that these measures may represent different learning processes: physiological measures of affective learning and self-report measures of associative learning. However, Lipp, et al. (2003) and Lipp & Purkis (2006) explain that differences in resistance to extinction, observed by these different indices, may be an artifact of the time of measurement. These studies by Lipp and colleagues demonstrated extinction effects for self-report measures of CS valence, and for US expectancy, when measured on-line during the extinction trials, however resistance to extinction was found when these self-report measures were taken post-hoc. Lipp and colleagues conclude that such resistance to extinction may represent an average contingency judgment 'calculated' from all contingency experiences, throughout the experimental procedure, rather than the latest contingency judgment between stimuli. Therefore the resistance to extinction found for fear beliefs in the

present study, for both FR and FI stimuli, may be artifact of the time of measurement that was used, and may simply represent an average contingency judgment strategy.

4.4.4 ERP indices of response modulation through information and conditioning

Superior resistance to extinction has frequently been demonstrated for phylogenetically FR stimuli, as opposed to ontogenetic FR stimuli or FI controls, when using physiological measures of response (see McNally, 1987 and Öhman & Mineka, 2001 for reviews). The present study investigated whether ERP indices would reveal resistance to extinction of CR when FR was manipulated by negative information. Additionally, as Field and Storksen-Coulson (2007) demonstrated magnified avoidance behaviour when negative experience and information were combined, this study investigated whether a similar interaction effect would be demonstrable from a physiological measure such as ERP.

In Experiment 2 a main effect of phylogentic fear-relevance showed larger N1 and P2 mean amplitude response for FR, as opposed to FI, stimuli. However, phylogentic fear-relevance showed no impact on the overall conditioning and extinction effects observed for the P2 mean amplitude response. In the present study we aimed to investigate the effect of fear-relevance, manipulated through verbal information, on overall conditioning and extinction effects.

Davey's expectancy model predicts that prior fear towards a CS, combined with *a priori* expectancy bias for the aversive US, leads to selective associations that are resistant to extinction training (Davey, 1995; 1997). Thus, as high fear beliefs and an expectancy bias were evident post information for the FR stimuli, resistance to extinction was predicted for the FR stimuli only. However, from the ERP results it was unclear as to whether a CR was demonstrated for the overall CS+, let alone whether this was resistant to extinction in the FR condition. There was a statistical trend interaction between experimental phase

(conditioning vs. extinction) and contingency for N1 mean amplitude, and this interaction was significant for P2 mean amplitude (right hemisphere). This interaction indicates differential change in response across phase for CS+ and CS-. However, there was no significant difference in response, between CS+ and CS-, at either conditioning or extinction phases that might indicate the CR. As the baseline phase was omitted in the present study (cf. Experiments 1 and 2), responses could not be compared between baseline and conditioning to determine differential change in response based on contingency, which might also have indicated a conditioning effect.

Similarly to Experiment 2, trends of general decrease in mean amplitude response from conditioning to extinction, were observed for N1 and P2 (left hemisphere) components in the present study. This could be interpreted as general habituation or extinction of a fear response. The interaction between phase and contingency for N1 mean amplitude showed a larger decrease in mean amplitude response for the CS-, from conditioning to extinction, than for the CS+. This pattern of results does suggest differential extinction effects dependant on contingency, but without differential response between the CS+ and CS- at conditioning this cannot be described as resistance to extinction of a CR.

Interestingly there was an increase in P2 mean amplitude response at extinction for the CS- (right hemisphere), whereas response towards the CS+ decreased. A similar (right hemisphere) increase, in N1 mean amplitude response, was found at extinction for the fear-relevant CS- in experiment 1. These results could be interpreted as heightened attention towards the CS- during extinction, when the predictive ability of the CSs is removed. As the CS+ no longer predicts the aversive outcome during extinction, participants' attention may increase towards the CS- because they expect 'something' to follow the previously unpredictable stimulus. However, the increase in response could also result from increased positivity in response towards the CS-. If no aversive association was made during conditioning then, when the partial aversive reinforcement was removed during extinction, participants might demonstrate a positive affective response towards the CS-. As with SCR, an increase in ERP amplitude can be indicative of both

positive and negative arousal (cf. Olofsson et al., 2008) therefore it is not possible to determine the direction of affective response here.

Limitations of this ERP study design, as discussed in experiment 2, include the possibility that by partially reinforcing the CS- participants might show increased arousal towards this stimulus. The CS- partial reinforcement could make it difficult to differentiate between a CR towards the CS+, resulting from US expectancy, and an arousal response towards the CS-, resulting from the unpredictability of its outcome.

Additionally the large number of trials, averaged across to calculate an average ERP response, might mask differential rates of CR acquisition and extinction based on the fear relevance manipulation. If threat information did increase the rate of acquisition or slow extinction of the CR, these effects might well be diluted when averaging across so many trials.

Peak latency modulations during conditioning did imply differential responses as the result of threat information and aversive conditioning manipulations. Early P1 peak latency was observed in the right hemisphere during extinction, regardless of the information condition. However for CSs paired with threat information the early right hemisphere response was also observed during conditioning. This early activation of the P1 component in the right hemisphere might represent heightened attentional processes towards stimuli that are considered ambiguous/threatening as a result of the aversive outcomes experienced, in partial and full contingency, with the CSs during the conditioning phase. Verbal-threat information may pre-empt this right hemisphere P1 response so that it is observable during both conditioning and extinction phases. Additionally, a contingency modulation of P2 peak latency in the left hemisphere demonstrated earlier peak latency towards the CS+ than towards the CS-, across both conditioning and extinction phases. This effect might represent a left hemisphere specialisation in increased attentional/arousal response resulting from aversive conditioning, which was resistant to extinction training, irrespective of threat information (no further interaction with phase or threat information was observed).

4.4.5 Analysis of epoched ERP response across conditioning and extinction phases

In an attempt to resolve the limitation posed by the number of trials used to calculate the average ERP in our standard overall-trial ERP analysis, an alternative analysis of the ERP data was attempted. This analysis broke down ERP responses into 5 EEG trial averages, across each phase. As there was missing data for some epochs, when all 5 EEG trials were rejected due to artifacts in the EEG recording, multilevel modeling was used as it is a more robust analysis for dealing with missing data. Mean amplitude response was modeled across epoch using a first order autoregressive covariance structure.

The epoched ERP data analysis did reveal an interaction between contingency, verbal information and phase that was not observed from the overall-trial ERP analysis. Early P2 peak latency was observed, during conditioning, for the FR CS+, FR CS-, and the FI CS+. Early modulation of the P2 component towards these three stimuli, but not the FI CS-, suggests heightened arousal/attention towards these stimuli as a result of aversive conditioning (FI CS+) and threat information (FR CS+ and FR CS-). However, like the self-report index of fear beliefs (FBQ scores) a superior response towards the FR CS+ was not demonstrated for P2 peak latency, as a result of the interaction between threat information and aversive conditioning. This interaction provides some evidence for both information and aversive conditioning as pathways to fear in the physiological domain, though little support was found for an interaction between these pathways that results in superior acquisition/resistance to extinction of CR.

As the ERP signal was less clear when calculating averages from such a small number of trials it might mot be surprising that little effects of epoch or interactions between epoch and other variables were found. In particular the interaction between contingency, verbal information, phase and epoch was of interest as this could have revealed differential rates of conditioning and extinction when threat-information was provided. This interaction was not significant for any component measure of the ERP response. Although this implies

similar modulation of ERP component latency/amplitudes *across* conditioning and extinction phases, regardless of verbal threat information and CS-US contingency, systematic changes across phase epochs might have been undetectable due to the low SNR provided by the 5-trial average ERP measures.

4.4.6 Summary

The present study supports the idea that verbally transmitted information alone can influence fear beliefs and create an aversive US expectancy bias, which allows for faster learning of the CS-US contingency, as indexed by US-prediction scores. These results reflect the 'expectancy evaluations' premise of Davey's (1997) conditioning model of phobias, and provide a cognitive explanation for prior fear which is deemed important in maintaining an expectancy bias and thus selective associations (Diamond et al., 1995; Tomarken et al., 1989). Additionally the ability to manipulate fear beliefs through information supports information as a direct pathway to fear (Rachman, 1977).

It was not possible to clearly demonstrate acquisition/extinction of CR using indices of ERP mean amplitude in the present study. Though modulation of P2 peak latency, revealed from the 5-trial epoched ERP data analysis, did show earlier P2 response during conditioning towards stimuli which were either paired with verbal threat information (FR CS+ and FI CS-) or simply predictive of the aversive US through conditioning (FI CS+). This finding implies heightened attention towards all stimuli that have been associated with some aversive information (verbal threat; CS-US contingency, or the combination). However, equally early P2 response between all three stimuli categories implies that there is not a superior attentive bias towards the FR CS+ as a result of the combined verbal and contingency threat information. Thus there was little evidence of a selective association for the fear-relevant condition.

However, lack of evidence for a selective association may also result from inadequacy of the information provided to induce the same level of fear beliefs established in western

culture towards phylogenetically fear-relevant stimuli (such as snakes and spiders cf. Davey, 1995). A ceiling effect in the FBQ ratings recorded gave the impression of high fear beliefs towards the FR CSs. Also patterns of contingency awareness mirrored the US expectancy seen in experiment 2, for phylogentically FR stimuli. Thus FBQ and contingency awareness results also supported that the information manipulation of fear relevance had been successful. However, no main effects of information were found for mean amplitude measures of ERP response in the present study. This contrasts with the main effects of fear-relevance, which neared significance for both N1 and P2 mean amplitude in experiment 2 (demonstrating larger mean amplitude for FR as opposed to FI stimuli). The lack of a fear-relevance effect in the present study may be indicative of a failure to induce an affective response through the information manipulation used.

Chapter 5 continues the investigation into the role of information and direct contingency experience on extinction of CR. Specifically a comparable experiment investigates the role of positive information, and extinction training combined, in 'un-learning' fear responses.

Chapter 5: The impact of Positive information on fear beliefs, and ERP indices of Extinction

5.1 Introduction

5.1.1 Information: a pathway to and from fear?

As discussed in Chapter 4, there is substantial evidence that fear acquisition follows three pathways (Rachman, 1977): direct aversive conditioning; observational (vicarious) learning; and instructional (information) learning. Aside from retrospective studies (see King, et al., 1998; Merkelbach, et al., 1996; Muris & Field, 2010 for reviews), Field and colleagues have provided prospective evidence that fear can be acquired directly through threat information. Using the paradigm developed by Field & Lawson (2003), information has been shown to increase fear beliefs (Field & Lawson, 2003; Field et al., 2008), behavioural avoidance (Field, 2006a, 2006d; Field & Lawson, 2003; Field & Storksen-Coulson, 2007), and physiological responses in children (Field & Schorah, 2007) and adults (Olsson & Phelps, 2004). Additionally Field and Storksen-Coulson (2007) demonstrated that that these pathways can interact (specifically information and experience) to heighten avoidance behaviour, one of the response systems identified in Lang's (1968, 1978) tripartite model of fear. Experiment 3 attempted to determine whether a similar interaction effect between threat information and experience would magnify fear beliefs and physiological response, indexed by ERP. Fear beliefs were significantly heightened either through information or aversive conditioning alone, but a magnified response in fear beliefs was not found from the combination of these pathways. Aversive conditioning maintained only the effect of information on fear beliefs. Threat information did increase the rate of learning of aversive US contingency, supporting predictions from the expectancy models of fear acquisition: that verbal information can increase both prior fear and creates an expectancy bias (Davey, 1997). However, no significant effects of information were found on ERP indices of response.

Kelly et al. (2010) stress the importance of research investigating whether fear can be un-learned through the same pathways through which it is learnt. Although research that investigates pathways that create fear is important for understanding anxiety prevention strategies, research investigating which pathways successfully reduce fear, and what components of fear are reduced, is equally important in understanding modes of intervention (Davis & Ollendick, 2005).

5.1.2 Conditioning models of fear extinction

Models of associative learning suggest that fear is reduced by weakening the association between the stimulus (CS) and the aversive outcome (US). Typically in extinction training this is achieved by reducing the contingency between the CS and the US. A new association is formed between the CS and no aversive outcome, which weakens the previous association with the US. Based on conditioning models of fear learning, Field (2006c) predicts that 'quick intervention' (i.e. following up bad experiences with good ones) would be important in weakening the association between the stimulus and the bad outcome, in order to reduce anxiety.

Field (2006c) also suggests that information (in instructional learning) and another's reaction (in vicarious learning) can act as USs. It is plausible that, following a direct CS-US experience, a new CS-information association could potentially reduce a fear response by weakening the previous association that had been learnt. Equally, if combined threat information and direct experience magnify a fear response in comparison to either pathway alone (Field & Storksen-Coulson, 2007), potentially this combination of pathways might have a superior effect in *reducing* the fear response.

5.1.3 Reducing fear through information

Kelly et al. (2010) demonstrated that both children's fear beliefs about and behavioural avoidance of a novel animal (the CS) that had been heightened by threat information, could be reduced by either verbal information or modelling interventions about the CS. Although verbal information was more successful than modelling in reducing fear beliefs, both interventions showed comparable reduction in behavioural avoidance. One possible explanation for the reduced efficacy of the modelling intervention was the difference between the pathway to fear (the threat information) and the intervention pathway (observational). Kelly et al. suggest that reduction of fear beliefs learnt along a particular pathway might be more efficient when fear is unlearnt along a similar pathway. Thus they highlight the importance of investigating other pathways to fear, and the combination of these pathways in 'un-learning' fear. Additionally they suggest that the efficacy of these pathways, in reducing fear along all three response systems: cognitive, behavioural and physiological (Lang, 1968, 1978), needs further investigation.

5.1.4 Investigating the reduction of physiological fear response and fear beliefs through positive information and extinction training.

The present study aims to investigate the effect of information and extinction training on reducing fear acquired via direct aversive conditioning. Much evidence has been accumulated for the efficacy of reducing fear beliefs by removing the CS-US contingency (extinction training) in associative learning. However, if a CR can be equally reduced through information alone, or by its combination with extinction training, this would have important implications for the role of information in counteracting associations formed through direct negative experience (Clark, 2004; Zinbarg, 1993).

Additionally, as discussed in Chapter 1 (Section 1.3.3), the efficacy of information alone in reducing fear beliefs that have been formed through direct experience would support a propositional explanation of associative fear learning (De Houwer, 2009; Mitchell, et al.,

2009). If positive information improves the reduction of an implicit (ERP) or explicit (fear beliefs) CR, acquired through aversive conditioning, then this would imply that reasoning processes are involved in the un-learning of fear. However, a further motivation for employing multiple measures of fear (ERP & FBQ), as well as accounting for the response systems proposed by Lang (1968; 1978), is that physiological measures are less subject to cognitive control and therefore represent a more reliable gauge of stimulus affect, which is not easily attributed to demand characteristics.

A similar experimental design to Experiment 3 was employed, using the FBQ (Field & Lawson, 2003) to measure fear beliefs, and ERP was used to measure implicit response. Positive information was provided post-conditioning to examine the direct impact of information in reducing fear beliefs and its combined effect with extinction training in reducing ERP response.

5.2 Method

5.2.1 Participants

A total of 28 adult participants were recruited from the University of Sussex paid participant pool and taught /research postgraduate mailing lists. Four participants' data were withdrawn from analysis, using the same data inclusion rule from Experiments 1, 2 and 3. The remaining sample of 24 participants consisted of 7 men and 17 women with an age range from 18 to 65 (M = 25.33, SD = 9.8) and fulfilled a full counterbalancing order of stimuli across conditions. Participants were paid for their participation.

5.2.2 Materials, Measures and Procedure

The stimulus materials, measures, design, procedure and ERP recording parameters of Experiment 4 were identical to Experiment 3, apart from the timing and valence of the information given about two of the CSs. In this experiment *positive* verbal information was presented (about one CS+ and one CS-) during the *pre-extinction,* as opposed to pre-conditioning, phase (see Appendix 5A for a transcript of the positive verbal information). Because of this participants also responded twice on the FBQ between conditioning and extinction phases: once post-conditioning, pre-information; and again post-information, pre-extinction (a version of the FBQ used in Experiment 4 is listed under Appendix 5B).

5.3 Results

5.3.1 Contingency Awareness

A 2(Information: positive vs. none) × 2(Contingency: CS+ vs. CS-) repeated measures ANOVA was run for the contingency awareness score calculated from the number of accurate CS outcome predictions made during conditioning. It should be noted that positive information was not provided until after conditioning/pre-extinction phase, therefore effects of information on contingency awareness are not expected.

A significant main effect of contingency, F (1, 23) = 109.71, $p < .001$ (η^2_p= .83), demonstrated that participants performed close to 100% accuracy for the CS+ (M = 74.38, SE = 4.05) and around 40-50% accuracy (chance) for the CS- (M = 42.35, SE = 1.48), demonstrating expected contingency awareness for these conditions. As positive information was only provided for half the CSs post-conditioning, there was no significant main effect of information, F (1, 23) = .14, p = .72 (η^2_p= .01), nor was the interaction between information × contingency on contingency awareness significant, F (1, 23) = 1.85, p = .19 (η^2_p= .07).

As in Experiment 3, to explore whether the effects of information and contingency were consistent over time in the conditioning phase, a 2(Information: positive vs. none) × 2(Contingency: CS+ vs. CS-) × 10(Epoch: 1st 10 trials, 2nd 10 trials, 3rd 10 trials, etc.) repeated measures ANOVA was run on accuracy scores calculated from 10 time epochs, from consecutive groups of 10 trials.

The assumption of sphericity was violated for the main effect of epoch (time), χ^2 (44), 115.16, $p < .001$ and the interaction between contingency × epoch, χ^2 (44), 70.96, p = .008. Therefore degrees of freedom were corrected using the Greenhouse-Geisser estimate of sphericity (ε = .35 and ε = .58 respectively).

Similar to Experiment 3 there was a significant main effect of epoch, F (3.19, 70.07) = 6.67, p < .001 (η^2_p= .23), suggesting that accuracy in prediction varies across these time epochs and therefore participants may not have been contingency aware from the start of conditioning.

There was also a significant interaction between contingency × epoch, F (5.18, 113.84) = 11.55, p < .001 (η^2_p= .34), indicating that differences between CS+ and CS- on awareness were dependant on the epoch of trials. As expected there was no further interaction between these variables and information.

Figure 5.1 demonstrates the interaction between contingency × epoch. This figure suggests that, similar to the no information condition in Experiment 3, participants' accuracy score is lower for the CS+ at the start of conditioning (1st 10 trials), but increases indicating contingency awareness thereafter.

As the mean number of accurate predictions for the CS+ is so close to 5, in the 1st 10 trials (ability to accurately predict outcome at chance), firstly a single paired-samples t-test was conducted to test whether accurate predictions for CS+ and CS- were significantly different at epoch 1, and secondly a one-sample t-test was run to test whether accurate predictions for CS+ were significantly greater than 5 (chance prediction). Results showed that although accuracy for the CS+ was significantly higher than for the CS-, t (23) = 2.92, p = .008, r = .32, accuracy for the CS+ was not significantly greater than 5 (chance), t (23) = .80, p = .43, r = .11. This finding echoes that of Experiment 3, in that no information prior to conditioning leads to a larger number of trials required before participants become contingency aware for a CS+.
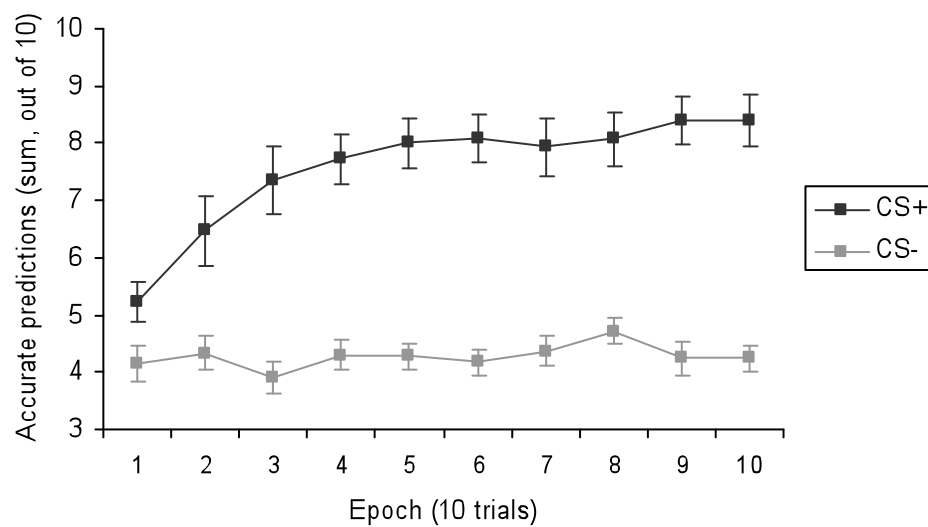
Figure 5.1: Mean number of accurate predictions, per 10 trial epoch, for CS+ and CS- (error bars represent standard error of the mean).

5.3.2 Self Report Results: Animal Fear Beliefs Questionnaire (FBQ)

Figure 5.2 shows the mean fear beliefs score for the CS+ and CS- pre-conditioning, post-conditioning post-information and post-extinction phases, split by whether positive information was provided or not.
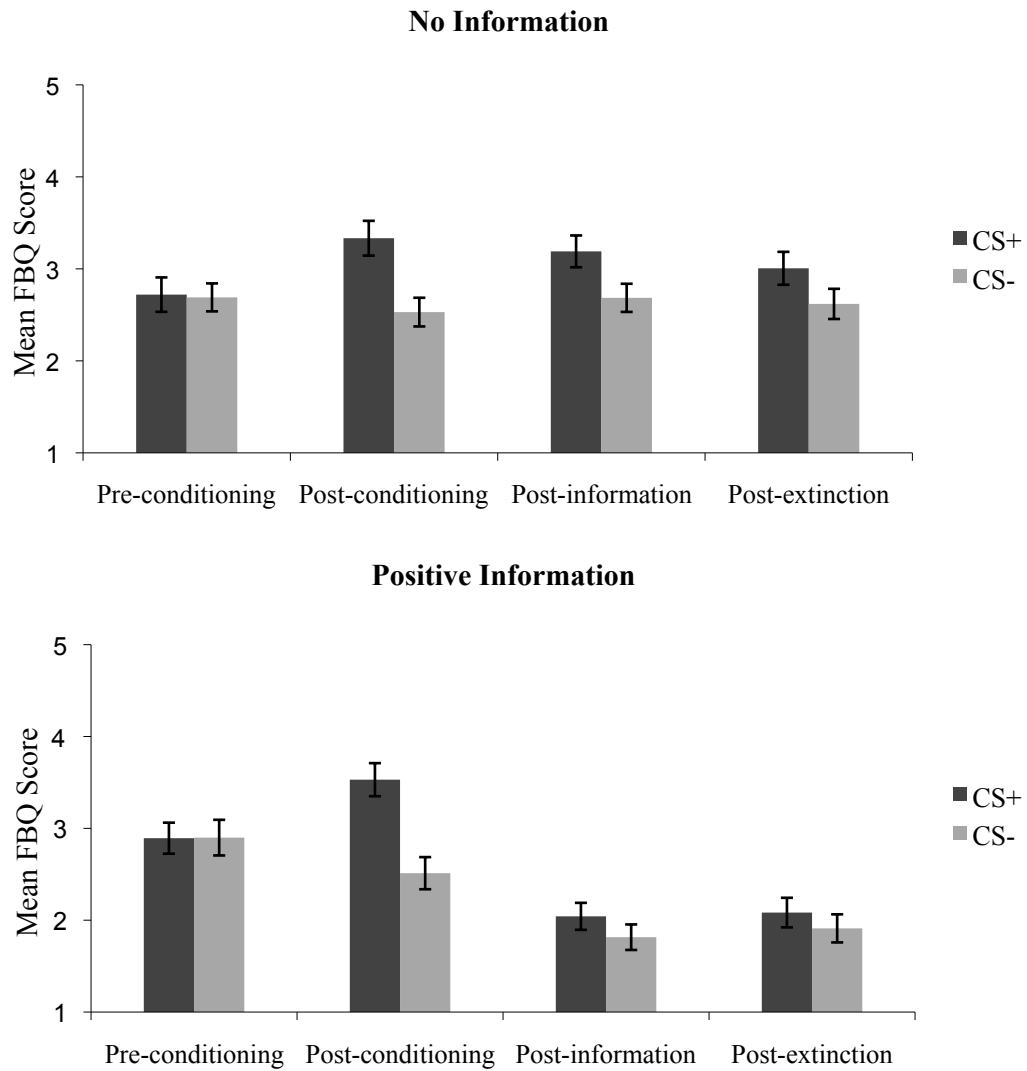
Figure 5.2: Mean fear belief scores pre-conditioning, post conditioning, post information and post-extinction, for CS+ and CS-, split by information condition (error bars represent standard error of the mean).

As in the previous study, information was only provided for half the stimuli (one CS+ and one CS-) however in this study positive information was provided after conditioning. As a result fear belief measures taken pre-conditioning and post conditioning looked very similar for both positive information and no information conditions, with mid-scale (Mean FBQ = 3; high score = more fear) fear belief scores towards all CSs (responses towards all CSs were neutral). Fear beliefs then increased, post-conditioning, for the CS+ but not the CS-, indicative of an increase in fear beliefs due to aversive conditioning. However, post information, fear beliefs decreased towards the animals about which participants were given positive information: so much so that responses were on the positive side for both CS+ and CS-. However for the CSs about which participants received no information, fear beliefs did not seem to change from post-conditioning.

Post-extinction fear belief scores, for CS+ and CS-, were very similar to those taken post-information, in both information conditions. Scores remained positive for both CS+ and CS- in the positive information condition, indicating that effects of extinction, accounted for by FBQ scores, occurred post information and were maintained through the extinction phase. In the no information condition however a difference between CS+ and CS- was maintained indicating that fear beliefs remained higher for the CS+ than for the CS- as a result of aversive conditioning, and these beliefs were resistant to extinction.

A 2 (Information: positive vs. none) × 4 (Time: pre-conditioning, post-conditioning, post-information, post-extinction) × 2 (Contingency: CS+ vs. CS-) repeated measures ANOVA was conducted on mean FBQ scores. The were significant main effects of time ($F_{(2.14, 49.14)}$ = 20.87, $p < .001$, η^2_p = .48), information ($F_{(1, 23)}$ = 24.54, $p < .001$, η^2_p = .52) and contingency ($F_{(1, 23)}$ = 13.01, $p = .001$, η^2_p = .36) on fear beliefs, and 2 way interactions between time × information ($F_{(1.73, 39.72)}$ = 38.05, $p < .001$, η^2_p = .62) indicating change in fear beliefs, overall contingency conditions, dependant on information; and, more interesting in terms of aversive conditioning, between time × contingency ($F_{(2.05, 47.20)}$

= 18.18, $p < .001$, $\eta^2_p = .44$), indicating change in fear beliefs, overall information conditions, dependant on contingency of the CS with the aversive US.

Bonferroni corrected contrasts showed that CS+ and CS- (collapsed across information) did not differ pre-conditioning ($CI_{.988} = -.44$ (lower), .42 (upper), $t(23) = -.08$, $p = .94$, $r = .02$). However, post-conditioning, post-information and post-extinction, fear beliefs were significantly higher for the CS+ than the CS- (post-conditioning: $CI_{.988} = -1.36$ (lower), -.46 (upper), $t(23) = -5.53$, $p < .001$, $r = .76$; post-information: $CI_{.988} = -.62$ (lower), -.11 (upper), $t(23) = -3.91$, $p = .001$, $r = .63$; post-extinction: $CI_{.988} = -.55$ (lower), -.01 (upper), $t(23) = -2.80$, $p = .01$, $r = .50$) indicating that, collapsed across information, aversive conditioning did occur and was resistant to extinction.

Of greater interest again, was the interaction between time × information × contingency, shown to be significant by multivariate tests ($F(3, 21) = 3.86$, $p = .02$, $\eta^2_p = .36$)[9] indicating that the effect of contingency on change in fear beliefs depended on whether positive information was provided.

Based on the multivariate tests this 3 way interaction was interpreted by using two 4 (time: pre-conditioning, post-conditioning, post-information, post-extinction) × 2 (contingency: CS+ vs. CS-) repeated measures ANOVAs, run for positive information and no information conditions separately. There was a significant interaction between time × contingency ($F(1.98, 45.63) = 12.22$, $p < .001$, $\eta^2_p = .35$), for the positive information condition, and the no information condition ($F(2.11, 48.49) = 8.26$, $p = .001$, $\eta^2_p = .26$), indicating that change in fear beliefs was dependant on contingency in both information conditions. Within-subjects contrasts, for the positive information condition, showed a significant change in CS+/CS- difference between pre-conditioning and post-conditioning ($p < .001$, $\eta^2_p = .45$), but not between pre-conditioning and post-information ($p = .28$, $\eta^2_p =$

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[9] This effect was not reflected by the within-subjects effects: $F(1.61, 37.13) = 1.79$, $p = .19$, $\eta^2_p = .07$.

.05), nor between pre-conditioning and post-extinction ($p = .40$, $\eta^2_p = .03$). This indicates conditioning and extinction effects both post-information/pre-extinction and post-extinction.

Bonferroni corrected contrasts showed that the positive information CS+ and CS- did not differ pre-conditioning ($CI_{.988} = -.56$ (lower), .57 (upper), $t(23) = .03$, $p = .98$, $r = .01$) but that post-conditioning the fear beliefs were significantly higher for the CS+ than the CS- ($CI_{.988} = -1.51$ (lower), -.52 (upper), $t(23) = -5.57$, $p < .001$, $r = .76$). This supports learning of an aversive response towards the CS+ through conditioning. Post-information and post-extinction the effects are less clear, with differences between CS+ and CS- only just non-significant (post-information, $CI_{.988} = -.54$ (lower), .09 (upper), $t(23) = -1.97$, $p = .06$, $r = .38$; and post-extinction, $CI_{.988} = -.41$ (lower), .07 (upper), $t(23) = -1.93$, $p = .07$, $r = .37$) however, compared to the effect size post-conditioning, these results still lend support towards an early extinction of conditioned response (post-information) maintained through to post-extinction.

Within-subjects contrasts, for the no information condition, showed a significant change in CS+/CS- difference between pre-conditioning and post-conditioning ($p < .001$, $\eta^2_p = .51$), and between pre-conditioning and post-information ($p = .007$, $\eta^2_p = .28$), but not between pre-conditioning and post-extinction ($p = .11$, $\eta^2_p = .11$). This indicates conditioning effects both post-conditioning and post-information (expected as no information was given) and extinction effects at post-extinction only.

In the no-information condition, Bonferroni corrected contrasts showed that again CS+ and CS- did not differ pre-conditioning ($CI_{.988} = -.63$ (lower), .57 (upper), $t(23) = .14$, $p = .89$, $r = .03$) but that post-conditioning the fear beliefs were significantly higher for the CS+ than the CS- ($CI_{.988} = -1.36$ (lower), -.25 (upper), $t(23) = -3.92$, $p = .001$, $r = .63$). This supports learning of an aversive response towards the CS+ through conditioning. As no information was provided in this condition, maintenance of conditioned response post-information is expected and supported by CS+ remaining significantly higher in fear beliefs than the CS- (post-information, $CI_{.988} = -.90$ (lower), -.11 (upper), $t(23) = -3.50$, $p = .002$, $r =$

.59). However there was a reduction in difference between the CS+ and CS- post-extinction ($CI_{.988}$ = -.91 (lower), .13 (upper), $t(23)$ = -2.02, p = .06, r = .39). Although the difference between CS+ and CS- is close to significant here, the reduction in effect size compared to post-information lends some support to extinction of conditioned response.

5.3.3 ERP Results
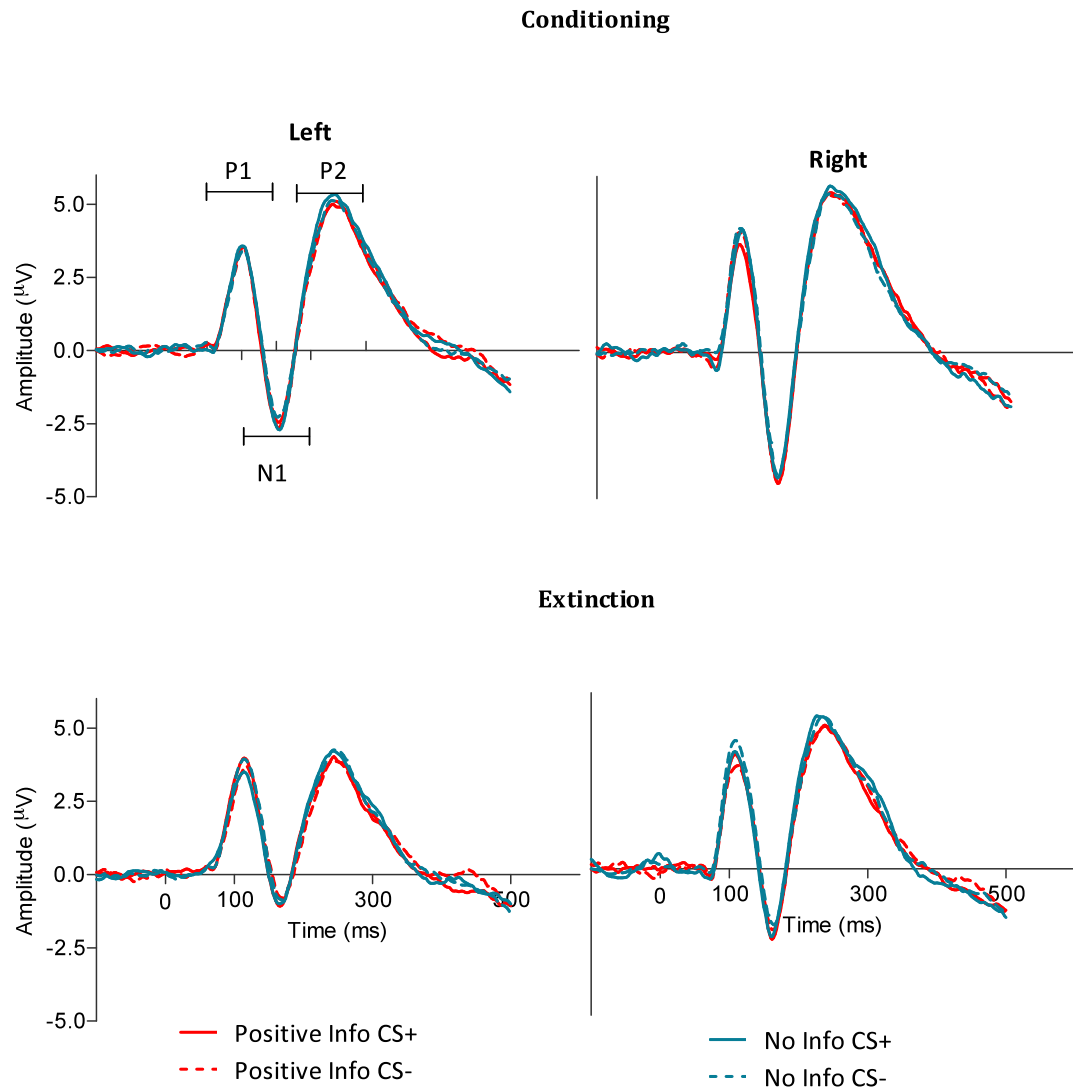
Figure 5.3: ERP grand average at conditioning and extinction, split by hemisphere. Collapsed across all analyzed parietal and occipital electrode sites, for the four conditions of interest: Information (positive vs. none) and contingency (CS+, CS-).

P1 Peak Latency

A 4-way, 2(Phase: conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Information: positive vs. none) × 2(Hemisphere: left vs. right), repeated measures ANOVA was conducted on the peak latency of the P1 component (61-161 ms after stimulus onset), collapsed across 9 left (P1, P3, P5, P7, PO3, PO5, PO7, O1 and CB1) and 9 right (P2, P4, P6, P8, PO4, PO6, PO8, O2, and CB2) hemisphere electrodes from parietal, occipital and cerebellum sites as in Experiments 1, 2 and 3.

As in Experiment 3, a significant main effect of phase, $F(1, 23) = 13.06$, $p = .001$ ($\eta^2_p = .36$), demonstrated overall faster P1 latencies in conditioning ($M = 113$, $SE = 2.45$) than extinction ($M = 117$, $SE = 2.87$), and there was also a significant 3 way interaction between phase × information × hemisphere $F(1, 23) = 4.27$, $p = .05$ ($\eta^2_p = .16$) indicating a hemispherical information effect on peak latency over phase. This was again explored by two, 2 (Phase: conditioning vs. extinction) × 2(Hemisphere: left vs. right), separate repeated measures ANOVAs for positive information and no information conditions (collapsed across contingency). A similar pattern of results was observed as in Experiment 3, with a significant interaction between phase × hemisphere in the no information condition, $F (1, 23) = 4.93$, $p = .04$ ($\eta^2_p = .18$), showing similar peak latencies in the right and left hemispheres at conditioning, but relatively slower peak latency at extinction, particularly in the left hemisphere. Again when information was provided the phase × hemisphere interaction was no longer significant $F(1, 23) = .03$, $p = .86$ ($\eta^2_p = .001$), however, in contrast to Experiment 3 showing differential hemisphere latencies similarly at conditioning and extinction as a result of threat information, this experiment showed similar peak latency across the hemispheres at both conditioning and extinction (see Figure 5.4). This indicates a reduction in hemispheric bias at extinction pre-empted by positive information pre-extinction.
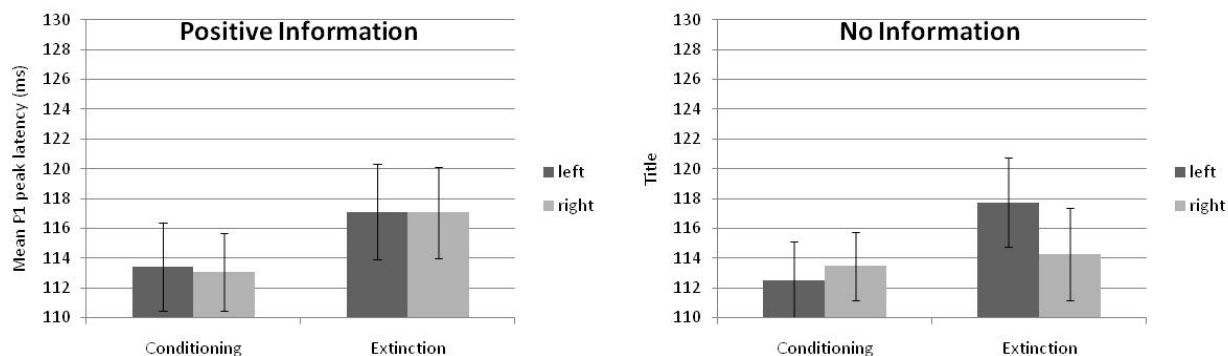
Figure 5.4: Mean Peak Latency of the overall 100 trials ERP, P1 component (61-161 ms after stimulus onset) from the left and right hemispheres during conditioning and extinction phases: split by positive and no information conditions (error bars show standard error of the mean).

In addition to these effects there was also a significant interaction, between contingency × phase, $F(1, 23) = 4.36$, $p = .05$ ($\eta^2_p = .16$), indicating differential peak latency between CS+ and CS- across phase. Bonferroni corrected contrasts showed that P1 peak latency did not differ between CS+ ($M = 113$, $SE = 2.56$) and CS- ($M = 113$, $SE = 2.43$) during the conditioning phase, $CI_{.975} = -1.97$ (lower), 2.48 (upper), $t(23) = .27$, $p = .78$, $r = .06$; during extinction however, latencies were significantly faster for the CS+ ($M = 115$, $SE = 2.88$) as opposed to the CS- ($M = 118$, $SE = 2.95$), $CI_{.975} = -5.11$ (lower), $-.05$ (upper), $t(23) = -2.45$, $p = .02$, $r = .45$. Therefore differential response, which might reflect the higher fear beliefs seen for the CS+ as opposed to the CS- from FBQ scores at post-conditioning, post-information and post-extinction, can be seen at extinction for P1 peak latency.

Effects of all 4 variables (time, contingency, information and hemisphere) on mean peak latency continued to be accounted for when calculating P1 mean amplitude time windows.

P1 Mean Amplitude

Mean amplitude time windows were defined as in Experiment 3, and adjusted for the effects of phase, contingency, information and hemisphere. Initial analysis of mean amplitude scores was conducted as per P1 peak latency scores.

As in Experiment 3 there was a significant main effect of phase, $F(1, 23) = 6.43$, $p = .02$ ($\eta^2_p= .22$), demonstrating larger P1 mean amplitude at extinction ($M = 2.88$, $SE = .49$), than at conditioning ($M = 2.53$, $SE = .51$).

Of great interest however was a significant 3 way interaction between phase × contingency × information, $F(1, 23) = 33.69$, $p < .001$ ($\eta^2_p= .59$), indicating an information effect on change in P1 mean amplitude response across phase, depending on whether the CS was reinforced 100% or 50% (CS+ vs. CS-).

In order to explore this 3 way interaction between phase × contingency × information, two 2(Phase: conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) repeated measures ANOVAs were run separately for positive and no information, collapsing across hemisphere.

In both the positive information condition and the no information condition there were significant 2 way interactions between phase × contingency: positive information, $F(1, 23) = 19.29$, $p < .001$ ($\eta^2_p= .46$); no information, $F(1, 23) = 8.28$, $p = .08$ ($\eta^2_p= .27$) indicating that there was a significant change, in CS+ and CS- difference, across phase in both conditions. However, Bonferroni corrected contrasts show that this interaction stemmed from a significant increase in P1 mean amplitude from conditioning to extinction for the CS+ in the positive information condition ($CI_{.975} = -.92$ (lower), $-.25$ (upper), $t(23) = -4.24$, $p < .001$, $r = .12$), whereas there was a significant increase for the CS- in the no information condition ($CI_{.975} = -1.00$ (lower), $-.12$ (upper), $t(23) = -3.05$, $p = .006$, $r = .11$). P1 mean amplitude did not significantly change across phase for the CS- in the positive information condition, or for the CS+ in the no-information condition (see Figure 5.5). This could possibly indicate some increase in attention to stimuli where a change in expectations has

occurred, thus an increase in response is seen when a CS is highly contingent with an aversive outcome, but positive information is later provided, and an increase is also seen when the outcome of a CS is unpredictable (i.e. contingent with an aversive outcome at chance) and no information is provided.
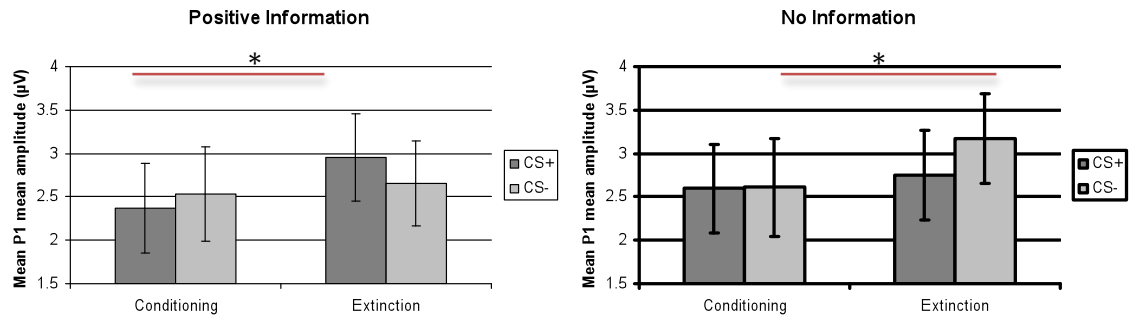
Figure 5.5: Mean P1 mean amplitude in response to the CS+ and CS- across phases of conditioning and extinction, split by information (error bars represent standard error of the mean) * p < .01.

N1 Peak Latency

A 4-way, 2(Phase: conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Information: negative vs. none) × 2(Hemisphere: left vs. right), repeated measures ANOVA was conducted on the peak latency of the N1 component (111-211 ms after stimulus onset), collapsed across the same parietal, occipital and cerebellum sites as for P1.

As in Experiment 3, a significant main effect of hemisphere, $F(1, 23) = 14.25$, $p = .001$ ($\eta^2_p = .38$), demonstrated overall faster N1 Latencies in the right hemisphere ($M = 160$, $SE = 2.49$) compared to the left ($M = 164$, $SE = 2.66$). Also similar to Experiment 3 was a significant interaction between phase × hemisphere, $F(1, 23) = 7.39$, $p = .01$ ($\eta^2_p = .24$) with faster peak latency in the right hemisphere at extinction ($M = 159$, $SE = 2.67$) as opposed to conditioning ($M = 160$, $SE = 2.42$); whereas in the left hemisphere peak latency was faster at conditioning ($M = 163$, $SE = 2.16$) than extinction ($M = 164$, $SE = 3.29$). Effects of

hemisphere and phase on peak latency were taken into consideration for mean amplitude time windows in the following analysis of N1 mean amplitude.

N1 Mean Amplitude

Mean amplitude time windows were defined as per the P1 component, and the mean peak latency was adjusted for the main effects of phase and hemisphere. Initial analysis of mean amplitude scores was conducted as per N1 peak latency scores.

As in Experiment 3 there was a significant main effect of phase, $F(1, 23) = 96.68$, $p < .001$ ($\eta^2_p = .81$), with N1 mean amplitude larger at conditioning ($M = -2.05$, $SE = .62$), than at extinction ($M = -.47$, $SE = .59$), suggesting a either habituation or greater attention during conditioning, and the trend of larger and earlier components in the right hemisphere as opposed to the left was again demonstrated by the significant main effect of hemisphere, $F(1, 23) = 6.03$, $p = .02$ ($\eta^2_p = .21$) (Left: $M = -.78$, $SE = .60$, Right: $M = -1.74$, $SE = .65$). There was no indication of N1 mean amplitude being affected by the manipulations of CS contingency (with the aversive US) or information, which might have indicated conditioning/extinction effects, or effects of information on conditioning/extinction. This result is not unlike that for N1 mean amplitude in Experiment 3.

P2 Peak Latency

A 4-way, 2(Phase: conditioning vs. extinction) × 2(Contingency: CS+ vs. CS-) × 2(Information: positive vs. none) × 2(Hemisphere: left vs. right), repeated measures ANOVA was conducted on the peak latency of the P2 component (sought 191-291 ms after stimulus onset), collapsed across the same parietal, occipital and cerebellum sites as for the P1 and N1 components.

The interaction between phase × contingency neared significance, $F(1, 23) = 3.69$, $p = .07$ ($\eta^2_p = .14$), indicating differential peak latency between CS+ and CS- dependant on phase (similar to the P1 component). Bonferroni corrected contrasts showed that P2 peak latency did not differ between CS+ ($M = 246$, $SE = 3.96$) and CS- ($M = 246$, $SE = 3.80$) during the conditioning phase, $CI_{.975} = -2.75$ (lower), 2.18 (upper), $t(23) = -.28$, $p = .78$, $r = .06$; during extinction however, a statistical trend showed latencies to be earlier for the CS+ ($M = 242$, $SE = 3.88$) as opposed to the CS- ($M = 245$, $SE = 3.29$), $CI_{.975} = -6.57$ (lower), $.74$ (upper), $t(23) = -1.91$, $p = .07$, $r = .37$. Therefore there is again indication from the P2 component towards differential response between CS+ and CS- at extinction, which might reflect the higher fear beliefs seen for the CS+, as opposed to the CS-, in the self-report data (mainly in no information condition).

Effects of phase and contingency on P2 peak latency were taken into consideration for mean amplitude time windows in the following analysis of P2 mean amplitude.

P2 Mean Amplitude

Mean amplitude time windows were defined as for the previous components, and the mean peak latency was adjusted for the main effects of phase and contingency. Initial analysis of mean amplitude scores was conducted as per P2 peak latency scores.

As for the N1 component, there was a significant main effect of phase, $F(1, 23) = 21.71$, $p < .001$ ($\eta^2_p = .49$), on P2 mean amplitude with larger mean amplitude at conditioning ($M = 5.01$, $SE = .52$), than at extinction ($M = 4.20$, $SE = .43$), suggesting a possible habituation at extinction or greater stimulation of attention during conditioning.

There was also a significant 2-way interaction between phase × hemisphere, $F(1, 23) = 4.82$, $p = .04$ ($\eta^2_p = .17$), indicating differential hemispheric P2 mean amplitude response depending on phase. Bonferroni corrected contrasts showed that there was no hemispheric difference in N1 mean amplitude response during conditioning ($CI_{.975} = -1.58$

(lower), .72 (upper), $t(23) = -.90$, $p = .38$, $r = .08$) however, during extinction, responses were significantly larger in the right hemisphere than the left: $CI_{.975} = -1.82$ (lower), $-.32$ (upper), $t(23) = -2.47$, $p = .02$, $r = .20$ (see Figure 5.6).
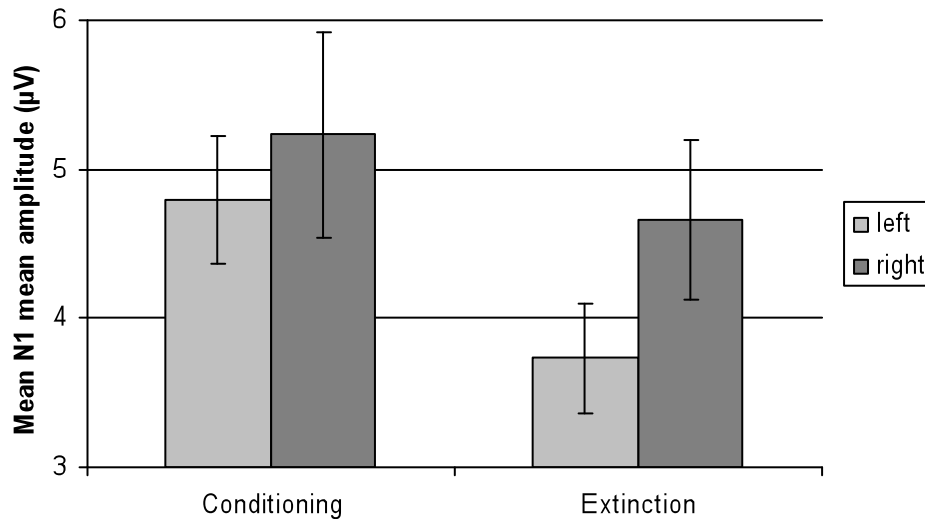
Figure 5.6: Mean P2 Mean Amplitude response between hemispheres, across phases of conditioning and extinction (error bars represent standard error of the mean).

There was no indication of any further interaction effects, with either contingency or information, on P2 mean amplitude, which might have indicated conditioning/extinction effects, or effects of information on conditioning/extinction.

5.3.4 5-trial Epoch multilevel regression analysis

Peak Latency effects

As in Experiment 3 (Chapter 4), a mixed model multilevel regression analysis was conducted on peak latency of the 5-trial average P1, N1 and P2 components. The effects of this analysis were also used to determine windows of measurement for mean amplitude calculations.

Similar general trends in model fit were observed, as in Experiment 3. To be concise, the effects of epoch, hemisphere, phase, contingency and positive information on peak latency are reported from the final model for all components, and comparisons to the effects from the overall-trial ERP analyses are described.

P1

Although a significant main effect of phase and significant interaction between phase × information × hemisphere were found for overall-trial P1 peak latency scores, there were no significant effects of hemisphere, phase, contingency, information or epoch for epoched peak latency scores. Thus P1 mean amplitude windows were based on mean P1 peak latency, collapsed across all levels of epoch, hemisphere, phase, contingency and positive information.

N1

In contrast to the overall-trial ERP analysis, the main effect of hemisphere ($t(7709) = .69$, $p = .49$) and interaction between phase × hemisphere ($t(7709) = -1.14$, $p = .25$) did not show significant modulation of the epoched N1 peak latency scores. However, the interaction

between contingency × phase was significant (t(7709) = -2.13, p = .03), indicating differential modulation of N1 peak latency across conditioning and extinction phase, between the CS+ and CS-. Mean N1 peak latencies demonstrate an earlier N1 response towards the CS+ during extinction, whereas a later N1 response is sustained from conditioning to extinction for the CS- (see Figure 5.7) [10].
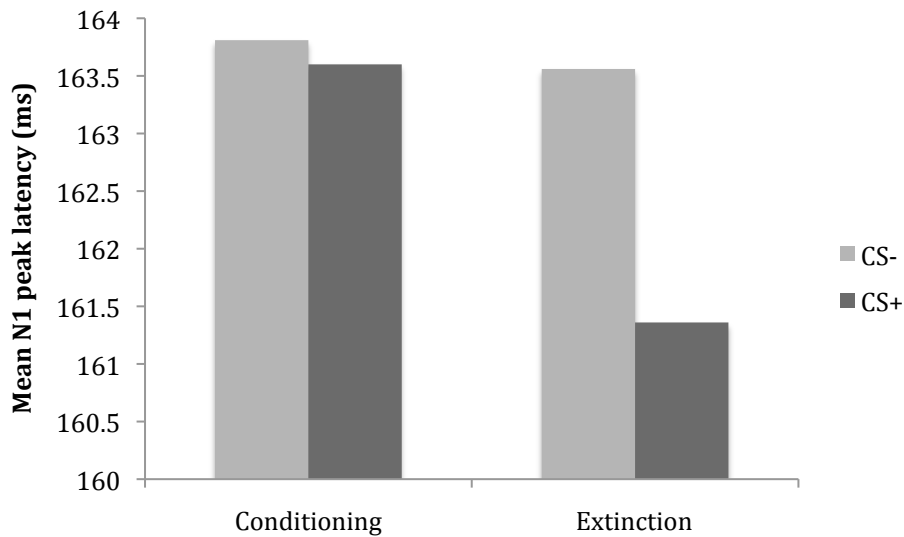
Figure 5.7: Mean N1 peak latency in response to the CS+ and CS- across phase.

No significant effects of epoch, or its interaction, were found for N1 peak latency scores, indicating that peak latency of the N1 component did not significantly differ across the time course of experimental phase. N1 Mean amplitude windows were adjusted for the main effects of contingency and phase on N1 peak latency.

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[10] As in Experiment 3, figures within this section are presented without error bars to represent standard deviations of the means, because heteroscedasticity was factored into the model. Thus error bars would misrepresent the remaining variance within levels of each variable.

P2

In contrast to the overall-trial ERP analysis, the interaction between contingency × phase did not have a significant effect on epoched P2 peak latency scores, $t(7709) = 1.96$, $p = .19$. However the main effects of contingency ($t(7709) = -1.96$, $p = .05$), phase ($t(7709) = -2.10$, $p = .04$), and hemisphere ($t(7709) = -2.16$, $p = .03$), were significant. Additionally there was a significant interaction between contingency × phase × hemisphere on P2 peak latency, $(7709) = -2.03$, $p = .04$. This interaction suggests that differential changes in mean peak latency, between CS+ and CS-, across experimental phase, are dependant on hemisphere. Generally P2 peak latencies demonstrate earlier in the right hemisphere than the left and earlier during extinction than conditioning (see Figure 5.8). Additionally, a general trend of earlier P2 peak latency was observed for the CS+, as opposed to the CS-. The interaction between contingency × phase × hemisphere indicates that P2 latency in response to the CS+ occurs earlier than for the CS-, across both conditioning and extinction, in the left hemisphere. Though in the right hemisphere, P2 latency in response to the CS+ occurs slightly later than for the CS- during conditioning, as opposed to a much earlier P2 peak latency towards the CS+ during extinction (see Figure 5.8).

Left hemisphere

Right hemisphere
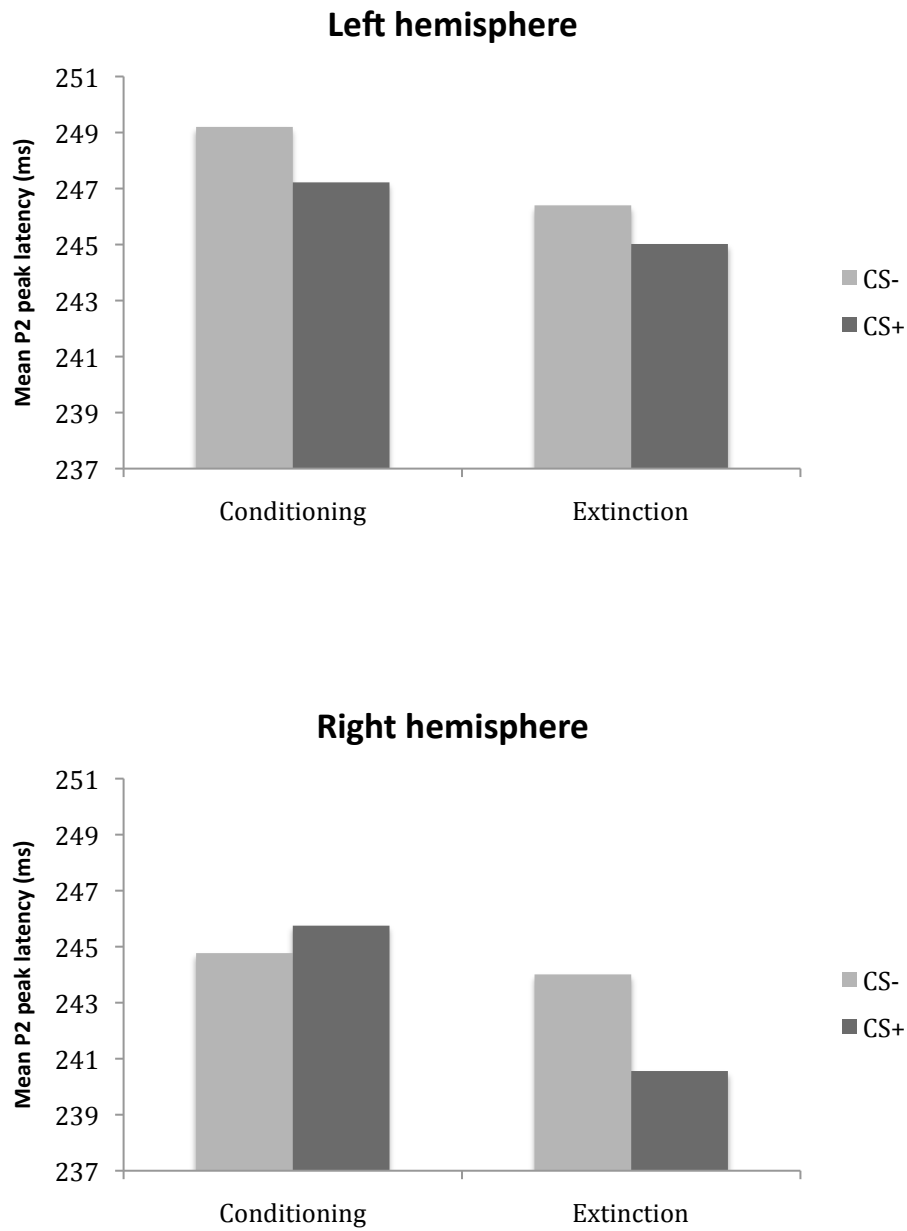
Figure 5.8: Mean P2 peak latency in response to the CS+ and CS- across phase, split by hemisphere.

This interaction suggests a hemispheric dissociation in differential response towards the CS+ and CS- during conditioning, whereas earlier responses towards the CS+ during extinction are simply more pronounced in the right hemisphere.

As for P1 and N1 components, no significant effects of epoch, or its interaction, were found for P2 peak latency scores, indicating that peak latency of the P2 component did not significantly differ due to the time course of the experimental phase. P2 mean amplitude windows were adjusted for the main effects of phase, contingency and hemisphere on mean P2 peak latency.

Mean amplitude effects

The same mixed model multilevel analysis conducted for epoched peak latency scores, was conducted on the epoched mean amplitude scores for the P1, N1 and P2 components. Similar general trends in model fit were observed and for all components. The effects of epoch, hemisphere, phase, contingency and positive information on mean amplitude scores are reported from the final model.

As in Experiment 3, a wider mean amplitude time window (60 ms as opposed to 50 ms in the overall-trial analysis), compared to the standard overall-trial ERP analyses, was implemented due to the increased variance found for 5-trial average ERP responses. Mean amplitude windows were adjusted based on the significant modulations of peak latency described above.

P1

Similar to the overall-trial ERP analysis, a significant main effect of phase was observed for P2 mean amplitude, $t(7709) = 3.97$, $p < .001$. Additionally the significant interaction between phase × contingency × information, observed in the overall-trial ERP analysis, was replicated for the epoched P1 mean amplitude data, $t(7709) = 2.67$, $p = .007$). This finding supports the information effect on differential change, between the CS+ and CS-, in P1 mean amplitude response across phase (described earlier).

No significant effects of epoch, or its interaction, were found for P1 mean amplitude scores, indicating that mean amplitude of the P1 component did not significantly differ across experimental phase.

N1

Similar to the overall-trial ERP analysis, significant main effects of phase ($t(7709) = 4.20$, $p < .001$) and hemisphere ($t(7709) = -2.13$, $p = .03$) were found for the epoched N1 mean amplitude scores. Additionally, the epoched data revealed a significant main effect epoch ($t(7709) = 2.16$, $p = .03$) on N1 mean amplitude. This indicates differential mean amplitude response towards all CSs across phase epoch, collapsed across phase, hemisphere, contingency and verbal information.

P2

Similar to the overall-trial ERP analysis, a significant main effect of phase ($t(7709) = -3.87$, $p < .001$) was found for the epoched P2 mean amplitude scores. However, the interaction between phase × hemisphere was no longer significant, $t(7709) = 1.36$, $p = .17$. The epoched P2 data also revealed a significant main effect epoch ($t(7709) = -3.31$, $p = .001$) on mean amplitude scores, indicating differential mean amplitude response towards all CSs across phase epoch, as for the N1 component.

5.4 Discussion

5.4.1 Positive information extinguishes fear beliefs learnt through aversive conditioning

The present study investigated the effects of positive information and extinction training, on fear beliefs and ERP indices of response towards animals that had been associated with an aversive outcome through aversive conditioning. Fear beliefs significantly increased as a result of aversive conditioning and, in the absence of positive information, were maintained until post-extinction training. After extinction training, however, fear beliefs were significantly reduced. This extinction effect on fear beliefs differed from Experiment 3, in which resistance to extinction was observed for fear beliefs that had been heightened through aversive conditioning (no information condition). In the present study, even in the condition where no positive verbal information was provided, differential extinction effects were seen for fear beliefs in comparison to Experiment 3. This finding implies that simply involving an information intervention regarding *other* stimuli might have a positive effect in reducing fear beliefs through further unreinforced experience of the CSs.

When positive information was provided, post-conditioning, early extinction of fear beliefs were observed. Extinction was achieved without the need for direct experience of CS-US contingency removal. There was no longer a significant difference between CS+ and CS-fear beliefs and fear beliefs became more positive in general (regardless of the previous US contingency).

The effect of positive information in reducing fear beliefs, acquired through direct aversive conditioning, is consistent with Kelly et al. (2010) who demonstrated the same effect in children, when fear beliefs were acquired through threat information. This consistency supports the role of information as an intervention strategy that may be successful in

reducing fear cognitions, irrespective of whether acquisition occurred through instructional learning or direct experience.

Additionally, the impact of information on associative learning raises the issue of whether the underlying processes driving acquisition and extinction of fear can be explained in terms of propositional learning (De Houwer, 2009; Mitchell et al., 2009). Mitchell et al. (2009) suggest that if rules or instructions can help/hinder fear learning then learning must be based on reasoning processes, as opposed to simply the formation of an associative link. Therefore the effect of information, on a previously learnt CS-US association, supports the idea that this learnt association is based on propositional knowledge. However, as mentioned earlier, explicit measures of affective response (such as fear beliefs) can be affected by demand awareness. Thus we cannot be sure that the FBQ scores recorded reflect genuine changes in affective response towards the stimuli, let alone represent associative or propositional learning.

5.4.2 Effects of information and extinction training on ERP indices of response.

Aside from the effect of positive information on fear beliefs, the present study aimed to investigate whether positive information would influence implicit, physiological measures of response. Kelly et al., (2010) provides evidence for the efficacy of information in reducing a behavioural avoidance response, in addition to decreasing fear beliefs. If it were possible to additionally demonstrate a change in physiological response, towards a CS that has been associated with an aversive outcome, this would provide an account of information as a mode of intervention for the third response system (physiological) proposed by Lang (1968, 1977). To this end, ERP was measured throughout the two experimental learning phases: conditioning and extinction, as in Experiment 3.

Apart from similar main effects of phase and hemisphere that have been observed in the previous experiments, there was a significant interaction between contingency and phase for the P1 peak latency, N1 peak latency (5-trial epoch analysis) and a similar trend interaction for P2 peak latency. All components showed a similar pattern of results, with earlier peak latency for the CS+ than the CS- at extinction only, when collapsing across information and hemisphere. Earlier response towards the CS+ might be reflective of the higher fear beliefs held towards the CS+, demonstrated post conditioning, post-information and post-extinction (when collapsing across information). However, a contingency dissociation was expected more during conditioning, when the differential US contingency was employed, than during extinction when the USs were removed. Contingency awareness results indicate that participants were fully aware, of the CS+ -US contingency, by the second block of 10 conditioning trials. A possible explanation for why the contingency dissociation is not demonstrated during the conditioning phase may be that the active US prediction task increased arousal/attention towards both CS types, and thus peak latency was earlier for both sets of stimuli. This might explain why differential response, based on contingency, is only observable when the prediction task was removed. Difference in response towards the CS+ and CS- during extinction may represent a differential affective response, which is 'masked' during conditioning by overriding attention/arousal from involvement in the prediction task. This effect of contingency, on peak latency in the extinction phase, was not dependant on information.

Verbal information did significantly interact with hemisphere and phase on P1 peak latency. P1 peak latency was generally faster during conditioning than during extinction, and this was clearly demonstrated both in the left and right hemisphere when positive information is provided. When no information was provided about the CSs, faster peak latency response is maintained from conditioning to extinction in the right hemisphere alone. Positive information, pre-extinction, interestingly provides a different phase × hemisphere effect to threat information, pre-conditioning (Experiment 3), on P1 peak latency (compare Figures 4.5 and 5.4). Providing positive information, pre-extinction, seems reduce the hemispheric bias, which is found at extinction when no information is

provided. In Experiment 3 the same hemispheric bias was found at extinction when no information was provided, however in the threat information condition the faster right hemisphere response was pre-empted at conditioning. This peak latency effect could represent right hemisphere sensitivity to fear, which is acquired through information alone: there was no further interaction with CS-US contingency.

Also of major interest was the significant interaction between contingency, phase and information, on mean amplitude response of the P1 component. There was a significant interaction between phase and contingency, indicating an extinction effect on P1 mean amplitude response, regardless of whether information was provided between the conditioning and extinction phase. However, contrasts demonstrated that the nature of this extinction effect differed depending on whether positive information was provided. When no information was provided, post-conditioning, there was a significant increase in P1 response, from conditioning to extinction, towards the CS-. When positive information was provided post-conditioning, there was a significant increase in P1 response towards the CS+. The increased response could represent increased attention/arousal as a result of expectation conflict. In other words, if an animal has been associated with an aversive outcome based on experience (CS+), and then conflicting positive information is provided regarding that animal, further attention/interest might increase towards that animal in an attempt to resolve the discrepancy. Additionally, if an animal has been partially reinforced with an aversive outcome but does not reliably predict it (CS-), and no further information is provided, attention might increase towards that animal in anticipation of some further experience/information that could resolve the previous conflict.

This interaction between information and contingency on change in response does not exactly match the interaction effect, which was hypothesised for ERP response at extinction. In previous experiments (Experiments 1 and 2 specifically) acquisition of a CR has been demonstrated either through maintained or increased mean amplitude response. Extinction of a CR was indicated through a decrease in mean amplitude response at extinction in Experiment 2. Therefore, we hypothesised that positive

information would decrease mean amplitude response towards the CS+ if information is a viable mode of intervention for physiological fear response. However, as noted in previous discussions, an increase in ERP response does not necessarily represent an increase in negative affect. It is possible that the increase in ERP response observed for the CS+ may reflect the increase in positive affect represented in the FBQ scores, post-information. The increase in ERP response might also represent some underlying driving force responsible for the decreased avoidance in children, post-positive information, demonstrated by Kelly et al., (2010).

In summary these ERP findings do not refute the hypothesis that positive information is an effective mode of fear intervention, especially as FBQ scores showed a large decrease in fear beliefs as a result of the verbal information. However, based on the extinction effect towards the CS+ in Experiment 2, these ERP results do suggest that verbal information may influence fear reduction in a different manner to extinction training alone. To further understand the effect of positive information, on the physiological response system, future studies would benefit from comparing ERP response to an online measure of SCR, commonly used to investigate extinction of CR. Comparison with SCR would enable investigation of whether the increase in ERP response, towards the CS+ during extinction, is common across physiological measures. If SCR decreased, as is common during extinction training, this would support that information affects the physiological response system in a similar manner to its impact on fear beliefs and behavioural avoidance. A difference in pattern of results between these physiological measures would also imply that the ERP response represents something other than affective response: perhaps attention or arousal.

Chapter 6: General Discussion

6.1 Summary of main findings

This thesis investigated factors that promote resistance to extinction of the conditioned fear response on the basis of our theoretical and practical understanding of the maintenance of fear in anxiety disorders.

This thesis had 4 main aims:

1. To explore whether EC and CC differ regarding resistance to extinction when compared procedurally using event-related brain potential (ERP) as an index of physiological affective response.

2. To explore the effect of phylogenetic fear relevance on the inhibition of extinction within both CC and EC.

3. To investigate whether verbal threat information and direct aversive conditioning experiences interact to heighten fear beliefs and physiological responses (EPR) and produce resistance to extinction.

4. To investigate whether positive verbal information, presented post aversive conditioning, has an equal or superior effect in reducing CRs to extinction training alone.

The main findings of the thesis will be summarised below to preface a more detailed discussion of what the data enable us to conclude about each of the above aims.

ERP Methodology: The studies within this thesis support ERP as a viable physiological measure of CRs that can be employed within typical EC and CC paradigms alike. Additionally, using ERP as an index of CR enabled cross-procedure comparison of

conditioning and extinction effects between EC and CC paradigms. Through this comparison evidence of differential extinction patterns between the two paradigms were identified. In Experiment 1, resistance to extinction of the CR was demonstrated within an EC paradigm, whereas evidence of extinction was demonstrated within a CC paradigm in Experiment 2. The dissociation of extinction effects between the two studies indicates that procedural differences in the types of US used, could be the reason why many previous studies have typically shown extinction when using physiological measures (SCR/startle response) of response in differential CC studies (e.g., Blechert et al., 2008; Lipp et al., 2003; Vansteenwegen et al., 1998; Vansteenwegen et al., 2006) but resistance to extinction when using EC paradigms.

Fear Relevancy: Phylogenetic fear-relevance did not promote resistance to extinction of the CR in either EC (Experiment 1) or CC (Experiment 2). In Experiment 1, to extinction was demonstrated regardless of fear-relevance, whereas in Experiment 2 extinction of the CR was demonstrated regardless of fear-relevance. Rather than refute previous findings that CS fear-relevance promotes resistance to extinction of the physiological fear response (for a review see Öhman & Mineka, 2001), other possible explanations, including the nature of the fear-relevance manipulation and the number of extinction trials, are discussed.

Verbal Threat Information: The manipulation of fear-relevance through verbal threat information, in Experiment 3, supported the role of verbal information as a direct pathway to fear on both a cognitive (increased fear beliefs) and physiological (ERP response) level. Similar to phylogenetic fear-relevance (Experiments 1 and 2), threat information also resulted in faster learning of the contingency between the CS+ and aversive US, thus supporting Davey's (1995) expectancy bias model. However, the addition of differential conditioning did not significantly interact with prior threat information to heighten fear beliefs or ERP response towards the FR CS+, as predicted in Davey's (1997) conditioning model. Instead, aversive conditioning served to maintain fear beliefs learnt through information: fear beliefs acquired through verbal threat information declined towards the FR CS- as a result of random reinforcement with the aversive US, whereas fear beliefs

towards the FR CS+ were maintained. However, a potential ceiling effect in fear beliefs, measured post-information, may have restricted the demonstration of further increase in fear beliefs post conditioning.

Positive Verbal Information: Evidence that positive verbal-information can reduce fear, acquired through direct aversive conditioning, was demonstrated in Experiment 4 for the self-report index of fear beliefs (FBQ scores). Interestingly evidence of extinction was also observed in the no-information condition, after extinction training. This contrasts with resistance to extinction of fear beliefs found in the no-information condition in Experiment 3. The early extinction effect, post verbal information, implies this mode of intervention is more efficient than extinction training in reducing the cognitive component of the fear response acquired within an experimental setting using 'normal' (non-anxious) participants.

Modulations of ERP component latency indicated differential conditioning effects (between the CS+ and CS-) at extinction only, which were not mediated by positive verbal information and may be indicative of resistance to extinction of an implicit CR. Positive verbal information did interact with contingency, however, resulting in *larger* P1 mean amplitude response towards the CS+, at extinction, *if* positive verbal information was provided. A similar increase in P1 mean amplitude was observed for the CS- that was not paired with the positive information. Further on in this chapter, potential explanations for the increased P1 amplitude activation during extinction are discussed with regard to possible effects of heightened attention or increased positive affect in the aforementioned conditions. Additionally, positive verbal information did impact on reducing an early P1 latency response in the right hemisphere (during extinction), which may be associated with feelings of general ambiguity/threat towards all CSs. A similar lateralised modulation of P1 peak latency, pre-empted during conditioning by threat information in Experiment 3, supports the premise that this response is associated with general arousal/attention.

6.2 The functional distinction between EC and CC: is resistance to extinction a procedural phenomenon?

Evidence from visual EC studies that learned affective response is resistant to non-reinforcement through extinction training has supported the premise that EC and CC are functionally distinct forms of learning (e.g., De Houwer et al., 2000; Diaz et al., 2005; Field, 2006b). Whereas the CR within CC seems dependant on expectancy of the US, and thus extinguishes more readily on removal of the CS-US contingency (extinction), resistance to extinction in EC suggests that the CR does not depend on a genuine expectancy that the US will follow CS presentation. This observation in turn supports a dual-process model of learning (Baeyens et al., 1995; Baeyens et al., 1992) in which EC is based on a referential form of learning that is not dependant on contingency knowledge.

Further evidence for the distinction between EC and CC, in terms of extinction effects, has been provided from studies comparing proposed indices of learned affect and US-expectancy, within the differential conditioning paradigm that is typical of CC (e.g., Blechert et al., 2008; Hermans et al., 2002; Vansteenwegen et al., 1998; Vansteenwegen et al., 2006). However, there is also a procedural explanation for differential extinction effects: differences in extinction in physiological and self-report measures might not reflect distinct underlying learning mechanisms, but could be because physiological responses are measured online, whereas self-report responses are measured post-hoc. Additional problems faced by the aforementioned studies have been highlighted by Blechert et al. (2008). First, comparing EC by verbal indices and CC by physiological measures could be problematic because the electrodermal system may reflect several factors other than the predictive ability of a CS. Second, comparing verbal indices of EC and CC, within the same differential CC paradigm, might result in equal rates of extinction (as reported by Blechert et al., 2008) because *both* indices are actually reflecting US-expectancies rather than dissociating between an EC response and a CC (or signal learning) response. This principle is put forward by Blechert et al. (2008) due to the possibility that different processes underlie the associative learning effects obtained

under the different conditioning paradigms (De Houwer et al., 2005). Thus, comparing proposed measures of EC and CC within a differential conditioning paradigm, and not comparing extinction effects for such measures across EC and CC paradigms, is problematic. One cannot assess whether the extinction effects observed are the result of the measure or the procedure that were implemented.

Experiments 1 and 2 provided novel evidence of whether extinction effects, as indexed by a physiological measure, differ across visual EC and differential CC paradigms. This comparison was achieved by keeping the measure of the CR constant (by implementing ERPs as an index of physiological affective response) but varying the conditioning procedure (EC vs. CC). Through this comparison of procedures, evidence of differential extinction patterns between EC and CC was obtained: this evidence implied that extinction of other physiological responses (such as SCR), in the aforementioned CC studies, can be explained by procedural differences between EC and CC.

6.2.2 ERP indices of conditioned response

In Experiment 1, ERP measures indicated a CR through mean amplitude modulation of the N1 component. This finding is in line with the general consensus that the amplitude of ERP components is more consistently modulated by affective stimulus factors, than component latency, within the affective picture processing literature (Olofsson et al., 2008). A significant interaction between contingency and phase demonstrated that although there was a significant reduction in negativity of the N1 response, from baseline to conditioning, when the CS was randomly reinforced (CS-), N1 amplitude was maintained when the CS was 100% reinforced with the aversive US (CS+). As a general reduction in mean amplitude response was observed from baseline to conditioning phase for the N1 component, the maintenance of a larger mean amplitude response for CS+ is indicative of this stimulus type acquiring an unpleasant affect and may indicate the focus of attentional resources on stimuli that are predictive of the aversive outcome. Most

important, this effect of conditioning, which was not dependant on the fear-relevance of the CS, did not show an effect of extinction. Unlike other online physiological measures of the CR (such as SCR and startle response), which consistently demonstrate extinction (e.g. Blechert et al., 2008; Lipp et al., 2003; Vansteenwegen et al., 1998 & 2006), there was no significant change in N1 mean amplitude response, from the conditioning phase to the extinction phase, for the CS+.

In Experiment 2, on the other hand there was no significant interaction between contingency and phase on N1 mean amplitude that would indicate acquisition of a CR. Instead, a significant interaction between contingency and phase modulated mean amplitude of the P2 component and contrasts demonstrated that the contingency × phase interaction was significant between the baseline and conditioning phases but not between conditioning and extinction. The results from these contrasts were therefore indicative of a conditioning effect, but not of extinction. A significant increase in P2 amplitude response was demonstrated from baseline to conditioning for the CS+ in comparison to no significant change in response for the CS-, demonstrating acquisition of the conditioned response. Larger P2 mean amplitude was also observed towards fear-relevant stimuli in general. Thus it was assumed that the direction of response shift towards the CS+, as a result of the 100% contingency with the aversive US, was associated with a negative shift in stimulus affect/arousal.

It is particularly interesting that evidence of CR acquisition occurred on different components of the ERP response in Experiments 1 and 2. There is evidence to suggest that earlier components (P1 and N1) may represent responsiveness to stimulus affect, whereas ERP components around 200-300 ms (such as the P2 component) may represent arousal towards the stimulus (see Olofsson et al., 2008, for a review). Thus one might argue that the presentation of CR on these different components does actually indicate some difference in the responses being formed due to the different learning paradigms. Learning within the EC paradigm, in Experiment 1, could have been reflected in amplitude modulation of the N1 component because the learnt response towards the stimulus is

affective, whereas learning within the CC paradigm in Experiment 2 could have been observed at the later P2 component because the learnt response represents arousal due to anticipation of the startle noise US.

Perhaps it is not surprising that the type of event that is anticipated by, or associated with, the CS will affect the type of response produced: a motivationally relevant stimulus such as that used in the CC paradigm (Experiment 2) is likely to be anticipated in a different way to a visually affective stimulus, which may be grotesque but does not produce a physiological UR as such.

6.2.3 A comparison of extinction effects

Interesting as it is that the CR was demonstrated on a later component in Experiment 2 (the CC paradigm) than Experiment 1 (the EC paradigm), the main point of interest is whether these paradigms demonstrated differences in extinction.

In Experiment 1 contrasts demonstrated a significant contingency × phase interaction from baseline to conditioning, but not from conditionng to extinction, thus indicating differential acquisition of a CR but not extinction. Bonferroni corrected paired samples t-tests suggest maitainance of larger meanamplitude for the CS+ across all phases whereas mean amplitudes decreased for the CS-. This finding is concurrent with N1 amplitude modulation in the affective picture processing literature in which amplitude of response shows habituation towards neutral stimuli but is maintained for stimuli of negative-high arousing affect (Carretie et al., 2003). Thus this finding seems indicative of an affective CR, which is resistant to extinction.

In Experiment 2, although contrasts did not show a significant contingency × phase interaction between conditioning and extinction phases, on P2 mean amplitude, and this seemed indicative of resistance to extinction, Bonferroni corrected paired samples t-tests suggest otherwise. Decrease in response towards both the CS+ and CS-, from conditioning

to extinction, meant that no significant contingency × phase interaction was found between these phases; however the decrease in response for the CS+ neared significance. As the effect size for this decrease in response was almost as large as the effect size for the significant increase in response seen for the CS+ from baseline to conditioning, and the same size as the effect size found for the significant decrease in N1 mean amplitude for the CS- in Experiment 1, there is evidence of extinction for the CR using a CC paradigm. It ought to be noted that some of the significant effects discussed in this thesis resulted from post-hoc follow-up analyses of statistical trends. These statistical trends may reflect a limitation in statistical power due to the sample sizes employed in these studies. Power analyses were not conducted due to the complexity of the study designs, therefore, in all cases where the statistical significance of an effect was questionable, effect sizes were considered before a follow-up analysis was conducted. This approach seemed suitable, as effect sizes are not as susceptible to the influence of sample size in their interpretation as significance tests can be.

The observation of general resistance to extinction in EC (Experiment 1) not only corresponds with findings from the EC literature in which verbal and affective priming measures tend to show resistance to extinction of the CR (e.g. Baeyens et al., 1988; Baeyens et al., 1989; Diaz et al., 2005; & Field, 2006a), but it also provides a physiological account of resistance to extinction of the CR within the typical EC paradigm. Thus demonstrations of CR extinction using other physiological response measures from typical CC paradigm studies, (e.g. Blechert et al., 2008; Lipp et al., 2003; Vansteenwegen et al., 1998 & 2006) could arguably be the result of the type of paradigm used. Evidence for extinction using ERP as an online physiological measure of response in a CC paradigm, when resistance to extinction was clearly demonstrated in a comparable EC paradigm, supports the possibility that previous failures to find resistance to extinction with other physiological measures (e.g., SCR and startle response), may have been because these measures necessarily rely on using a CC paradigm. The indication that procedural differences, in the type of US employed by EC and CC paradigms, might be responsible for extinction effects previously found when using physiological measures of response

opposes the premise that the type of measure used (physiological vs. self-report) distinguishes between expectancy (signal) learning and affective learning. This finding also supports the suggestion of Blechert et al. (2008), that the failure to dissociate extinction effects between verbal measures of EC and CC, measured within a differential CC paradigm, might be the result of the CC paradigm employed. Both verbal measures of EC and CC could be associated with US-expectancies when measured within a CC paradigm (also see De Houwer et al., 2005).

However, other explanations for differential extinction effects observed across the two experiments include the possibility of qualitative differences in the type of CR acquired and, as mentioned earlier, that different components of the ERP response represent different forms of learning.

Evidence that subjective measures of fear attenuate faster through extinction training than subjective measures of disgust/dislike was provided in a differential EC paradigm by Olatunji, Forsyth and Cherian (2007). Such findings imply that more evaluative responses, such as disgust, are more resistant to extinction than subjective experience of fear and thus fit better with the conceptualisation of evaluative as opposed to signal learning (Baeyens et al., 1992). It is possible that by using unpleasant affective images as USs in Experiment 1 (EC), as opposed to the loud/affective noise employed in Experiment 2 (CC), the CR acquired in Experiment 1 may reflect a disgust response rather than a fear/anxious response. Based on Olatunji et al.'s (2007) findings this may provide an explanation for why resistance to extinction was observed, regardless of fear-relevance, in Experiment 1 but not in Experiment 2. Additionally the presentation of conditioning effects on different components of the ERP response may be a reflection of such qualitative differences in the CR acquired. The N1 mean amplitude index of the CR, in Experiment 1 (EC), could have been resistant to extinction because the learnt response towards the CS+ was affective. The extinction effect, as indexed by P2 mean amplitude in Experiment 2 (CC), may have been more prevalent because modulation of P2 mean amplitude represents arousal due to anticipation of the startle noise US. However, the resistant to extinction properties of

negative valence and disgust are not definite. Baeyens et al. (1989) predicted that, for spider phobia, exposure therapy alone was insufficient to reduce the affective valence and disgust properties of spiders and positive counter-conditioning might provide a constructive addition to exposure therapy to combat these negative evaluative responses. Based on such predictions De Jong, Vorage and Van den Hout (2000) measured the effects of exposure therapy and exposure including counter conditioning on measures of avoidance, fear of spiders and the disgust/negative evaluations of spiders. With no superior effects of the counter-conditioning, exposure therapy resulted not only in a decrease in avoidance and reported spider fear, but also reductions in reported disgust and negative evaluations.

Unfortunately our ability to base our conclusions solely on differences in the type of US employed across these paradigms is confounded by the CS-US context that was created in Experiment 1 but not Experiment 2. The context between the CSs (pills) and the USs (described as 'side effects' of medical trials involving the pills) may have created a boundary condition of 'belongingness', which promoted resistance to extinction in Experiment 1 (EC), whereas in it's absence (Experiment 2) extinction prevailed. Future studies would benefit by incorporating similar context within the CC paradigm to observe whether context promotes resistance to extinction across EC and CC paradigms.

In summary, the dissociation of extinction effects across EC and CC paradigms in Experiments 1 and 2 do support a procedural explanation for the resistance to extinction phenomenon. However, this finding does not entirely rule out the possibility that differential extinction effects could be the result of qualitatively distinct CRs that respond differently to extinction and may rely distinct underlying learning mechanisms; or due a stronger 'belongingness' created between CS and US strengthening their association.

6.3 Does phylogentic fear relevance support resistance to extinction in CC and EC?

Resistance to extinction of the physiological fear response (e.g. SCR) has been successfully demonstrated within CC paradigms in which the fear-relevance of the CS has been modulated (see McNally, 1987, for reviews; Öhman & Mineka, 2001). Such observations imply that resistance to extinction is not a unique factor of EC but also occurs in CC under conditions in which the CS is phylogenetically FR (as opposed to FI). Similar to the dual-process explanations for the resistance to extinction phenomenon in EC, resistance to extinction in CC towards phylogenetically FR CSs has been explained in terms of an *automatic* evolutionary fear-learning module which is impenetrable to cognitive control (Öhman & Mineka, 2001). However, evidence that phylogenetic fear-relevance not only results in resistance to extinction of the implicit physiological response (e.g., SCR) but also the cognitive aspect of US-expectancy, has led some to question whether resistance to extinction is the result of automatic processes, or rather the effect of an increased cognitive expectancy bias towards FR stimuli (Davey, 1992b, 1995). We predicted that, if EC represents a functionally different form of learning that does not rely on US-expectancy, resistance to extinction should occur regardless of increased US-expectancy modulated through phylogenetic fear-relevance of the CS (Experiment 1). Equally, if extinction effects are the result of expectancy learning, and fear-relevance promotes maintenance of US-expectancies through extinction, we predicted resistance to extinction for FR CSs over FI CSs in CC (Experiment 2).

6.3.1 US expectancy: fear-relevance effects on contingency awareness

In both Experiments 1 and 2, fear-relevance did seem to impact on US expectancy learning to some degree. In Experiment 1 the mean accuracy in prediction of the aversive US was significantly higher within the first 10 trials for FR than for FI CSs. In Experiment 2, a larger effect of fear-relevance was observed: during the first 10 trials participants were not significantly better than chance at predicting the aversive US, when the CS+ was FI. Though participants did not learn the CS-US contingency before the second 10 trials for the FI CS+, participants were contingency aware within the first 10 trials for the FR CS+. This effect of fear-relevance on contingency learning, along with overall higher accuracy scores in predicting the aversive US when the CS+ was FR, supports a preparedness account (Seligman, 1971; Öhman & Mineka, 2001) or cognitive bias account (Davey, 1995 & 1997) for contingency learning: higher expectation of aversive outcomes for FR CSs permit contingency awareness within the first 10 trials of conditioning.

6.3.2 Fear-relevance effects on ERP indices of the conditioned response

In spite of the contingency awareness data in Experiments 1 and 2 demonstrating faster US-expectancy learning for FR CSs, superior acquisition/resistance to extinction of the CR towards the FR CS+ was not apparent in ERP measures, as we might have expected due to theories of selective associations (Davey, 1997; Öhman & Mineka, 2001).

In both Experiments 1 and 2, significant main effects of fear-relevance were found for the mean amplitude of N1 and P2 component responses. These components indicated larger amplitude response towards the FR stimuli, as opposed to FI, and thus correspond with the affective picture processing literature which has largely demonstrated larger amplitude responses when images are unpleasant, as opposed to pleasant (see Olofsson et al., 2008, for a review). This effect also gives strong support for the notion that early/mid latency amplitude modulation is linked to the processing of affect and arousal

properties of visual stimuli (Olofsson et al., 2008) and that unpleasant stimulus valence demands greater attention early during information processing. In Experiment 1, there was also an increase in the P2 mean amplitude response to FR stimuli from baseline phase to conditioning. This increase in response amplitude towards FR stimuli during conditioning probably represents an increase in attention directed towards such stimuli when aversive outcomes are incorporated into the experimental procedure. However, this effect was not dependant on contingency; therefore, it seems to indicate a generalised increase in attention towards FR stimuli as a result of aversive US introduction, as opposed to a specific increase in attention towards the FR CS+ as a result of this FR stimulus predicting the aversive US.

Though CRs towards phylogenetically FR stimuli have demonstrated resistance to extinction in differential conditioning studies using physiological measures, such as SCR and startle response (e.g., Fredrikson & Öhman, 1979; Lipp & Edwards, 2002; Öhman et al., 1975; Öhman et al., 1976), extinction effects on ERP indices of CR in both Experiments 1 and 2, were not influenced by the CS fear-relevance. Modulation of N1 mean amplitude in Experiment 1 (EC) indicated the acquisition of a CR. However, there was no significant change in N1 mean amplitude towards the CS+ between conditioning and extinction phases, indicating resistance to extinction. On the other hand, modulation of P2 mean amplitude in Experiment 2 (CC) indicated the acquisition of a CR, but extinction of the CR was indexed by a decrease in mean amplitude of P2 response towards the CS+ at extinction. These extinctions effects were not mediated by CS fear-relevance.

Lack of fear-relevancy effects on resistance to extinction in the EC paradigm (Experiment 1) might be due to a functional difference in the type of response learnt under these conditions. If EC does indeed represent a functionally distinct form of learning to CC, which is less reliant on US-expectancy, perhaps it is not surprising that resistance to extinction was not exclusive to fear-relevant stimuli. This point is particularly salient because Experiment 1 made use of a typical EC picture-picture paradigm similar to those

used in EC studies where resistance to extinction has been observed for FI stimuli before (e.g., Diaz et al., 2005; Field, 2006a).

However the lack of extinction effects in Experiment 2 are less easy to explain considering the CC paradigm employed. Öhman and colleagues consistently demonstrated superior conditioning and resistance to extinction with SCR when using images of FR animals such as snakes and spiders, as opposed to FI images of stimuli such as flowers and mushrooms, in a differential CC paradigm (e.g. Fredrikson et al., 1975; Öhman et al., 1975; Öhman et al., 1976; see McNally, 1987, and Öhman & Mineka, 2001 for reviews). Experiments 1 and 2 employed degraded FR images of a snake and a spider and FI images of a rabbit and a squirrel. The degraded nature of the animal images employed could explain the lack of fear-relevancy effects on the acquisition and extinction of CRs. To ensure that the stimuli were neutral in affect before conditioning, animal outlines in the forms of imprints on white pills were used as opposed to vivid animal images. Although fear-relevance did have a general impact on measures of ERP response, perhaps the difference between FR and FI images was not strong enough to impact on the CR.

Another explanation for the lack of fear-relevancy effects on the acquisition and extinction of CRs could be the extreme number of acquisition and extinction trials implemented to calculate a clear average ERP response. Evidence from human laboratory studies has shown that the acquisition of a CR can occur faster (within less trials) and will take longer (more trials) to extinguish for FR CSs (e.g. Fredrikson, Hugdahl & Öhman, 1976; Fredrikson & Öhman, 1979; Öhman et al., 1975; Öhman et al., 1976). However, these studies typically employ 5-8 trials of conditioning and 8-10 trials of extinction, whereas Experiments 1 and 2 employed 100 trials of each experimental phase. If the distinction between FR and FI stimuli largely depends on the speed/number of trials it takes for extinction of the CR to occur, then it is not surprising that fear-relevance did not moderate extinction: within 100 trials of extinction training the CR would surely have time to extinguish regardless of fear-relevance.

6.4 Does verbal threat information interact with aversive conditioning to promote acquisition and maintenance of the CR?

In Experiment 3 (Chapter 4) we investigated the cognitive bias account (Davey, 1995, 1997; Field & Davey, 2001) for selective associations, by implementing verbal threat information as a manipulation of fear-relevance for affectively neutral/novel animal CSs (see appendices 4A & 4B). As verbal-threat information has before been demonstrated as a direct pathway to fear in human laboratory studies (Muris & Field, 2010) we investigated the existence of both a direct pathway to fear through verbal information and its interaction with direct conditioning experience to heighten the fear response on both a cognitive (fear beliefs and US-expectancies) and physiological level (heightened modulation of ERP response). In particular, if resistance to extinction was observed exclusively towards the FR CS+, this would provide evidence for a cognitive explanation of selective associations (Davey, 1997; Field & Davey, 2001) over evolutionary selection pressures (Öhman & Mineka, 2001; Seligman, 1971).

6.4.1 A cognitive bias explanation for increased aversive outcome expectancy

Similar to phylogenetic fear-relevance (Experiments 1 and 2), threat information also resulted in faster learning of the contingency between the CS+ and aversive US, thus supporting Davey's (1995) expectancy bias model; increased expectancy bias, generally found for phylogenetic FR stimuli (e.g. Davey, 1992a; Davey & Craigie, 1997; Davey & Dixon, 1996; Honeybourne, et al., 1993), may equally result from prior fear originating in verbally and culturally transmitted information, as from selective processes (Davey, 1995; 1997; Field & Davey, 2001).

6.4.2 Increased fear beliefs may be learned through information alone

Experiment 3 also demonstrated that not only could fear beliefs, towards fear irrelevant novel animals, be inflated in adults through aversive conditioning, they could also be inflated by negative verbal information alone. This finding supports the view that verbally/culturally transmitted information regarding a CS is important in the development of prior fear beliefs towards a particular stimulus and that such fear beliefs do not need to be explained in terms of genetic transmission (Davey, 1995; 1997; Field et al., 2001).

These findings replicated previous effects of verbal threat information in increasing fear-beliefs in children (e.g. Field, et al., 2001; Field & Lawson, 2003; Field & Storksen-Coulson, 2007; Field, et al., 2008). However, the current results did not support an interaction between information and fear conditioning, as predicted in Davey's (1997) conditioning model. Rather than this interaction between conditioning and expectancies resulting in increased fear beliefs towards the CS+, fear beliefs *decreased* towards the CS-. Verbal threat information alone served to heighten fear beliefs, without the need for a direct conditioning experience, supporting the premise that information alone can act as an US (Field, 2006) and additionally supporting the propositional account of associative learning (De Houwer, 2009; Mitchell et al., 2009). Yet aversive conditioning served to maintain fear beliefs learnt through information. It ought to be noted that a ceiling effect in fear beliefs, measured post-information, may have restricted our ability to detect further increase in fear beliefs post conditioning.

6.4.3 Resistance to extinction of fear beliefs

Contrary to predictions of the expectancy model of selective associations, fear beliefs towards the CS+ remained resistant to extinction for *both* FR and FI conditions when measured post-extinction phase (Experiment 3). However, this resistance to extinction effect may be the result of having measured responses with self-report and post-hoc. Studies by Blechert et al. (2008) and Vansteenwegen et al. (2006) demonstrated that when physiological measures, such as SCR or startle response, are used to measure the CR, extinction of the response is generally found, whereas post-hoc self-report and affective priming measures generally show resistance to extinction of the CR. It is plausible that these measures tap different learning processes: physiological measures tap affective learning and self-report measures tap associative learning. However, as discussed previously, Lipp, et al. (2003) and Lipp & Purkis (2006) explain that differences in resistance to extinction, observed by these different indices, may be an artifact of the time of measurement. Lipp and colleagues suggest that post-hoc indices of resistance to extinction might represent an average contingency judgment 'calculated' from all contingency experiences, throughout the experimental procedure, rather than the latest contingency judgment between stimuli. Therefore, the resistance to extinction found for fear beliefs in Experiment 3, for both FR and FI stimuli may simply represent an averaged contingency judgment in the participants' evaluation of subjective fear.

6.4.4 ERP indices of response modulation through verbal information and conditioning

As discussed earlier, superior resistance to extinction has frequently been demonstrated for phylogenetically FR stimuli, as opposed to ontogenetic FR stimuli or FI controls, when using physiological measures of response (see McNally, 1987 and Öhman & Mineka, 2001 for reviews). Experiment 3 investigated whether ERP indices would reveal resistance to extinction of CR when FR was manipulated by verbal threat information. Additionally,

because Field & Storksen-Coulson (2007) demonstrated magnified avoidance behaviour when negative experience and information were combined, Experiment 3 investigated whether a similar interaction effect would be demonstrable from an indirect physiological measure such as ERP.

Unlike Experiments 1 and 2, modulations of mean amplitude response across ERP components, as an index of CR, were mostly inconclusive. Differences in modulations of the ERP response between Experiments 1 and 2 and Experiments 3 and 4 could be related to the different CSs used. Experiments 1 and 2 used simple outline images of animals on white circular pills, whereas Experiments 3 and 4 used vivid monochrome images of FI animals.

However, verbal threat information demonstrated modulation of P1 peak latency in the right hemisphere during conditioning with earlier peak latency in response towards FR stimuli. This effect may reflect a dissociation in the CR, based on stimulus affect, which resulted from the threat information manipulation. This effect was not mediated by contingency with the aversive US. Additionally, a contingency modulation of P2 peak latency in the left hemisphere demonstrated earlier peak latency towards the CS+. This effect might represent a left hemisphere specialisation in increased attentional/arousal response resulting from aversive conditioning, which was resistant to extinction training, irrespective of threat information (no further interaction with phase or threat information was observed).

Furthermore, a multilevel regression analysis on epoched ERP peak latency scores revealed a significant interaction between contingency × information × phase on P2 peak latency. Similar early P2 response between the FR CS+, FR CS- and FI CS+ suggest heightened arousal/attention towards these stimuli as a result of aversive conditioning (FI CS+) and threat information (FR CS+ and FR CS-). However, like the self-report index of fear beliefs (FBQ scores) a superior response towards the FR CS+ was not demonstrated by P2 peak latency, as a result of the interaction between threat information and aversive conditioning.

Thus we found evidence for both information and aversive conditioning as pathways to fear in the cognitive and physiological domains. However, little support was observed for an interaction between these pathways that results in superior acquisition/resistance to extinction of CR.

6.4.5 Analysis of epoched ERP response across conditioning and extinction phases

Limitations of the ERP study design, as discussed previously, include the possibility that the large number of trials, averaged across to calculate a 'clear' ERP response, might mask differential rates of CR acquisition and extinction based on fear relevance manipulations. If threat information did increase the rate of acquisition, or slow extinction of the CR, these effects might well be diluted when averaging across so many trials. In an attempt to resolve the limitation posed by averaging across so many trials, an alternative analysis of the ERP data was attempted to track across-phase changes in ERP response.

In Experiments 3 and 4 ERP response was 'epoched' into 5 EEG trial averages, across each phase. This enabled us to keep our data processing techniques similar to our standard overall-trial ERP analysis, for reasons of cross-analysis comparisons, but brought us closer to newer techniques for analyzing across-trial variability (Blankertz et al., 2010; Hu et al., 2010). This analysis was implemented to enable us to track differences in longitudinal change of ERP response, based on the information manipulation, across the conditioning and extinction phases. Averaging across 5 EEG trials and across 9 posterior electrode sites, for each hemisphere response, enabled some improvement in the SNR without employing further feature extraction techniques to isolate the ERP signal (as used in single-trial ERP analyses). However, as the SNR was still low, in comparison to the ERP response acquired by averaging across all the trials in each experimental phase, across-phase differences might have been obscured by variance in the data.

Many effects from the overall-trial ERP analyses were replicated by the 5-trial epoched ERP analysis, in both Experiments 3 and 4; however the epoched data also produced some additional effects, which were not observed in the overall-trial analyses, such as the 3-way interaction between contingency, information and phase, on peak latency of the P2 component (described above). However, little effect of the epoch variable was found across experiments. In particular, we were interested to see whether a 4-way interaction between contingency, information, phase and epoch would be significant in Experiment 3, because this would provide evidence of differential rates of conditioning and extinction when threat-information was provided. This interaction was not significant. This either indicates similar modulation of ERP component latency/amplitudes, between the CS+ and CS-, across conditioning and extinction phases, irrespective of verbal information manipulations, or systematic changes across phase epochs were undetectable due to the low SNR provided by the 5-trial average ERP measures.

Due to the low SNR provided by the 5-trial average ERPs, it is not surprising that main effects of epoch, and most interactions between epoch and other variables, were not significant. Thus, in future across-trial analysis strategies it may well be worth attempting some of the feature extraction methods described by Blankertz et al. (2010).

6.4.6 Summary

Experiment 3 supported the idea that verbally transmitted information alone can influence fear beliefs and create an aversive US expectancy bias, which allows for faster learning of the CS-US contingency, as indexed by US-prediction scores. These results reflect the 'expectancy evaluations' premise of Davey's (1997) conditioning model of phobias, and provide a cognitive explanation for prior fear which is deemed important in maintaining an expectancy bias and thus selective associations (Diamond et al., 1995; Tomarken et al., 1989). Additionally, the ability to manipulate fear beliefs through information supports the idea that verbal information is a direct pathway to fear

(Rachman, 1977). Thus we found evidence for both information and aversive conditioning as pathways to fear in the cognitive domains. In the physiological domain, modulation of ERP peak latency indicated both effects of information and aversive conditioning in speeding attentive response. However, little support was found for an interaction between these pathways that results in superior acquisition/resistance to extinction of CR, as would be predicted based on expectancy bias models of selective associations (Davey, 1992b, 1995, 1997). If such an interaction were to effect rates of acquisition/extinction, the lack of evidence here may result from our analysis strategy (5-trial epochs of ERP response) being insensitive to systematic variance in the ERP response across-phase.

6.5 Can a CR, acquired through direct aversive conditioning, be extinguished through positive verbal information and its combination with extinction training?

Although research that investigates pathways to fear acquisition is important for understanding anxiety prevention strategies, research investigating which pathways successfully reduce fear, and what components of the fear response are reduced, is equally important in understanding modes of intervention (Davis & Ollendick, 2005).

Behavioural treatments for anxiety disorders are largely based on learning theory, with the extinction process in CC studies offering a 'mini-model' of exposure therapy (Zinbarg, 1993). Therefore, research that investigates the mechanisms underlying extinction in CC can offer further understanding of the mechanisms that underlie exposure therapy. The scientific basis of exposure therapy is praised as one of it's strengths, whereas early cognitive therapies have been criticised for focusing on therapy targets (e.g., negative images and thought patterns) rather than therapy procedures based on an experimental background (Clark, 2004). Clark (2004) stresses the need for research that constructs a theoretical account of maintaining factors in anxiety disorders; tests these factors empirically; develops and tests the efficacy of treatments designed to reverse these maintenance factors. The success of this research strategy, in the development of effective cognitive therapy (CT) programmes, is evident from studies which have shown superior efficacy of the CT programmes in comparison to longer established behavioural and pharmacological treatments (Clark et al., 2006; Clark et al., 2003).

Thus Experiment 4 (Chapter 5) investigated whether positive verbal information, implemented post-conditioning/pre-extinction, would have an equal or superior effect to extinction training alone in reducing the CR, on both cognitive (FBQ scores) and physiological (ERP response) measures. Such an effect would have practical implications regarding the role of cognitive factors in anxiety reduction and also provide support for the role of propositional reasoning in the reduction of a learnt response.

6.5.1 Verbal positive information extinguishes fear beliefs learnt through aversive conditioning

Evidence that positive verbal-information can reduce fear, acquired through direct aversive conditioning, was demonstrated in Experiment 4 for the self-report index of fear beliefs (FBQ scores). An early extinction effect was observed through positive verbal information alone, and also demonstrated a larger effect in reducing fear-beliefs than extinction training alone. Thus explicit verbal information seems more efficient than extinction training in reducing the cognitive component of the fear response.

The observed effect of verbal positive information in reducing fear beliefs, acquired through direct aversive conditioning, is consistent with Kelly et al. (2010) who demonstrated the same effect in children, when fear beliefs were acquired through verbal threat information. This consistency supports the role of information as an intervention strategy that may be successful in reducing fear cognitions, irrespective of whether acquisition occurred through instructional learning or direct experience. However it is important to mind that the fear beliefs acquired under such an experimental procedure, using non-anxious participants may be very different to the fear-beliefs held by clinically anxious individuals, and so the efficacy of verbal information over extinction based interventions in a clinical setting is still questionable.

Additionally, the impact of information on associative learning raises the issue of whether the underlying processes driving acquisition and extinction of fear can be explained in terms of propositional learning (De Houwer, 2009; Mitchell et al., 2009). Mitchell et al. (2009) suggest that if rules or instructions can help/hinder fear learning then learning must be based on reasoning processes, as opposed to simply the formation of an associative link. Therefore the effect of verbal information on a previously learnt CS-US association supports the idea that this learnt association is based on propositional knowledge.

However, explicit measures of affective response, such as fear beliefs, can be affected by demand awareness. Thus we cannot be sure that the FBQ scores recorded reflect genuine changes in affective response towards the stimuli, let alone represent associative or propositional learning.

6.5.2 Effects of information and extinction training on ERP indices of response.

Aside from the effect of verbal positive information on fear beliefs, Experiment 4 aimed to investigate whether positive information would influence implicit, physiological measures of response. Kelly et al., (2010) provides evidence for the efficacy of information in reducing a behavioural avoidance response, in addition to decreasing fear beliefs. If it were possible to additionally demonstrate a change in physiological response, towards a CS that has been associated with an aversive outcome, this would demonstrate that information could be a useful mode of intervention for the third response system (physiological) proposed by Lang (1968, 1977).

As in Experiment 3, verbal information modulated peak latency of the P1 component in the right hemisphere, across phase. However, in Experiment 4 verbal positive information (post-conditioning) had a reverse effect to threat information (pre-conditioning) on differential P1 peak latency across phase, in the right hemisphere. Whereas P1 peak latency was faster in the right hemisphere when no information was provided, when verbal positive information was provided P1 peak latency was later (equivalent to left hemisphere) in response to the CSs. This finding supports an attentional bias in the right hemisphere towards stimuli, which might be considered ambiguous/threatening, during extinction. Whereas threatening information, in Experiment 3, seemed to pre-empt the early right hemisphere response during conditioning, verbal positive information seemed to eradicate it in Experiment 4. This result lends support towards the efficacy of verbal positive information in reducing a possible attentional bias; however, there was no

interaction with CS-US contingency that would indicate that such an attentional right hemisphere bias is the result of aversive conditioning. Indeed, earlier P1, N1, and P2 peak latencies were observed towards the CS+ during extinction, in comparison to the CS-, indicating a bilateral effect of differential conditioning that may be resistant to extinction, irrespective of verbal positive information.

However, a 3-way interaction between contingency, verbal positive information and phase showed significant modulation of P1 mean amplitude. Differential increase in mean amplitude response was observed between the CS+ and CS-, from conditioning to extinction, as a function of whether verbal positive information was provided. Response significantly increased at extinction towards the CS+ when it was consequently paired with verbal positive information. Equally a significant increase in P1 mean amplitude response was observed towards the CS- when no positive information was provided. This interaction between information and contingency on change in response does not exactly match the effect, which was hypothesised for ERP response at extinction: that amplitude of the ERP response would lessen as an effect of positive verbal information and extinction training reducing the strength of the aversive association and thus attention/arousal towards the CS+.

Whereas other experiments within this thesis (Experiments 1 and 2 specifically) demonstrated acquisition of a CR either through maintained or increased mean amplitude response, extinction of a CR was indicated through a decrease in mean amplitude response at extinction in Experiment 2. Therefore, we hypothesised that verbal positive information would decrease mean amplitude response towards the CS+ if information is a viable mode of intervention for the physiological fear response. However, as noted in previous discussions, an increase in ERP response does not necessarily represent an increase in negative affect. It is possible that, after verbal positive information, the increase in ERP response observed for the CS+ may reflect an increase in positive affect, as represented in the FBQ scores, post-information. The increase in ERP response might also represent some underlying driving force responsible for the decreased avoidance

behaviour in children, post-positive information, demonstrated by Kelly et al., (2010). However, this explanation is uncertain based on the smaller mean amplitude response observed for the CS- which was also paired with positive verbal information, pre-extinction phase. If the increased response was indeed associated with an increase in positive affect we would expect to see increased mean amplitude response for both the CS+ and CS-, paired with positive verbal information, during extinction. This was not the case.

Alternatively, the similar increase in P1 mean amplitude response at extinction, between the CS+ in the verbal positive information condition and the CS- in the no information condition, could be explained by increased attention initiated by a 'mismatch' in the information (contingency experience and verbal) regarding each stimulus. In other words participants might focus their attention on the CS+ that is consequently described in a positive manner due to the conflicting information provided through experience (contingent aversive outcome) and positive verbal information. This combination of information may make the CS+ ambiguous in nature and thus demand greater attention. Likewise the CS-, which did not predict the aversive outcome (the CS- was 50% contingent with the aversive US), remains ambiguous if it is not described with positive information post-conditioning.

6.5.3 Summary

Experiment 4 provides evidence that positive verbal-information is more efficient than extinction training in reducing the cognitive component of the fear response within an artificial experimental setting. This finding also supports that conditioned responding is based on propositional reasoning processes (De Houwer, 2009; Mitchell et al., 2009).

However, ERP indices of CR did not provide a clear demonstration of CR reduction through positive verbal information. These ERP findings do not refute the hypothesis that verbal positive information is an effective mode of intervention for the physiological component

of the fear response. Based on the extinction effect observed in Experiment 2, these ERP results do suggest that verbal information may influence fear reduction in a different manner to extinction training alone. To further understand the effect of verbal positive information, on the physiological response system, future studies would benefit from comparing ERP response to an online measure of SCR, commonly used to investigate extinction. Comparison with SCR would enable the investigation of whether the increase in ERP response towards the CS+ during extinction is common across physiological measures. If SCR decreased, as is common during extinction training, this would support the proposition that information impacts upon the physiological response system in a similar manner to its impact on fear beliefs and behavioural avoidance (Kelly et al., 2010). A difference in pattern of results between these physiological measures would also imply that the ERP response represents something other than US-expectancy/arousal: perhaps, after all, an increase in positive affect.

6.6 Potential implications of this research and future directions

6.6.1 Theoretical implications

The research in this thesis has contributed to our understanding of differences between EC and CC, with regards to extinction processes, on a procedural level. Previous studies, which have reported differential extinction effects for physiological measures of expectancy learning (e.g., SCR) and measures of affective learning (e.g. explicit self-report measures and the implicit affective priming measure) may have found online extinction of the physiological response (SCR) due to the differential CC paradigm employed (Blechert et al., 2008; Lipp et al., 2003; Vansteenwegen et al., 1998; Vansteenwegen et al., 2006). The results reported in Experiments 1 and 2 of this thesis demonstrate that procedural differences between EC and CC paradigms contribute to extinction effects of the physiological CR, indexed by ERP measures. However, the differences found between these paradigms do not refute the idea that EC and CC might differ on a process level. Indeed the combination of observations that CR extinguishes in CC, but not in EC, and that the CR demonstrates on different components of the ERP response (EC: N1 mean amplitude, CC: P2 mean amplitude) imply that different components of the ERP response might be associated with different learning mechanisms, which underlie EC and CC. It is also not implausible that the N1 response is associated with changes in stimulus valence, whereas the P2 response may be associated with changes in stimulus arousal in anticipation of the aversive US, as these components have differentially been associated with valence and arousal factors of stimulus affect within the affective picture processing literature (Olofsson et al., 2008). Thus these findings comply with the premise that EC and CC differ procedurally, in terms of extinction, and potentially that EC represents a distinct form of learning to CC at the process level too (De Houwer et al., 2005).

A practical implication also arises from these findings. If EC does indeed represent a form of learnt response which is resistant to extinction this would indicate that exposure therapy may be limited in its efficacy in diminishing all aspects of the learnt fear response

in anxiety disorders. As suggested by Hermans et al. (2002), the implication of differential extinction rates for EC and CC is that exposure therapy might reduce expectancy of the aversive outcome, and thus arousal towards the CS, but the affective value of the CS may remain and act as a potential source for relapse after exposure therapy.

The finding that phylogenetic fear-relevance of the CSs did not impact on acquisition or extinction of the conditioned ERP response, in both Experiments 1 and 2, may have resulted from a limitation in the experimental design. As discussed earlier, the large number of trials, which were averaged across to achieve a clear ERP response, may have concealed differences in rates of acquisition/extinction between the FR and FI stimuli. However, the observation that larger amplitude of the N1 component was resistant to extinction in the EC paradigm (Experiment 1), regardless of CS fear-relevance, implies a learnt response that is less reliant on increased US-expectancies associated with the FR CS+. Future research could implement single trial/epoched trial analyses (as reported in Experiments 3 and 4) to asses whether conditioned ERP response differs systematically across conditioning and extinction phases, as a function of the CS fear-relevance. This analysis would enable us to distinguish whether the lack of a fear-relevance impact on the CR in the overall-trial ERP analysis was based on differences in the susceptibility of EC and CC to fear-relevance effects or whether differential rates of acquisition/extinction were concealed by averaging across all trials within experimental phase.

6.6.2 Practical Implications

The research within this thesis also contributes to our understanding of pathways to and from fear and their importance for potential anxiety prevention and intervention strategies. However, as we did not explore the generalisabilty of fear responses towards other stimuli within this thesis, conclusions are limited to treatments and interventions of discreet fears, such as phobias and perhaps social phobia, as opposed to some of the more generalised anxiety disorders, such as general anxiety disorder (GAD) or obsessive compulsive disorder (OCD).

If fear can be acquired through simply observing the fear of others (Askew & Field, 2008) or through threat information about particular stimuli/situations (Muris & Field, 2010), then there is potential for prevention of unnecessary fear acquisition through controlled verbal information and modelling, especially in the parent-child context. Observations of heightened fear beliefs and modulations of ERP peak latencies in Experiment 3 (Chapter 4) support the role of verbal threat information and direct aversive conditioning as independent pathways to fear in both the cognitive and physiological domain. Thus, although it may be difficult to avoid the acquisition of fear through direct traumatic experience, by reducing the amount of negative/threat information provided to children about particular stimuli/situations, parents may be able to reduce the number of aversive learning experiences their child encounters and potentially prevent specific phobias from developing (Field, 2006c).

Additionally, Experiment 3 supported the idea that verbally transmitted information alone can create an aversive US expectancy bias, which allows for faster learning of the CS-US contingency, as indexed by US-prediction scores. These results reflect the 'expectancy evaluations' premise of Davey's (1997) conditioning model of phobias (also see Field & Davey, 2001), and provide a cognitive explanation for prior fear which is deemed important in maintaining an expectancy bias and thus selective associations (Diamond et al., 1995; Tomarken et al., 1989). Support for a cognitive expectancy bias model implies that selective associations may not be solely dependant on evolutionarily based

predispositions to fear certain stimuli (Öhman & Mineka, 2001) and specific aversive associations could again be prevented by limiting verbal threat information. However, little support was found for an interaction between threat information and direct aversive conditioning resulting in superior acquisition/resistance to extinction of the CR. If such an interaction were to effect rates of acquisition/extinction, the lack of evidence here may result from our across-phase analysis strategy (5-trial epochs of ERP response) being insensitive to systematic variance in the ERP response across-phase.

To further explore differential rates of acquisition/extinction across experimental phase, as a function of threat information, alternative across-trial analysis strategies of the ERP response could be implemented. These might include some of the feature extraction methods described by Blankertz et al. (2010), such as temporal and spatial filters, to distinguish the signals of interest (ERP signals) from the interfering noise.

An additional implication of the premise that verbally/culturally shared information can heighten outcome expectancies, and consequently maintain the CR (Davey, 1997; Field, 2006c), is that positive expectancies (e.g., those induced by positive verbal information) should inhibit the CS-US association formed during a direct aversive conditioning experience. A potential investigation of the impact of positive verbal information, implemented *prior* to aversive conditioning, would enable assessment of the role of information in preventing acquisition of the CR in the first place. This would have positive implications for the role of verbal information in the prevention of specific fear acquisition.

Experiment 4 did investigate the impact of positive verbal information on the CR but information was provided after conditioning. As such, Experiment 4 explored whether the CR, acquired through aversive conditioning, could be reduced equally through positive verbal information (as an intervention strategy), as through extinction training, and whether both cognitive (FBQ scores) and physiological (ERP response) indices of the learnt response would be reduced. Similar to Experiment 3, fear beliefs (FBQ scores) were heightened through aversive conditioning, and maintained through extinction training

(evidently resistant to extinction). However, when verbal positive information was implemented post-conditioning, fear beliefs were significantly reduced pre-extinction. This early extinction effect, resulting from positive verbal information, was sustained post-extinction training but not enhanced.

The efficacy of verbal information alone in reducing fear beliefs mirrors findings by Kelly et al. (2010) who demonstrated superior reduction in fear beliefs and avoidance behaviour through verbal information when the CR was acquired through verbal threat information. Additionally the findings of reduced fear beliefs in Experiment 4 imply superior efficacy of verbal information over direct contingency experience (extinction training) in the reduction of fears learnt through direct experience. Thus verbal information seems a more efficient mode of intervention, for the cognitive component of the fear response, irrespective of the pathway through which the fear-response was acquired. This finding highlights the importance of positive verbal information in counteracting associations formed through direct negative experience, and also supports the propositional explanation of associative fear learning (De Houwer, 2009; Mitchell, et al., 2009), which implies that reasoning processes are involved in the reduction of the fear response. Therefore the importance of cognitive intervention strategies, in reducing cognitive aspects of the fear response (such as fear beliefs), is stressed over extinction based exposure therapies for the treatment of specific phobias.

Although there was some evidence that positive verbal information modulates peak latency and amplitude of ERP response, ERP indices of CR did not provide a clear demonstration of CR reduction through positive verbal information. A similar increase at extinction in P1 mean amplitude, observed for the CS+/positive information and CS-/no information, could either signify an increase in positive affect (evident of a reduced CR), or increased attention due to conflicting contingency and verbal information. Based on the extinction effect observed in Experiment 2, in which P2 mean amplitude reduced during extinction, these ERP results do suggest that verbal information may influence fear reduction in a different manner to extinction training alone. Further investigation of ERP

response modulation is needed to further understand the effect of verbal positive information, on the physiological response system. Future studies would benefit from comparing ERP response to an online measure of SCR, commonly used to investigate extinction in differential conditioning studies.

Comparison of ERP and SCR indices would enable investigation of whether the increase in response towards the CS+ during extinction, is common across physiological measures after positive verbal information. If SCR decreased towards the CS+ during extinction training, this would support extinction of the CR and imply that information impacts upon the physiological response system in a similar manner to its impact on fear beliefs and behavioural avoidance (Kelly et al., 2010). A disparity in the pattern of results between ERP (increased response) and SCR (decreased response) would also imply that the ERP response represents something other than US-expectancy/arousal: perhaps the increased P1 mean amplitude modulation does indeed represent an increase in positive affect.

6.8 Final conclusion

This thesis explored some of the key factors and circumstances believed to promote resistance to extinction in human fear learning. Using ERP as an implicit physiological measure of affective response, the studies within this thesis explored the effects of extinction across different procedural paradigms (EC vs. CC) and the impact on fear-relevance manipulations (phylogenetic vs. verbal information) on the demonstration of extinction. To summarise, the research presented in this thesis supported ERP as a viable measure of CR, and demonstrated a procedural distinction between EC and CC, in which resistance to extinction in the physiological domain is more prevalent within the visual EC paradigm than the CC paradigm. However, ambiguity regarding underlying mechanisms, which stimulate activity on the various components of the ERP response, is still an issue for the interpretation of ERP modulations. Differences in extinction effects were observed, not only between paradigms, but also between components of the ERP response, which might also imply a possible distinction between EC and CC at the process level.

Additionally support for fear acquisition, in both the cognitive and physiological domain, is supported equally through verbal threat information as through direct experience of CS-US contingency, and support is provided for the reduction of the CR through positive verbal information. These findings support the role of propositional reasoning in the acquisition and extinction of aversive associations and provide a conditioning framework for explaining the verbal information pathway to and from fear. Furthermore, these results highlight the importance of verbal information in the prevention of fear and potentially for intervention strategies in treating specific phobias. Lack of support for an interaction between fear-relevancy effects and direct conditioning experience is explained in terms of limitations in the standard ERP methodology, when averaging across large numbers of trials. However piloting an alternative across-phase analysis, with epoched ERP response, provided initial support for the prospect of tracking variance in the ERP response across experimental phase. Although no significant interactions with epoch were demonstrated for effects of contingency and fear-relevance manipulations, further

developments in ERP feature extraction for such across-trial analyses are suggested, which could reveal differences in rates of acquisition and extinction of the CR depending on CS fear-relevance.

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Appendices

Appendix 2A: Conditioned stimuli employed within Experiments 1 (Chapter 2) and 2 (Chapter 3).

Fear relevant (FR) 'Snake' Conditioned Stimulus (CS):

Fear relevant (FR) 'Spider' Conditioned Stimulus (CS):

Fear irrelevant (FI) 'Rabbit' Conditioned Stimulus (CS):

Fear irrelevant (FI) 'squirrel' Conditioned Stimulus (CS):

Appendix 4A: Neutral/fear-irrelevant conditioned stimuli employed within Experiments 3 (Chapter 4) and 4 (Chapter 5).

'Cuscus'

'Pizote'

'Quokka'

'Quoll'

Appendix 4B: Threat information about animals for fear-relevance manipulation

(Script recorded as audio file and played through headphones to participants)

News reader:

"This is a news bulletin:

Please pay close attention to the images of these two animals on the screen in front of you.

These animals are known carriers of the fatal rabies disease!

Both are native to Indonesia, Papua New Guinea and Australia, but specimens are known to be here in the UK, and in the US, brought over through illegal pet trade: A black market which is continually increasing risk to our native species, and ourselves, by spreading disease.

Both animals are of similar size and weight with head and body lengths of around 30 inches and weight of around 30 pounds. That is roughly the size of a large domestic cat or small dog.

Now although these animals are not particularly large they are know to be very aggressive and fearless towards humans. And as they carry the rabies virus we cannot stress enough how important it is that you keep an eye out for them and avoid them at all costs.

Rabies is a <u>severe</u> viral disease which affects the central nervous system and is transmitted through the saliva of the infected animal if you are bitten.

The virus causes convulsions, untypical and unpredictable/erratic behaviour, as well paralysis of the throat causing foaming saliva at the mouth.

As of yet the treatments known for the disease are not 100% reliable and symptoms should be taken seriously as the disease <u>is </u>fatal!

Due to the aggressive natures of these animals, and their unpredictable behaviour from the virus, it is important to take measures to avoid encounters with either animal. Both are nocturnal and normally roam through deciduous forests, open woods and farmland, attacking and devouring birds and small mammals. However rabies does make animals

unpredictable and there <u>have</u> been sightings <u>and</u> attacks on people in urban areas. Also, although you are most likely to find them at night, they can be equally aggressive if disturbed during the day, and are known to jump and repeatedly bite, often attacking the face and neck.

To avoid them, at best you can try to avoid walking in areas of shrub or woodland, especially at night, and do not disturb the bushes and trees where either animal might rest during the day. Also they have been known to hide in garages and sheds so be precautious and avoid spaces, which are often left undisturbed.

We have two accounts of attacks from these animals, although due to some complications with recording the information it is not known which attack was by which animal……"

Friend of attack victim 1:

" My friend's a mother of two, with no real past medical history.

Last year in the backyard of her home she was attacked while hanging out laundry on the clothes line.

The attack was completely unprovoked and the animal came from no-where: biting her three times on her right hand and arm and scratching her whilst she struggled with it. Her husband was home luckily and he ran outdoors to help her when he saw the animal attacking her. He choked and stabbed it to death.

Although he was not bitten he had scratches on his arms and legs too and both called emergency services and were brought to accident and emergency for treatment.

I think the animal was sent to the Department of Health for testing, and it definitely showed positive for rabies.

My friend had several deep puncture wounds on her right hand and arm from the things teeth, and even though her husband only had scratches, they were both treated.

I remember we were all so worried for them both, but luckily they recovered well.

Attack victim 2, first person account:

" It was Monday night and my fiancée and me were walking up the steps to our flat on the second floor, when I saw the animal. It was not even five feet away and it ran at me. Unfortunately as I was a couple of steps below it didn't really have far to go I guess, but it went straight for my face! I struggled to get it off me, and started kicking it to get it to go away. I thought it was a cat or a dog or something at first but soon realised it wasn't. Apparently they're native to Indonesia and have been brought over through illegal pet trade.

Anyway I was bitten on the left shoulder and had scratches on my neck and face! I've never come across something so vicious! My main thought was to get Sarah into the flat safe. We slammed the door and could still see the animal trying to get in so we called emergency services and they sent an environmental conservation officer round. The animal even attacked the wheel of his four by four when he arrived! Eventually the animal was killed, the officer ran it over, but the animal's brain was kept intact and tested for rabies.

That was my biggest fear, and I remember being so scared when I found out the results were positive. I was terrified all the way through treatment. Thankfully the virus was caught in time and I came out ok but I'll never forget it!

Appendix 4C: Animal fear beliefs questionnaire (FBQ) adapted from Field and Lawson (2003).

Ratings 1: Animal 4

Please tick the box to show your answer to each question.

No.	Questions	Answers				
1	Would you be happy to have this animal for a pet or look after it for a few weeks?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, defi...
2*	Do you think this animal would hurt you?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, defi...
3	Would you approach this animal if you saw one?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, defi...
4*	Would you go out of your way to avoid this animal?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, defi...
5*	Do you think this animal would hurt you?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, defi...
6	Would you be happy to feed this animal?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, defi...
7*	Would you be scared if you saw this animal?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, defi...
8	Would you be happy if you found this animal in your garden?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, defi...
9	Did you receive information that this animal carries rabies?	No	Yes			

Appendix 4B: Positive verbal information about animals for Experiment 4.

(Script recorded as audio file and played through headphones to participants)

Radio Presenter telling listeners about 2 animals:

"We have been introduced to two of the friendliest animals that you are ever likely to come across in the wild!

I have been told that these animals are native to Indonesia, Papua New Guinea and Australia, but specimens are known to be here in the UK, and in the US, brought over through the exotic pet trade: this is a market which is continually widening our exposure to exotic species and encouraging conservation of these animals both here and in their native countries.

Both animals are of similar size and weight and are roughly the size of a domestic cat or small dog, and I can tell you listeners now they are incredibly cute!

They are known to be very docile and tame. They are also semi-nocturnal, and as a result of this spend large amounts of the day sleeping. As a tragic result of this they are often victim to poachers who kill them and sell them on the black market as some tribes in Indonesia believe that parts of these animals have magical properties and are used in healing rituals. In addition to this there is growing concern at the loss of these animals' habitat due to deforestation and global warming.

Due to the stresses on the livelihood of these animals, and their friendly behaviour, more people are taking to keeping these animals as pets and breeding them. This is also an attempt to preserve the species and encourage awareness of the need to protect these lovely animals. They have become increasingly popular as pets as they are quite easy to look after and they are great with children, they don't jump or bite, but are very calm, even around exited youngsters! They will sleep most of the day whilst people are out

working and then normally wake up when you arrive home! With regards to their diet they are also easy to look after with a diet of mainly consisting of vegetables and fruit. Also they are known to be very affectionate towards their owners. Some people have been raising these animals with more common domestic pets such as cats and dogs, and both seem to live side by side happily, so even if you already have pets this doesn't pose so much of a problem.

If you are interested in keeping these animals as pets it is worth speaking to a breeder already in the UK although as the animals are still pretty rare on the pet market over here and demand for these cute and interesting little animals is high! Ridiculously long waiting lists for these animals have been reported and people are queuing to buy them for over £400 each!

Breeder Bonnie Martin, 35, said: "There are only eight serious breeders in the country and we can't keep up with demand.

"I have a waiting list that is 20 strong, which is about five litters and will take about a year to clear. One man in Edinburgh is waiting to pick one up.

We have two accounts of people who keep both these breeds of animals as pets........................

Pet keeper 1:

"My friend and her family, back home in Australia, have kept these animals for years, and they are such cute and friendly little animals.

We grew up together and I used to love going round to her place when we were little to play with all the animals, they were so much fun!

Her parents still breed them which I think is great because they are really becoming endangered with a lot of their habitats being burned down to make way for urbanisation. It's really sad.

Anyway when I was little we kept one as a pet and I loved him so much.

My mum wasn't really that keen on pets, but as these guys are pretty quiet, easy to train and really clean, we were allowed!

My mum always said how he'd sleep most the day while I was at school, but then he'd get really excited about half an hour before I was due home. They are really are quite intelligent creatures!

Anyway he died when I was 17, and not long after I came to the UK to study. I was so sad to lose my pet.

I think when I have a house of my own I will definitely consider getting another one. They make really good companions.

Pet keeper 2:

My Wife and I have just bought one of these animals as a pet.

We had to wait almost a year to get one from a UK breeder as they are still very rare over here, with just a few people breeding them.

I have been interested in exotic animals for years and also keep other small mammals, such as 'African pigmy hedgehogs' and 'sugar gliders': both of these animals are very cool and interesting, but are in no way as affectionate and fun as this little guy!

They are amazingly intelligent and calm animals, so they are very easy to train. Our breeder has them all litter trained at one month old so that's something you, as an owner, don't even have to worry about when taking on a new pet like this. No mess!

Since we've had this animal it seems like it has become really attached to us, and he loves to sleep at the foot of our bed, or curl up on our laps if we are watching TV.

It's like having an extra member of the family, and I would recommend them as pets to anybody.

Appendix 5B: Animal fear beliefs questionnaire (FBQ) employed in Experiment 4. Adapted from Field and Lawson (2003).

Ratings 1: Animal 1

Please tick the box to show your answer to each question.

No.	Questions	Answers				
1	Would you be happy to have this animal for a pet or look after it for a few weeks?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, de
2*	Do you think this animal would hurt you?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, de
3	Would you approach this animal if you saw one?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, de
4*	Would you go out of your way to avoid this animal?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, de
5*	Do you think this animal would hurt you?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, de
6	Would you be happy to feed this animal?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, de
7*	Would you be scared if you saw this animal?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, de
8	Would you be happy if you found this animal in your garden?	No, not at all	No, not really	Don't Know / Neither	Yes, probably	Yes, de
9	Have you been given any information about this animal?	No	Yes			