An associative analysis of recognition memory in humans

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Abstract

Experiments in this thesis tested recognition memory tasks in human participants. Recognition memory tasks measure novelty preference when participants are exposed to familiar and novel stimuli. The majority of this research has been conducted using non-human animal samples, although there have been some experiments testing humans. The experiments in this thesis expand on and modify recognition memory tasks for humans. The experiments presented tested an associative model of recognition memory, as recognition memory can also be explained by other accounts. Recognition memory tasks were adapted for human participants by presenting images on a computer screen fitted with a non-invasive eye-tracker. Eye movements were recorded so dwell times could be used to determine if participants were spending more time looking at expected (familiar) or unexpected (novel) stimuli. It was predicted that humans would perform recognition memory tasks in a similar way to animals and that results would be best explained by the associative account (Wagner's SOP model). The experiments in Chapter 2 did find support of a contextual learning task in human adults and children, which can be explained by the associative, declarative and generalisation decrement accounts. Experiments in Chapter 3 that sought to test the associative account by testing a Pavlovian manipulation known to affect learning, namely extinction, were unsuccessful. Experiments in Chapter 4 tested the associative model using spacing experiments that manipulate the time between sample presentations during training. These experiments were also unsuccessful. The conclusion of this thesis is that results from non-human animal

studies suggest that the associative account better explains behaviour in recognition memory tasks, however the experiments presented in this thesis, which tested human participants, were unable to find evidence to support the associative account being superior at explaining behaviour in the tasks tested.

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Abbreviations

CS: Conditioned Stimulus

US: Unconditioned Stimulus

CR: Conditioned Response

UR: Unconditioned Response

SS: Single System

ROCs: Receiver-Operating Characteristics

fMRI: Functional Magnetic Resonance Imaging

SOP: Standard Operating Procedures

A1: Primary Activity State

A2: Secondary Activity State

I: Inactive state

S-R: Stimulus-Response

ISI: Inter-Stimulus-Interval

ITI: Inter-Trial-Interval

RI: Retention Interval

LTH: Long Term Habituation

SOR: Spontaneous Object Recognition

OICL: Object-in-Context Learning

OIP: Object-in-Place

VPC: Visual Paired Comparison

AD: Alzheimer's Disease

MCI: Mild Cognitively Impaired

NC: Normal Controls

PD: Parkinson's Disease

M: Mean

SD: Standard Deviation

Sqrt: Square root

cm: Centimètres

Hz: Hertz

ms: Milliseconds

Sec: Seconds

Min: Minutes

GIFs: Graphics Interchange Format

ROI: Region of Interest

ANOVA: Analysis of Variance

CI: Confidence Interval

O-LIFE: Oxford-Liverpool Inventory of Feelings and Experiences

CHAPTER 1

1 General Introduction

1.1 Recognition Memory

Mandler (1980) defines recognition memory as the ability to recognise objects or events that have previously occurred. In recognition memory tasks, observed behaviour is different to objects or events that have been previously exposed than to novel stimuli. It has long been debated whether recognition relies on one single process or two separate processes (i.e. dual-process model).

A dual-process model focuses on recognition consisting of a feeling of knowing (familiarity) and that this 'knowing' can be verified by 'remembering' (recollection) details of a specific episode. One well-known example to demonstrate the contrasting roles of familiarity and recollection in episodic memory recall is the butcher-on-the-bus scenario (Mandler, 1980). When boarding a busy bus, you can imagine you would be exposed to many people. One such person is a man; you get a sense that you have seen this man before, however do not remember who he is. This automatic feeling is familiarity. You then begin to try to remember who this man is. You begin searching and retrieving specific details about any previous encounters you may have had with this man. During this process of recollection, you may remember him wearing a white apron or handing you meat at the supermarket. Eventually, you recall that he is the local butcher. The combined processes of familiarity detection and recollection make up episodic memory recall.

An opposing model, the single-system model, argues that recognition is driven by a single memory system or source, familiarity (Berry, Kessels, Wester, & Shanks, 2014; Berry, Shanks, Speekenbrink, & Henson, 2012). This model assumes that the single system that accounts for familiarity in the dual-system model can also account for recollection. The model proposes that studied items are more familiar than new items. Familiarity distributions for old and new items overlap, so a response criterion is set to only accept items above the familiarity level as having been studied (Yonelinas, 2001). This model uses a single memory component, and therefore has a single memory parameter, which makes it a relatively simple model. It has been further developed to make several predictions. Predictions are tested against dual-system models to assess whether a dual-system is necessary to explain familiarity and recollection or if a single-system will suffice.

The single-system model makes one main assumption, stating that the same memory strength signal drives familiarity, recollection and fluency, which refers to the speed of processing an item (Berry et al., 2012). Berry et al. (2012) tested this in several experiments. They first made advanced predictions based upon the single system (SS) computational model (see Berry, Shanks, & Henson, 2008) that (1) there is a fluency effect with old, previously exposed items and new, novel items, (2) the overall priming effect is greater than priming for items judged new, where priming refers to enhanced responding to an item caused by previous exposure to that item, and (3) an overall priming effect cannot occur without overall recognition. In a series of experiments participants were presented with two study tasks and a test task. In the first study task, participants were simultaneously presented

with two words on the screen at a time. Trials were split into two conditions, condition one contained cued (designated by arrows pointing to the word) and new words and condition two contained uncued and new words. They were instructed to read any cued words aloud. Next, in the second study task, participants were presented with a single word which was repeated in longer and longer durations and the word appeared clearer and clearer with each presentation. Participants had to press a key once they were sure they could identify the word and type the word they saw. In a test phase, participants completed this same word identification task, but were asked to identify if the word was old or new from the first study task. They were told if a series of words were from cued or uncued trials and asked to judge if they had seen that word before. Results supported predictions one and two. The single-system model correctly predicted fluency effects within new and old items, meaning that old items had quicker identification times than items that were judged new. The single system model also correctly predicted that the overall priming effect would be greater than the priming effect of items judged new, meaning that the difference in identification reaction times to correct rejections and misses was smaller for items judged new than overall. However, the results from the experiments failed to support the third prediction, which suggested that overall priming cannot occur without overall recognition. The dual-system models better addressed this point.

Additional tasks can be used to investigate whether recognition relies on one or two processes. If recognition does rely on two processes, a single task can be used to demonstrate the functioning of both processes. Recognition memory can be tested in two different ways, introspectively or behaviourally.

An introspective approach to test recognition memory asks participants to record responses about previous events. This can only be conducted in humans, as it requires the use of language (Tulving, 1983). There are two main techniques that use introspective approaches. One assumes that the processes can be measured independently with different tests, the remember/know task, and the other tries to measure this more agnostically, the process-dissociation procedure. Both of these tasks will be described below.

In the remember/know task, participants are asked to judge if recognised stimuli feel familiar (know) or if they can explicitly recall the event (remember). Participants are presented with a series of stimuli (e.g. images on a screen) and asked to remember what they are shown. During a test phase, participants are shown a series of images, both new and old images, and asked to indicate if they think the image presented is new, if they are able to remember the image (recall information about it) or if they know the image (it feels familiar).

The process-dissociation procedure measures recollective-recognition by having participants judge when or where each test item was originally presented. This task can be used to separate automatic from intentional processes. Familiarity is thought to be an automatic use of memory, whereas recollection is thought to be an intentional divide of attention during a test. Process-dissociation procedures can be used to test if one, automatic process is used or if an additional, intentional process is used (Jacoby, 1991). In this task, participants are asked to study two lists of stimuli. During the test, they are asked to only recognise stimuli from one of the two lists. Participants may

recollect items as belonging to the relevant list or may find items to be sufficiently familiar to flag without explicitly recollecting them from the relevant list. It is also possible that items from the irrelevant list are wrongly recollected because they are familiar and not recognised as being from the irrelevant list. (Espinosa-García, Vaquero, Milliken, & Tudela, 2017). In addition, it is important to note that one process is easier than the other, which may cause one to be found without the other, not because the processes are different, but because one process is easier to detect.

There have been a number of studies conducted to distinguish between familiarity and recollection using the introspective tasks discussed above, that provide support for a dual-system model. For example, functional magnetic resonance imaging (fMRI) has been used with the remember/know task to assess brain activation during the test. fMRI results demonstrate that participants reporting recollection (remember) have increased hippocampal activity compared to reports of familiarity (know; Eldridge, Knowlton, Furmanski, Bookheimer, & Engel, 2000; Yonelinas, 2005). This supports the dual process view that the two processes depend on separate, but interlinked, brain structures (Aggleton & Brown, 2006). In addition, studies using the process-dissociation procedure have demonstrated increased hippocampal activity with recollection, as suggested by studies using the remember/know task, however also demonstrate increased anterior para-hippocampal cortex activity with familiarity detection (Daselaar, Fleck, Dobbins, Madden, & Cabeza, 2006; Davachi, Mitchell, & Wagner, 2003).

The receiver-operating characteristic (ROC) procedure also demonstrates support for a dual-process model. This procedure creates plots of ROC

curves, that relate the proportion of correct recognitions to the proportion of incorrect recognitions. This is computed by having participants rate their confidence of recognition judgements. Studies that plot the false alarm rates of participants as a function of confidence in response (ROC) demonstrate curved functions, meaning that the shape of the curve changes across conditions and can only be described by two different independent memory parameters (Yonelinas, 1994, 2002).

Studies using patients with amnesia can provide additional support for a dual-process model. Amnesia is caused by brain damage or disease and results in impaired episodic memory recall. Although the majority of those with amnesia have impaired functioning in recall and recognition, there are some studies suggesting participants were able to recognise more than they could recall. For example, one patient that participated in a remember/know task was able to perform non-verbal word recognition but had difficulties with recall (Holdstock, Mayes, Gong, Roberts, & Kapur, 2005). This patient had damage to the anterior temporal lobe, including the perirhinal cortex, which has been linked to familiarity detection, but not recollection, suggesting support for a dual-process model (Brown & Bashir, 2002).

Translational work requires tests that have parallels across species. Therefore, it is also important to consider the non-human animal recognition literature. Aggleton and Brown (2006), who worked with animals, argue that there are two processes that make up recognition memory. These processes are familiarity detection and recollection; and they argue that recollection is dependent on episodic memory. They argue that the two processes depend on separate, but interlinked, brain structures. This makes it a dual-process

model, meaning that both familiarity (single process) and recollection (a separate, additional process) are needed in recognition memory (Rugg & Yonelinas, 2003; Yonelinas, 1994, 2001, 2002; Yonelinas & Parks, 2007).

To test recognition memory in non-human animals, behavioural measures can be administered. Behavioural tests can be conducted in both non-human animals and in humans, as no language is required to perform the test. Behavioural tasks test if a different response is observed when novel or new stimuli are presented in comparison to the response to familiar or old stimuli. Behavioural tasks will be used in this thesis and will be explained and discussed throughout.

Studies on recognition memory have found that rodents explore novel stimuli more than familiar stimuli (see for example Aggleton & Brown, 2006; Robinson & Bonardi, 2015; Whitt & Robinson, 2013). One account to explain findings in recognition memory tasks is proposed by Aggleton and Brown (2006), who suggest that recognition memory requires the use of episodic memory (also see Eacott, Easton, & Zinkivskay, 2005). Episodic memory is a subcategory of declarative memory and can be defined as a memory of events that have happened in the past (Papagno, 2015). This account of recognition memory will be referred to as the episodic/declarative memory account throughout this thesis and will be used to challenge the account this thesis is testing, the associative account, which will be further explained in the next section. The declarative account can be used to explain performance, however, does not make specific theoretical predictions.

1.2 Wagner's SOP Model (1981)

There is an alternative dual-process account that can be used to explain performance in recognition memory tasks, which relies on the use of associations. An association is a mental connection formed by a pairing between two mental representations (Woodruff-Pak, 1997). A mental representation is a cognitive symbol to represent a stimulus or element of that stimulus. A pairing is typically between a predictive stimulus (conditioned stimulus; CS) and a subsequent stimulus or event (unconditioned stimulus; US). Through associative learning, CSs can be learnt to activate a representation of a US (Holland & Sherwood, 2010). Learning that a CS signals a US is referred to as excitatory learning. This learning can affect performance or responding to future exposure to the CS. For example, if a rat reliably receives food (US) immediately following the presentation of a tone (CS), the rat will acquire learned behaviours (conditioned response; CR) when presented with the tone (Holland, 1990). Over time, an association is made between the mental representation of the tone and the food, so the rat expects the food and demonstrates learned behaviours that suggest anticipation of the food (e.g. approaching the pellet dispenser) when presented with the tone (also see Pavlov, 1997; Pavlov, 1927). There is another type of learning, inhibitory learning, in which a CS is presented followed by the surprising absence of the US. This is an unexpected omission and the learning becomes inhibitory. Inhibitory learning competes with excitatory learning and prevents the previous learning from being expressed. There are two main procedures that will be discussed that can make a stimulus (e.g. stimulus A) inhibitory. The first is extinction; if a previously

excitatory stimulus is later presented without the US, the stimulus will elicit less responding (A+ then A-). The second is a standard inhibitory training task; if a stimulus (B) undergoes excitatory training and is later presented in compound with a new stimulus (A) without the outcome, stimulus A will form an inhibitory association (B+ then BA-). Both of these procedures make stimulus A inhibitory. Extinction will be further discussed below, as this procedure is used to test the associative account in this thesis.

There are several theories to explain how associative learning works, one of them is Standard Operating Procedures (SOP; Brandon, Vogel, & Wagner, 2003; Wagner, 1981). This model will be used as an account of recognition memory and discussed in relation to the episodic memory account throughout this thesis, as in addition to explaining the formation of associations, it also includes details about stimuli representation and activation that help explain recognition. In the SOP model, stimuli are represented by groups of elements, in the organism's sensory system, that correspond to their physical characteristics. For example, a tone is made up of many elements, including pitch and amplitude and a shock has several elements, including voltage and length of administration.

According to the model, these elements move between three different activity states (primary activity state: A1, secondary activity state: A2, and inactive state: I; see Figure 1). When pre-exposure to an object occurs, the object's elements enter the primary state of activity (A1), which results in the organism responding to the stimulus. The object's elements will quickly decay from the A1 activity state to the secondary state of activity (A2). When an object's elements are in A2, although there is still some responding,

responding becomes weaker than when the object's elements were in the A1 activity state. From the A2 activity state, the object's elements will eventually become inactive again. The decay from the A2 state is much slower than decay from the A1 state. It is important to note that in this model, representational elements are unable to move from the A2 activity state to the A1 state and only inactive elements are able to move into the A1 activity state.

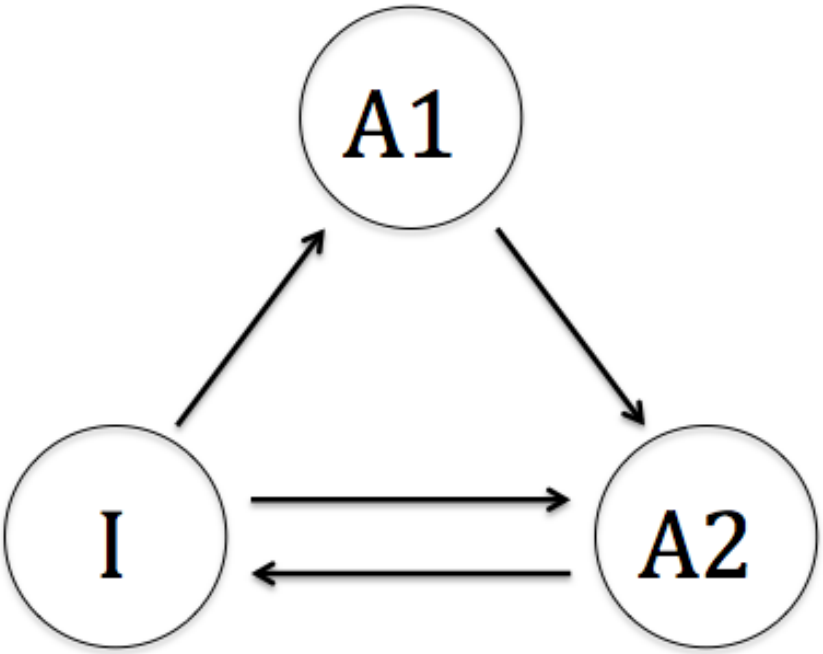


Figure 1: *A visual representation of activity transitions in Wagner's (1981) SOP model. I represents the inactive state, A1 represents the primary activity state, and A2 represents the secondary activity state. An object's elements start in the inactive state of activity and move into A1. The elements quickly decay into A2, before eventually becoming inactive again. Elements can move from I into A2, however elements in the A2 state must become inactive before returning to the A1 state.*

Furthermore, there are four important learning rules to note (see Table 1). First, when two stimuli simultaneously have elements in their A1 state (e.g. tone → shock), excitatory associations can be formed. After successful excitatory learning, a CS can prime elements of the US into the A2 state. When the CS (that predicts the US) is presented in compound with a novel stimulus (whose elements will go into the A1 state), and no US appears, inhibitory learning will occur between the added novel stimulus and the US (e.g. when a CS is in A1 and a US is in A2, you get inhibitory learning: rule 2). Inhibitors prevent elements of the US from entering the A2 activity state. Third, when the tone's elements (CS) are in the A2 state and the shock's elements (US) are in the A1 state, no excitatory learning will occur; the tone will not be able to form an association with the shock, however the shock can form an inhibitory association with the tone. And fourth, when both stimuli have their elements in the A2 state no learning will occur, as there are no associative changes when elements from both stimuli are in the A2 state (i.e. there is no learning about a CS when its elements are in A2).

Rule	Signal (Tone; CS)	Outcome (Shock; US)	CS→US Learning
1	A1	A1	Excitatory
2	A1	A2	Inhibitory
3	A2	A1	No learning
4	A2	A2	No learning

Table 1: *The four learning rules of the SOP model. Each rule demonstrates what type of learning would occur when the signal (CS) and outcome (US) are in either their primary (A1) or secondary (A2) state of activity. When both the CS and US have elements in the A1 state, excitatory learning can occur. When the CS has elements in the A1 state and the US has elements in the A2 state, inhibitory learning can occur. No learning may occur when the CS has elements in the A2 state, regardless of whether the US has elements in the A1 or A2 state.*

The learning rules make it clear how the SOP model can explain associations. For example, an association can be made between a tone (CS) and another stimulus, a shock (US). Presentation of the CS followed by the US will allow an association to be formed, as both stimuli will have elements in the A1 activity state. Later, after an association has been formed (tone → shock), exposure to the tone will prime the shock's representational elements directly into their A2 states (Wagner, 1981).

According to this account there are two ways you can explain a change in behaviour as a result of familiarity. These are referred to as two different types of priming predicted by the SOP model (Wagner, 1981), self-generated priming and retrieval-generated priming. Self-generated priming happens when a stimulus is presented, and its elements move into the A1 state before quickly decaying into the A2 state. If a stimulus' elements have already been primed into the A2 state and have not yet had enough time to decay back to the inactive state, the stimulus will elicit little responding when presented again. This is because elements have to return to the inactive state before they are able to re-enter the A1 activity state. Retrieval-generated priming happens when there is an existing association. When the retrieval cue (e.g. tone) is presented, it primes the associated stimulus' elements (e.g. shock) straight into the A2 state and this makes it less effective upon presentation. Therefore, responding to a stimulus is decreased if the same stimulus was recently presented (self-generated priming) or a retrieval cue for the stimulus has just been presented (retrieval-generated priming).

This model has been applied to object recognition tasks in non-human animals and humans, which will be explored in the following sections. This

thesis will test the associative account of recognition memory and compare findings to other accounts (e.g. the declarative account) that can also explain behaviour in recognition memory tasks to challenge the account.

1.3 Recognition in Non-human Animals

1.3.1 **Implicit Measures**

Implicit measures refer to tasks that can be interpreted as recognition, although they do not explicitly test recognition, as subjects show a change in behaviour due to prior exposure. One type of implicit measure is habituation. Habituation tasks can be used to test recognition memory in animals. Harris (1943) defines habituation as a response decrement as a result of repeated stimulation. It is specified that habituation demonstrates the ability to use past experiences to adapt behaviour and that the observed decrease in response is not due to fatigue or an inability to respond. Habituation relies on the central nervous system to use the past to predict future incoming stimuli, resulting in a response reduction (Harris, 1943). Habituation is a useful task to test recognition because there is a clear link; in these tasks, animals are repeatedly presented with a stimulus and eventually they react differently to this stimulus because they have seen it before. Habituation learning can be short-term, which tends to last for a single session or day, or long-term, which can last for days or weeks (Thompson & Spencer, 1966).

Habituation has been shown as a reliable behavioural measure of recognition in several species of animals, using many different types of stimuli. Some of the earliest examples of simple habituation were demonstrated in snails. For example, the land snail, *Helix albolabris*, were placed on a platform that was connected to an electrical attachment, allowing the platform to be jerked longitudinally at regular intervals.

When the platform was jerked, the snails initially demonstrated a tentacular withdrawal response. After several platform jerks, the response gradually declined until there was no obvious reaction (Humphrey, 1933; also see Cook, 1970; Dawson, 1911).

Habituation has been explained by several accounts, some more elaborate than others. Castelluci and Kandel (1976) explain the simplest account of habituation, the Stimulus-Response (S-R) account. This account is so simple, as it uses the minimal amount of assumptions. The S-R account explains that habituation is observed because the S-R pathway becomes less effective after several presentations of the stimulus (Castelluci & Kandel, 1976; Hay & Sokolov, 1966; Skinner, 1945). This decrease in efficiency of the S-R pathway eventually causes a decrease in responding. There have been many advancements proposed for the theory to expand on the original simple explanation. For example, Sokolov (1963) added a sensory register component that is used to process the stimulus. The stimulus is compared to information stored in memory and if there is a match, the original response is not observed. Other more elaborate accounts also considered the role of memory in habituation, namely the SOP model. It has previously been explained how the associative model describes recognition and hence habituation in general. Habituation has these additional features of short- and long-term learning, which are both explained by the associative model. Wagner (1976, 1979) suggests that habituation occurs when the stimulus is already represented or primed in memory. In order for the stimulus to be primed into memory, it requires a retrieval cue (e.g. context). This implies that long-term habituation (LTH)

depends on stimulus-context associations. Wagner's model can also predict short-term habituation, which uses self-generated priming and therefore does not require a retrieval cue.

Habituation has some key features to consider. One important aspect of habituation to note is that although there is decreased responding as a result of repeated exposure to a stimulus, there is the ability to spontaneously recover, meaning the response could reappear at a later time (Thompson & Spencer, 1966). This is also relevant to the dual-process model, as it speaks to the retrieval process. Responding can spontaneously return after the passage of time, which follows self-generated priming predictions, as stimulus elements will no longer be in the A2 activity state, so it is expected that responding will return, however this does not follow retrieval-generated priming predictions. Wagner's (1981) SOP model, suggests that a retrieval cue should prime stimulus elements into the A2 state, resulting in decreased responding, which should prevent response recovery regardless of time passage. However, it is possible that a retrieval failure may cause spontaneous recovery due to the time that passed between testing sessions (Uribe-Bahamonde, Becerra, Ponce, & Vogel, 2019). For example, time may be affecting how the retrieval cue is perceived, and therefore, the more time that passes, the less effective the retrieval will be. In addition, spontaneous recovery is less frequently observed with greater training in long-term habituation (Thompson & Spencer, 1966). This is because with more extensive training, the association between the retrieval cue and the stimulus is

greater, leading to increased response decrement and decreased spontaneous recovery (Uribe-Bahamonde et al., 2019).

The contextual component of habituation is another important aspect to consider, as this provides support for the retrieval process in the dual-process model and strong support for Wagner's (1981) SOP model, specifically in regard to retrieval-generated priming. Context specificity is a key prediction from the SOP model. Wagner's (1981) associative account states that in habituation studies, the context and object form an association during training, as both will have their elements in the A1 state. After a successful association is formed, the context is able to prime the object's elements into the A2 state, so responding decreases and habituation is observed. When the object is presented in a new context, the context is unable to prime the object, so the object's elements enter the A1 state of activity and responding to the object returns. A review of the literature on context specific habituation is a test of the associative model.

Although this thesis is specifically testing the associative model, it is important to consider alternative explanations of associative effects. A possible explanation for context specific habituation can be suggested using the episodic memory account, although this account does not explain or predict this type of learning naturally. In very general terms, one might say that the episodic account can predict that after several presentations of the object, the animal would recognise it as familiar and responding would decrease. When moved to a new context, the animal would recognise that the object was familiar. Then, through a process of recollection, by searching and retrieving details from previous encounters

with that object, it would be recognised as being in a new context. Therefore, the item is recognised as familiar, however the context is novel, which may result in increased responding, or less recognition in the new context (Mandler, 1980).

A central part of the associative model is that long-term habituation should be context dependent. Literature will be reviewed to assess if the model accurately predicts this. Evidence will help determine if recognition memory is better accounted for by the associative model. There have been mixed results reported, with some supporting context-specific habituation, and therefore supporting the associative model, and others failing to find evidence of habituation being context-dependent.

Wagner's SOP model predicts that both habituation and another phenomenon, latent inhibition, should be context specific (Wagner, 1976). In latent inhibition, if a stimulus has been previously exposed, subsequent conditioning with that stimulus will be retarded (Lubow & Moore, 1959). Retarded conditioning is observed because the animal has been pre-exposed to the CS in the context, resulting in a context→CS association. Therefore, when presented with the context, the CS is primed into the A2 activity state, ensuring that it cannot support learning in that context. The associative model predicts that latent inhibition will only be observed if conditioning takes place in the same context as previous exposure. This suggests that animals who receive pre-exposure to the CS in one context and conditioning with the CS in a different context will learn associations faster than animals who receive pre-exposure and conditioning in the same context. Wagner's (1981) SOP model explains that this is due to retrieval-

generated priming. When conditioning takes place in a new context, latent inhibition is not observed, as the new context will not prime the CS into the A2 activity state. This will allow the CS to enter the A1 state. The US will also enter the A1 state, allowing a CS→US association to form faster than if conditioning occurred in the pre-exposure context. Many studies have found that latent inhibition is context-specific (see e.g. Anderson, O'Farrell, Formica, & Caponigri, 1969; Channell & Hall, 1983; Dexter & Merrill, 1969; Hall & Minor, 1984).

Although there are many accounts suggesting that Wagner's (1976, 1979) model applies to latent inhibition, there have been some reports that it does not apply to habituation. For example, Leaton (1974) pre-exposed rats to a loud auditory stimulus and measured the suppression of licking. Eventually, the rats habituated to the tone and no longer showed a suppression of licking. When rats were tested in a different context, there was no restoration of the response. In a similar study, rats were exposed to a brief burst of white noise and the habituation of the startle response was measured. When tested in a novel context, dishabituation was not observed (Marlin & Miller, 1981). These studies include stimuli that may contain a defence component. Variables that affect habituation, such as a defence response to loud noises, suggest that orienting and defensive responses may differ (Hall & Channell, 1985). For example, it has been suggested that orienting responses are associated with heartrate deceleration and defensive responses are associated with heartrate acceleration (Graham, 1979), which may affect habituation. Therefore, Hall and Channell (1985) measured rats' orienting responses to a localized

light to eliminate the defensive component, as lights are a more neutral stimulus that do not tend to create a startle response. The contexts used in this study differed by scent and one had white noise continuously playing in the background. Channell and Hall (1983) used the same contexts in a previous study that demonstrated the contexts were distinguishable, as latent inhibition was abolished by changing between the two contexts. In the first experiment, rats were pre-exposed to a light in Context A. They were then tested with the light in novel Context B. Results suggested that a context change caused dishabituation. This effect supports associative predictions (Wagner, 1981). However, one alternative explanation of the dishabituation observed in this experiment is that the test context was completely novel and therefore may have caused sensitisation. This happens when a novel stimulus is presented before the habituated stimulus and causes habituation to be disrupted. Dishabituation is observed, as the animal may appear to respond to the stimulus again but responding could be due to general increased arousal. In a second experiment, Hall and Channell (1985) went on to test this alternative explanation. Rats were pre-exposed to both Contexts A and B to avoid sensitisation. Rats were presented with the light in Context A, but not in Context B. They were then tested with the light in Context B. Results from this experiment found that a context change did not cause dishabituation. This made it seem as though the results from the first experiment were due to the novelty of the test context, suggesting that habituation is not context specific, and results do not support the associative predictions (also see Cranney & Ashton, 1985; Hall, 1991; Pliz, Arnold, Rischawy, & Plappert, 2014).

There have, however, also been reports of context-dependent habituation. The following studies provide support for Wagner's (1976, 1979) associative model, as this model relies on context-stimulus associations. This first set of studies demonstrates habituation to drugs. These studies should be given particular consideration, as drug tolerance has been suggested to be special, as it is assuming that tolerance is the same as habituation to a tone or light. It may be that animals find risk in habituating to significant stimuli (e.g. drugs and distress calls) across contexts for safety reasons (Mackintosh, 1987). Studies investigating habituation in morphine injection (decline in the response: analgesia) demonstrate that habituation was relatively context dependent. In these studies, rats are given access to saccharin (CS) followed by an injection of either morphine or saline. Rats are placed on an inactive hot plate thirty minutes after the injection to habituate to the hot plate environment. During testing, all rats receive the CS alone. Thirty minutes later, rats' pain responses are assessed when placed on an active hot plate. Rats that received morphine during training show analgesia (greater paw-lick latencies) compared to rats that received saline. Control rats (saline injection group) that received morphine unpaired with the CS did not show analgesic responses, demonstrating that the response is associative. Only rats that had the CS paired with morphine demonstrated habituation at test (Miller, Kelly, Neisewander, McCoy, & Bardo, 1990). Moreover, studies demonstrate that rats show a habituation to the morphine injection in one context (context A). When they are tested in a new location (context B), where morphine injections have not previously been

delivered, there is an analgesic response recovery, demonstrating context-specificity (Siegel, 1975; Siegel, Hinson, & Krank, 1974; Tiffany & Baker, 1981).

Drug studies are difficult to interpret and special due to the ambiguity in how tolerance differs from habituation. Therefore, it is also important to consider studies without the use of drugs. Maldonado and colleauges (1997) provide evidence of context-specific habituation in the semiterrestrial crab, *Chasmagnathus*, in Argentina. These crabs have an escape (running) response when a rectangular screen is presented overhead, which simulates birds of prey flying above. Crabs were suspended in a container, which was connected with a stylus to read oscillations when the crabs responded. The crabs were given 15 minutes to adapt to the container before each session. There was a training session of 5, 10, 15, or 30 trials and a testing session of 6 trials. Crabs were tested in the same or different context at test. Moving the light or adding an object to the container changed the context. The escape response declined over trials, but it persisted for at least five days. LTH was impaired when the context was changed between sessions, demonstrating context-specific habituation. Hall and Channell (1985) suggested that introducing a novel context at test may cause context-specific habituation due to sensitisation. However, the result reported in this study is unlikely due to sensitisation, as crabs were given time to adapt to the environment before trials were administered in each session.

A study by Honey, Good and Manser (1998) used discrete stimuli as contexts (e.g. a tone) instead of presenting neutral stimuli in experimental

contexts (e.g. an apparatus). Therefore, it is not possible to suggest that results can be explained by sensitisation, as the stimuli are all presented in the same environment. In a first experiment, orienting responses to two localised lights on the left and right sides of the apparatus (X and Y) were measured. Lights could be predicted by two auditory stimuli (A and B). Rats received one 48-minute session a day for four days. Every trial presented an auditory stimulus immediately followed by the presentation of a light. The ITI between trials was 120 seconds. There were two different groups of rats, a consistent group and an inconsistent group. On days one and three, all rats received the same trials (A-X and B-Y), whereas on days two and four, the consistent group continued to receive A-X/B-Y trials, but the inconsistent group received A-Y/B-X trials. Therefore, the inconsistent group had both tones signalling both lights across the four training sessions. Regardless of group, there was very little difference in how the groups responded to X and Y, and therefore no evidence for 'context'-specific habituation, as on days two and four, a change in tone preceding the light did not change responses in the inconsistent group. This may be because A and B provoked responses that interacted with the orienting response to X and Y, as rats had to physically move to the side of the environment signalled by the tone. Rats were more likely to orient to the light when they were in close proximity to the that light. This made it difficult for rats to orient to the light on inconsistent trials because it was harder for them, as they had to move to the opposite side of the apparatus, which interfered with the return of the response. Therefore, in a second experiment, a single light that was either constant

or flickering was used to keep the light location constant. This enabled rats to approach the same location when presented with tones A and B and therefore equates the rats' behaviour prior to the test trials. Again, rats received one 48-minute session a day for four days, however this study was done within-subjects. On the first three days, all rats received habituation training with A-X and B-Y. On day four, a test session was administered; the first 12 trials were the same as training, however the remaining trials were split into consistent (A-X/B-Y) and inconsistent (B-X/A-Y) trials. During the test phase, rats were less likely to orient to the light when it was preceded by the auditory stimulus from training (consistent trials) than when it was preceded by a different auditory stimulus (inconsistent trials). This suggests 'context' specific learning; however, it may be argued that a discrete stimulus is not a context.

The context-specific habituation effect has been demonstrated in many species, for example zebra finches (Kruse, Stripling & Clayton, 2004) and stickleback (Peeke & Veno, 1973; also see Evans & Hammond, 1983). The evidence presented does offer mixed results, as some studies support context-independent habituation (e.g. Hall & Channell, 1985) and others offer support for context-dependent habituation (e.g. Maldonado et al., 1997). One common argument is that participants may not be able to discriminate between the two contexts in studies demonstrating context-independent habituation. In many experiments, there is no way to tell if participants can discriminate between contexts, but in a subset, this has been controlled for (e.g. Hall & Channell, 1985). Hall and Channell (1985) found that latent inhibition was sensitive to context change, suggesting

that animals were able to discriminate between contexts. This suggests that Wagner's (1976, 1979) account does not apply to habituation. However, it is possible that some failures to demonstrate context-specific habituation may have been due to an inability to locate the retrieval cues that prime the stimulus. As previously noted, it is also possible that some of the context-specific habituation effects are due a biological disadvantage to habituate across contexts (e.g. drug tolerance; Miller et al., 1990; Siegel, 1975; Siegel et al., 1974; Tiffany & Baker, 1981) or can be explained by sensitisation due to a novel context being introduced at the test stage (Hall & Channell, 1985). It is also important to note that the majority of the context-specific habituation effects can be explained by a non-associative process (Hall & Honey, 1989). A non-associative process that can be used to describe context-specific habituation is generalisation decrement. This suggests that a change in context slightly alters how the stimulus is perceived by the participant, making it appear as a novel stimulus, and this can cause dishabituation (Mackintosh, 1987). This account is not actually possible to rule out, as there is no way of assessing if the stimulus is perceived differently or changing the context without it possibly affecting the stimulus. However, it is less likely that context-specific effects demonstrated by Honey, Good and Manser (1998) are due to generalisation decrement, as in their studies, all stimuli were presented in the same environment.

The habituation studies discussed demonstrate an indirect way of measuring how animals react to things that they have previously been exposed to, and therefore recognition. Another variation, which is a more

direct measure of recognition, Spontaneous Object Recognition (SOR), will be explored in the following section.

1.3.2 **Explicit Measures**

An explicit measure is a test designed to show recognition. One explicit measure is spontaneous object recognition, which is a common technique for looking at recognition memory in non-human animals (SOR; Ennaceur & Delacour, 1988; Kivy, Earl, & Walker, 1956). This differs from habituation, an implicit measure, as it is a more direct measure of recognition. In this task, animals are pre-exposed to an object (e.g. object A). After that, they are given a recognition memory test where they are exposed to the familiar object (object A), along with a novel object (e.g. object B). During test, if animals recognise object A, they will explore the new object, B.

For example, Ennaceur and colleagues tested rats in a spontaneous-object-recognition task. Rats were first presented with two identical stimuli for three minutes. Stimuli consisted of heavy, solid objects made of glass, plastic or metal. One minute later, rats were tested with the previously presented, familiar object and a novel object for three minutes. Rats spent more time exploring the novel object, demonstrating that they recognised the familiar object (Ennaceur, Cavoy, Costa, & Delacour, 1989).

A variation of the SOR task to test recognition memory in animals adds the role of context, namely object-in-context learning (OICL; Dember, 1956; Dix & Aggleton, 1999). This task is highly relevant, as it directly tests context specificity. As previously discussed, the associative

account predicts context dependence and OICL can directly examine this. In this task, animals are pre-exposed to two objects in sequence (A followed by B), each in their own context (respectively X & Y). During a test phase they are presented with A and B in X, they explore B more than A. Although both objects are familiar, one is unexpected in that particular context.

For example, Whitt, Haselgrove and Robinson (2012) tested rats in an OICL task. In their experiment, rats were exposed to different objects alongside an additional object, which served as a contextual cue. Objects consisted of a blue plastic bottle, a plastic penguin bottle, a black glass hourglass-shaped bottle and a transparent glass water bottle. During training, rats were presented with object P alongside X and object Q alongside Y. During the test phase, rats were exposed to X then presented with objects P and Q. Rats explored object Q significantly longer than object P.

OICL is very similar to studies that test context specificity in habituation. If learning is context specific, the unexpected object should have a greater response than the expected object, as the expected object should be primed into the A2 state due to previous habituation training in that context. This effect cannot be explained by sensitisation, as both contexts and objects are pre-exposed. SOR and OICL will be the main focus of the research conducted in this thesis. OICL will be the critical technique used to test the SOP account (Wagner, 1981) in humans.

Like habituation, SOR and OICL can be explained by more than one account. Some claim, including Aggleton and Brown (2006), that

discrimination is based on familiarity and that learning in these types of tasks requires recall, using episodic memory (e.g. Eacott, Easton & Zinkivskay, 2005). In SOR, the episodic account would suggest that the participant would use familiarity detection to recognise object A, however, will fail to recognise object B as familiar. In the OICL task, although the participant will detect both objects (A & B) as familiar, during recollection they will only retrieve details of specific encounters of object A in context X. These attempts to describe behaviours observed in SOR and OICL are vague. According to this account, the animal must have some knowledge of the details of the event, which is difficult to assess without language (Macphail, 1998). Recognition memory can be explained in more detail using an associative model of memory (Wagner, 1981; Brandon et al., 2003). The SOP model makes advanced and detailed predictions, far beyond any predictions made by the declarative account. For example, SOP is able to predict how differing ISIs and retention intervals will affect learning in SOR and OICL effects, which will be further discussed below.

Wagner's (1981) SOP model can be applied to the recognition memory tasks described above. In SOR, the familiar object's elements (object A) move into the A1 activity state during pre- exposure. Object A's elements then move into the A2 state, where only weak responding is elicited. During test, the novel object (object B) is presented and its elements move from a state of inactivity to A1, while object A's elements are still in A2 (assuming the test directly follows pre-exposure), unable to move into A1. This results in greater exploratory behaviour towards object B. Context can also be considered in SOR tasks. For example, during pre-

exposure, object A and context X's elements would both be in the A1 activity state, where they would form an association. During test, context X would prime object A's elements into the A2 activity state, whereas object B's elements would move straight into the A1 activity state, and therefore elicit greater responding.

Likewise, in OICL tasks, first context X and object A are presented together during a training stage, where their elements move into their A1 activity state and form an association. Over time, they decay into the A2 state and then become inactive again. Upon test, when context X is presented, the associated object A is primed into its A2 state, whereas the unexpected object (object B) moves into the A1 state and therefore elicits stronger responding.

Wagner's (1981) SOP model can be considered a clearer way to interpret these recognition memory tasks. This model makes many predictions about learning in recognition memory tasks that other accounts cannot predict. For example, SOP predicts manipulations known to influence Pavlovian conditioning, such as extinction (e.g. Bouton, 2004), which will be explained in the following section. These Pavlovian manipulations are not predicted by the declarative account.

1.3.3 **Extinction**

In order to test if recognition memory is supported by Wagner's (1981) associative account, Pavlovian manipulations that are known to affect learning can be applied. Effects observed from manipulations are not theoretically predicted by the declarative account, giving stronger support

to an associative account of recognition memory. One such manipulation is extinction, where the conditioned stimulus is presented alone repeatedly after successful conditioning (pairing of the conditioned and unconditioned stimuli). Eventually, responding decreases until there is little or no responding (Bouton, 2004b).

There have been a countless number of demonstrations of extinction in the animal literature dating decades back. For example, rats were presented with a tone followed by a foot shock and freezing response was measured. After several presentations, rats learnt the tone-shock association and began to show the freezing behaviour in response to the tone. Rats were then presented with the tone without foot shocks to extinguish learning. Eventually, rats no longer froze in response to the tone, demonstrating successful extinction of the association (LeDoux, Morgan, & Romanski, 1993). Extinction has been demonstrated in numerous species since original documentations from Pavlov (Pavlov & Anrep, 1927) and is a very robust effect (for example, also see e.g. Amsel, 1962; Capaldi, 1966; Chan & Harris, 2017; Haselgrove & Pearce, 2003; Lovibond, Davis, & O'Flaherty, 2000; Maldonado et al., 1997; Myers & Davis, 2007; Orsini & Maren, 2012; Rescorla, 2003; Shipley, 1974).

As previously noted, according to SOP, extinction produces inhibitory learning, meaning that extinction is not thought of as unlearning (Wagner, 1981; Bouton, 2004a). Extinction has been demonstrated to be especially context-dependent (see Bouton, 1993, 2002). When a response is extinguished, the CS has two available associations with the US (pre and post extinction) and selecting between them heavily depends on the

context. The majority of the research on context extinction begins with CS→US training in context A, then the CS is presented alone in context B, resulting in a complete loss of response. Later, upon a return to context A, the extinguished response returns, as it is primed by the context (Bouton & Bolles, 1979; also see e.g. Bouton, 1993; Harris & Andrew, 2017; Hepp, Pérez-Cuesta, Maldonado, & Pedreira, 2010; Miranda-Dukoski, Bensemann, & Podlesnik, 2015). These studies demonstrate that the response is renewed in context A, as the association was not extinguished in that context, it was extinguished in context B. In order to extinguish learning in context A, extinction training must occur in this context. That is what the studies in Chapter 3 aim to explore; training, extinction training and testing will all occur in the same context. In the studies that will be presented, the CS is the context, so the context can be presented alone to extinguish any CS→US associations from training.

Studies testing extinction do not completely dismiss the declarative account. Although the declarative account does not theoretically predict extinction effects, it may be used to attempt to explain these findings post-hoc. When participants are exposed to the CS alone during the extinction phase, they are given a new episode to remember. The participant will be able to recall two episodes, the CS-US pairing and the CS alone. However, after several presentations of the CS alone, the participant will decrease responding. The participant will not forget the previous pairing but will learn to expect that the CS is no longer being paired with the US.

Although other accounts can be used to explain extinction, this is an effect that the SOP model predicts, and therefore is a direct test of the

model (Wagner, 1981). Experiments in Chapter 3 will investigate extinction in OICL. There will be an attempt to extinguish context-image associations to test the associative model of recognition memory. Another way to further test the associative account is to apply spacing manipulations. Studies presented in the following section demonstrate how Wagner's (1981) associative model has been applied to recognition memory tasks in SOR and OICL tasks by manipulating spacing between stimulus presentation and between pre-exposure and test phases.

1.3.4 **Spacing Effects in Non-human Animals**

Research showing the effects of spacing between stimulus presentations (spaced vs. massed training) provides evidence for Wagner's (1981) associative model of recognition memory (also see Honey & Good, 2000). The spacing effect is uniquely predicted by the SOP model; other models are unable to predict this effect. SOP makes very clear predictions about spacing, specifically that there is a benefit of spaced training and that the retention interval after training will reveal the level of self and retrieval generated priming. These predictions will be further explained below. There has been a clear spaced advantage in several studies testing many different species, including rats, pigeons, and rabbits (e.g. Gibbon et al., 1977; Salfia, Terry, & Daston, 1975; Stein, Sidman, & Brady, 1958), but most commonly rodents.

In the following examples, rodents were trained with either a short (i.e. massed) or long (i.e. spaced) inter-trial-interval (ITI). When the time between pre-exposure trials is short, rodents are less likely to form strong

arena-object associations. The associative account assumes that on the first pre-exposure trial, the object's elements will go into the A1 activity state and quickly decay into A2. On the second trial, the object's elements will still be in A2, unable to return to A1 before becoming inactive again. Subsequent pre-exposure trials will behave in the same way. When an object's elements are in the A2 state, there is less responding to that object, and also less learning about that object. The elements for both the arena and object have to be in the A1 state for an association to form. When the ITI is lengthened, the object's elements are able to return to a state of inactivity between each trial. This allows the object's elements to re-enter the A1 activity state on every trial, forming a stronger arena-object association, and therefore a greater novelty preference upon testing, if testing is delayed. If the space between training and testing, or the retention interval (RI), is long, it allows the object's elements to return to the inactive state, so that upon testing, the arena can prime the object's elements into the A2 state. However, when testing occurs directly after training, shorter ISIs demonstrate stronger habituation. This is because the object's elements remain in the A2 state from training, demonstrating a greater novelty preference at test.

Wagner's (1981) model uses unique terminology that applies to spacing manipulations, by referring to levels of self- and retrieval-generated priming. Self-generated priming happens when the stimulus' elements have not had enough time to decay from the A2 state, so if the test immediately follows training (short interval), the level of self-generated priming will be higher than if the test happened later (long interval). The

inter-stimulus-interval (ISI) during training can determine the level of retrieval-generated priming at test. This is because retrieval-generated priming relies on associations and having long ISIs allows for stronger associations to be formed during training, as previously described. Therefore, longer ISIs during training would result in higher retrieval-generated priming than when ISIs at training are short if testing occurs after a delay, allowing self-generated priming effects to dissipate.

Anderson, Jablonski and Klimas (2008) tested spacing predictions from the SOP model by presenting rats with an object novelty preference task with various ITIs, but only one retention interval. This experiment used a SOR procedure, where rats were first pre-exposed to two different objects. Pre-exposure was either nine consecutive minutes (massed) or three separate three-minute sessions (spaced) with one hour between sessions. One hour after pre-exposure, rats were presented with the familiar object and a novel object. Rats with spaced training sessions showed a significant preference for the novel object over the familiar object, whereas rats with massed pre-exposure showed no preference. These results suggest that SOR is sensitive to the spacing effects predicted by SOP. When pre-exposure was spaced, the representational elements had time to decay into a state of inactivity, allowing them to re-enter the A1 state on each session. In the massed condition, the representational elements did not have time to decay from the A2 state, resulting in elements being unable to re-enter the A1 state, which decreased exploration of the object. This suggests that there was a long enough

interval to prevent the self-generated priming process from dominating, which would have produced the reverse effect.

Another set of studies included more than one retention interval, which allows the levels of self- and retrieval-generated priming to be manipulated by shortening or lengthening the RI. Davis (1970) exposed rats to tones and measured startle responses. First, rats were exposed to 300 presentations of the tone in a pre-habituation session with mixed ITIs of 2, 4, 8 and 16 seconds. Responses from the pre-habituation session were used to assign rats to two different ITI groups for training. Rats were split in half, with each group having comparable means and variances for each of the four intervals used in the pre-habituation session. Next, during a habituation training session, rats were exposed to 1000 presentations of a tone with either a short two second ITI (massed) or a longer 16 second ITI (spaced). Finally, during a post-habituation test session, rats were again exposed to 300 presentations of the tone with mixed ITIs of 2, 4, 8 and 16 seconds. During habituation training, rats in the massed training group exhibited lower startle responses compared to the spaced group, demonstrating stronger short-term habituation. However, stronger long-term habituation was observed only with the spaced habituation training group. When tested 1 minute or 24 hours after habituation training, rats in the spaced condition showed lower startle responses compared to rats in the massed condition.

In a similar study, Sanderson and Bannerman (2011), tested mice in a spatial novelty preference task with various ITIs between pre-exposure trials. This study also included various intervals between the pre-exposure

and test phases (retention interval). Mice were either given ten two-minute pre-exposure trials (spaced) or two ten-minute pre-exposures (massed) to a Y-shaped maze. The ITI between pre-exposures was either one minute or 24 hours. They were then tested either one-minute or 24-hours later on a novelty preference task, where they were able to explore the two arms of the maze they were previously exposed to and a third, novel arm of the maze. Mice were divided into four groups and received one of four train/test interval conditions, 1-minute train/1-minute test, 1-minute train/24-hour test, 24-hour train/1-minute test, or 24-hour train/24-hour test. During pre-exposure training, habituation was greater for the short, 1-minute ITI groups than for the longer, 24-hour ITI groups, demonstrating stronger short-term habituation, i.e. mice tested after a 1-minute retention interval had a greater preference for the novel maze arm than mice tested after 24-hours. Mice trained with a longer, 24-hour ITI showed a stronger novelty preference than those mice trained with a 1-minute ITI when tested after the 24-hour retention interval, demonstrating an associative effect, which suggests greater long-term habituation with spaced training compared to massed training (Wagner, 1981).

One potential alternative interpretation of the previous examples presented is that context-specific effects were demonstrated because the rodents were handled between the pre-exposure sessions. This means the rats were handled more overall, specifically directly before each trial, in the spaced condition than in the massed condition, which may have contributed to the rodents' behaviours due to changes in arousal. Rats may have a response to being handled by humans that causes arousal and

therefore may interfere with their behaviour at test. In an attempt to rule out this potential alternative explanation, a replication of the studies ran by Sanderson and Bannerman (2011) and Anderson, Jablonski, and Klimas (2008) was conducted by Whitt and Robinson (2013), without allowing handling cues. Whitt and Robinson (2013) had no handling differences in the spaced and massed conditions. Rats were handled only at the beginning and end of a single pre-exposure session. The session was split into eight trials, by altering the lighting, with either a 30- second or a four-minute ITI. Lights were turned off during the ITI and turned back on during the trials. Additionally, all objects were presented in glass cylinders, so rats could only use visual features to distinguish the stimuli; this was important to do, as the exposure time was being manipulated with lighting. Therefore, because rats were not being removed from the arena, presenting stimuli in glass cylinders ensured that rats could not touch the stimuli during ITIs. There were two glass cylinders on every trial in opposite corners of the arena. During pre-exposure, rats were presented with object A in both of the glass cylinders. After the eight pre-exposure trials, rats were returned to their holding cage for 15 minutes before the test. Rats then returned to the experimental arena for the two-minute test and were presented with familiar object A from pre-exposure and novel object B. Results supported the findings of Anderson et al. (2008) and Sanderson and Bannerman (2011), suggesting that exploration of the novel object is significantly greater when there is a longer interval between pre-exposure trials. Longer ITIs allowed the elements to become inactive between trials, allowing more time in the A1 state. This provides

additional support for Wagner's (1981) associative model and cannot be discounted due to handling cues. However, it is also important to consider that the lighting manipulations may have also caused an increase in arousal; there were more frequent changes in lighting in the short ITI condition, which may have affected performance. This is the only possible way that an arousal argument can be applied in this experiment, as the procedure eliminated the possibility of arousal due to handling.

1.3.4.1 Spacing in Conditioning

Another set of relevant studies use conditioning procedures. Spacing in these studies is slightly different to spacing in the previous recognition memory tasks. In these studies, a CS is used to signal food, meaning that the CS is doing the priming. In previous studies presented in the section, the background was doing the priming. In conditioning studies, self-generated priming of the CS can reduce excitatory learning. This is because after a recent presentation of the CS (massed training), conditioning would be reduced, as the CS's elements would remain in the A2 state (increased self-generated priming) and both the CS and US have to have elements in the A1 state for successful conditioning. Therefore, massed training can cause a permanent reduced learning effect. In addition, a temporary effect is caused by massed training, as when the CS does not have enough time to decay from the A2 state due to a recent presentation, there is less control of performance in conditioning (Bouton & Sunsay, 2003). These effects are both consistent with predictions of Wagner's (1981) SOP model, and therefore, applying spacing

manipulations in conditioning studies is another way to test the associative model.

In addition, self-generated priming of the US may also reduce excitatory learning. With massed trials, it is possible that the US elements can remain in the A2 activity state from a previous trial, preventing its elements from entering the A1 state on the next trial. This means it is possible to get inhibitory learning, as the US remains in the A2 state and the CS may enter the A1 state when presented. For example, Ewing, Larew and Wagner (1985) conducted two experiments in which they presented rats with CS1 or CS2 on each trial followed by an ISI, terminating with presentation of the US. CS1 and CS2 differed in how long after the previous trial they were presented. CS1 (massed CS) was presented 60 seconds after the preceding trial and CS2 (spaced CS) was presented 600 seconds after the preceding trial. This difference in spacing may affect the US A2 activity that is produced by the CS on the previous trial. In the first experiment, the CSs were reinforced during the experimental phase and there was reduced excitatory learning after massed trials, as discussed in previous experiments presented. However, in the second experiment, the CSs were trained as excitatory stimuli and were nonreinforced during the experimental phase. In this experiment, there was more extinction after massed trials. Therefore, although self-generated priming of the CS can only reduce learning, self-generated priming of the US can enhance inhibitory learning (Ewing, Larew, & Wagner, 1985).

Sunsay and Bouton (2008) tested effects of spacing in rats in conditioning studies. In one experiment, rats were presented with a tone

reinforced according to a partial reinforcement schedule. During training, tone presentations were separated by one of eight inter-stimulus intervals (ISIs; 60, 120, 180, 240, 480, 960, 1440 or 1920 seconds). The tone was followed by food pellets on four of 16 trials. Results demonstrated a significant linear trend, suggesting that the longer the ISI, the greater the learning. This could be because self-generated priming of the CS was reducing excitatory learning on massed trials, as the CS remained in the A2 state. In addition, self-generated priming of the US may have also affected learning, as there was a partial reinforcement schedule, which means the US could have remained in the A2 state on some massed trials, causing inhibitory learning. This experiment suggests that there is a benefit of spaced training from explicit conditioning experiments, providing additional support for Wagner's (1981) SOP theory (also see subsequent experiments in Sunsay & Bouton, 2008; Bouton & Moody, 2004).

There has also been a benefit of spacing in extinction studies, demonstrating CS processing deficits. For example, after successful conditioning in a taste-aversion task, rats were given two non-reinforced exposures to the CS with varied ITIs between .5-24 hours. Extinction testing demonstrated that there was a benefit of spaced extinction training (6-24 hour ITIs) relative to the .5 hour ITI condition (Westbrook, Smith, & Charnock, 1985). As predicted by the associative model (Wagner, 1981), spacing extinction trials results in greater response decrements than massed extinction trials (also see e.g. Bouton, 1993; Urcelay, Wheeler, & Miller, 2009).

1.3.5 **Retention Interval Manipulations**

Manipulating the interval between training and test, or the retention interval (RI), also produces effects predicted by Wagner's (1981) SOP model. As previously mentioned, manipulating the delay before the test is administered affects the levels of self- and retrieval-generated priming. A test directly after training will reveal self-generated priming, as stimulus elements will not have had time to decay from the A2 activity state, whereas a delayed test will reveal retrieval-generated priming because elements will have returned to the inactive state during the delay and any learning demonstrated will be due to contextual priming (Wagner, 1981).

Tam, Robinson, Jennings, and Bonardi (2014) manipulated the retention interval in different versions of an object recognition task to test the associative model. Rats were tested in SOR, temporal order, and object-in place (OIP) tasks. The SOR task was administered the traditional way, as previously described. In the temporal order task, rats were presented with an identical pair of items (e.g. AA) followed by a second pair of identical items (e.g. BB). During test, one of each item was presented (e.g. AB). Rats were expected to explore the item they saw first because this item was more likely to have returned to its inactive state, allowing it to command more A1 activity. In the OIP task, rats were presented with four different items during training, one in each of four corners, allowing the rats to form object-location associations. In the test trial, two of the items were moved diagonally and therefore in a new location. If the location remained the same, the location should have primed the objects' elements directly into their A2 activity state; however,

if the object was moved, it was expected to command more A1 activity, and the rat should therefore spend more time exploring the moved object.

All three tasks were administered with either a five-minute or two-hour delay. The delay was between the training phase and the test phase (retention interval) in the SOR and OIP tasks and between the two sample phases in the temporal order task. According to Wagner's (1981) model the SOR and temporal order tasks should be affected by the delay, whereas the OIP task should not because of the object-location associations formed during training. The SOR and temporal order tasks are sensitive to the delay because the familiar (SOR) or first (temporal order) item's elements will remain in the A2 state if the delay is short, meaning that the temporal order effects will be better and the SOR effects will be worse with a longer delay compared to a short delay. When the delay is longer, the object's elements will eventually become inactive again and objects (SOR: novel and familiar; temporal order: first) will be able to enter the A1 state at test. In the OIP task this is not an issue. The location cues will prime the unmoved objects into their A2 state regardless of delay time, allowing the moved objects to elicit stronger responding. Results from Tam et al. (2014) report the expected findings, the increased delay from five minutes to two hours, reflecting increased retrieval-generated priming and decreased self-generated priming, impaired performance on the SOR task, enhanced performance on the temporal order task and had no effect on the OIP task. These findings are supported by predictions from Wagner's (1981) SOP model and offer support for an associative model of recognition memory.

1.4 Recognition in Humans

The majority of the studies discussed thus far have tested non-human animals, mostly rodents. These studies have broadly influenced theorising on mechanisms of memory, and this includes human memory. Humans have much more complex cognitive abilities, such as language (Macphail, 1998), so it is important that these procedures are demonstrated in human experimentation if we want to apply these theories to human samples. Although limited, some of the previously mentioned behavioural measures in recognition memory tasks have been studied in human samples.

1.4.1 **Implicit Measures**

As discussed in the non-human animal section, a simple implicit measure, habituation, can be used to test recognition memory. Habituation is an implicit measure, as it can be interpreted as recognition, but does not explicitly address recognition. Habituation procedures are commonly used in non-human animal studies, as they require no explicit responses to be made and do not require the use of language. This phenomenon has also been widely studied in humans.

For example, Ponce, Quintana, Philominraj, and Vogel (2011) studied habituation of the eyeblink response in humans. Participants were split into two groups, the constant group and the incremental group. All participants were exposed to 100 presentations of a tone at 40-second intervals during the habituation phase. Participants' eyeblinks were recorded throughout the experiment. The constant group consistently received tones at an intensity of 90dB. The incremental group started with

10 tones at an intensity of 60dB, which rose gradually by 3dB every 10 presentations, ultimately reaching a maximum intensity of 87dB. During a test phase, both groups were presented with 10 trials of the tone at an intensity of 90dB. Both groups demonstrated decreased responding to the 90dB tone in the test phase, suggesting that habituation was successful, however, there was a significantly larger decrement in the incremental group than in the constant group. This suggests that incremental habituation training was more efficient in producing habituation (also see O'Gorman & Jamieson, 1978; O'Gorman & Jamieson, 1975).

In a similar study, Ponce, Vogel, and Wagner (2015) presented participants with an auditory tone and measured humans eyeblink response. Participants were split into four groups during training, group incremental (100 tones: increased from 60 to 87dB, increasing by 3dB steps), group random (presented with the same 100 tones ranging from 60-87dB from group incremental in a random order), group constant (100 presentations of the 90dB tone) and group apparatus (no stimulation). All conditions containing tone presentation had an ITI of 30 seconds. During a test phase, which followed 30 seconds after the final training trial, participants received 10 presentations of a 90dB tone and 15 presentations of an air-puff; again a 30 second ITI was used. Results from this study indicated that there was habituation in all conditions, however the greatest response decrement was observed in the incremental training group, similar to results from Ponce, Quintana, Philominraj, and Vogel (2011). In addition, the incremental group also demonstrated significantly less responding to the air-puff, which was an untrained stimulus.

In both of the presented studies, incremental training produces a greater response decrement at test (Ponce et al., 2011, 2015). It is suggested that the gradual increase in the incremental condition may increase habituation because participants are exposed to relatively intense stimuli, but only after each increase in intensity was considered less arousing due to the previous habituation to the less intense value. This is suggested to be considered a change in state on each trial and that it depends on the prior habituation to the stimulus, so it uniquely affects the incremental condition, but not the constant or random conditions (Davis & Wagner, 1969).

This incremental stimulus intensity effect can be explained by the associative model. SOP is able to account for both excitation and inhibition on each trial, as excitation is directly related to A1 activity and inhibition to A2 activity (Wagner, 1981). On any given trial, the excitatory learning that is accrued to the context is predicted to be proportional to stimulus intensity on that trial (which increases A1 activity) and inversely related to the previous association accrued on prior trials (which increases A2 activity). When there is increased A2 activity, it leads to greater inhibition and decreased A1 activity, which leads to less excitation. Therefore, in the incremental condition, the association is stronger between the context and the stimulus when compared to the random condition because incremental training allows all trials with a greater intensity to be preceded by trials with lower intensities (Ponce et al., 2015).

There are added assumptions to the SOP model that explain the responses to the air-puff. The added assumptions claim that the context is

able to form an association with both the sensory and emotive aspects of the tone. The association with the emotive aspect of the tone is assumed to control a generalised conditioned emotional response. It is assumed that in the incremental training condition, there is greater sensory conditioning to the context (habituation) and less emotive conditioning (sensitization) than when the tone is presented in a constant or random order. Therefore, the processing of any stimuli, which includes the untrained air-puff, would be enhanced by the conditioned emotional response that was established by the context being associated with the tone (Wagner & Brandon, 1989).

There have also been numerous other studies that have tested habituation procedures with a human participant sample. This phenomenon is very widely studied and is well documented in the human literature (also see e.g. Dalton & Wysocki, 1996; Li, Luxenberg, Parrish, & Gottfried, 2006; Poellinger et al., 2001). There has, however been less research into the context-specificity of habituation in humans compared to research conducted in non-human animals, although there has been some research, which was unable to find context dependence of habituation. For example, Schaafsma, Packer, and Siddle (1989) presented participants with tone and vibratory stimuli and recorded skin conductance. Each participant received 15 trials; stimuli were presented in a random order and with random ITIs (30, 40 or 50 seconds). On random trials, a signal was presented, and participants were instructed to press a button with their thumb when the signal was present. One week later, participants were tested in either the same context or a different context. Context was altered by experimenter, testing seat, lighting and room furnishings. Half of the

participants were tested in the same context and half in a different context. All participants demonstrated a decline in skin conductance responses across trials and there were no differences between groups or between contexts. All participants had lower responses in the test phase compared to initial habituation training, demonstrating successful habituation, but no evidence of context-dependence (also see Churchill, Remington, & Siddle, 1987; Cranney & Ashton, 1985; Remington & Churchill, 1988).

As previously suggested, context dependence may not have been found due to participants failing to discriminate between contexts. It is also possible that the altered elements of the context were not the most salient elements, and therefore prevented response recovery in the different context condition (Schaafsma et al., 1989). Wagner (1978) suggests that stimuli vary in salience and this results in differing abilities for associations to form and for retrieval cues to be formed for subsequent priming.

It is also possible that the retention interval between habituation training and testing may affect stimulus generalisation (Riccio, Richardson, & Ebner, 1984). It is suggested that when the retention interval is increased, the participants' memory of specific characteristics of the stimuli weakens, and therefore there is an increase in stimulus generalisation. With increased stimulus generalisation, the participants will be less able to determine a difference in stimulus characteristics, making an increased number of stimuli effective at serving as retrieval cues during the test. This means that after a very long retention interval, any minor changes made between the training and test contexts become less discriminable. Overtime there is increased stimulus generalisation, so

when tested a week later, minor changes in context will not affect the retrieval process. Studies have found effects of context change with humans in memory tasks with a shorter retention interval of one day (e.g. Smith, Glenberg, & Bjork, 1978).

1.4.2 **Explicit Measures**

More direct behavioural measures that explicitly address recognition have also been demonstrated in human samples. Explicit measures include spontaneous-object-recognition and object-in-context learning. Many of the following studies use eye-tracking to investigate recognition memory in human participants. Eye-tracking will also be used in this thesis with these tasks to test the associative model (Wagner, 1981) in humans.

Eye-tracking has been used because this provides an indirect measure of viewing behaviour, reflecting the participants' learnt behaviour during the task (Mahoney, Kapur, Osmon, & Hannula, 2018). It is assumed that visual orientation is comparable to exploration in the non-human animal studies, which is more likely to occur when a stimulus has elements in the A1 activity state. In studies that ask participants to locate encoded items in memory tasks, eye movements demonstrate rapid identification of target items (Hannula, Ryan, Tranel, & Cohen, 2007). In addition, eye-movements have been seen to indicate responses in advance of participants making explicit responses in memory tasks (Nickel, Henke, & Hannula, 2015). Therefore, it is suggested that eye-movements are an automatic, implicit response. Other tasks using an introspective approach to test recognition memory, such as the remember/know task (e.g. Dewhurst &

Anderson, 1999), ask participants to make categorical reports of judgement. The experiments in this section and in this thesis will measure eye movements in SOR and OICL tasks, which rely on implicit responses. Eye-tracking is a better way to measure recognition memory, as it does not ask participants to make responses. Asking participants to respond in these tasks can influence behaviour and possibly mask novelty preference measures, as a categorical response would require the participant to indicate the novel or familiar stimulus, and therefore direct their attention towards that object. Analogous versions of these tasks in non-human animals (e.g. Whitt et al., 2012) rely on automatic behaviour measures, such as exploration, in response to stimuli, as non-human animals lack language. Eye-tracking can be used as the parallel measure in human experimentation.

An analogue of the SOR effect has been demonstrated in human infants. Fagan (1970) explored infant retention for visual stimuli. In his study, infants, aged 3-6 months, were exposed to a pair of visual stimuli during training. Visual stimuli consisted of images of black and white patterns. During a test phase, infants were presented with the familiar image and a novel image. Infants shifted their attention to the novel image, indicating that they recognised the familiar image.

In addition, results consistent with those of the infant study (Fagan, 1970) have been found in adult humans (Richmond, Sowerby, Colombo, & Hayne, 2004). Richmond et al. (2004) ran a study using three different exposure times to stimuli during training. Stimuli consisted of sequences of morphing faces. These complex stimuli helped maintain high attention

rates. Adults were split into three groups, and were exposed to stimuli for 15, 30 or 60 seconds. When tested with the familiar stimulus and a novel stimulus, the greater the exposure time the adults received, the stronger the novelty preference. Richmond et al. (2004) also demonstrated that the novelty preference could be maintained for up to a month after first exposure to the familiar stimulus. Although the novelty preference was much stronger when tested immediately after training, participants still spent more time looking at the novel stimulus 24 hours, one week, two weeks, and one month later.

An analogue to the SOR tasks, the Visual Paired Comparison (VPC) task, has also demonstrated a novelty preference in looking behaviour. This task has been used as a way of predicting the onset of Alzheimer's Disease (AD; Crutcher et al., 2009). Three different participant groups took part in the study: mild cognitively impaired patients (MCI: a slight but noticeable decline in cognitive abilities, including memory), healthy matched controls (NC) and subjects with Parkinson's disease (PD: degenerative disorder that mainly affects the motor system). Participants were shown an image, and then after either a two-second or two-minute delay, were shown the same picture again alongside a novel image. When there was a two second delay, all participants looked at the novel image longer. This is in line with results of SOR tasks. However, in the two-minute delay condition, only NC and PD participants continued to look at the novel image, whereas MCI patients showed no novelty preference. This demonstrates SOR tasks can be used to distinguish between normal and impaired functioning.

Further to this, the VPC task was also used as a tool to predict future MCI in controls, and predict future AD in MCI patients (Zola, Manzanares, Clopton, Lah, & Levey, 2013). Zola and colleagues (2013) tested control participants and MCI patients in VPC tasks and followed them for three years after testing. The scores from the VPC task were able to predict clinical diagnosis three years in advance. This provides evidence that SOR tasks have clinical applications and it also demonstrates further support for a novelty preference in healthy humans.

Although limited, there are also adaptations of OICL tasks using human participants. In an eye-tracking study by Mahoney, Kapur, Osmon, and Hannula (2018) participants were first presented with scene-face pairs during a training phase and instructed to remember the pairs. Scene-face pairs consisted of a scene that covered the entire screen with a face superimposed on top of the scene. Later, during a testing phase, participants were presented with three familiar faces on a familiar scene. There were target present and target absent trials. On target absent trials, participants saw three familiar faces, however none of the faces had previously been presented in the test scene, meaning all three faces were unexpected. On the target present trials, all the faces were familiar from the training phase, however only one face had previously been presented with that scene, meaning participants saw one expected face and two unexpected faces on each scene. Participants were told to press a button indicating whether the matched face from training was present or absent in each test scene. Eye tracking results demonstrated that participants spent an equal amount of time looking at faces in the target absent condition,

whereas they spent a disproportionate amount of time looking at the expected or matched faces in the target present condition. This is opposite to the effect predicted by the SOP account, which would predict decreased responding to the expected face (Brandon et al., 2003; Wagner, 1981). It is important to highlight that participants were instructed to indicate whether the matched or expected face was present or absent on each test trial. This may have influenced participants' eye movements, as they were always searching for the expected or matched face. A very similar study conducted by Hannula and Ranganath (2009), using nearly the same procedure, also reports that participants spent a disproportionate amount of time looking at the expected image. Again, this study instructed participants to locate the face that was previously associated with each context. However, in this study, it is noted that viewing of the expected face was correlated with response accuracy, supporting the idea that participants spent more time looking at the expected image due to the task instructions. Ryan, Hannula and Cohen (2007) demonstrated that results from SOR tasks also demonstrate that participants looked more at the familiar image when instructed to detect it, whereas they looked more at novel images when they were given free viewing instructions.

A similar OICL study, using a very similar procedure to Mahoney et al. (2018), included a group of participants that were instructed to study the three faces and the associated scene because they would later be given a recognition test at the end of the experiment (that was never administered). This study therefore did not instruct participants to locate the expected or matched face on each test scene. Results indicated that

participants spent more than 33% of total viewing time looking at the expected or matched image; however, this effect did not carry over to the proportion of total fixations. This means that although participants spent more time overall looking at the expected image, they did not have as many fixations on the expected image compared to other images. A fixation denotes an instance when the participant's eye movements entered the region of interest for each image. This suggests that the participants had a greater number of total fixations on the unexpected images, but each fixation was shorter in time than the fewer fixations on the expected image (Hannula et al., 2007).

Richmond and Nelson (2009) tested 9-month old infants in a similar study. Infants are unable to make responses, so any eye movements they make are assumed to be free viewing and reflect relational memory. Again, the procedure was very similar, however infants were given no instructions. Results demonstrated that infants spent more than 33% of the time looking at the expected or matched image. This study noted that the expected image was counterbalanced in a manner so that it either appeared in the trial directly before the test or appeared two trials before the test. However, the study does not specify when the unexpected images appeared before the test; they only focus on counterbalancing the order of appearance for the expected image. This lack of detail makes the study difficult to evaluate and as noted in the spacing studies, it is important to know when both the expected and unexpected image appear and how long the delay is from each before the test is presented to fully interpret the results.

The majority of human experimentation in this area focuses on spontaneous-object recognition. Those who have used OICL tasks in humans (e.g. Hannula & Ranganath, 2009; Mahoney et al., 2018; Richmond & Nelson, 2009) have demonstrated that participants spend more time looking at the expected image, opposite to what is predicted by the associative model. This thesis will include an adaptation of object-in-context learning tasks in human experimentation and will test a Pavlovian manipulation known to impact learning, extinction, to test the associative model.

Spacing effects in spontaneous-object-recognition tasks will also be tested in human participants in this thesis. Evidence of spacing effects can help discriminate between the declarative and associative accounts, as these effects are not as clearly described from a declarative standpoint. The following section introduces some examples of spacing in human experimentation.

1.4.3 **Spacing Effects in Humans**

In addition to the above-mentioned spacing effects reported in non-human animal studies, there have been several examples of spacing effects in human experimentation as well. For example, Gatchel and Lang (1974) conducted a study measuring heart-rate and skin-conductance upon presentation of a moderately intense tone. They found that both responses habituated quicker with shorter ISIs when tested immediately after training (also see Raskin, Kotses, & Bever, 1969). In a similar study, Gatchel (1975) presented human participants with a tone, and heartrate

and skin conductance were measured. In this study, participants were split into two groups, one group had a 20-second ISI between tone presentations and the second group had a 100-second ISI. After subjects in both groups received 15 presentations of the tone in part one of the experiment, they were given a 15-minute rest before being presented with the tone again in part two of the experiment. After training was complete in part one of the study, participants in the short ISI group demonstrated greater habituation, however when presented with the tone in part two, this group demonstrated less habituation in comparison to the long ISI group (Gatchel, 1975). Similar to non-human animal results by Davis (1970), these findings suggest that a shorter ISI leads to better short-term habituation, whereas a longer ISI results in better long-term habituation.

Spacing effects have also been demonstrated in memory tasks in humans. Several studies suggest that information is better remembered when presented in spaced intervals compared to massed training (e.g. Crowder, 1976; Dempster, 1987; Glenberg, 1979; Melton, 1970). For example, in a study conducted by Greene (1989), participants were shown a list of words at a 10 second rate. Words were repeated with different spacing intervals of 0, 1, 2, 4, 8, or 16 trials between presentations. Words were either repeated 1, 2, 3 or 4 times. For all words repeated twice or more, participants were able to better freely recall words with longer spaces between repeats than words that were presented with shorter spaces (Greene, 1989).

The human spacing effects reported mirror the results observed in the non-human animal studies. There is a clear advantage of spaced training

compared to massed training. This provides support for the associative model of recognition memory, as this model predicts spacing effects. The declarative model does not predict these effects and cannot clearly account for results observed in spacing studies.

1.5 Aim of Thesis

Studies presented in the introduction provide a strong basis for Wagner's (1981) SOP account, as this account makes specific predictions about contextual learning and memory performance with spacing interval manipulations. Predictions made by the SOP model are not clearly predicted or explained by other accounts (e.g. the declarative account, Aggleton & Brown, 2006).

This thesis aims to test the associative model of recognition memory in humans by administering object-in-context learning tasks and investigating the effects of extinction on OICL and by administering spontaneous-object-recognition tasks and examining the effects of spacing. All of these tasks will be investigated in a comparable way to the explicit behavioural measures in non-human animal studies by using eye-tracking techniques.

CHAPTER 2

2 Object-in-Context Learning

Experiments that test object-in-context learning (OICL) are presented in this chapter. In OICL, rats are pre-exposed to two objects (A & B), each in their own context (respectively X & Y). In a test phase, they are presented to A and B in X, and they explore B more than A (e.g., Dember, 1956). In this chapter, results of computer-based versions of this task are reported. Both human adults and children were presented with animated dogs on patterned computer backgrounds (e.g., dog A on background X and dog B on background Y) before being tested with dogs A and B on background X. Analogous to the rat version of object-in-context learning, it was expected that people would orient to B relatively more than to A.

The results observed in OICL tasks can be explained by Wagner's (1981) SOP model. According to this model, when participants are pre-exposed to objects A and B in their respective contexts, X and Y, they form object-context associations because both the object and context have elements in the A1 activity state. During the test, when context X is presented, object A is primed into the A2 activity state because of the previously formed association. However, when object B is shown, it is unexpected, and its elements move into the A1 activity state. Therefore, object B elicits more exploratory behaviour.

There are several examples of OICL tasks testing rodents. For example, Dix & Aggleton (1999) tested rats in an object recognition task. In their task, X and Y served as the contexts and differed by wall colour (X: plain grey walls; Y: striped black and white walls) and floor type (X: sawdust floor; Y:

aluminium floor). The objects, A and B, were solid, heavy objects that could not be moved by the rats. Rats were exposed to four sample phases (two X→A and two Y→B) with a two-minute ISI. They then had a five-minute retention interval followed by the test phase (e.g. X with A and B). Each sample and test phase were three minutes long. Results demonstrated that rats were able to discriminate between expected and unexpected objects in each context. Rats spent a longer time exploring the unexpected object (e.g. greater exploration of B in X). This effect was present in the first two minutes of the three-minute test phase. This study provides evidence of OICL in rodents (also see Dellu, Fauchey, Le Moal, & Simon, 1997; Whitt, Haselgrove, & Robinson, 2012).

The majority of the experiments conducted in this area have tested rodents. There has been evidence of associative effects in recognition memory tasks in humans (e.g. Richmond, Sowerby, Colombo, & Hayne, 2004), although very few human recognition memory studies to date used OICL procedures. There have, however, been several human studies looking at novelty preference of individual items, for example, using SOR tasks. Richmond et al. (2004) used an SOR procedure with adult humans. Participants were first presented with two identical morphing faces during a training phase. They were later tested in either the same training context or in a novel context with a familiar and novel morphing face. Eye tracking results demonstrated that the novelty preference was impaired after a context change, meaning participants spent a comparable amount of time viewing the novel and familiar morphing faces. In the same context condition,

participants demonstrated a strong novelty preference. Results support associative predictions (Wagner, 1981).

There have been some studies using different tasks to look at relational memory, or the memory of how things relate to each other, which may be comparable to OICL. For example, Gronlund and Ratcliff (1989) presented participants with word pairs. Participants were then tested with previously studied pairs, new pairs created with words from two previous studied pairs, and some completely novel words (a novel pair or one novel word paired with a studied word). Participants were asked to indicate if the pair had previously been studied or not. Responses demonstrated that participants took longer to identify pairs created from two previously studied pairs than previously studied pairs and novel words (also see Donaldson & Rugg, 1999; Donaldson & Rugg, 1998; Humphreys, 1976). These tasks did not directly study novelty preference; however, they do suggest that it took longer to respond to new pairs created from previously studied pairs due to time allotted for associative retrieval. It is also important to consider how Wagner (1981) may explain these results. The new pairs created from previously studied pairs should be considered familiar, but unexpected to be presented in that pair. This means these pairs should be identified quicker, not slower.

There are also some studies that have directly tested associative properties of relational memory using OICL tasks with human participants. For example, Hannula and Ranganath (2009) first asked participants to study several face-scene pairs. Face-scene pairs consisted of a unique scene that covered the entire screen, with a face superimposed on top of the scene. During a test phase, participants were presented with a familiar scene and

three familiar faces from the study phase. One of the faces had previously been presented with that scene (expected) and two of the faces had never been previously presented with that scene (unexpected). Participants were instructed to indicate which face in the display had previously been presented with that scene. Eye-tracking results indicated that participants spent a disproportionate amount of time viewing the expected faces in the three-face display (also see Hannula et al., 2010; Mahoney, Kapur, Osmon, & Hannula, 2018). This is opposite to what is predicted by the associative model, which predicts that participants would spend more time viewing the unexpected stimuli (Wagner, 1981). It is important to note that participants' viewing of the expected face did correlate with response accuracy. It was initially argued that the instructions for this task may have biased looking behaviour, as participants were explicitly told to locate the expected face, which may have directed eye movements, however, later there was work demonstrating this explanation was not correct. Hannula et al. (2007) used a very similar procedure, however participants were given 'free viewing' instructions rather than being told to locate the face that was previously paired with the scene. Eye-tracking results from this study indicated that participants still spent a disproportionate amount of time viewing the expected faces (also see Richmond & Nelson, 2009).

Previous demonstrations of OICL tasks in humans indicate that participants spent more time looking at the expected stimulus, which is the opposite to what the associative account would predict. It is therefore important to replicate these studies to test the SOP model. OICL tasks in this thesis allow for 'free viewing' of the stimuli and there is only one unexpected

and one expected stimulus on each test trial. Viewing times towards each stimulus type (expected and unexpected) are directly compared to one another in the analyses. These changes in procedure do not provide an explanation for why prior studies suggest participants spent more time viewing the expected image. One thing to consider, however, is the use of face stimuli in previous studies. There have been many studies suggesting that faces are special and do not behave like normal cues. For example, Yue, Tjan, and Biederman (2006) suggest that the neural representation for faces may be fundamentally spatial, which affects performance when faces are used as stimuli when compared to non-face objects (also see, e.g. Biederman & Kalocsai, 1997; Galper, 1970; Leder & Bruce, 2000; Tanaka & Farah, 1993; Yin, 1969). Studies in this thesis use animal images in place of face stimuli.

Studies in this thesis were administered in a more similar way to the studies conducted with non-human animals. An eye-tracker was used to measure dwell times (total time spent looking in the same area) towards two images presented on a computer screen. The aim of this chapter was to adapt the OICL task for human participants and find support that similar findings (greater orientation towards the unexpected object) are observed in humans.

Basic OICL has to first be demonstrated using the OICL experimental procedures presented in this chapter before manipulations can be tested (e.g. extinction) in subsequent experiments. Recognition memory can be explained by the episodic memory account (e.g. Aggleton & Brown, 2006), however effects from manipulations to the task (e.g. extinction) are not clearly explained by the episodic account.

Both human children and adults were tested in OICL tasks. There is no specific reason to predict that children will perform differently to adults in OICL tasks, however, children have shown difficulties in learning in other tasks. For example, children learned worse than adults on choice tasks where feedback is important (Hämmerer, Li, Müller, & Lindenberger, 2011). In addition, children were worse than adults at identifying relevant feedback (Crone, Jennings, & Van Der Molen, 2004), and when feedback is not consistent, children also performed worse than adults (Eppinger, Mock, & Kray, 2009). When asked to discriminate between a stimulus that predicts an aversive outcome and one that does not, many studies suggest that children perform worse than adults (e.g. Glenn et al., 2012; Jovanovic et al., 2014; Lau et al., 2011; A. Waters, Theresiana, Neumann, & Craske, 2017), although some studies do not find this difference in performance (e.g. Craske et al., 2012; Waters, Henry, & Neumann, 2009). There was also no difference between child and adult performance in a Pavlovian-to-instrumental transfer task (Alarcón & Bonardi, 2020). In addition, infants and adults both showed the same non-associative pattern of results in the OICL tasks discussed (Hannula et al., 2007; Richmond & Nelson, 2009). As demonstrated, there are some studies suggesting that children perform differently in learning tasks, and some that find no differences in child and adult performance. Therefore, Experiment 1 tested for OICL in children and Experiment 2 replicated this study using adult participants to examine if children and adults demonstrate the same learning effects in this task.

2.1 Experiment 1

Experiment 1 is an adaptation of the object-in-context learning tasks preformed in studies using rodents (e.g. Dix & Aggleton, 1999). Instead of using physical objects placed in apparatuses, images were created and were presented on computer backgrounds. An eye-tracker was used to measure dwell times during stimulus presentation. Participants were pre-exposed to two images (A & B), on different computer backgrounds (respectively X & Y) in the study phase. During the test phase, participants were presented with A and B in X. It was expected that participants would spend more time looking at B than at A.

It was important to follow this design instead of using the design seen in previous OICL tasks in human experimentation (e.g. Hannula & Ranganath, 2009; Richmond & Nelson, 2009), as this procedure allows a more direct comparison to the animal studies. Similar to non-human animal studies, participants were presented with two images during the study (e.g. AA) and test (e.g. AB) trials, making the trial appearance consistent.

This experiment tested OICL in children because the University of Nottingham hosts an annual event, giving access to this participant group. Experiment 1 aimed to provide evidence of object-in-context learning in humans using the current experimental design so that manipulations can later be tested.

2.1.1 **Method**

2.1.1.1 Participants

Fifty children (26 females, 24 males) from the University of Nottingham Spring Scientist Week, ages 5 to 11 (M= 8.72, SD = 1.83) participated in the experiment. Children received a ticket to play a game for participating in the study. Participants were naive to the experimental aims and hypotheses and were required to have normal or corrected-to-normal vision. Parental consent was obtained from all participants and debriefing documents were given upon completion of the event. A minimum of 80% of eye movements had to be recorded from each participant. If this criterion was not met, participants were excluded from the analyses.

2.1.1.2 Apparatus and stimuli

The current experiment was run using a Python user interface and PsychoPy software (Peirce, 2007) on a Tobii TX300 eye-tracker (Tobii, 2010) with a 28 (height) x 51 (width) cm monitor. Participants were situated approximately 60 cm away from the screen.

Stimuli consisted of four animated dogs that were created using copyright free GIFs downloaded from giphy.com. Six serial images from each GIF were used to create short animations. All the images were 10cm x 13cm and were 25cm apart (each 12.5cm from the centre on the horizontal plane). The regions of interest were set to be the same size as the dog stimuli. The dogs were presented on four different colourful computer backgrounds, which were set to cover the entire screen (28 x 51cm; see Figure 2). The same dog was presented on the left and right during training, as seen in Figure 2. Test

trials were the same as training trials, except two different dogs were presented, one expected and one unexpected, on each particular background. The different trial types appeared in a random order in both phases. The location of the unexpected and expected dogs during the test trials was counterbalanced (left/right) as well as the background on which each dog was presented during the training phase. There were two different counterbalanced sub-groups of the experiment created so that each dog was presented on two different backgrounds in the training phase (e.g. dog A was on context 1 in version 1 and on context 2 in version 2).



Figure 2: *A possible training trial on the Tobii TX300 eye-tracker. The other three possible dogs and backgrounds can be seen to the left.*

2.1.1.3 Procedure

All children were tested on a Dell PC computer equipped with a Tobii TX300 eye-tracking device running at a 60 Hz sampling rate. The Tobii eye-tracker was fixed onto the screen, allowing participants to sit freely in front of the device. Ocular movements from the left and right pupils were tracked throughout the course of the experiment, however it was of particular interest to monitor gaze in the regions of interest during stimulus presentation. A region of interest (ROI) is a specific sub-region of the screen that is observed in the dataset. A ROI is the area of interest to analyse; in this experiment, the ROIs were set to the locations of the dog stimuli. Other regions of the screen, such as the computer background, were not of interest for analysis purposes. The regions of interest were defined in PsychoPy using the geometric shape function to create transparent squares the same size as the stimuli. Left and right frame counts were also created using PsychoPy code, which measured the duration the participant's gaze was in each region of interest for each trial. The count increased by one on each frame refresh when the eye gaze was overlapping with a region of interest. Dwell time can be measured by using the number of frames spent in each region of interest. PsychoPy was connected to the Tobii eye-tracker via the Input-Output Hub, allowing eye movements and frame counts to be recorded to the PsychoPy output files.

This was a within-subjects design, so all children completed both training and testing phases in the experiment. Before the experiment began, the eye-tracker was calibrated. Calibration allows the eye-tracker to be fully customised to each participant's eye movements to allow for an accurate gaze point calculation. This process consisted of having participants fixate on a

series of five targets in the visual display. Calibration was repeated if measurement accuracy was poor. After the machine was successfully calibrated, participants were given written and verbal instructions. Children were told to carefully watch the images that were presented on the screen because they would be given a short memory test upon completion. They were also told that if they received a perfect score on the memory test, their name would be placed on the leader board at our 'Pick-a-Pet' game station.

In the training phase, participants were pre-exposed to all of the stimuli. Each of the four dogs were presented on their respective backgrounds (dog A on context 1, dog B on context 2, dog C on context 3, and dog D on context 4). To begin each trial, participants first fixated on a smiley face in the centre of the screen for one second. Children were then presented with two identical dogs on a colourful background, one on each side of the screen (left and right; see Figure 2 for an example training trial). Each of the six serial images that formed the GIF was on the screen for 0.3 seconds, equalling a total of 1.8 seconds for each dog per trial. There was then a blank grey screen presented during the inter-trial-interval (ITI) of 2 seconds, before the next trial's smiley face fixation commenced (see Figure 3). Every participant completed 48 learning trials. They therefore received each training combination (e.g. dog A on context 1) twelve times. After all of the training trials were presented, the test phase commenced immediately, with no breaks.

Training		Testing	
Context	**Dog**	**Context**	**Dog**
1	AA	1	A**B**
2	BB	2	**A**B
3	CC	3	C**D**
4	DD	4	**C**D

Table 2: *The design for Experiment 1. The bold letters in red indicate the unexpected dog in each trial type during the test phase; this is where participants were expected to orient their gaze.*

Test trials were the same as training trials, except participants saw two different dogs instead of two identical dogs. Each background from training was presented with the familiar dog to that context (expected) and one equally familiar but unexpected dog (see Table 2). For example, context 1 was shown with dogs A (expected) and B (unexpected). Dogs A and B were paired together on contexts 1 and 2 and dogs C and D were paired together on contexts 3 and 4 during the test, which made a total of four different test trial types. Each participant completed 32 test trials and were therefore presented with each testing combination (e.g. dogs A & B on context 1) eight times (dog A would be on the left 4 times and on the right 4 times). The entire experiment lasted approximately six minutes. Figure 3 shows an example test trial, where the unexpected dog is on the left and the expected dog is on the right. Participants were predicted to spend a longer time looking at the unexpected dog on the left.

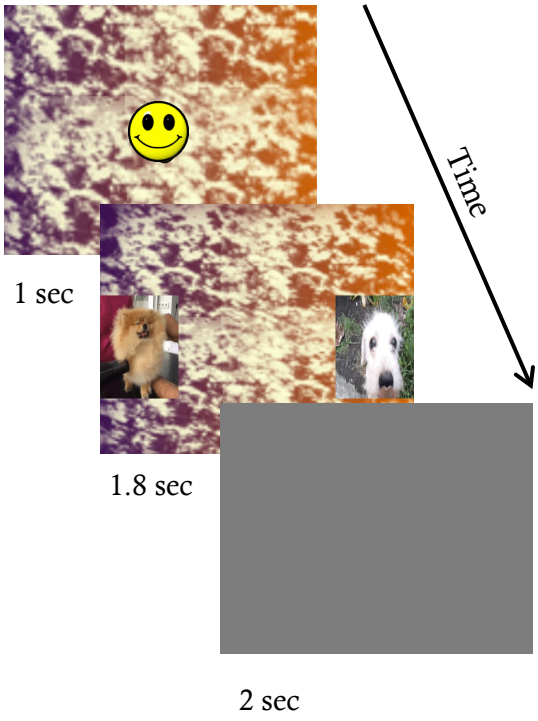


Figure 3: *Example test trial. Each training and test trial included fixation (1 sec), stimulus presentation (1.8 sec) and an ITI (2 sec).*

After the experiment was finished, a memory test was administered. This allowed the children to play the game aspect of the experiment. For this test, children were shown images of the original dog stimuli and random filler images. They had to indicate if they saw each image during the study or not. All four of the dogs from the experiment were used in the memory test, as well as four additional animal images. Results from the test were not included in the analysis, as it was only administered to motivate participants to watch the screen throughout the entire task and to allow them to have a physical task to perform.

2.1.2 **Data Treatment and Analyses**

Training data will not be presented, as all participants attended to the screen for a minimum of 80% of the time, suggesting that participants attended to the stimuli. In addition, stimuli were counterbalanced, meaning that there are no concerns about stimulus differences.

Test performance was expressed in dwell time (ms) towards unexpected and expected stimuli. Greater orientation towards the unexpected stimulus suggests a novelty preference. Trials have been binned into 8-trial blocks to demonstrate how the effect changes over the course of the experiment. Data were analysed using a repeated-measures analysis of variance (ANOVA). η_p^2 and 90% confidence intervals were given for the main effects and interactions in the ANOVAs. For an ANOVA, a small effect size (η_p^2) is considered .01, a medium effect is considered .06 and a large effect is considered .14 (Cohen, 1988; Miles & Shevlin, 2001). 90% confidence intervals were computed in RStudio using the MBESS package (Kelley, 2007). All significant interactions were explored using simple main effects analyses; η_p^2 and 90% confidence intervals were also reported for significant simple main effects. In all analyses, the significance level α was set to 0.05, so any analyses with a $p<.05$ were considered to be significant.

Groups sizes were determined by conducting a power analysis in G Power (Faul, Erdfelder, Lang, & Buchner, 2007). The G Power parameters were set to measure the sample size required with an effect size f of .25 (calculated based on a medium effect size, $\eta_p^2 = .06$), an α error probability of .05 and

power was set to .80. It was determined that a minimum of 7 participants would be required in Experiment 1, which includes 32 test trials.

2.1.3 **Results and Discussion**

All participants' eye movements were calculated by the Tobii eye-tracking software, Tobii Studio (Tobii, 2010). The software provides a percentage for each participant, detailing the amount of time the machine was able to track the participants eyes throughout the task. Participants were required to have a minimum of 80% of eye movements recorded to be included in the analysis. This is a common cut-off used in other eye-tracking studies (e.g. Le Pelley, Beesley, & Griffiths, 2011). All participants met this criterion, so there were no exclusions in this experiment. Participants were presented with expected and unexpected images over four blocks of trials (independent variables) and dwell time (dependent variable) was measured. Participants spent more time looking at unexpected images than at expected images, demonstrating an associative OICL effect. This effect appeared to be strongest in the first block of trials, and less apparent in blocks 2-4 (see Figure 4).

A 2x4 repeated measures Analysis of Variance (ANOVA) was run with the factors stimulus type, unexpected or expected dog, and trial block; the trials were binned into four blocks of eight trials. A main effect of stimulus type, $F(1,49) = 5.40$, $p = .024$, $\eta_p^2 = .101$, 90% CI [.007, .239], was found, indicating that the stimulus type, unexpected or expected, had an effect on looking behaviour. There was no main effect of trial block, $F(3,47) = 1.27$, $p = .288$, $\eta_p^2 = .026$, 90% CI [0, .168]. However, there was an interaction between stimulus type and trial block, $F(3,47) = 3.28$, $p = .023$, $\eta_p^2 = .064$,

90% CI [.010, .292], indicating that participants' looking behaviour changed throughout the course of the experiment. Dwell time decreased throughout the experiment with block one having the longest overall dwell time (M= 1780.72 ms) and gradually decreasing over time (block four M= 1639.34 ms). This is likely due to habituation taking place and causing a decrease in dwell time.

Simple main effects suggest that participants were initially spending more time looking at the unexpected image than the expected image in the first block of trials, $F(1,49) = 15.29$, $p < .001$, $\eta_p^2 = .238$, 90% CI [.081, .386]. There were no differences in dwell times towards the unexpected and expected images in blocks 2-4 (ps>.1).

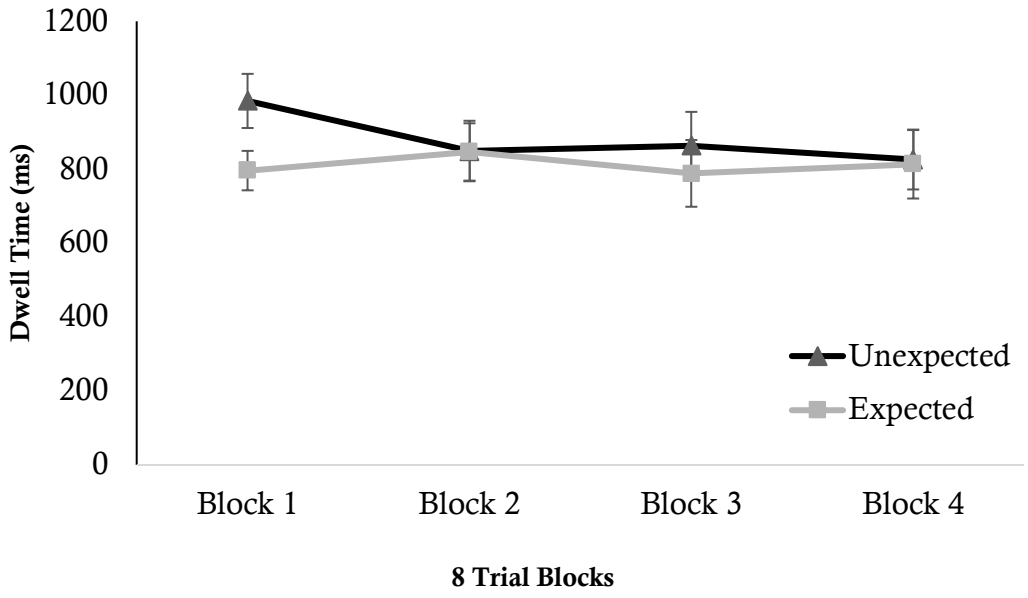


Figure 4: *Mean dwell times towards unexpected and expected stimuli across 8-trial blocks. Participants spent a longer time looking at the unexpected image than the expected image in the first block of trials. All stimuli were presented for 1800ms, therefore a mean dwell time of 900ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

The results from this experiment demonstrate an associative OICL effect in the first block of trials (Brandon et al., 2003). Unlike results seen in previous OICL tasks in humans (e.g. Hannula & Ranganath, 2009; Mahoney et al., 2018; Richmond & Nelson, 2009), participants spent more time looking at the unexpected image. This is what is predicted by the associative account. Therefore, results from previous studies may have shown a disproportionate amount of time viewing the expected image due to the different experimental design. The current experiment was designed in a more similar way to the non-human animal OICL studies, using the

traditional procedure of presenting two identical items in each context during the study phase and presenting each context with two equally familiar items, one expected and one unexpected in the test phase. The comparable, free-viewing human studies had some notable differences. For example, study phases included one image on each background and test phases included 3 images (Hannula et al., 2007; Richmond & Nelson, 2009). In addition, Hannula et al. (2007) included fewer, longer trials; there were six test trials that were comparable to the test trials used in this experiment (other test trials included completely novel images or all unexpected images) and they were 10 seconds long. Results do however demonstrate that the disproportionate amount of viewing time is greatest in the first 2 seconds, which is comparable to the trial durations used in this experiment. One important difference to note is that although Hannula et al. (2007) included free-viewing instructions before the test phase, participants were told to commit each face-scene pair to memory so that they would be able to identify the match between a particular face and the associated background scene before the study phase. This may have affected eye movements during the test phase. However, Richmond and Nelson (2009) also found a greater proportion of time spent viewing the expected images with infants, who were unable to receive verbal instructions before the study or test phases due to their young age, suggesting their responses were truly automatic. There are no notable differences that would cause the observed change in results; however, it may simply be due to the slight differences in procedure or the use of face stimuli, which as previously discussed, may affect participant performance (Yue et al., 2006).

Experiment 1 results suggest that children were able to discriminate unexpected from expected stimuli in each particular context. The effect was only present in the first block of trials. This experiment suggests evidence for object-in-context learning in humans; however, it was also of interest to see if this effect could be replicated in adults. As previously discussed, there are some studies suggesting that children and adults may perform differently in learning tasks (e.g. Crone et al., 2004; Hämmerer et al., 2011), so it was important to test adults in the same OICL task to replicate this result. In addition, all subsequent experiments in this thesis will use an adult participant sample, so it was necessary to replicate this result in adults before manipulations could be applied.

2.2 Experiment 2

In the previous experiment, child participants were tested due to access to that participant group at the University of Nottingham's spring and summer scientist week events. Throughout the year, children are typically more difficult to recruit, so subsequent experiments will use adult samples. It was therefore important to replicate this effect in adults before applying manipulations. Experiment 2 intended to replicate Experiment 1 in an adult sample. This experiment aimed to test if adults performed in the same way to children in Experiment 1. The same task as in Experiment 1 was used. It was predicted that again participants would spend a longer time looking at the unexpected dog in the object-in-context learning task.

2.2.1 **Method**

2.2.1.1 Participants

Thirty-three undergraduate students from the University of Nottingham participated in the experiment. Five participants had to be excluded, as they failed to understand the instructions due to difficulty with the English language, so twenty-eight (18 females, 10 males) participants, ages 19 to 44 (M= 24.69, SD = 4.65) were included in the analyses. A £3 inconvenience allowance was provided upon completion of the study. Participants were naive to the experimental aims and hypotheses and were required to have normal or corrected-to-normal vision. Consent was obtained and debrief forms were given to all participants. The same eye-tracking criterion as in Experiment 1 was applied in this experiment.

2.2.1.2 Apparatus and stimuli

Everything was conducted in the same way as in Experiment 1 unless otherwise stated (see stimuli in Figure 2).

2.2.1.3 Procedure

This was a replication of Experiment 1 (see Experiment 1 Method) with minor changes. The number of test trials was reduced, as the previous experiment demonstrated that the effect decreased significantly after the first block of eight trials. In the current experiment there were 48 training trials and 16 test trials. Each participant was presented with each training combination (e.g. dog A on context 1) 12 times and each testing combination (e.g. dogs A & B on context 1) four times.

Again, participants were given a memory test after the computer task. The test included seven short answer and true/false questions. This test was only included to help participants maintain motivation and attention and, therefore, was not included in the analyses.

2.2.2 **Data Treatment and Analyses**

Data were treated and analysed in the same way as in Experiment 1 (see Experiment 1 Data Treatment and Analyses section). The G power analysis was conducted using the same parameters; it was determined that a minimum of 11 participants were required in Experiment 2, which had 16 test trials.

2.2.3 **Results and Discussion**

A minimum of 80% of eye movements was recorded from all participants, so there were no additional exclusions in the analyses based on this criterion (Le Pelley et al., 2011). Consistent with the first block of Experiment 1, participants spent more time looking at unexpected images than at expected images. This effect was also most profound in the first block of trials. The difference between unexpected and expected dwell times in Block 1 does appear to decrease in Block 2 (see Figure 5).

A 2x2 repeated measures ANOVA was run. Factors included stimulus type, unexpected or expected image, and trial block. A reliable main effect of stimulus type, $F(1,27) = 8.16$, $p = .008$, $\eta_p^2 = .232$, 90% CI [.038, .421], was found, indicating that the stimulus type, unexpected or expected, had an effect on dwell time.

The main effect of trial block was also reliable, $F(1,27) = 15.31$, $p = .001$, $\eta_p^2 = .362$, 90% CI [.123, .532], however there was no interaction between stimulus type and trial block, $F(1,27) = 2.45$, $p = .129$, $\eta_p^2 = .083$, 90% CI [0, .131].

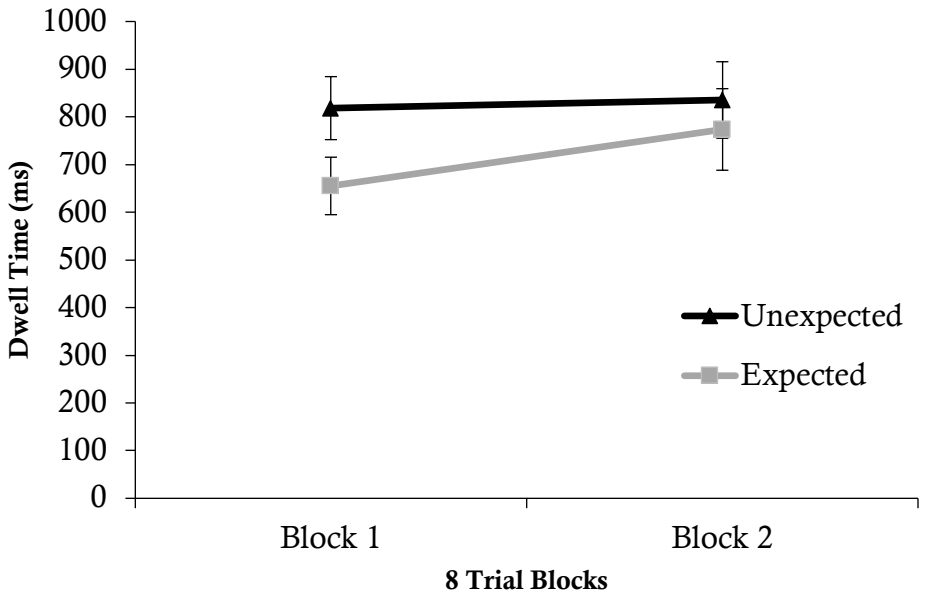


Figure 5: *Mean dwell times for the unexpected and expected stimuli for each test block of Experiment 2. Participants spent a longer time looking at the unexpected stimuli and this effect was stronger in the first block of trials. All stimuli were presented for* ***18****00ms, therefore a mean dwell time of* ***9****00ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

As in the first block of Experiment 1, participants spent a longer time looking at the unexpected stimuli in this experiment. Although there was not a statistically significant interaction, the numerical difference between unexpected and expected dwell time was greatest in the first block of eight trials, demonstrating that it decreased rapidly in both experiments. Experiment 2 results demonstrate that the current OICL task can be replicated using an adult sample.

2.3 Chapter Discussion

Together, Experiments 1 and 2 offer support for associative OICL effects in humans, both children and adults. Unlike previous learning experiments (e.g. Glenn et al., 2012; Jovanovic et al., 2014), experiments in this chapter showed a parallel pattern of results, suggesting that children and adults perform in a similar way in OICL learning tasks. This is comparable to Alarcón and Bonardi (2020) who found that children and adults perform similarly in a learning task, specifically a Pavlovian-to-instrumental transfer task. The OICL effect found in Experiments 1 and 2 can be explained by Wagner's (1981) model. This model states that object-context associations are formed during training, when both the object and context have their elements in the A1 activity state. During the test, when presented with the context, the expected object's elements are primed into the A2 activity state, whereas the unexpected object's elements move into the A1 activity state. The participant therefore orients more towards the unexpected object.

However, this effect can also be explained by the declarative account (Aggleton & Brown, 2006). This account would suggest that participants are able to familiarise and encode both object-context pairs during training. Participants would learn which object belongs in each context and store the pairs in memory for later recollection. During the test, the participant would recognise both objects, however, fail to recall that the unexpected object was previously seen in that context. Therefore, the unexpected object would receive more attention. This is a valid explanation of OICL, so it is not yet possible to decide which account is better at explaining recognition memory.

It is also important to note that OICL effects may also be explained by generalisation decrement (e.g. Hull, 1943; Lovibond, Preston, & Mackintosh, 1984; Wheeler, Amundson, & Miller, 2006). If participants learn X→A and Y→B associations during training, and are later tested with X→AB, this account explains that participants may experience B different in context X than in context Y. It is assumed that the image and context interact and because the stimulus is perceived differently, it may be perceived as a partially new stimulus and therefore elicit stronger exploratory behaviour.

This explanation cannot be completely disregarded (e.g. Hall, 1991), although there are some arguments that OICL effects are still present when measures have been taken to reduce potential generalisation decrement explanations (Whitt et al., 2012). Whitt et al. (2012) used a strategy reported by Honey et al. (1998) to reduce any potential generalisation decrement explanation. This strategy was to present the context and objects serially rather than simultaneously. Doing this ensured that the cue that served as a context and object were not presented at the same time, so it was less likely that B would be perceived differently on test trials with context X than in the previously explained example. OICL effects were still observed and were less likely to be explained by an account of generalisation decrement, so were suggested to be explained by the associative account (Brandon et al., 2003). This demonstrates that OICL may be explained by the associative account rather than by generalisation decrement in some scenarios, suggesting the associative analysis is valid. This study does not eliminate generalisation decrement as a possible explanation for the results presented in this chapter, which may not be possible to do.

Previous examples of OICL in human experimentation have shown the opposite effect, suggesting that participants spent a disproportionate amount of time looking at the expected images (e.g. Hannula & Ranganath, 2009; Mahoney et al., 2018; Richmond & Nelson, 2009). Some of these studies asked participants to locate the previously associated image on each test scene. This may have caused participants to spend a greater amount of time viewing the expected image, as they were instructed to locate this image. Other studies did allow participants to freely view the stimuli, however the same results were observed. As previously noted, there are no obvious differences between previous studies and studies in this chapter that would explain the opposite results observed. However, in the current experiments, participants were instructed to freely view the images and the procedure was more similar to procedures used in non-human animal studies. Results from experiments in this chapter indicated that participants spent a longer amount of time viewing the unexpected image, suggesting that the changes made to the experimental design may have affected the pattern of results observed. It is also possible that the use of face stimuli may have affected the results in previous studies; as noted, faces are considered to be special and can have an effect on participant performance (Yue et al., 2006).

The decrease in novelty preference observed in Experiments 1 and 2 is also present in rodent studies. Dix and Aggleton (1999) reported that rats initially spent more time exploring the unexpected object at test, however this response decreased over time. By the third minute of the test phase, rats no longer demonstrated a preference towards the unexpected object. Participants in Experiments 1 and 2 also showed a much stronger novelty preference in

the first block of test trials, which quickly decreased over time. One explanation for this decrease in novelty preference is that participants are habituating to the unexpected stimuli and eventually stop responding to them. This is completely consistent with predictions from Wagner's (1981) SOP model. When first presented with a test trial, participants spend more time looking at the unexpected image, as the elements for the image are able to enter the A1 activity state, whereas the background primes the elements for the expected image into the A2 activity state due to an association formed during training. When the participant is presented with the unexpected image on the background in early test trials, both have their elements in the A1 state, where they are able to form a new association. After several test trials, the background will eventually be able to prime both the previously unexpected and the expected images' elements into the A2 state, and a decrease in response is observed in later test trials.

The next chapter will apply a Pavlovian manipulation, extinction (e.g. Pavlov, 1927), to the OICL task from this chapter. If the context is repeatedly presented alone after the study phase, without the dog animations from training, orientation towards the unexpected dog at test is expected to diminish. The object-context associations are extinguished, so both of the dogs presented at test are able to elicit looking behaviour, as both dogs' elements will be able to enter the A1 activity state; the associative explanation for this theory will be further explained in the next chapter.

CHAPTER 3

3 Extinction

In the previous chapter, OICL tasks were adapted for human participants. Data were presented, demonstrating that associative OICL effects are present in both children and adult humans. In order to test the associative model, experiments in this chapter attempt to extinguish OICL. Extinction is a Pavlovian manipulation that is known to affect learning (Pavlov, 1927). In extinction tasks, first the participants are trained to form associations, as in the OICL tasks. To extinguish learning, the CS is presented alone repeatedly. This causes inhibitory learning between the CS and the US, until eventually there is little or no responding when the CS is presented. There is also an operant explanation of extinction, which suggests that removing reinforcement for a response will result in extinction (Skinner, 1979). Both the Pavlovian and operant definitions of extinction suggest that presenting a predictor in absence of the associated outcome will result in a reduction in responding.

There have been several demonstrations of extinction in many different species since original studies from Pavlov (1927). This is a well-studied, robust effect that has been documented in the literature for decades (see e.g. Capaldi, 1966; Shipley, 1974; Rescorla, 2003; Orsini & Maren, 2012). A very recent example is demonstrated by Chan and Harris (2017), who presented rats with either white noise or a steady light followed by food pellets in a training phase. Rats head entry into the food magazine was observed. All rats learnt that the white noise or steady light predicted food. After successful training, the white noise or steady light was presented without the

administration of food to extinguish the learnt behaviour. After extinction training, rats showed very little responding to the steady light or white noise, demonstrating that extinction was successful (Chan & Harris, 2017).

There are also several important factors of extinction to note. First, extinction has been shown to be context specific, suggesting that original conditioning and extinction training have to occur in the same context for extinction to be successful (Bouton, 1993, 2002), and if extinction occurs in one context then is later tested in a different context, there may be a response recovery (Bouton & Bolles, 1979b). In addition, extinction is not a demonstration of forgetting or unlearning, as it can return with experimental manipulations, such as spontaneous recovery, reinstatement or renewal (Bouton, 2004). Extinction has also been seen to be influenced by the strength of the original conditioning and the number of extinction trials administered (Byrne, 2007; Denniston, Chang, & Miller, 2003; Tamai & Nakajima, 2000).

In OICL tasks, object-context associations are formed during training. After training, the participants demonstrate a greater dwell time towards the unexpected object in each context. If the context is repeatedly presented alone, without the object, extinction can occur. Extinction is a prediction of the SOP model (Wagner, 1981; Wagner & Brandon, 1989, 2001). When the background is presented alone, the previous formed association activates the elements for the dog into the A2 activity state. When the elements for the background are in the A1 state and the elements for the dog are in the A2 state, an inhibitory connection is formed. On every trial that the background is presented alone, this inhibitory relationship is strengthened. Eventually, the context will no longer prime the object. Wagner (1981) explains how the

excitatory and inhibitory associations counteract one another, as the excitatory association primes the object's elements into the A2 state, whereas the inhibitory association prevents the object's elements from entering the A2 state, therefore this results in no effect. After an inhibitory relationship is formed between the background and the previously expected dog, and the dog is reintroduced alongside the previously unexpected dog, there is little or no looking preference, as the elements for both dogs are able to enter the A1 activity state.

Extinction is not explicitly predicted by the declarative model (Aggleton & Brown, 2006), however it is possible to create an explanation using this account. One could say that when participants are exposed to the extinction phase (contexts presented alone), they are introduced with a new episode to remember. When presented with the test phase (context presented with objects A & B), the participant will be able to recognise the context as familiar. They will be able to recall that context with the expected object, however they will also be able to recall that context being presented alone, causing retrieval interference. Because the more recent episode contained the context being presented alone, the participant may explore the previously expected object, surprised that it reappeared.

Although both accounts can explain extinction, the associative model (Wagner, 1981) is able to do so naturally, whereas the episodic account required assumptions to be made in order to explain extinction effects. The experiments in this chapter aim to test the associative model of recognition memory, by attempting to extinguish OICL. If four context-image pairs are formed during training, and two are extinguished, the remaining contexts

should be unaffected by the extinction training. This is one way to test extinction using the current OICL task. After OICL training occurs, there should be four context-image pairs (context 1- dog A; context 2- dog B; context 3- dog C; and context 4- dog D). During an extinction phase, contexts 1 and 2 are repeatedly presented alone, without dogs A and B. Then during test, contexts 1 and 2 are presented with dogs A and B, where there is expected to be no looking preference, as both dogs will be able to enter the A1 activity state. Contexts 3 and 4 are presented with dogs C and D, where participants are expected to look at the unexpected dog in each context. The unexpected dog will move into the A1 activity state, whereas the expected dog will be primed into the A2 activity state. Participants are expected to look at dog D on context 3 and dog C on context 4, as in Experiments 1 and 2 (OICL effect).

3.1 Experiment 3

Experiment 3 was a continuation of Experiment 2. After participants completed the training and test phases in Experiment 2, they moved on to complete two additional phases (Experiment 3) in attempt to extinguish object-in-context learning. First, there was an extinction phase, where two contexts were repeatedly presented without the dog stimuli. This was followed by a test phase, identical to the test in Experiment 2, to test if extinction had been successful. Chapter 2 suggests evidence of object-in-context learning in humans, as both child and adult participants spent more time viewing unexpected images during the test phases of Experiments 1 (block 1) and 2. Results from these studies do not allow the episodic memory account to be dismissed. In order to test the associative model of object-in-context learning, extinction was tested. It is important to note that because the contexts were already presented with the expected dog and an unexpected dog in the test phase in Experiment 2, the context-object associations may have already been extinguished. This may cause the current experiment to be ineffective, as all associations may have already been extinguished, which would result in there being no differences in looking behaviour in the test phase of this experiment.

3.1.1 **Method**

3.1.1.1 Participants

The same participants as in Experiment 2 were used in this experiment (see Experiment 2 method).

3.1.1.2 Apparatus and stimuli

The same stimuli as in Experiment 1 were used for this experiment (see Figure 2), with an additional two stimuli for the extinction phase (see Figure 6). Two new cat stimuli were used in the extinction phase to prevent boredom. Cat GIFs were included instead of presenting the background alone during the extinction phase. This also made each trial consistent, as there were always two images present on the screen. The cat animations were created in the same way as the dog animations in the previous experiments.



Figure 6: *Example extinction trial on the Tobii TX300. The other possible extinction stimuli can be seen to the left. Each participant had new stimuli (cats) presented on two of the four backgrounds during the extinction phase.*

3.1.1.3 Procedure

The first two phases were completed in Experiment 2. Participants from Experiment 2 completed two additional phases, an extinction phase (phase 3) and a second testing phase (phase 4), which are reported in the current experiment. The extinction phase was analogous to the training phases in previous experiments, except on two of the four backgrounds, the dogs were replaced with cats, as seen in Table 3. This phase was an attempt to extinguish two of the four previous associations made with the backgrounds and the dogs formed in the learning phase (from Experiment 2; e.g. context 1→dog A). In the fourth phase, a second test, identical to the test phases in previous experiments, was administered to see if participants had extinguished the associations made in phase one (see Table 3).

Extinction		**Test 2**	
Context	**Cat**	**Context**	**Dog**
1	EE	1	AB
2	FF	2	AB
		3	**CD**
		4	**CD**

Table 3: *Design for Experiment 3. This experiment was a continuation of Experiment 2 and directly followed Experiment 2 without any breaks. Participants completed an extinction phase and a second test phase in this experiment. The bold letters in red indicate which stimuli participants were expected to look at longer.*

This experiment directly followed Experiment 2, with no breaks. The trial order and timings were the same for the extinction (phase 3) and final test (phase 4) phases. Participants were told to carefully watch the images that were presented on the screen because they would be given a short memory test upon completion of the experiment. The test was administered after all four phases were completed to maintain motivation and attention. The test included seven short answer and true/false questions and was not included in the analyses.

The location of the unexpected and expected dogs (left/right) during the test phase, and the background on which the dogs appeared during the training phase were counterbalanced in the experiment. Also, the backgrounds that were extinguished (two of the four backgrounds) were counterbalanced across participants. There were four different sub-groups of the experiment created for counterbalancing.

Every participant completed a learning phase of 48 trials (Experiment 2), a testing phase of 16 trials (Experiment 2), an extinction phase of 32 trials, meaning each trial type was presented 16 times (current experiment) and a second testing phase of 16 trials, meaning each possible trial type was presented four times (current experiment), to make a total of 112 trials. These experiments took approximately 30 minutes total to complete.

3.1.2 **Data Treatment and Analyses**

Data were treated and analysed in the same way as in Experiment 1 unless otherwise stated (see Experiment 1 Data Treatment and Analyses section). Sample sizes were determined by conducting a power analysis; it was determined that a minimum of 11 participants would be required in the extinction tasks with 16 test trials; all other input parameters were the same as previous power analyses (Faul et al., 2007). In this experiment, data are expressed in dwell time (ms) and split into two conditions, extinction and no extinction. This was a within-subjects design, so all participants received extinction training on half of the contexts and data are presented for both conditions. Data were not binned into 8-trial blocks because each trial type was only presented four times, making binning unnecessary.

3.1.3 **Results and Discussion**

Before discussing the results from the extinction test, it is important to note that although there was a small OICL effect from the unextinguished test in Experiment 1, this effect was very small and no longer present in the last block of trials (see Experiment 1 Results and Discussion). It can therefore be argued that there was not an effect to eliminate. Results from phase four, the second test phase, demonstrated no effects of extinction. There were no differences in dwell times on trials that included contexts that were presented in the extinction phase compared to those containing contexts that were not extinguished (see Figure 7).

A 2x2 repeated measures ANOVA was run, including stimulus type (unexpected/expected) and trial type (extinction/no extinction). There was

no main effect of stimulus type, $F(1,27) = .05$, $p = .832$, $\eta_p^2 = .002$, 90% CI [0, .783], no main effect of trial type, $F(1,27) = .14$, $p = .711$, $\eta_p^2 = .005$, 90% CI [0, .113], and no interaction, $F(1,27) = 2.10$, $p = .159$, $\eta_p^2 = .072$, 90% CI [0, .250].

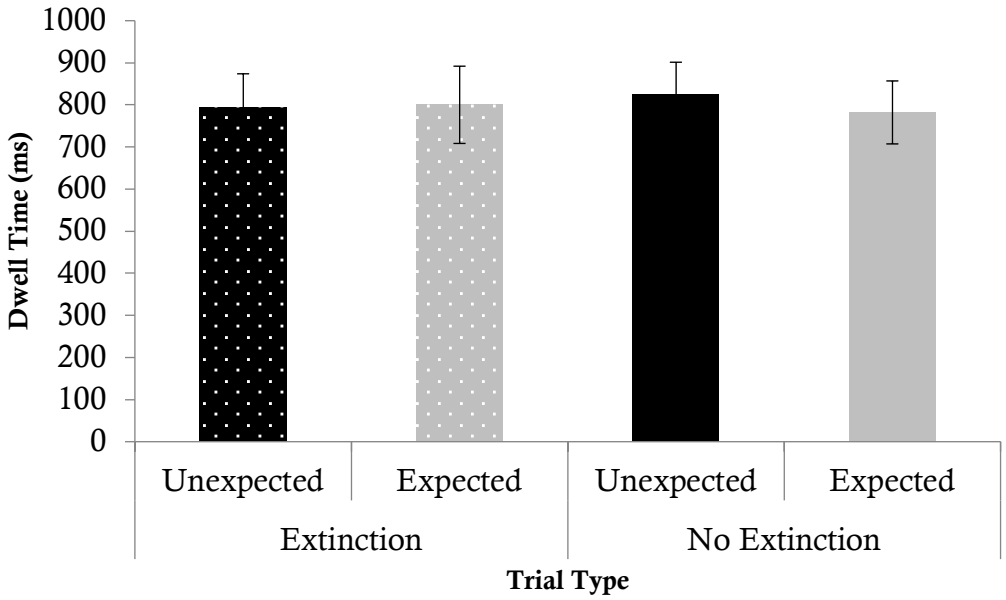


Figure 7: *Mean dwell times for unexpected and expected stimuli in both the extinction and no extinction conditions. All stimuli were presented for **18**00ms, therefore a mean dwell time of **9**00ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

There were no differences in dwell times for the extinction and no extinction trials in this experiment. It is possible that extinction may have already occurred in the first test phase in Experiment 2, resulting in no

differences for the test phase in the current experiment. The first test (in Experiment 2) may have interrupted learning. Participants may have created new object-context pairs during the first test phase, as all contexts were presented with an expected and unexpected dog (e.g. context 1- dogs A and B; context 2- dogs A and B). This means that the 'unexpected' and expected dogs in each context would both become expected (e.g. dogs A and B expected in contexts 1 and 2). This also helps explain why the OICL effect decreased over time in Experiments 1 and 2. Initially an OICL effect is observed, however after multiple presentations of the context with a new dog, new associations may have been formed. Therefore, over time, the context was able to prime both dogs into the A2 state and both would have been expected, giving the dogs equal exploration later in test 1 and during test 2. In order to prevent the first test from affecting the extinction and test 2 phases, the next experiment does not include the first test phase. OICL has already been demonstrated in Experiments 1 and 2, making the first test phase unnecessary in Experiment 4.

3.2 Experiment 4

In Experiment 3, the results were unable to demonstrate an effect of extinction. Extinction may have been unsuccessful due to the inclusion of the first test (phase 2 of Experiment 2). This test may have interrupted learning before the extinction phase and the final test phase. Participants may have created new associations with the 'unexpected' dog on each context after several presentations in the first test phase, making both dogs become expected (e.g. dogs A and B expected in context 1). Evidence of this is suggested by the previous experiments, as the basic OICL effect disappeared by the second test (see Experiments 2 and 3). Because of this, the first test phase has been eliminated in the current experiment. Experiments 1 and 2 have already demonstrated evidence of object-in-context learning, so the current experiment only tested for extinction.

3.2.1 **Method**

3.2.1.1 Participants

Sixteen (15 females, 1 male) undergraduate students from the University of Nottingham, ages 17 to 20 (M= 18.63, SD = 0.81) participated in the experiment. Students received credit for participating in the study to meet course requirements. All other participant and eye-tracking conditions were the same as in Experiment 2.

3.2.1.2 Apparatus and stimuli

The same stimuli as in Experiments 2 and 3 were used for this experiment (see Figures 2 & 6). Everything was conducted in the same way unless otherwise stated.

3.2.1.3 Procedure

All participants completed training (48 trials; 12 of each trial type), extinction (32 trials; 16 of each trial type) and testing (16 trials; 4 of each trial type) phases, as in Experiments 2 and 3 (see Experiments 2 and 3 method sections), however they did not complete phase 2 (see Table 4).

Training		Extinction		Test	
Context	Dog	Context	Cat	Context	Dog
1	AA	1	EE	1	AB
2	BB	2	FF	2	AB
3	CC			3	**CD**
4	DD			4	**CD**

Table 4: *Design for Experiment 4. All participants completed phase 1, training, phase 2, extinction, and phase 3, test. Participants were expected to spend a longer time looking at the unexpected stimuli on the no extinction trials, represented in red, bold letters.*

3.2.2 **Data Treatment and Analyses**

Data were treated and analysed in the same way as in Experiments 1 and 3 (see Experiments 1 & 3 Data Treatment and Analyses sections).

3.2.3 **Results and Discussion**

There was a minimum of 80% of eye movements recorded for all participants, so there were no exclusions in the analyses (Le Pelley et al., 2011). Participants spent more time looking at expected images than at unexpected images across all conditions. There were no effects demonstrating extinction (see Figure 8).

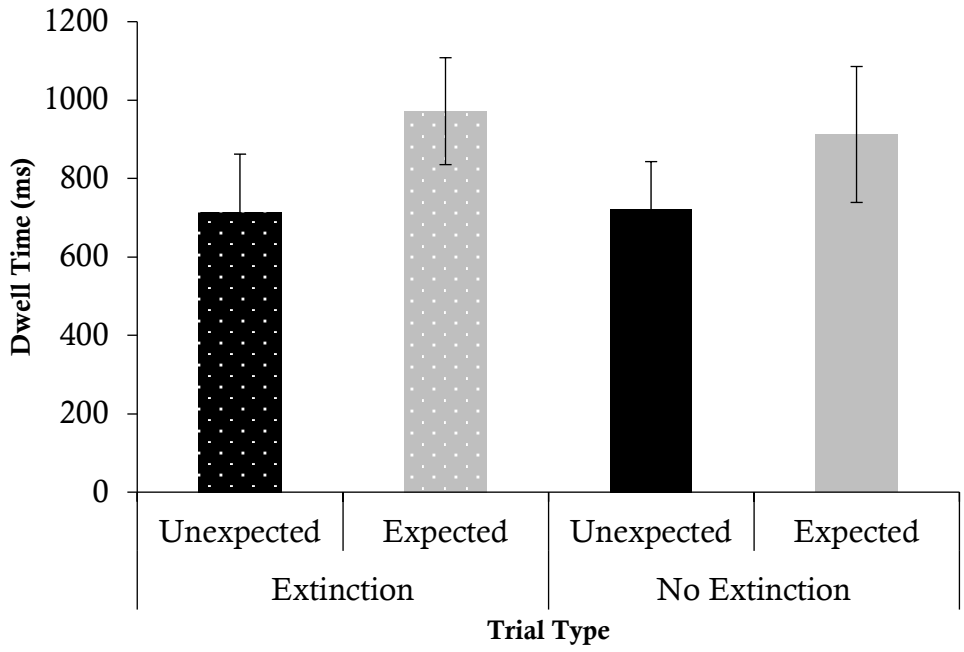


Figure 8: *Mean dwell times for the unexpected and expected stimuli across both trial types (extinction and no extinction). All stimuli were presented for* ***18****00ms, therefore a mean dwell time of* ***9****00ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

A 2x2 repeated measures ANOVA was run. Factors included stimulus type (unexpected/expected) and trial type (extinction/no extinction). There was a reliable main effect of stimulus type, $F(1,15) = 6.66$, $p = .021$, $\eta_p^2 = .308$, 90% CI [.029, .528], indicating that the stimulus type, unexpected or expected, had an effect on dwell time. There was no main effect of trial type, $F(1,15) = .68$, $p = .421$, $\eta_p^2 = .044$, 90% CI [0, .264], and no interaction between stimulus type and trial type, $F(1,15) = .38$, $p = .546$, $\eta_p^2 = .025$, 90% CI [0, .228].

It was surprising that participants spent a longer time looking at the expected images than at the unexpected images overall. This is the opposite of what was observed in Experiments 1 and 2, in which participants spent a longer time looking at the unexpected images, as predicted by Wagner's (1981) SOP model. The trials that included contexts that were not extinguished were predicted to demonstrate OICL effects, similar to results reported in Experiments 1 and 2. In addition, there were no effects demonstrating extinction in the current experiment.

The previous results in Experiments 1 and 2 may be explained by a conditioned diminution of the unconditioned response (UR), which is a reduction in responding to a US that may be directly related to an associated CS preceding the US (Donegan & Wagner, 1987). In the current experiment, the CSs are the colourful computer backgrounds and the USs are the dog animations. During training, CS→US associations were formed, and then during test, the CS always appeared on the screen before the US, which may have caused conditioned diminution of the UR (diminished responding to the

expected stimulus, which indirectly causes increased orientation toward the unexpected stimulus). The SOP model (Wagner, 1981) does have some predictions that result in conditioned facilitation of the UR (increased orientation toward the expected stimulus). This has been demonstrated in a number of studies (e.g. Baxter, 1966; Donegan, 1981; Kimble & Ost, 1961). The UR can be affected by the US intensities and therefore can show a facilitative or diminished response. The SOP model can predict whether diminished or facilitative responding will be observed. Wagner (1979) suggests that although responding to the US is usually decreased (i.e. diminished UR) when the stimulus is primed into the A2 state by the CS, facilitation may be observed when the CS provokes a CR that mimics the UR and a combination of the CR and UR is measured when the US is presented. Diminished responding is more likely to result when there are high US intensities. For example, in a lexical decision and naming task, priming-produced facilitation was demonstrated to be the greatest in the lowest target stimulus intensity (Becker & Killion, 1977), suggesting that when the US is at a lower intensity, a smaller UR is demonstrated and facilitation is observed. This indicates that when the CR amplitude to UR amplitude ratio is higher, there is greater CR-UR mimicking (Donegan, 1981). Therefore, the model can account for both effects. Although the model can allow for both effects, the direction of the effect should not differ between studies, especially as the US intensities were the same across experiments.

The current experiment eliminated the first test phase and contained an extinction phase directly after training; this is how it differed from previous experiments. This was expected to increase extinction effects; however, the

results demonstrate the same effect for trials from the extinction and no extinction conditions. There is no evidence that extinction was effective in Experiment 3, so it is possible that extinction was not effective in the current experiment as well, leaving both conditions to behave in the same way. It is possible that there were not enough extinction trials for successful extinction to occur, or that the change of context between the extinction phase and the other phases, to ensure context specificity of extinction, resulted in extinction failing to transfer to the test phase. Regardless, the results from this study do not demonstrate what is theoretically predicted.

There have been reports of studies demonstrating this effect that use episodic and semantic memory to explain the results (e.g. Hannula et al., 2010). A similar OICL task was tested in human participants in several studies, all of which included training trials that introduced face-scene pairings before participants were tested. Test trials presented one of the scenes with three faces (one face that was paired with that scene previously and two that were not but were equally familiar). These studies report that participants spent more time looking at the expected image (Hannula et al., 2010, 2007; Mahoney et al., 2018). The results are explained by the standard memory-based viewing effect (Hannula et al., 2007). The results are said to reflect episodic and semantic memory recall because the tasks tested participants' previous experiences and knowledge, specific to particular viewing situations. This demonstrates that participants were able to remember the face-scene pairs they were trained with. Therefore, although an associative effect is not demonstrated in the current experiment, results demonstrating greater orientation towards the expected image may at least suggest the participants

do remember the stimuli pairs they were trained with. Hannula et al. (2007) report that participants look at novel images in SOR/VPC tasks, where one image is novel, however in OICL tasks, when all images are equally familiar, they argue that participants look more at expected images due to the previous exposure eliminating a novelty effect. This may be because they recognise all images as being familiar but recall one image being previously presented with that particular scene, so attention is directed towards that image, indicating they recall the face-scene match. There are no obvious explanations as to why the results demonstrated in these studies vary from traditional OICL effects (e.g. Dix & Aggleton, 1999; Whitt, Haselgrove, & Robinson, 2012).

This experiment included new stimuli during the extinction phase, cat stimuli. This was done to give the participants something to look at and prevent boredom. It also allowed the trial format to remain consistent, by presenting a colourful background and two animated images. However, there have been some studies that have found that the original association can remain unextinguished, despite training with a second outcome during the extinction phase. For example, in one study, rats initially received Pavlovian training with one outcome (e.g. A→X; B→Y) before receiving extinction training with a second outcome (e.g. A→Z; B→Z). When tested, the original outcome remained intact, demonstrating that training with a second outcome was not a successful extinction treatment. Extinction can be a difficult effect to demonstrate, especially with the use of neutral outcomes (Delamater, 1996; also see Rescorla, 1996).

Traditional extinction experiments (e.g. Pavlov, 1927) present the CS alone during extinction. In the current experiment, the cat stimuli may have

affected extinction, so in the next experiment the extinction phase is presented in the traditional way, the background is presented alone (without any new stimuli).

3.3 Experiment 5

Previous experimental results in this chapter did not demonstrate effects of extinction. These experiments presented new stimuli during the extinction training phase. Traditional extinction experiments (e.g. Bouton & Bolles, 1979) present the context alone, so in this experiment the coloured backgrounds were presented without the new stimuli. This experiment was a replication of Experiment 4, with the cat stimuli in phase 2 removed.

3.3.1 **Method**

3.3.1.1 Participants

Sixteen female undergraduate students from the University of Nottingham ages 18 to 19 (M= 18.38, SD = 0.50) participated in the experiment. Students received course credit for participating in the study. All other participant and eye-tracking conditions were the same as in Experiment 2.

3.3.1.2 Apparatus and stimuli

The same stimuli as in previous experiments were used for the current experiment (see Figure 2). The experiment was created and run in the same way as previous experiments unless otherwise stated.

3.3.1.3 Procedure

Experiment 5 was identical to Experiment 4; however, the cat stimuli were excluded from the extinction phase (see Table 5).

Training		Extinction		Test	
Context	Dog	Context		Context	Dog
1	AA	1		1	AB
2	BB	2		2	AB
3	CC			3	**CD**
4	DD			4	**CD**

Table 5: *The design for Experiment 5. All participants completed phase 1, training, phase 2, extinction, and phase 3, test. Red, bold letters indicate the stimulus participants were expected to orient towards for a longer period of time.*

3.3.2 Data Treatment and Analyses

Data were treated and analysed in the same way as in Experiments 1 and 3 (see Experiments 1 & 3 Data Treatment and Analyses sections).

3.3.3 Results and Discussion

All participants had at least 80% of eye movements recorded during the task, so there were no exclusions in the analyses (Le Pelley et al., 2011). As in Experiment 4, the results suggest that participants spent more time looking at expected than unexpected images, although the effect in the current experiment seems somewhat smaller than in the previous study. This pattern of results does not seem to differ between the extinction and no extinction conditions (see Figure 9).

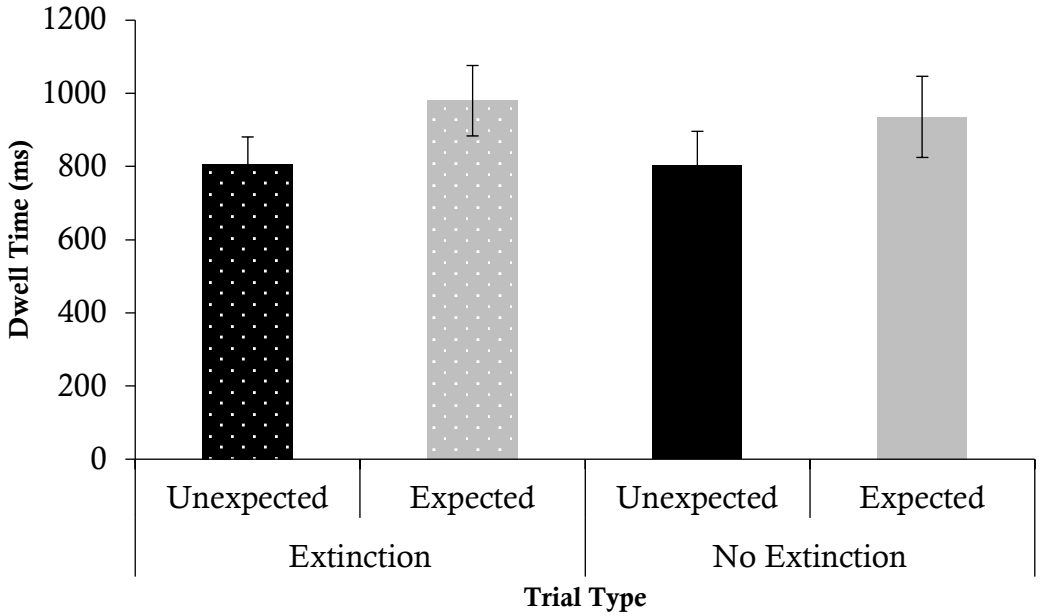


Figure 9: *Mean dwell times for expected and unexpected stimuli in the extinction and no extinction conditions. All stimuli were presented for **18**00ms, therefore a mean dwell time of **9**00ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

A 2x2 repeated measures ANOVA was run with the factors stimulus type (unexpected/expected) and trial type (extinction/no extinction). There was not a reliable main effect of stimulus type, $F(1,15) = 3.86$, $p = .068$, $\eta_p^2 = .205$, 90% CI [0, .443], no main effect of trial type, $F(1,15) = 2.44$, $p = .140$, $\eta_p^2 = .140$, 90% CI [0, .383], and no interaction between stimulus type and trial type, $F(1,15) = .49$, $p = .496$, $\eta_p^2 = .031$, 90% CI [0, .242].

Results from Experiment 5 fail to provide effects of basic OICL for trials including contexts that were not extinguished, and therefore, also fail to

demonstrate effects of extinction. Without a basic OICL learning effect, it is not possible to have an effect of extinction. This was surprising, as these trials were trained and tested in the same way as in Experiments 1 and 2. Although not significant, the results show a similar pattern to what was observed in Experiment 4. Participants appear to have spent more time looking at expected stimuli compared to unexpected stimuli. This is the opposite to what would be predicted by Wagner's (1981) model.

In order to identify exactly why the effect reversed from Experiments 1 and 2 (test 1) to Experiments 4 and 5, it is important to compare the differences in procedures. The extinction phase added time to the experiment when compared to Experiments 1 and 2. Participants did report that they struggled to attend throughout the entire task. Results seen in the current experiment could be due to boredom, causing an overall lack of attention to the stimuli. In order to prevent this, without making major manipulations to the design, the next experiment introduces more engaging stimuli to help encourage participants to attend throughout the entire task.

3.4 Experiment 6

The previous attempts to demonstrate extinction of object-in-context learning were unsuccessful, so in the current experiment, more engaging stimuli were included to maintain attention throughout the entire task. In previous experiments, many participants reported that they had ignored the presence of the backgrounds and quickly became tired and unengaged with the task. This may mean that learning was not as strong during training, preventing a strong formation of an association to later extinguish in some tasks. There was no significant effect in Experiment 5, suggesting little to no learning; however, there was clearly some learning in Experiment 4, as there was a significant interaction, although the effect was not strong. In the current experiment, scenic photographs were used to replace the colourful computer backgrounds. The new backgrounds were paired with a sound to make the contexts more complex, engaging and salient. New dog stimuli were included in the training and test phases and new cat stimuli were included in the extinction phase.

Test 1 was reinstated because new stimuli were introduced; the same experimental design as in Experiments 2 and 3 was used. OICL has not yet been established with these stimuli, so test 1 was necessary to ensure participants were learning context-image associations before that learning could undergo extinction training. It should be noted that this may cause issues, as test 1 may cause associations to be extinguished, as contexts are presented with the expected dog and one unexpected dog. This may affect performance in the extinction and test 2 phases, preventing any effects of extinction. Also, as there was no seen advantage of presenting the context

alone during the extinction phase in Experiment 5, cat stimuli were included in the current experiment to encourage participants to attend to the screen. It was expected that further evidence of object-in-context learning would be demonstrated in test 1 and that test 2 would provide evidence of extinction.

3.4.1 **Method**

3.4.1.1 Participants

Twelve (11 females, 1 male) undergraduate students from the University of Nottingham ages 18 to 20 (M= 18.75, SD = 0.87) participated in the experiment. Students received course credit for participating in the study. All other participant and eye-tracking conditions were the same as in Experiment 2.

3.4.1.2 Apparatus and stimuli

This experiment was created and run in the same way as previous experiments unless otherwise stated. Stimuli consisted of four scenic backgrounds, which were all photographs that I have personally taken. Four new dog and two new cat stimuli were also created. Stimuli were created in the same way as in Experiment 1 (see Experiment 1 method). In addition, four sound clips were added to the backgrounds; all sounds (gong, water drop, helicopter, and glass shatter) were downloaded from freesound.org. See Figure 10 for images of the stimuli used in this experiment.

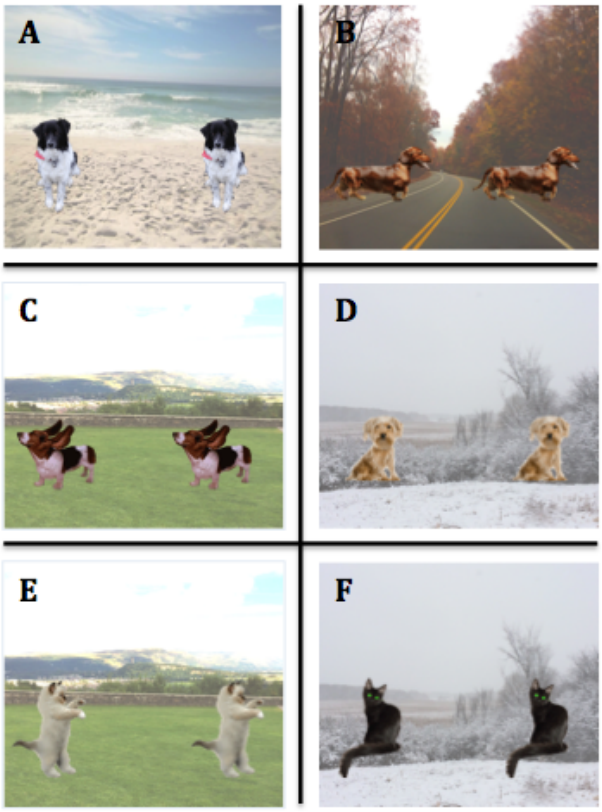


Figure 10: *Dog and cat stimuli on the scenic backgrounds that they appeared on. Images A-D are examples of trials presented during the learning phase, whereas images E-F are example extinction trials.*

3.4.1.3 Procedure

The experimental design was similar to Experiments 2 and 3 (see Experiments 2 and 3 method sections). The only change in the design was the addition of sound clips to the contexts (see Table 6). Every participant completed a learning phase of 32 trials (8 of each trial type), a testing phase of 32 trials (8 of each trial type), an extinction phase of 32 trials (16 of each trial type) and a second testing phase of 32 trials (8 of each trial type), to make a total of 128 trials. In total, the experiment lased approximately 30 minutes.

Training		Test 1	
Context	Dog	Context	Dog
1	AA	1	**AB**
2	BB	2	**AB**
3	CC	3	**CD**
4	DD	4	**CD**
Extinction		**Test 2**	
Context	Cat	Context	Dog
1	EE	1	AB
2	FF	2	AB
		3	**CD**
		4	**CD**

Table 6: *Experimental design. All participants completed phase 1, training, phase 2, test 1, phase 3, extinction, and phase 4, test 2. The red, bold letters indicate which stimuli participants were expected to look at longer. Each context was paired with one tone. The different colour sound symbols represent the four different tones used (from top to bottom: black = gong, blue = water drop, green = helicopter, and purple = glass shatter).*

Sounds clips were played as soon as the context appeared during fixation. Therefore, the smiley face fixation was on the screen for an extra half second (1.5 seconds total) to allow time for the clip to play. After this, the stimuli animations were presented for 1.8 seconds, followed by the plain grey screen ITI for 2 seconds. See Figure 11 for an example trial; in this example, a test trial is displayed with the unexpected dog on the right, so participants would be expected to spend a longer amount of time looking in the right region of interest. Training and extinction trials were presented in the same manner,

except in training trials, two of the same dog stimuli were presented and in extinction trials, two of the same cat stimuli were presented after fixation.

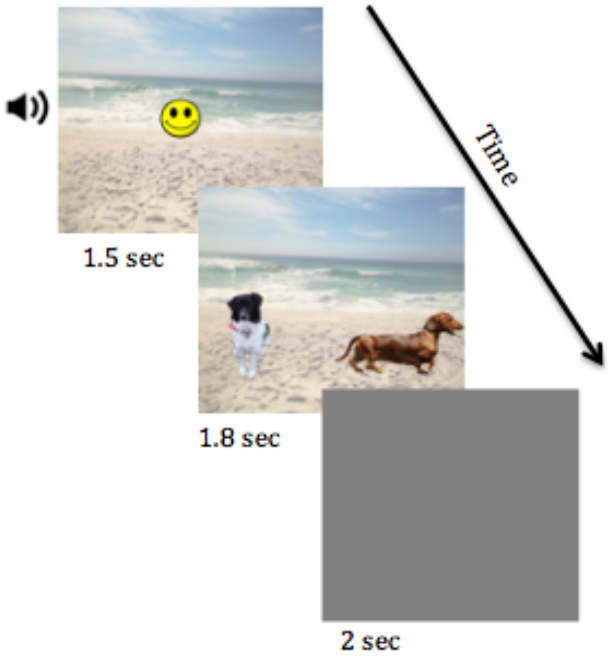


Figure 11: *Example test trial. All training, extinction and test trials followed the same procedure. A smiley face fixation and tone were presented for 1.5 seconds, participants then saw the dog (training and test phases) or cat (extinction phase) animations for 1.8 seconds, followed by a two second ITI.*

This experiment was fully counterbalanced in the same manner as in Experiments 2 and 3, so again, four counterbalanced sub-groups of the experiment were created. Each version of the experiment was tested three times, resulting in a total of 12 participants (see Experiments 2 and 3 method sections).

3.4.2 **Data Treatment and Analyses**

Data were treated and analysed in the same way as in Experiments 1 and 3 (see Experiments 1 & 3 Data Treatment and Analyses sections) unless otherwise stated. Data from the first test (after training) were binned into 8-trial blocks so the effect could be analysed over time. The second test (after extinction) in this experiment did include additional trials, however trials were still not binned, as there were only 8 trials of each trial type, so binning was unnecessary. The power analysis was conducted with the same input parameters as previous experiments, except this experiment had 32 trials, so it was determined that a minimum of 7 participants were necessary for a medium effect size.

3.4.3 **Results and Discussion**

3.4.3.1 Test 1 Eye Movements (OICL)

All participants had a minimum of 80% of eye movements recorded, so there were no exclusions in the analyses (Le Pelley et al., 2011). There were no differences in dwell times towards the expected and unexpected stimuli. Test 1 demonstrates no effects of OICL (see Figure 12).

A 2x4 repeated measures ANOVA was run. Factors included stimulus type (unexpected/expected) and trial block (blocks 1-4); trials were binned into 8-trial blocks. There was no main effect of stimulus type, $F(1,11) = .84$, $p = .378$, $\eta_p^2 = .071$, 90% CI [0, .337], no main effect of trial block, $F(1,11) = 1.90$, $p = .148$, $\eta_p^2 = .147$, 90% CI [0, .419], and no interaction between stimulus type and trial block, $F(1,11) = 1.46$, $p = .244$, $\eta_p^2 = .117$, 90% CI [0,

.389]. Looking at the graph, the first block of trials appeared to show an OICL effect, before quickly declining. To check this, a t-test was conducted on a smaller block of four trials. There was a significant OICL effect in the first four trials (p=. 05). This can be compared to Experiments 1 and 2, which also demonstrated that the effect quickly declined. All of the subsequent blocks of four trials did not demonstrate a significant effect in either direction.

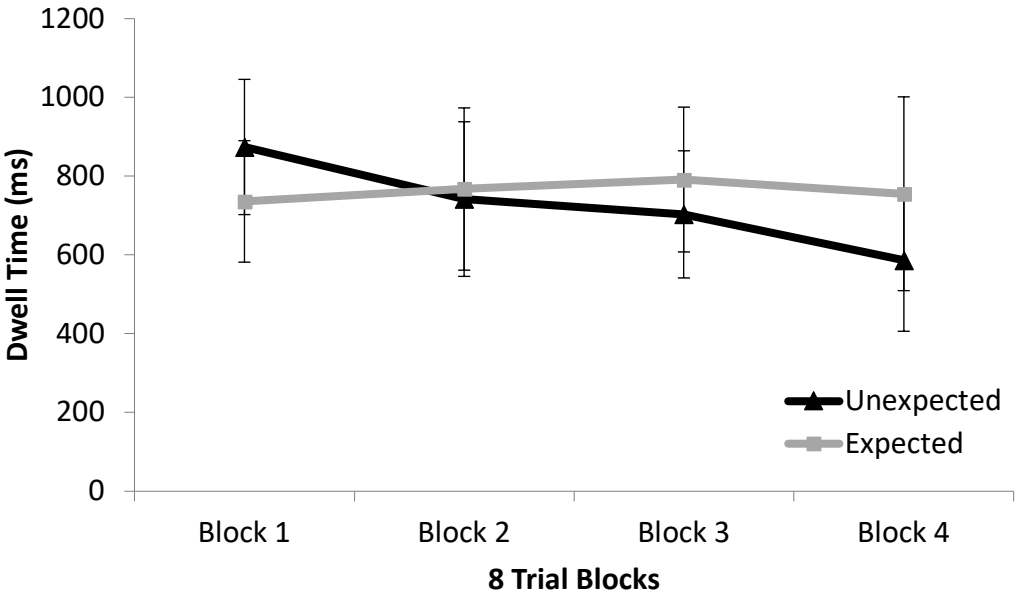


Figure 12: *Mean unexpected and expected dwell times across 8-trial blocks (Test 1). All stimuli were presented for* ***18****00ms, therefore a mean dwell time of* ***9****00ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

3.4.3.2 Test 2 Eye Movements (Extinction)

Participants spent a similar amount of time looking at unexpected and expected stimuli and showed no differences across conditions. Results from test 2 demonstrate no effects of extinction (see Figure 13).

A 2x2 repeated measures ANOVA was run with stimulus type (unexpected/expected) and trial type (extinction/no extinction). There was no main effect of stimulus type, $F(1,11) = .16$, $p = .700$, $\eta_p^2 = .014$, 90% CI [0, .226], no main effect of trial type, $F(1,11) = .02$, $p = .904$, $\eta_p^2 = .001$, 90% CI [0, .091], and no interaction between stimulus type and trial type, $F(1,11) = .75$, $p = .404$, $\eta_p^2 = .064$, 90% CI [0, .328]. Results demonstrate no effects of extinction.

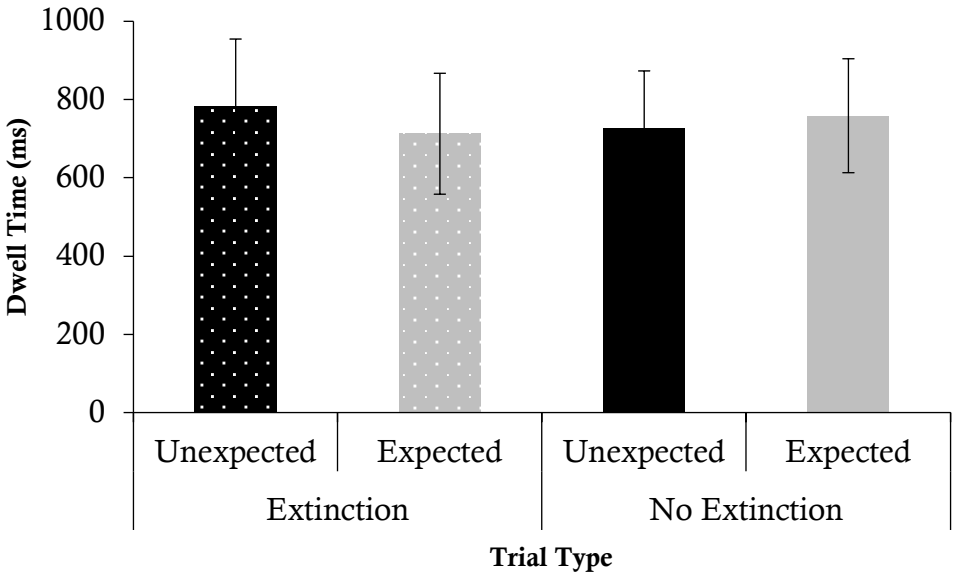


Figure 13: *Mean dwell times for unexpected and expected stimuli across trials with and without extinguished contexts (Test 2). All stimuli were presented for **18**00ms, therefore a mean dwell time of **9**00ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

The current experiment only showed a pattern of results consistent with OICL in the first block of trials from Test 1 (see Figure 12) and upon further investigation, this effect was only significant in the first four trials. This experiment was unable to demonstrate effects of extinction in Test 2. Results in this experiment do not show patterns consistent with the previous experiments. Participants do not spend more time looking at expected images (Experiments 4 & 5) or at unexpected images (Experiments 1 & 2). However, the results in this experiment are consistent with Experiment 3. This experiment reinstated test 1, so this experiment can be explained in the same way as Experiment 3. In test 1, the first block of trials demonstrated a pattern

of results consistent with OICL. Later trials may have been affected by the backgrounds being shown with both the expected and unexpected dogs. Participants may have formed new associations with the backgrounds and unexpected dogs, eventually making both dogs expected. Therefore, there is no difference in looking behaviour. In test 2, participants may have no looking preference, as they may have formed associations with both dogs in test 1, so both were expected during this test.

In all of the previous experiments, participants completed all phases without any breaks. This can be tiring and cause boredom, so in the next experiment breaks were included between the experimental phases. In addition, this will allow all of the object's and context's elements to return to a state of inactivity between phases. The SOP model states that all elements must return to the inactive state before they can re-enter the A1 activity state (Wagner, 1981). Adding breaks between phases will allow elements to decay from the A2 activity state to the inactive state. Therefore, elements can re-enter the A1 activity state in the next study stage.

3.5 Experiment 7

This experiment was a replication of Experiment 6, with the addition of breaks between phases. Test 1 was not eliminated, as Experiment 6 did not demonstrate evidence of OICL effects. It is important to establish learning with these stimuli before applying manipulations to ensure there is an effect to extinguish. This again causes the issue that test 1, during which all contexts are paired with the expected and an unexpected image, may allow for extinction of any associations formed during training. This may affect performance in the second test and prevent there from being any effects of extinction training, as extinction may have already occurred.

Breaks were included before the first test phase and before the extinction phase of this experiment. This allowed participants to take a break from attending to the screen and aimed to prevent boredom during the task. Breaks also allowed time for all of the elements to return to their inactive state. According to SOP, elements must return to inactive before they can re-enter the A1 activity state (Wagner, 1981). It is unknown how long it takes elements in the A2 state to decay into the inactive state, so three different break conditions were included in the current experiment (1, 3 and 5 minutes).

In this experiment, it was hypothesised that the changes in procedure from previous experiments would improve results. It was predicted that participants would spend a longer amount of time orienting to the unexpected stimuli in the first test (OICL effect). It was also predicted that there would be evidence of extinction in the second test (i.e. participants were

expected to spend more time looking at unexpected stimuli only on contexts that were not extinguished).

3.5.1 **Method**

3.5.1.1 Participants

Twenty-four (23 females, 1 male) students from the University of Nottingham ages 18 to 30 (M= 21.71, SD = 2.85) took part in this study. There were 8 participants in each spacing group (1, 3 or 5 minutes). Either a £3 inconvenience allowance or course credit was given to all people who participated. All other participant and eye-tracking conditions were the same as in Experiment 2.

3.5.1.2 Apparatus and stimuli

The same stimuli as in Experiment 6 were used for the current experiment (see Figure 10). This experiment was created and run in the same way as Experiment 6 unless otherwise stated. A handheld basketball game was used to give participants a task to complete during the breaks between phases, as the breaks were quite long (1, 3 or 5 minutes). A physical game was used to give participants a break from looking at the computer screen. The game was a clear plastic sphere with a basketball net fixed to one side. There was a loose basketball floating in the sphere and the task was to try to roll the ball into the basketball net.

3.5.1.3 Procedure

The current experiment was a replication of Experiment 6 (see Experiment 6 method), with the addition of one-, three- or five-minute breaks before the

test 1 and extinction phases. The break length was a between subjects' factor, so participants had the same break length for their two break times (before test 1 and before extinction). During the break, participants were given a handheld basketball game and asked to make as many baskets as possible. All participants completed 32 training trials (8 of each trial type), 16 test 1 trials (4 of each trial type), 32 extinction trials (16 of each trial type), and 16 test 2 trials (4 of each trial type; see Table 7 for design). The number of test trials was decreased, as learning effects have consistently only been present in the first block of trials in previous experiments. The experiment lasted approximately 35 minutes.

Training		BREAK 1/3/5 min	Test 1	
Context	Dog		Context	Dog
1	AA		1	AB
2	BB		2	AB
3	CC		3	CD
4	DD		4	CD

BREAK 1/3/5 min	Extinction		Test 2	
	Context	Cat	Context	Dog
	1	EE	1	AB
	2	FF	2	AB
			3	CD
			4	CD

Table 7: *Design for Experiment 7. All participants completed phase 1, training, phase 2, test 1, phase 3, extinction, and phase 4, test 2. There was a 1, 3, or 5-minute break before the Test 1 phase and before the Extinction phase. Each context was paired with a tone, as indicated by the coloured sound symbols. Each colour represents a different tone (from top to bottom: black = gong, blue = water drop, green = helicopter, and purple = glass shatter). The bold, red letters indicate where participants were expected to have longer dwell times.*

3.5.2 Data Treatment and Analyses

Data were treated and analysed in the same way as in Experiments 1 and 3 (see Experiments 1 & 3 Data Treatment and Analyses sections) unless otherwise stated. This experiment included a between subjects' factor (spacing condition: 1, 3 or 5 minutes). This between subjects' factor was included in the ANOVAs for both tests to explore if participants in different spacing groups performed differently in the tests. The power analysis was conducted using the same input

parameters as Experiments 3, 4 and 5, as there was the same number of test trials, however also accounted for the increase in number of groups, 3 for the three spacing conditions; it was determined that a minimum of 12 participants were required.

3.5.3 **Results and Discussion**

3.5.3.1 Test 1 Eye Movements (OICL)

All participants had a minimum of 80% of eye movements recorded, so there were no exclusions in the analyses (Le Pelley et al., 2011). Participants showed no differences in dwell times towards the expected and unexpected stimuli. Similar to Experiment 6, test 1 demonstrated no effects of OICL (see Figure 14).

A 2x2 repeated measures ANOVA was run with a between subject factor. Factors included stimulus type (unexpected/expected) and trial block (blocks 1-2); trials were binned into two 8-trial blocks. The spacing condition was included as a between subject factor (1, 3, or 5 minutes). There was no main effect of stimulus type, $F(1,23) = 1.45$, $p = .242$, $\eta_p^2 = .065$, 90% CI [0, .247], no main effect of trial block, $F(1,23) = 3.05$, $p = .095$, $\eta_p^2 = .127$, 90% CI [0, .320], and no interaction between stimulus type and trial block, $F(1,23) = .29$, $p = .596$, $\eta_p^2 = .014$, 90% CI [0, .156]. There was also no effect of spacing, $F(2,22) = .01$, $p = .987$, $\eta_p^2 = .001$, 90% CI [0, .045], and no interactions with spacing (Fs<1, ps>.1). Due to the effect revealed when the data in Experiment 6 was further investigated, these data were also further analysed in smaller blocks of 4 trials (mean dwell times: Block 1 novel=

660.59ms, familiar= 611.46ms; Block 2 novel= 632.99ms, familiar= 551.74ms; Block 3 novel= 557.81ms, familiar= 555.56ms; Block 4 novel= 588.37ms, familiar= 540.28ms) there were still no significant effects (*p*s>.05).

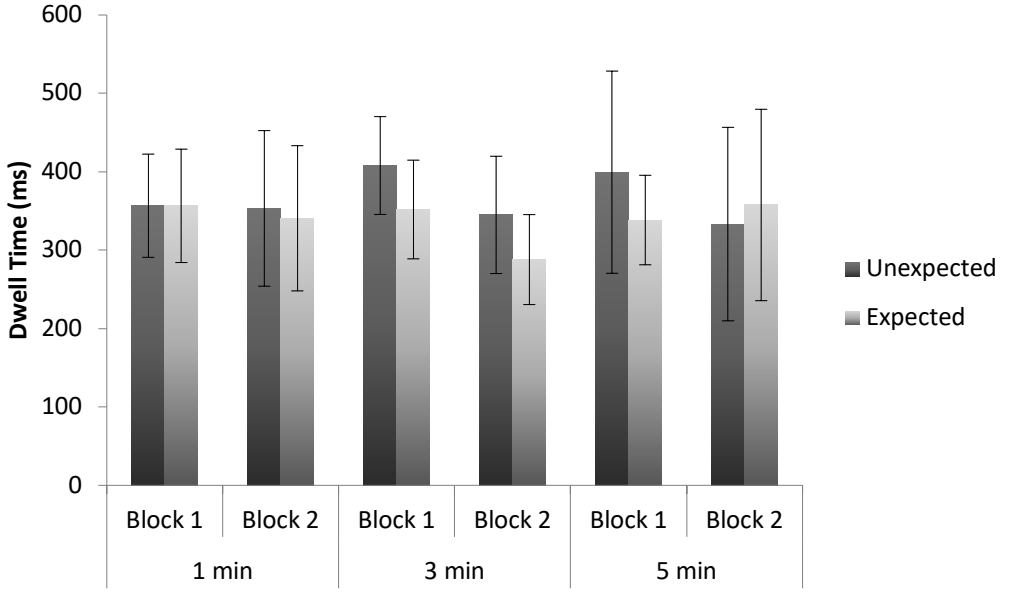


Figure 14: *Mean dwell times for unexpected and expected stimuli across 8-trial blocks in all spacing conditions (1, 3 and 5 minutes) from Test 1. All stimuli were presented for **18**00ms, therefore a mean dwell time of **9**00ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

3.5.3.2 Test 2 Eye Movements (Extinction)

Participants showed no differences in dwell time towards the expected and unexpected stimuli on both the extinction and no extinction trials. Similar to Experiment 6, test 2 demonstrates no effects of extinction (see Figure 15).

A 2x2 repeated measures ANOVA was run with a between subject factor. Factors included stimulus type (unexpected/expected) and trial type (extinction/no extinction). The spacing condition was included as a between subject factor (1, 3, or 5 minutes). There was no main effect of stimulus type, $F(1,23) = 1.14$, $p = .298$, $\eta_p^2 = .051$, 90% CI [0, .228], no main effect of trial type, $F(1,23) = .12$, $p = .733$, $\eta_p^2 = .006$, 90% CI [0, .123], and no interaction between stimulus type and trial type, $F(1,23) = .53$, $p = .475$, $\eta_p^2 = .025$, 90% CI [0, .183]. There was also no effect of spacing, $F(2,22) = .32$, $p = .731$, $\eta_p^2 = .029$, 90% CI [0, .137], and no interactions with spacing (*p*s>.1).

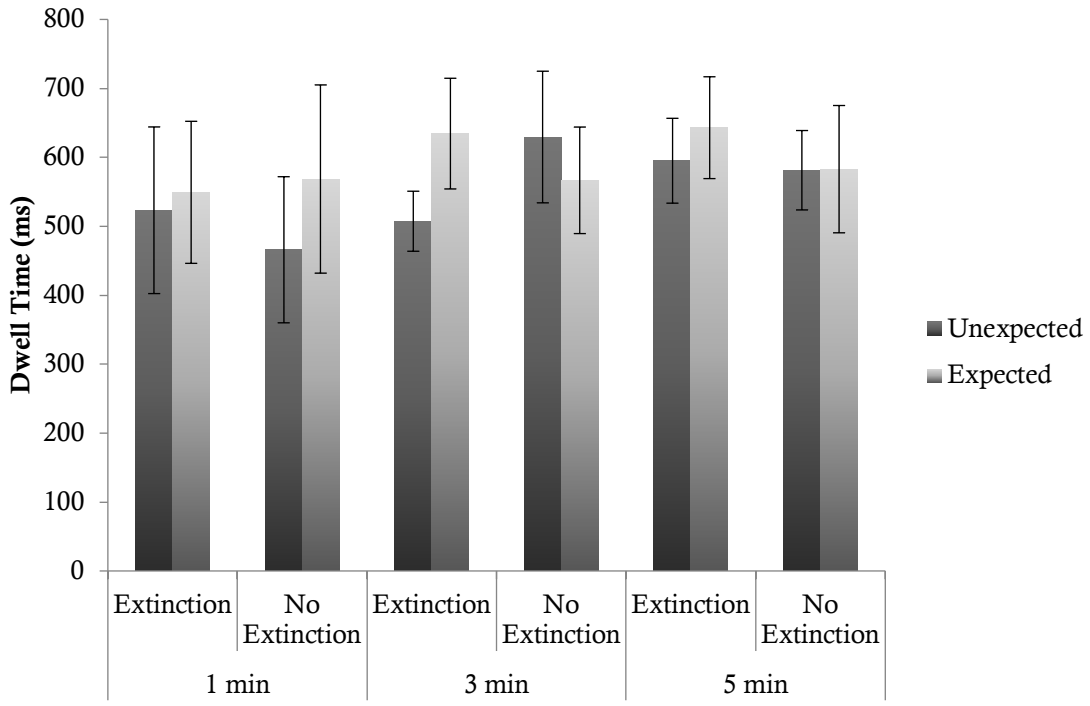


Figure 15: *Mean dwell times towards unexpected and expected stimuli for extinction and no extinction trials across all spacing conditions (1, 3 and 5 minutes) from Test 2. All stimuli were presented for **18**00ms, therefore a mean dwell time of **9**00ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

The current experiment was unable to demonstrate effects of OICL or extinction. Including 1, 3 and 5-minute breaks between phases added no benefit to participant performance. This experiment was unable to demonstrate the basic effect of OICL in the first test. This means that there may not have been any effect to extinguish. If there was any learning, the extinction test may have been affected by the first test phase. It is possible that participants were able to form associations between the background and both dogs (expected and unexpected) during the first test phase. This may have

caused them to have no looking preference during this extinction test, as both dogs would have become expected and able to move into the A1 activity state.

Upon closer inspection of the data across all extinction experiments (Experiments 3-7), it appeared that there was a lot of variability in performance across participants. In order to investigate this difference across the data sets, the next experiment looks for individual differences in personality traits that can explain test performance.

3.6 Experiment 8

In the previous experiments presented in this chapter, there was a lot of participant variability. Experiment 8 intended to look for individual differences in personality traits that may explain the variable performance across extinction tests in Experiments 3-7. Discrimination ratios (unexpected dwell time- expected dwell time)/ (unexpected dwell time + expected dwell time) were computed for all participants who took part in the extinction tasks presented in this chapter. These ratios indicate if participants were spending more time looking at expected images (negative scores) or unexpected images (positive scores). A score around zero indicates that the participant spent an equal amount of time looking at expected and unexpected images. When looking at performance in the no extinction condition, it was predicted that participants would spend more time looking at the unexpected images (OICL effect), however only 27 out of the 96 participants showed positive scores that were equal to or greater than .1. There were 34 participants that appeared to spend more time looking at the expected image (discrimination ratio score of equal to or less than -.1) and 35 participants that spent a similar amount of time looking at expected and unexpected images (scores less than .1 and greater than -.1). It was therefore of interest to investigate if there were any individual differences driving performance by administering a questionnaire to those who took part in the extinction experiments.

The Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) questionnaire (e.g. Burch, Steel, & Hemsley, 1998; Dembińska-Krajewska & Rybakowski, 2014; Mason & Claridge, 2006; Mason, Claridge, & Jackson, 1995) was used to address individual differences. This questionnaire is a

schizotypy scale that is commonly used in psychiatry. Schizotypy is a personality trait that has both positive and negative aspects. The trait consists of a continuum of personality characteristics and personal experiences that range from normal imaginative states to more extreme states of the mind that can be related to psychosis (Dembińska-Krajewska & Rybakowski, 2014). The survey includes questions that look for positive and negative symptoms in four different areas that are commonly associated with schizotypy, unusual experiences (unusual perceptual and other cognitive experiences), cognitive disorganisation (tendency for thoughts to become derailed or disorganised), introverted anhedonia (introverted, emotionally flat and asocial behaviour) and impulse non-conformity (unstable mood and behaviour towards rules and social conventions; Mason et al., 1995; Burch et al., 1998).

The O-LIFE questionnaire was administered in the current experiment to investigate individual differences. This questionnaire was used because it has been demonstrated that those who score high on the schizotypy scale may experience deficits in working memory, executive function and attention (Dembińska-Krajewska & Rybakowski, 2014). These deficits could directly affect performance in the extinction tasks in this chapter. Therefore, deficits produced by schizotypy are predicted to also cause deficits in performance during extinction tasks. This tool can be useful for assessing individual differences by testing if participant measures from the schizotypy scale predict performance in the extinction tasks.

There have been a number of studies that have used the O-LIFE questionnaire to measure schizotypal traits within a healthy population (e.g. Burch et al., 1998; Claridge & Broks, 1984; Mason et al., 1995). This tool is

easily accessible, easy to administer and schizotypy is represented on a continuum, meaning schizotypal characteristics are observed in healthy individuals (Dembińska-Krajewska & Rybakowski, 2014). Therefore, this questionnaire can be used to look at individual differences in a normal, healthy sample, as many people demonstrate such characteristics (Claridge & Broks, 1984). Burch et al. (1998) demonstrated reliability of the O-LIFE questionnaire. They report consistency of results in a test-retest with the O-LIFE in 30 participants. This questionnaire is relatively short compared to other schizotypy measurements and has been used reliably in the laboratory environment (e.g. Burch et al., 1998; Steel, Hemsley, & Jones, 1996).

The O-LIFE questionnaire was distributed to all participants who took part in Experiments 3-7. It is expected that O-LIFE scores will be able to predict how participants perform in the extinction tasks. It is hypothesised that high schizotypy scores may predict performance in those who have no looking preference, as these individuals may have trouble forming associations during training, and therefore demonstrate a lack of learning. Experiments 4 and 5 demonstrated that participants may orient more towards the expected images and Experiments 1 and 2 demonstrated that participants may orient more towards the unexpected images. Participants in both of these scenarios demonstrate a form of learning; it can be predicted that those with low schizotypy scores may demonstrate some form of learning (greater orientation towards the expected or unexpected stimuli).

3.6.1 **Method**

3.6.1.1 Participants

All 96 participants that took part in Experiments 3-7 were contacted to participate in this experiment. Twenty-four (21 females, 3 males) people ages 18 to 46 (M= 22.67, SD =6.24) responded to the email and completed the questionnaire. All those who completed the questionnaire were entered into a prize draw to win a £30 amazon voucher. Consent was given by ticking a box before the questionnaire commenced and debriefing information was presented on the screen upon completion of the study.

3.6.1.2 Apparatus and stimuli

The 104 question version of the O-LIFE questionnaire was used in this experiment (Mason & Claridge, 2006). This questionnaire contains questions relating to thoughts, feelings, experiences and preferences. The questions are split into four sub-scales, including unusual experiences (e.g. Do you often have days when indoor lights seem so bright that they bother your eyes?), cognitive disorganisation (e.g. Do you find it difficult to keep interested in the same thing for a long time?), introvertive anhedonia (e.g. Do you prefer watching television to going out with other people?) and impulsive nonconformity (e.g. Do you often have an urge to hit someone?). These scales include positive and negative items; positive items are scored +1 for yes and 0 for no, whereas as negative items are scored +1 for no and 0 for yes (see Appendix 7.1 for full questionnaire). The questionnaire was created in Qualtrics to allow participants to complete the questionnaire online in their own time.

3.6.1.3 Procedure

Participants were emailed an invitation to take part in this study. The email included an information sheet and a link to the online questionnaire. They were told that they were contacted because they previously completed one of my experiments and that participation was completely voluntary. If they decided to participate, they were asked to review the information sheet, which described the nature of the questionnaire and informed them that all people who participated would be entered into a £30 prize draw. If they still wished to continue, they were asked to follow a link to the Qualtrics survey and 'click' to show consent. Because some questions were of a sensitive nature, participants were free to skip any questions that they felt uncomfortable answering. The survey took approximately 15 minutes to complete and upon completion, debriefing information was displayed on the screen.

3.6.2 **Data Treatment and Analyses**

Data were treated and analysed in the same way as in Experiment 1 (see Experiment 1 Data Treatment and Analyses section) unless otherwise stated. This experiment used a multiple regression analysis to test if O-LIFE scores were able to predict performance in extinction tasks. Performance in the extinction tasks was computed into discrimination ratios. Discrimination ratios were computed by taking all dwell times towards the unexpected and expected dogs in the extinction tests and applying the following equation: (unexpected dwell time- expected dwell time)/ (unexpected dwell time + expected dwell time). Beta-coefficients and *p*-values were reported from the

analysis. The proportion of variance in the outcome measure that can be explained by the model was also reported (R^2). A power analysis was conducted to compute the required sample size for the linear multiple regression analysis with the following input parameters: effect size f^2 of .15, α error probability of .05, power set to .8 and the number of predictors set to 4. It was determined that a minimum of 85 participants were required.

3.6.3 **Results and Discussion**

A standard multiple regression analysis was conducted with the four O-LIFE sub-scales (unusual experiences, cognitive disorganisation, introvertive anhedonia, and impulsive nonconformity) as predictor variables and the combined discrimination ratios from the extinction tests in chapter 3 as the dependent variable. If any of the predictor variables were associated with the dependent variable, then the analysis should reveal a relationship between the two. None of the O-LIFE subscales significantly predicted extinction performance (ps > .1). All standardized regression coefficients and corresponding p-values can be seen in Table 8.

O-LIFE subscales	Beta-coefficients	*p*-values
Unusual Experiences	.393	.315
Cognitive Disorganisation	-.369	.222
Introvertive Anhedonia	.150	.553
Impulsive Non-conformity	-.028	.941

Table 8: *Beta-coefficients and corresponding p-values from the multiple regression analysis of O-LIFE subscales with performance scores on extinction tests.*

The results of the multiple regression analysis indicated that the model was not significant and that the four predictors explained 12.4% of the variance (R^2= .124, F(4, 19) = .67, p= .621). Performance on the O-LIFE questionnaire was not a good predictor of performance on the extinction tests reported in this chapter. The theoretical prediction was not supported by this analysis, as schizotypy score did not predict extinction performance. However, it should be noted that out of the 96 participants who completed the extinction experiments, only 24 completed the O-LIFE questionnaire. A rule of thumb for multiple regression analyses states that a sample of 50 + (8*number of predictor variables) should be used to obtain a medium effect size; the current analysis would therefore require 82 participants (Green, 1991). In addition, the power analysis determined that 85 participants were required. Both guidelines suggest a sample much higher than the sample included in the current experiment. Therefore, this analysis may have been underpowered. This would prevent the possibility of effects demonstrating

that the predictor variables could significantly predict extinction performance. It should also be noted that the extinction tasks presented did not demonstrate the basic OICL effect; aside from Experiment 2/3. Therefore, it is difficult to assess if extinction has been successful when there may not have been an effect to extinguish in the first place.

3.7 Chapter Discussion

Overall, the experiments presented in this chapter were unable to demonstrate support for extinction of OICL. Experiments attempted to extinguish two of the four context-dog pairs created during training, before performance was tested in all four contexts. It was predicted that there would be no difference in dwell times towards the unexpected and expected dogs in the two contexts that were extinguished and that participants would orient more towards the unexpected dog in the two contexts that had no extinction training (OICL effects). Results indicated that there were no basic OICL effects in the no extinction conditions and demonstrated no effects of extinction, which may be directly related to the lack of the basic effect; basic learning must be present so there is an effect to extinguish.

Experiment	Training	Test 1 (OICL)	Test 1 Results	Extinction	Test 2 (Extinction)	Test 2 Results
2/3	48 Trials	16 Trials	Look more at unexpected	32 Trials	16 Trials	No differences in dwell times
4	48 Trials	X	X	32 Trials	16 Trials	Look more at expected in both conditions
5	48 Trials	X	X	32 Trials	16 Trials	Look more at expected in both conditions (insignificant)
6	32 Trials	32 Trials	No differences in dwell time	32 Trials	32 Trials	No differences in dwell times
7	32 Trials	16 Trials	No differences in dwell time	32 Trials	16 Trials	No differences in dwell times

Table 9: *Design and results of extinction experiments 2/3-7. The number of trials for each phase of each experiment is specified. An X demonstrates that the phase was not included in the experiment. Results state whether participants spent more time looking at the expected or unexpected images or if there were no differences in dwell times. In Test 2 there were two conditions, the extinction and no extinction condition, results were collapsed in the table, as there were no differences between conditions in all experiments.*

Table 9 presents the design and outcomes of the extinction experiments reported in this chapter (Experiments 2/3-7). There are some key differences in the findings of these experiments. There was no effect of extinction in any of the experiments, however there was substantial variation in whether there was a basic pre-extinction effect and what direction this pre-extinction effect was in. Looking at the differences across the experiments can help identify why some studies had pre-extinction effects and why the direction varied.

In Experiments 2/3, 6 and 7, an initial test phase was included to test if participants had first obtained basic OICL effects. Experiment 2/3 demonstrated a pre-extinction effect with more orientation towards the unexpected stimuli; this was only present in the first block of eight trials. Experiment 6 only had a pre-extinction effect in the first block of four trials and this was also towards the unexpected stimuli. Experiment 7 did not show any pre-extinction effects. The main difference in Experiment 7 when compared to Experiments 2/3 and 6 was the inclusion of spaces between phases. This change was predicted to strengthen the effect, but instead there was no effect at all. It is also important to consider how these tasks may have affected extinction. Extinction may not have been observed because all of these experiments included a first test phase before extinction training and the second test phase (see Table 9). The initial test phase may have caused participants to form new associations with the unexpected dog, making these dogs expected in subsequent presentations. This would explain why there were no differences in dwell times toward the expected and unexpected dogs in the extinction and no extinction conditions in the final test.

Experiments 4 and 5 differed from other experiments in this chapter because they did not include the first test phase. The results from these experiments demonstrated a pre-extinction effect (in the no extinction conditions; only significant in Experiment 4); participants oriented more towards the expected stimuli (see Table 9). This is opposite to what is predicted by the associative account (Wagner, 1981). There have been some studies reporting greater orientation towards the expected stimuli (e.g. Hannula et al., 2010). There are no obvious explanations as to why these results vary from associative OICL effects (e.g. Dix & Aggleton, 1999; Whitt, Haselgrove, & Robinson, 2012). However, it is possible for the SOP model (Wagner, 1981) to predict this opposite effect (orientation towards the expected image) and this has been demonstrated in a number of studies (e.g. Baxter, 1966; Donegan, 1981; Kimble & Ost, 1961). US intensities have been shown to affect the UR and the SOP model can predict whether diminished or facilitative responding will be observed, as diminished responding is more likely to result when there are high US intensities (Becker & Killion, 1977). This demonstrates that the associative model can account for both effects, however, experiments in this chapter used the same US intensities across experiments and participants had greater orientation towards the unexpected in some (Experiments 1 and 2) and towards the expected in others (Experiments 4 and 5). Although the effect demonstrated was opposite to what is predicted by the SOP model, it does demonstrate that there was some pre-extinction learning. This learning pattern is also present in the extinction condition, suggesting that extinction was not successful. This suggests that

removing the first test phase was not successful in allowing for an extinction effect to be revealed.

It is also important to note that Wagner's (1981) model predicts that inhibitory learning is slower than excitatory learning. In Experiments 2/3, 4 and 5, there were 48 training trials and 32 extinction trials (see Table 9). This may cause an issue, as this design allows more time for excitatory learning than for inhibitory learning, when inhibitory learning requires more time. If participants did form associations in the training phase, it may be that the extinction phase was not long enough to extinguish the learning.

Closer inspection of performance across individual participants revealed that there was a lot of variability in the extinction tests. The O-LIFE questionnaire was sent out to all 96 participants that took part in the extinction tasks to address individual differences (e.g. Burch et al., 1998; Claridge & Broks, 1984; Mason et al., 1995). It was predicted that O-LIFE scores would predict performance on the extinction experiments, as high O-LIFE scores have been correlated with deficits in working memory, executive function and attention (Dembińska-Krajewska & Rybakowski, 2014); however, a multiple regression analysis was unable to support this prediction. The analysis was underpowered and most likely required a greater sample size to address this prediction.

Chapter 3 was unable to provide any support for which of the two models best explains recognition memory. Wagner's (1981) model and the declarative account (Aggleton & Brown, 2006) are both able to explain OICL. Extinction is better explained by Wagner's (1981) model; however, this chapter offers no support for extinction. Therefore, Chapter 4 attempts to

distinguish which account is better at explaining recognition memory by applying spacing effects.

CHAPTER 4

4 Spacing Effects: Manipulating Experimental ISIs

Chapter 3 sought to test a prediction from the associative analysis of OICL, extinction. The experiments presented were unable to demonstrate basic OICL and therefore, also unable to demonstrate evidence of extinction, as there may not have been a basic effect to extinguish. It is also important to note that although the associative model explains extinction more clearly, it is also possible to explain this phenomenon using the declarative model, but this explanation must be forced out of the model and is not naturally predicted. Chapter 4 explores spacing effects, which can only be clearly explained by the associative model. Evidence of spacing effects would demonstrate that recognition memory is better explained from an associative standpoint.

The task that will be used in this chapter to explore spacing effects is spontaneous object recognition. In this task, object A is pre-exposed during training before object A is presented alongside object B during testing. It is expected that participants will orient more towards object B if associations have been formed between object A and the context, or if the test occurs shortly after training. Spacing manipulations can alter the effect observed in this type of task to test Wagner's (1981) SOP model, as manipulating the ISI can affect the object-context association during pre-exposure and manipulating the retention interval can affect orientation due to recent exposure. This will be further discussed in the paragraphs that follow.

Wagner (1981) uses two key terms when predicting and explaining associative effects in spacing tasks, self- and retrieval-generated priming. Self-

generated priming occurs by recall from recent presentations. The retention interval will determine the level of self-generated priming at test, as self-generated priming is higher when tested shortly after training. The stimulus is likely to remain in the A2 activity state due to the recency of the last presentation, so if tested immediately, there should be decreased responding to object A. Retrieval-generated priming is used to describe spacing effects observed due to ISI manipulation. Retrieval-generated priming uses retrieval cues or associations to prime memories. Retrieval-generated priming does not rely on recent presentations and is high when time between pre-exposures is long, as this allows the elements to return to a state of inactivity between each trial, subsequently allowing them to return to the A1 activity state on each pre-exposure and strengthening the excitatory association. Strong object-context associations are less likely to be formed when time between the pre-exposure trials is short. During the first pre-exposure, both object A and the context will have elements in the A1 activity state, where they will elicit strong exploratory behaviour and form an excitatory association. Eventually the elements will decay into the A2 activity state, where they will only elicit weak responding. On subsequent pre-exposure trials, if the ISI is short, the elements will not have had enough time to decay back into the inactive state, so will remain in the A2 state, preventing the excitatory association from being strengthened. Therefore, a longer space between trials allows a stronger object-context association to be formed and when object A is presented alongside object B during the test, orientation towards B is expected to be greater when there are longer ISIs during training, if testing occurs after a delay.

One common way to test this prediction of the model is by comparing massed (a single longer pre-exposure trial) and spaced (multiple shorter pre-exposure trials) training. The massed condition behaves similar to when time between pre-exposure trials is short and the spaced condition is identical to training with longer ISIs. Therefore, for the same reasons as described in the previous paragraph, in massed training, elements of object A will be in the A2 activity state and if tested immediately, responding will be less with massed than spaced trials.

Performance at test may reflect a mixture of self- and retrieval-generated priming, meaning one may mask the presence of the other when effects such as ceiling effects are observed. Therefore, it is expected that pre-exposure spacing effects may only be revealed when the retention interval is long and retrieval-generated priming is high, and effects suggesting self-generated priming at test may only be revealed when retrieval-generated priming is low (e.g. short pre-exposure spacing). Effects demonstrating this pattern of results has been reported by Davis (1970). In this study, rats were presented with tones and startle responses were measured. In a pre-habituation session, rats were exposed to 300 presentations of the tone with mixed ITIs of 2, 4, 8 and 16 seconds. Using responses from the pre-habituation session, rats were assigned to two different ITI groups for training. During a habituation training session, rats were exposed to 1000 presentations of a tone with either a short two second ITI (massed) or a longer 16 second ITI (spaced). During the post-habituation test session, rats were again exposed to 300 presentations of the tone with mixed ITIs of 2, 4, 8 and 16 seconds. Rats in the massed training group demonstrated lower startle responses compared to the spaced

group during habituation training, suggesting stronger short-term habituation. However, stronger long-term habituation was observed only with the spaced habituation training group. When tested 1 minute or 24 hours after habituation training, rats in the spaced condition showed lower startle responses compared to rats in the massed condition.

In a similar study, Sanderson and Bannerman (2011) tested mice in a spatial novelty preference task with different ITIs between pre-exposures and various retention intervals between pre-exposure and test. The mice were pre-exposed to a Y-shaped maze with either ten two-minute pre-exposures or two ten-minute pre-exposures. The ITI between pre-exposure trials was either one minute or 24 hours. They were later tested on a novelty preference task after either a one-minute or 24-hour retention interval. Mice were able to explore the two arms of the maze that they were pre-exposed to, as well as a third, novel arm of the maze. Habituation during pre-exposure training was greater for mice that had a one-minute ITI than mice that were trained with a 24-hour ITI; this demonstrates greater short-term habituation. When mice were tested after the 24-hour retention interval, the novelty preference was stronger for those in the 24-hour ITI training group when compared to the mice who had a one-minute ITI during training, which suggests greater long-term habituation.

There have also been spacing effects documented in the literature testing human participants. For example, Gatchel (1975) presented humans with a tone with either a 20-second or 100-second ITI and measured both heartrate and skin-conductance. All participants were tested after a 15-minute retention interval. Participants demonstrated greater habituation during training in the

shorter ITI group than in the longer ITI group, demonstrating stronger short-term habituation. However, after the retention interval, participants who were trained with the longer ITI demonstrated greater habituation when compared to the shorter ITI group, indicating greater long-term habituation. This study suggested that humans are also sensitive to spacing, however this study did not test novelty preference.

The experiments in this chapter will test for spacing effects in spontaneous object recognition (SOR) tasks. Evidence of spacing effects in SOR tasks has been demonstrated in several studies testing rodents (e.g. Sanderson & Bannerman, 2011; also see Anderson, Jablonski & Klimas, 2008; Whitt & Robinson, 2013; Tam, Robinson, Jennings & Bonardi, 2014). The declarative model (Aggleton & Brown, 2006) does not offer a prediction or an explanation for the spacing effects demonstrated in spacing studies. This model has no sound justification for why a greater novelty preference is observed when the time between training trials is increased. If anything, the model would predict the opposite, as increased time allows for forgetting. It is possible to produce an explanation and suggest that this account may have some time-dependent process that would benefit from having longer spaces (e.g. memory consolidation). However, this is not clearly predicted or well specified, and therefore, evidence of spacing effects is better explained from an associative standpoint.

Experiments in this chapter aim to replicate findings reported in recognition memory tasks in non-human animal spacing studies using a human participant sample and to extend the generality of spacing effects. The SOR task used in the experiments presented has been adapted for humans by

presenting images on a computer screen while tracking eye-movements to measure dwell time. It is predicted that having a longer time between pre-exposure (training) trials will produce a greater novelty preference when tested after a delay. The levels of self- and retrieval-generated priming can be determined by the retention interval, as novelty preferences observed after a short retention interval may reflect self-generated priming and novelty preferences after a long retention interval may reflect retrieval-generated priming (when ISIs were long).

4.1 Experiment 9

Experiment 9 is an adaptation of the spontaneous object recognition tasks conducted in rodent studies (e.g. Jablonski & Klimas, 2008; Sanderson & Bannerman, 2011) including various inter-stimulus intervals (ISIs), 0, 2, 4 or 8 seconds, and retention intervals (RIs; time between training and test), 1 or 10 seconds.

Participants were pre-exposed to one image (object A), four times, with various short and long ISIs. Participants were then presented with a test, objects A and B, with either a short or long RI before the test. It was expected that with short RIs there would be greater novelty preferences with short ISIs than with long ISIs, but with long RIs the opposite would be observed. This is because after a short RI, there will be greater self-generated priming at test, as the stimulus is likely to remain in the A2 activity state due to the recency of the last presentation. However, when the RI is long, longer ISIs are expected to produce a greater effect due to retrieval-generated priming. Retrieval-generated priming is high when time between pre-exposures is long, as this allows time for the elements to return to the inactive state between stimulus presentations and re-enter the A1 activity state on each trial, thus enabling stronger associations to be formed (Wagner, 1981).

This experiment aimed to provide evidence of spacing effects in spontaneous object recognition tasks in humans to extend the generality of the associative effects observed in non-human animal studies. Evidence of spacing effects offer support for an associative analysis of object recognition, as the declarative model does not clearly predict or explain these effects.

4.1.1 **Method**

4.1.1.1 Participants

Twenty-four (18 females, 6 males) university students from the University of Nottingham, ages 18-36 (M= 21.71, SD = 3.92) participated in the experiment. Students received course credit or a £3 inconvenience allowance for participating in the study. All other participant and eye-tracking conditions were the same as in Experiment 2.

4.1.1.2 Apparatus and stimuli

Stimuli consisted of 64 images of everyday objects from the Bank of Standardized Stimuli (BOSS; Brodeur, Dionne-Dostie, Montreuil, & Lepage, 2010). Visual noise stimuli, constantly moving small dots that appear to look like static, were created in PsychoPy and presented on the screen between image presentations. All the stimuli were 10cm x 13cm and were 25cm apart (each 12.5cm from the centre on the horizontal plane). The regions of interest were set to be the same size and in the same location as the stimuli. The images were presented on a grey coloured background set to cover the entire screen (28 x 51cm). The same sample image was shown on the left and right sides of the screen during training, whereas one old (familiar) and one new (novel) image were shown during test. The location of the novel image at test was counterbalanced (left/right) as well as which stimuli served as sample or test images in the experiment (e.g. image A was presented during training in version 1 and as a novel test image in version 2 of the experiment). This created a total of four counterbalanced sub-groups of the experiment.

4.1.1.3 Procedure

The experiment program and eye-tracker were set up in the same way as in Experiment 1 (see Experiment 1 method). This was a within-subjects design, so all participants were exposed to every condition. This experiment included four different ISIs, 0, 2, 4 or 8 seconds (8 trials of each ISI type) and two different retention intervals, 1 or 10 seconds (16 trials of each RI type). Each ISI was presented with a 1-second RI four times and with a 10-second RI four times. The different conditions were presented in a randomised manner. Every participant completed 32 trials.

As in previous experiments, participants were told to carefully watch the images that were presented on the screen because they would be given a short memory test upon completion of the experiment. To begin each trial, participants first focused on a fixation cross in the centre of the screen for one second. They were then presented with the sample image, object A, on both sides of the screen (left and right) with a grey background for 2 seconds. This was followed by the ISI, where visual noise was presented in place of the images. Sample images repeated for a total of four presentations, each time with the same ISI. After the fourth presentation, there was a retention interval, again with visual noise in place of the images. Participants were then presented with the test, where the familiar image, object A, was presented alongside a novel image, object B (see Figure 16).

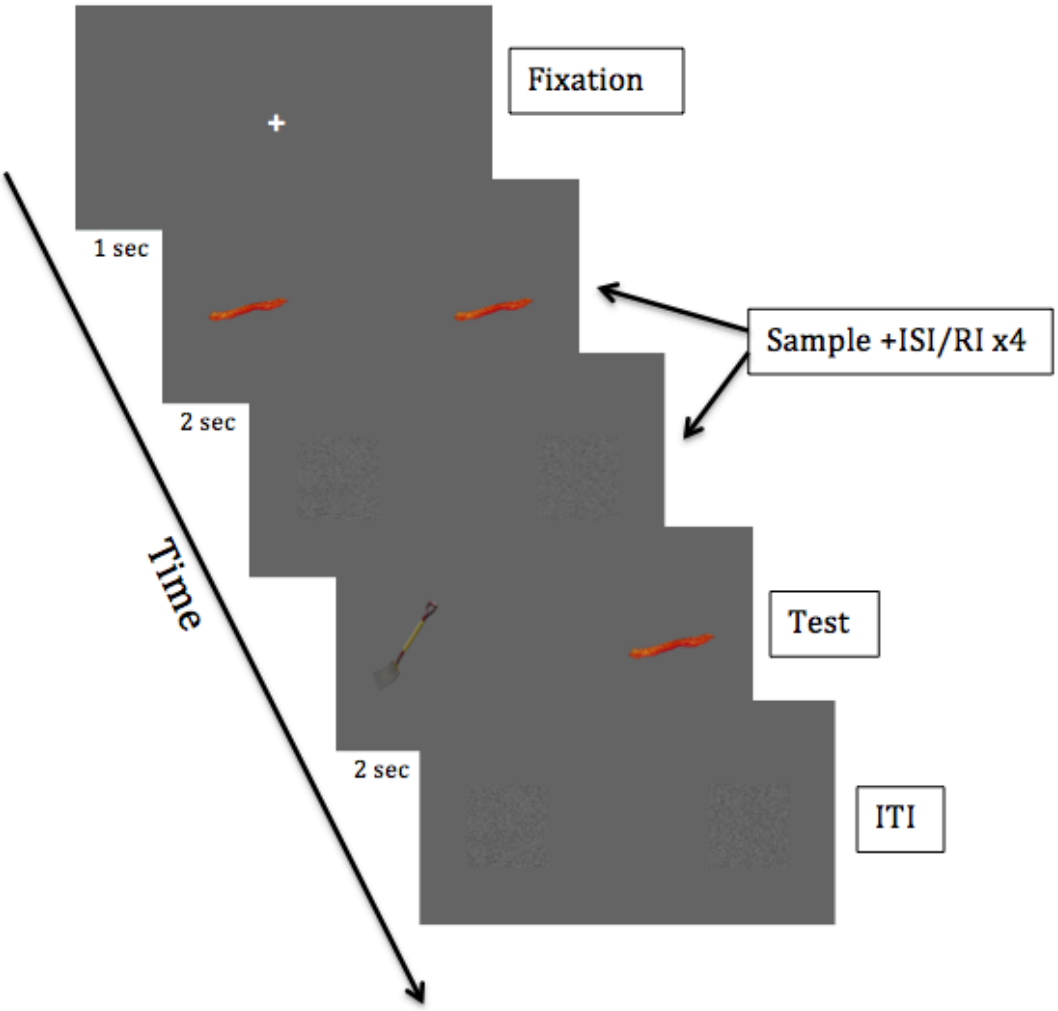


Figure 16: *Example trial. Every trial commenced with a one second fixation cross. This was followed by the sample image presented for two seconds on the left and the right (e.g. bacon) and the inter-stimulus-interval (ISI; 0, 2, 4 or 8 seconds). The sample repeated for a total of four presentations. The same ISI was used after the first three sample presentations. The retention interval (RI) was presented after the fourth and final sample presentation (1 or 10 seconds). Participants were then presented with the test, one familiar image (bacon) and one novel image (e.g. garden rake). Lastly, there was an inter-trial-interval (ITI) before the next trial began (same length as ISI).*

The experiment lasted approximately 20 minutes. After the experiment was finished, the post-test was administered on a piece of paper. Participants were given true/false questions and asked to identify which of 16 images was present during the study. As in previous experiments, the memory test was excluded from analyses and given to help participants maintain attention throughout the task.

4.1.2 **Data Treatment and Analyses**

Data were treated and analysed in the same way as in Experiment 1 (see Experiment 1 Data Treatment and Analyses section) unless otherwise stated. A power analysis determined that a minimum of 7 participants would be required in this experiment. All the same input parameters were used as in previous power analyses, with the number of measures adjusted to 32 for this experiment (Faul et al., 2007). In this experiment, dwell time (ms) was analysed across different spacing conditions. Trials were not binned into trial blocks, as there were only 8 trials of each trial type.

4.1.3 **Results and Discussion**

All participants had a minimum of 80% of eye movements recorded, so there were no exclusions in the analyses (e.g. Le Pelley, Beesley, & Griffiths, 2011). Participants spent more time looking at novel images than at familiar images, however there were no differences in novelty preference across the spacing conditions (see Figure 17).

A 2x4x2 repeated measures ANOVA was run. Factors included in the ANOVA were stimulus type (novel/familiar), ISI (0, 2, 4 or 8 seconds), and retention interval (1 or 10 seconds). There was a main effect of stimulus type,

$F(1,23) = 158.49$, $p < .001$, $\eta_p^2 = .873$, 90% CI [.766, .911], no main effect of ISI, $F(3, 69) = 1.72$, $p = .171$, $\eta_p^2 = .070$, 90% CI [0, .150], and no main effect of retention interval, $F(1,23) = 0.54$, $p = .470$, $\eta_p^2 = .023$, 90% CI [0, .183]. However, the three-way interaction between stimulus type, ISI and RI was significant, $F(3, 69) = 3.13$, $p = .031$, $\eta_p^2 = .120$, 90% CI [.006, .216].

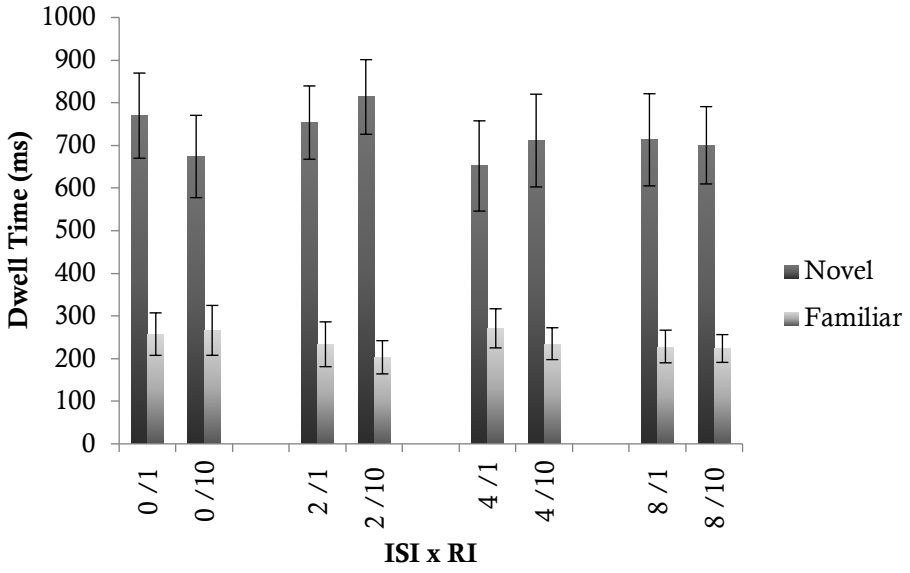


Figure 17: *Dwell time towards the novel and familiar stimuli across all ISI conditions (0, 2, 4 or 8 seconds) and RI conditions (1 or 10 seconds). All stimuli were presented for 2000ms, therefore a mean dwell time of 1000ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

Additional two-way ANOVAs were conducted to explore the three-way interaction. The ANOVAs analysed the short (RI 1) and long (RI 10) retention interval data separately. The first ANOVA was on the short, one-second retention interval data and included the factors stimulus type (novel/familiar) and ISI (0, 2, 4 or 8 seconds). There was a reliable main effect of stimulus type, $F(1, 23) = 123.83$, $p < .001$, $\eta_p^2 = .843$, 90% CI [.715, .890], no main effect of ISI $F(3, 69) = 1.84$, $p = .148$, $\eta_p^2 = .074$, 90% CI [0, .156], and no interaction between stimulus type and ISI, $F(3, 69) = 1.83$, $p = .149$, $\eta_p^2 = .074$, 90% CI [0, .156]. This suggests there were no effects of spacing with the shorter RI.

The second two-way ANOVA was on the long, ten-second retention interval data and included the factors stimulus type (novel/familiar) and ISI (0, 2, 4 or 8 seconds). There was a main effect of stimulus type, $F(1, 23) = 159.14$, $p < .001$, $\eta_p^2 = .874$, 90% CI [.767, .911], no main effect of ISI, $F(3, 69) = 1.32$, $p = .275$, $\eta_p^2 = .054$, 90% CI [0, .127], however, there was an interaction between stimulus type and ISI, rendering the main effect of stimulus type meaningless, $F(3, 69) = 2.78$, $p = .049$, $\eta_p^2 = .107$, 90% CI [.001, .201]. Simple main effects suggest that there was a significant effect of stimulus type across all ISI conditions ($Fs > 30$, $ps < .001$); as demonstrated in the chart, there were large novelty preferences across all ISI conditions. In addition, there was no effect of ISI at the novel or familiar level ($ps > .08$). A post-hoc Tukey test confirmed that all novel conditions significantly differed from all familiar conditions ($ps < .001$). In addition, novel ISI 0 was significantly different than novel ISI 2 ($p = .040$); as seen in Figure 17,

participants spent more time looking at the novel stimulus in the ISI 2 condition than in the ISI 0 condition with RI 10. 95% confidence intervals [-16.823, .073] suggest this effect may be unreliable and this effect is not of theoretical importance, as it does not support predictions. No other comparisons were significant (*ps*>.1). Post-hoc analyses suggest that the spacing predictions were not supported in this experiment.

Participants spent more time looking at novel images compared to familiar images, as predicted by Wagner's (1981) model. However, this experiment provided no evidence of spacing effects and does not offer support for an associative model. This may be due to the spacing conditions used. The associative model is unable to predict the required length of time between stimulus presentations; therefore, it is possible that the ISIs and RIs used in the current experiment are unable to result in spacing effects. Wagner's (1981) SOP model predicts that there will be an interaction between self- and retrieval-generated priming. Retrieval-generated priming may be producing the novelty preference in the longer RI condition, whereas self-generated priming may be producing the novelty preference in the shorter RI condition. However, there was a strong novelty preference demonstrated across all ISI conditions with a long RI, suggesting this manipulation was unsuccessful, as it is expected that only long ISI conditions will demonstrate strong learning in the long RI condition using retrieval-generated priming. In the next experiment, the ISIs and RIs were manipulated and contexts were added to better test the associative model of recognition memory.

4.2 Experiment 10

It is possible that Experiment 9 was unsuccessful due to the spacing intervals used, as the associative model offers no guidelines to determine the optimum length of spacing needed to obtain spacing effects. The current experiment included adjusted ISIs (1, 3 or 5 seconds) and RIs (1, 3, 5, 10, 15 or 20 seconds) to test for spacing effects.

In addition, this experiment tested context change between training and test trials. A change of context can also test the associative account, specifically the retrieval-generated priming aspect. On trials where the retention interval is longer and the context changed at test, the context will not be able to prime the familiar image's elements into the A2 state, which may result in an impaired novelty preference. Examples of this have been reported in the literature. For example, Richmond et al. (2004) presented human adults with two identical morphing faces during a training phase. They were later tested with the familiar face from training and a novel morphing face in either the same context or in a novel context. Eye tracking results demonstrated that the novelty preference was impaired after a context change; results demonstrated that participants spent a comparable amount of time viewing the novel and familiar morphing faces. However, in the same context condition, participants demonstrated a strong novelty preference. Therefore, it is predicted that results in the current study will demonstrate a reduced novelty preference on trials where the context changed at test compared to when the context remained the same.

4.2.1 **Method**

4.2.1.1 Participants

Twenty-four undergraduate students (21 females, 3 males) from the University of Nottingham, ages 18-21 (M= 18.38, SD = 1.64) participated in the experiment. Students received course credit for participating in the study. All other participant and eye-tracking conditions were the same as in Experiment 2.

4.2.1.2 Apparatus and stimuli

The current experiment was created in the same way as Experiment 9, however there were 72 images that were presented on either a day or night sky background set to cover the entire screen (28 x 51cm). The location of the novel image at test was counterbalanced (left/right) as well as which stimuli served as sample or test images. The background paired with each stimulus during training (day or night sky) and whether the same or different background was presented at test was also counterbalanced. There was a total of eight counterbalanced sub-groups of the experiment created.

4.2.1.3 Procedure

This experiment was run in the same way as Experiment 9 (see Experiment 9 Method) with the inclusion of new ISIs and retention intervals, as well as new contexts (computer backgrounds).

The new ISIs were 1, 3 or 5 seconds (12 trials of each ISI type) and the images were displayed on either a day or night sky scene. There was a retention interval of 1, 3, 5, 10, 15 or 20 seconds (6 trials of each RI type)

before the sample image was shown alongside a novel image. The background during the test could be the same or different to what it was during the sample presentations. If the background changed, the onset of the new background and the termination of the old background occurred simultaneously (see Figure 18). Each ISI type was presented with each RI type twice, once with the same background at test and once with a different background at test. Every participant completed 36 trials.

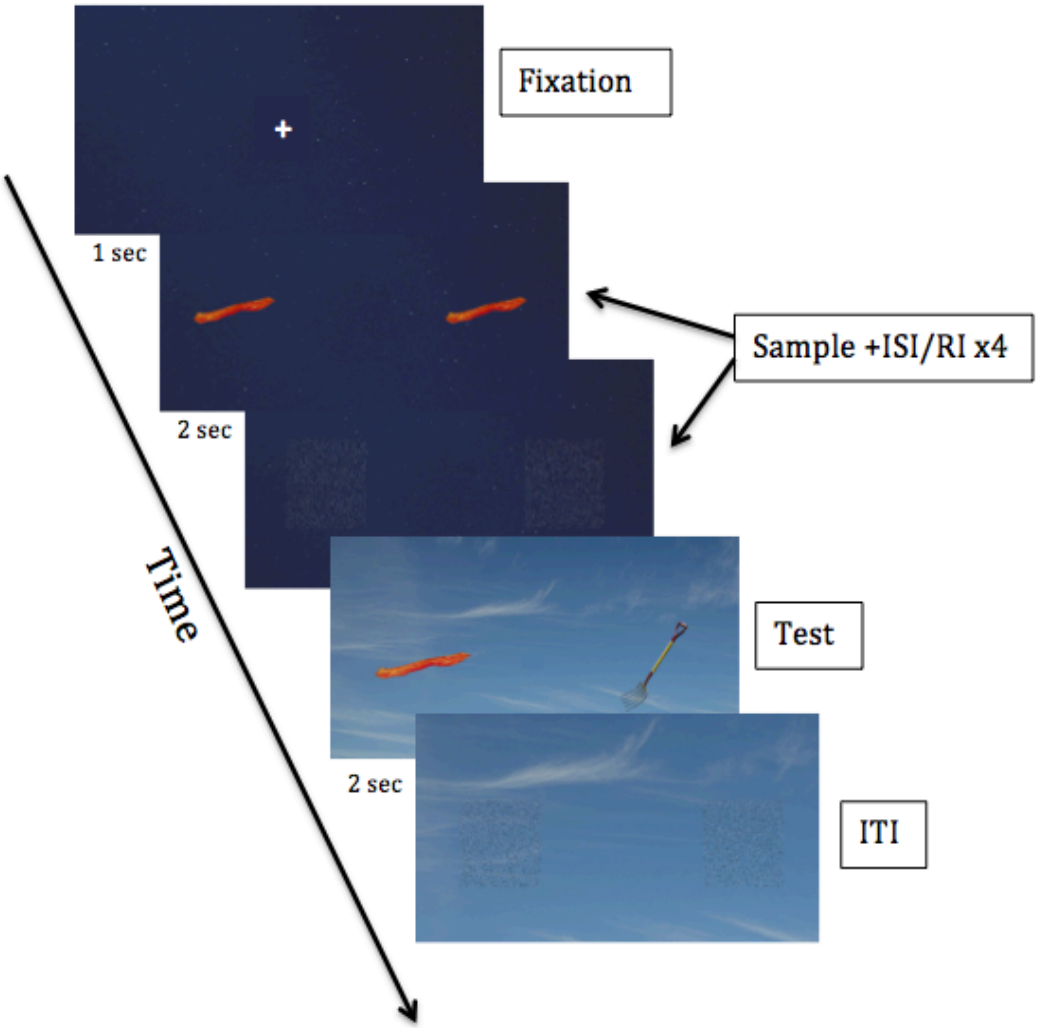


Figure 18: *Example trial. Every trial commenced with a one second fixation cross. This was followed by the sample image presented for two seconds on the left and the right (e.g. bacon) and the ISI (1, 3 or 5 seconds). The sample repeated for a total of four presentations with the same ISI after the first three sample presentations. The RI was presented after the fourth sample presentation (1, 3, 5, 10, 15 or 20 seconds). Participants were then presented with the test, one familiar image (bacon) and one novel image (e.g. garden rake). Lastly, there was an ITI before the next trial began (same length as ISI). The background was either a day or night sky and could be the same or different at test.*

4.2.2 **Data Treatment and Analyses**

Data were treated and analysed in the same way as in Experiments 1 and 9 (see Experiments 1 & 9 Data Treatment and Analyses section) unless otherwise stated. A power analysis determined that a minimum of 7 participants would be required in this experiment, which had 36 trials (Faul et al., 2007). Again, data were not binned into trial blocks in the current experiment because there was only one trial of each trial type. The context at test was either the same or different to what it was during training, so context was added as a factor in the ANOVA.

4.2.3 **Results and Discussion**

There were no exclusions in the analyses, as all participants had a minimum of 80% of eye movements recorded (e.g. Le Pelley, Beesley, & Griffiths, 2011). Again, participants spent more time looking at novel images than at familiar images and spacing did not alter novelty preferences. Participants spent more time looking at novel images compared to familiar images regardless of the ISI or RI. Context affected looking preference; participants spent more time looking at images when the context changed at test compared to when it was the same (see Figures 19, 20 & 21).

A 2x2x3x6 repeated measures ANOVA was run. The ANOVA factors were stimulus type (novel/familiar), context (same/different computer background at test), ISI (1, 3 or 5 seconds), and RI (1, 3, 5, 10, 15 or 20 seconds). There was a main effect of stimulus type, $F(1,23) = 274.71$, $p < .001$, $\eta_p^2 = .923$, 90% CI [.855, .945], and a main effect of context, $F(1,23) = 28.59$, $p < .001$, $\eta_p^2 = .554$, 90% CI [.292, .686].

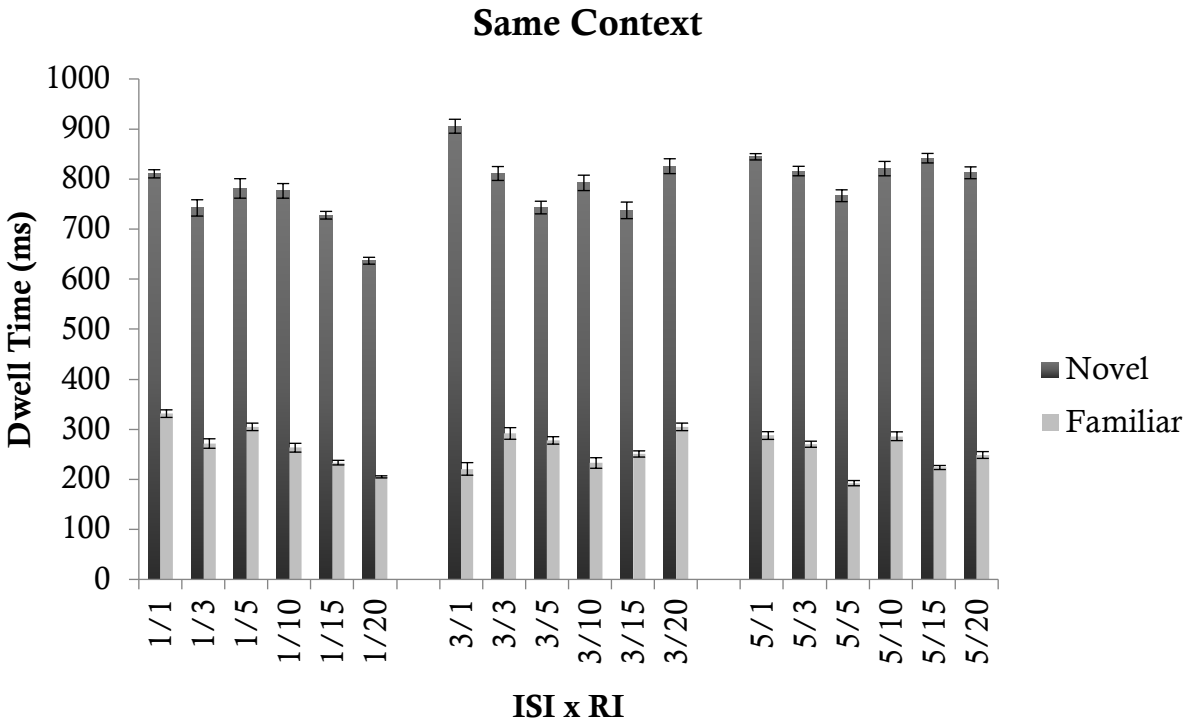


Figure 19: *Dwell times towards novel and familiar stimuli across all ISI conditions (1, 3 or 5 seconds) and RI conditions (1, 3, 5, 10, 15 or 20 seconds) in the same context condition. All stimuli were presented for 2000ms, therefore a mean dwell time of 1000ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

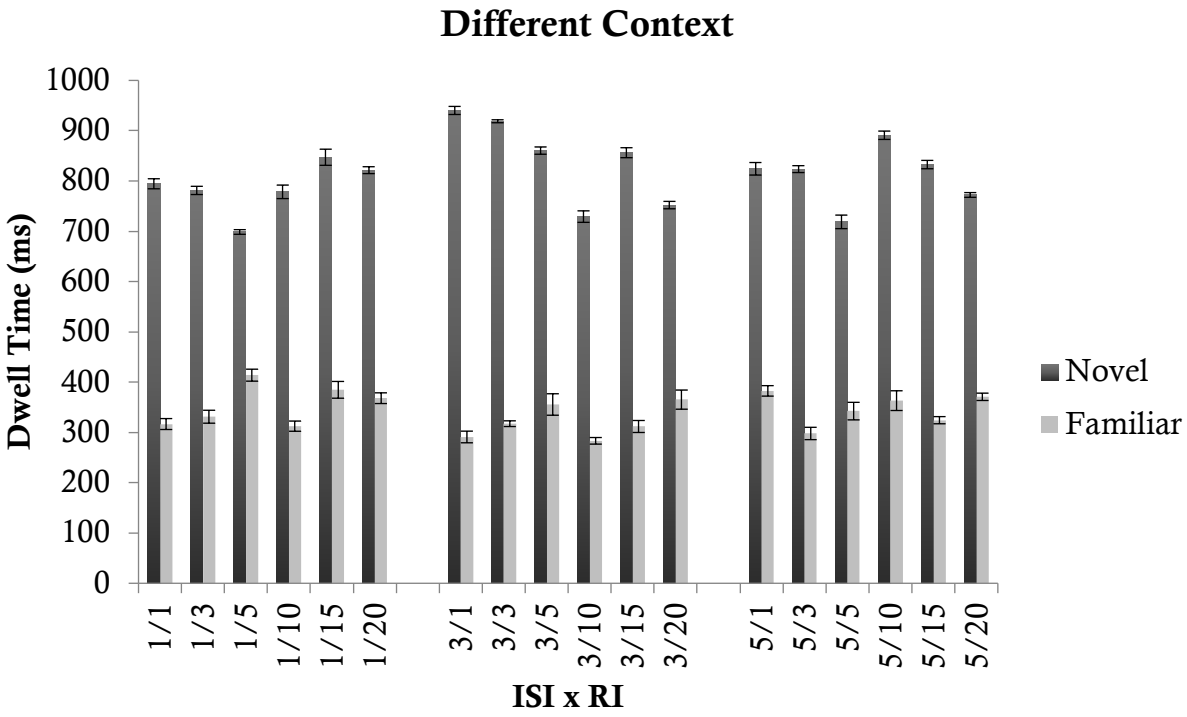


Figure 20: *Dwell times towards novel and familiar stimuli across all ISI conditions (1, 3 or 5 seconds) and RI conditions (1, 3, 5, 10, 15 or 20 seconds) in the different context condition. All stimuli were presented for 2000ms, therefore a mean dwell time of 1000ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

However, main effects are not of interest, as there was also a reliable interaction between stimulus type and context, $F(1, 23) = 7.01$, $p = .014$, $\eta_p^2 = .234$, 90% CI [.028, .435]. Simple main effects suggest that participants spent more time looking at the familiar image when the context was different than when it was the same at test, $F(1, 23) = 40.23$, $p < .001$, $\eta_p^2 = .636$, 90% CI [.396, .745]. The dwell times for the novel images were similar in the same and different context conditions (*ps*>.1; see Figure 21). This may offer some support for an associative model, as the model predicts that when the context changes at test, it is unable to prime the familiar image into the A2 state (retrieval-generated priming), therefore the image can move into the A1 state. Participants may have spent more time looking at images on the different background because both images were able to move into the A1 state and therefore this may increase the overall dwell time.

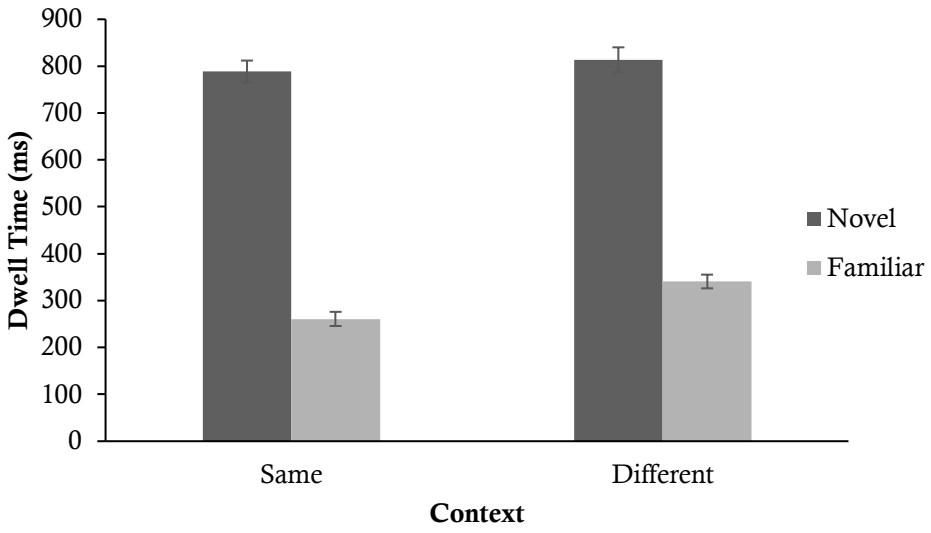


Figure 21: *Mean dwell times towards novel and familiar stimuli across all ISI conditions (1, 3 or 5 seconds) and RI conditions (1, 3, 5, 10, 15 or 20 seconds) collapsed in the same and different context conditions. All stimuli were presented for 2000ms, therefore a mean dwell time of 1000ms demonstrates that participants spent half of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

The interaction between ISI and RI was significant, $F(10, 230) = 2.01$, $p = .033$, $\eta_p^2 = .080$, 90% CI [.003, .102], but rendered meaningless, as there was a significant three-way interaction between context, ISI and RI, $F(10, 230) = 2.28$, $p = .015$, $\eta_p^2 = .090$, 90% CI [.009, .114]. Post-hoc analyses were not included, as there is no obvious theoretical significance of the interaction, as there was no interaction with stimulus type.

There was no main effect of ISI, $F(2, 46) = 1.09$, $p = .345$, $\eta_p^2 = .045$, 90% CI [0, .145], or retention interval, $F(5,115) = 2.15$, $p = .064$, $\eta_p^2 = .086$, 90% CI [0, .140], and no other significant interactions (ps>.08).

Participants spent more time looking at novel images than familiar images, as predicted by Wagner's (1981) model. In addition, participants spent more time looking at the familiar image when the context was different at test, which is also predicted by the associative model. One possible explanation for this is that the context change at test prevented the context from priming the familiar image into the A2 activity state, therefore participants spent more time looking at the familiar image on these trials compared to dwell time towards the familiar image on same context trials. However, it is also possible to produce an explanation for this effect using the declarative account. Participants are able to store the familiar image and context into memory during pre-exposure. During the test, when the context remains the same, the participants were able to use episodic memory recall and familiarity detection to match the previously presented image with the context and therefore spend little time looking at the familiar image. When the context was different at test, the participant would recall that the image was familiar, however that it was not previously observed in that particular context, so therefore the participant would explore it more than when the context remained constant.

Again, this experiment provided no evidence of spacing effects. As in Experiment 9, it is possible to predict that self-generated priming revealed a novelty preference with short RIs and retrieval-generated priming revealed a novelty preference with long RIs, however, there were no differences in

novelty preference across ISI conditions in the long RI conditions, suggesting no effect of spacing manipulations. It is also possible the RIs were not long enough in this experiment and that all novelty preferences observed were due to self-generated priming. In the next experiment, a much longer RI is used to test differences in ISI conditions. Also, in the current experiment, the context remained on the screen during the ISIs and RIs. According to the associative account, this would mean that the elements for the context were unable to return to a state of inactivity between trials. If the context is changed during ISIs and RIs, it will allow stronger context-image associations to be formed in long ISI conditions. In the next experiment, this change in procedure was applied to ensure conditions allowed for strong associations to be formed to test retrieval-generated priming with longer ISIs.

4.3 Experiment 11

Experiment 11 was conducted because the previous spacing experiments were inconclusive and unable to demonstrate evidence of spacing. This study focused on a subset of predictions from previous experiments by no longer testing short-term effects of spacing and focusing on the long-term effects of spacing. This experiment included one long retention interval (2 minutes), and the ISIs were much more spaced (1, 10 or 30 seconds).

The spacing intervals were changed in this experiment, as Experiments 9 and 10 were unable to demonstrate spacing effects. This may challenge Wagner's (1981) SOP model, or it may be because the spacing intervals used were unable to produce spacing effects. There is no way to predict or compute the spacing intervals necessary to produce spacing effects, therefore this experiment used new intervals that were hypothesised to affect the novelty preference at test.

As previously suggested, it is possible that prior experiments demonstrated a mixture of self- and retrieval-generated priming, as a novelty preference may have been demonstrated with short RIs because of self-generated priming and a novelty preference may have been demonstrated with long RIs because of retrieval-generated priming. However, prior experiments also demonstrated no differences in novelty preference across ISI conditions, suggesting ceiling effects. Therefore, it may be that RIs were not long enough and that all novelty preferences observed were due to self-generated priming. This experiment included one much longer RI, predicting that it would be long enough to test long-term effects of spacing.

The current experiment also included ISIs that were much more spaced out and a 30 second ISI, which is longer than any ISI included in previous experiments. This experiment also introduced a different context when the stimuli were present, compared to when they were not present (during fixation, ISIs and RIs). This may allow the context to have the opportunity to recover by returning to a state of inactivity between stimulus presentations, consequently allowing for stronger context image associations to be formed with the longer ISIs. In addition, presenting the context alone, as there are no stimuli present during fixation, ISIs and RIs, can allow extinction to occur. Therefore, it is predicted that changes made in the current experiment will allow for stronger associations to be formed in long ISI conditions and therefore, result in a stronger novelty preference than short ISI conditions, demonstrating retrieval-generated priming.

4.3.1 **Method**

4.3.1.1 Participants

Twenty-four (16 females, 8 males) undergraduate students from the University of Nottingham, ages 18-37 (M= 22.04, SD = 4.84) participated in the experiment. Students received course credit for participating in the study. All other participant and eye-tracking conditions were the same as in Experiment 2.

4.3.1.2 Apparatus and stimuli

The current experiment was created in the same way as Experiment 9, however new ISIs and RIs were included and the background changed to black when the stimuli were not present, fixation, ISIs, and RIs. There were

12 images used in this experiment; the images came from the stimuli set used in Experiment 9. The location of the novel image at test was counterbalanced (left/right) as well as which stimuli served as sample or test images. There was a total of four counterbalanced sub-groups of the experiment created.

4.3.1.3 Procedure

This experiment was run in the same way as Experiment 9 (see Experiment 9 Method), unless otherwise stated. The new ISIs included were 1, 10 or 30 seconds (2 trials of each ISI type) and the images were displayed on a grey screen. There was a retention interval of 2 minutes before the sample image was shown alongside a novel image. Every participant completed 6 trials. The experiment lasted approximately 20 minutes (see Figure 22).

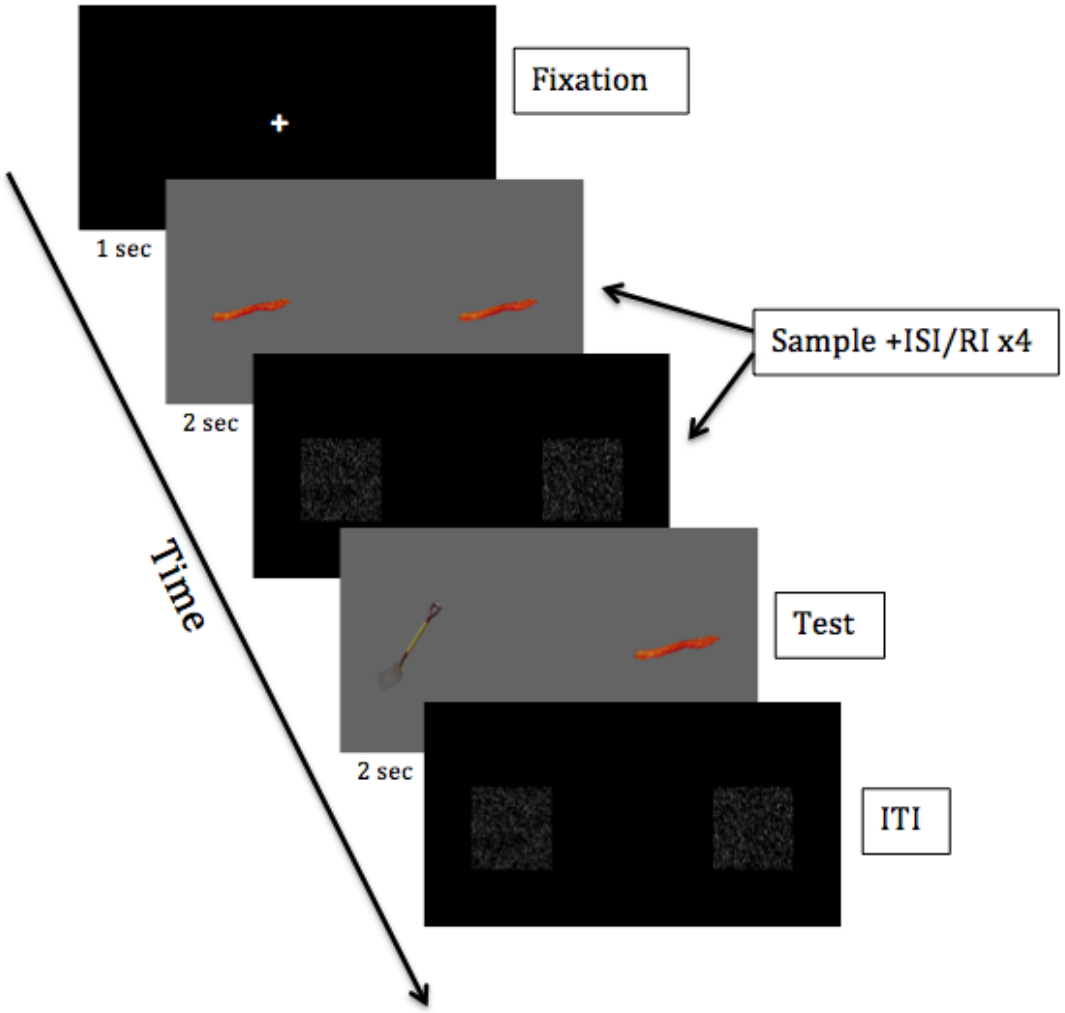


Figure 22: *Example trial. Every trial commenced with a one second fixation cross. This was followed by the sample image presented for two seconds on the left and the right (e.g. bacon) and the ISI (1, 10 or 30 seconds). The sample repeated for a total of four presentations with the same ISI after the first three sample presentations. The RI was presented after the fourth sample presentation (2 minutes). Participants were then presented with the test, one familiar image (bacon) and one novel image (e.g. garden rake). Lastly, there was an ITI before the next trial began (same length as ISI). The background was grey when the stimuli were present and black at all other times.*

4.3.2 **Data Treatment and Analyses**

Data were treated and analysed in the same way as in Experiments 1 and 9 (see Experiments 1 & 9 Data Treatment and Analyses section) unless otherwise stated. A power analysis determined that a minimum of 18 participants would be required in this experiment. All input parameters were the same as previous experiments, except the number of measurements was adjusted to 6 (Faul et al., 2007). Again, data were not binned into trial blocks, as there were only two trials of each trial type.

4.3.3 **Results and Discussion**

All participants met the cut-off criterion (80% of eye-movements recorded), so there were no exclusions in the analyses (e.g. Le Pelley, Beesley, & Griffiths, 2011). Consistent with Experiments 9 and 10, participants spent more time looking at novel images than at familiar images and spacing did not affect novelty preferences. Participants spent more time looking at the novel image regardless of the ISI (see Figure 23).

A 2x3 repeated measures ANOVA was run, with the factors stimulus type (novel/familiar) and ISI (1, 10 or 30 seconds). A reliable main effect of stimulus type, $F(1,23) = 60.30$, $p < .001$, $\eta_p^2 = .724$, 90% CI [.521, .806], was found, indicating that the stimulus type, novel or familiar, had an effect on looking behaviour. There was no main effect of ISI, $F(2, 46) = 6.30$, $p = .871$, $\eta_p^2 = .006$, 90% CI [.047, .353], and no interaction between stimulus type and ISI, $F(2, 46) = 1.20$, $p = .311$, $\eta_p^2 = .049$, 90% CI [0, .125].

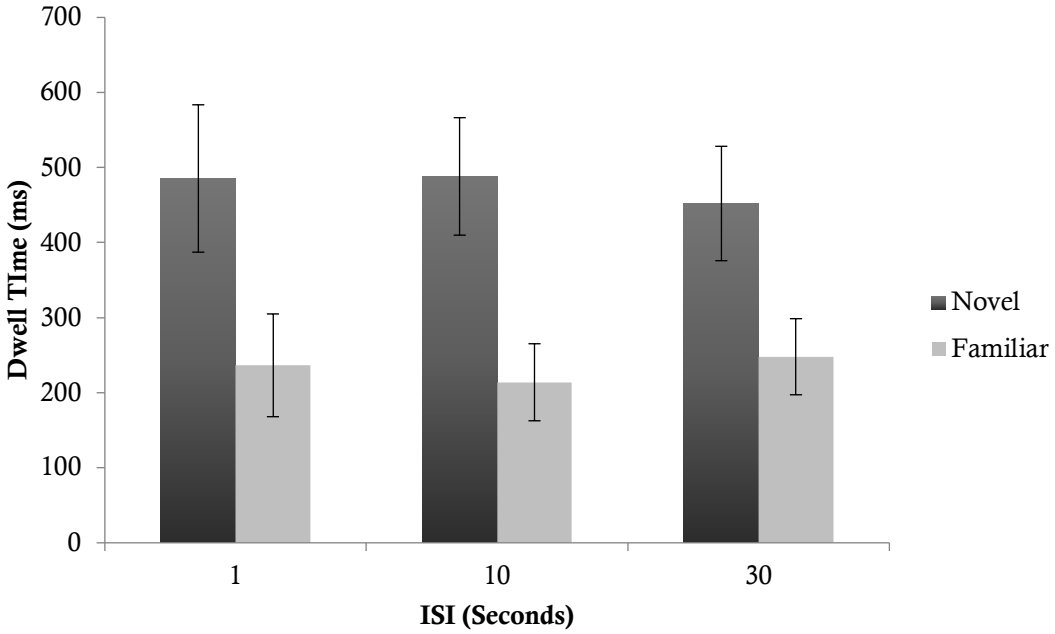


Figure 23: *Dwell times towards novel and familiar stimuli across all ISI conditions (1, 10 or 30 seconds). All stimuli were presented for 2000ms, therefore a mean dwell time of 500ms demonstrates that participants spent a quarter of the total trial time looking at that stimulus. Errors bars represent 95% confidence intervals (1.96 * (SD/sqrt(N)).*

As predicted by Wagner's (1981) SOP model, participants spent more time looking at novel images than familiar images. There was only one longer RI condition in this experiment, so it was expected that retrieval-generated priming would produce a stronger novelty preference in the longer ISI conditions, however this was not observed, suggesting spacing manipulations were unsuccessful. There is no way to predict the time it takes elements to decay from the A2 state to the inactive state, so it is possible that the intervals used in the experiments presented are incorrect, however many different

variables were tested across the three experiments, making this explanation less likely.

4.4 Chapter Discussion

Experiments in this chapter aimed to demonstrate evidence of spacing effects in a novelty preference task with human participants to support the associative model. The test of the associative model was unsuccessful, as the experiments presented were unable to demonstrate evidence of spacing effects. All three attempts did provide strong evidence of a novelty preference, however none of the ISI or RI manipulations were successful.

In Experiment 9, various ISIs (0, 2, 4 or 8 seconds) and retention intervals (1 or 10 seconds) were introduced to test the associative model. It was predicted that with short RIs there would be a greater effect with short ISIs than with long ISIs, whereas with long RIs the opposite was predicted. This is because the associative model predicts that after a short RI, there will be greater self-generated priming at test, as the stimulus will remain in the A2 state. However, with longer RIs, longer ISIs are predicted to produce a stronger effect due to retrieval-generated priming, as there will be time for the elements to return to the inactive state between stimulus presentations and re-enter the A1 activity state on pre-exposure, thus enabling stronger excitatory associations to be formed (Wagner, 1981). The declarative model (Aggleton & Brown, 2006) does not clearly predict or explain spacing effects. Although this model does not account for spacing effects, it is possible to propose an explanation. One potential explanation would be that when trained with shorter ISIs, the time between stimulus presentation is so short, that participants still remember the learning phase as a single 'episode', making test behaviour similar to single trial learning. When there are longer ISIs, it is possible to argue that there is time for memory consolidation, making the

recall better with longer ISIs. However, this explanation is forced out of the model and is not a clear, natural prediction. In addition, the interaction produced by the associative model, suggesting greater self-generated priming after a short delay and greater retrieval-generated priming after a long delay cannot be explained by the declarative model. The associative model clearly and precisely accounts for spacing effects. Chapter 9 results suggest that participants spent more time looking at novel images than at familiar images, however there were strong novelty preferences across all of the spacing conditions.

In Experiment 10, new ISIs (1, 3 or 5 seconds) and RIs (1, 3, 5, 10, 15 or 20 seconds) were included to further test for spacing effects. The experiment also included a context change between training and test trials to further test the associative account, specifically the retrieval-generated priming aspect. Again, participants spent more time looking at novel images than familiar images, but there were no effects of spacing. In addition, participants spent more time looking at the familiar image when the context was different at test. The associative account would predict that during the test, the context was unable to prime the familiar image's elements into the A2 state, as the context was different than it was during pre-exposure. Therefore, participants spent more time looking at the familiar stimuli in the different context condition than they did in the same context condition. It is also possible to produce an explanation from the declarative account for this effect (Aggleton & Brown, 2006). The declarative model may suggest that a novelty preference is observed because the familiar image and context are stored in memory during pre-exposure. When presented with the test, the participant uses

episodic memory recall and familiarity detection to match the previously presented image with the context and detect which object is new. When the context was different at test, the participant would recall that the image was familiar, however that it was not previously observed in that particular context, so therefore the participant would explore it more than when the context remained constant. Richmond et al. (2004) also reported that a context change affected performance in an SOR task. Results from this study indicated that the novelty preference was impaired when participants were tested in a novel context, but only after a longer delay of two weeks. Participants continued to show a novelty preference after a three-minute delay, however it was a smaller novelty preference than observed in the same context condition (also see e.g. Haaf, Lundy, & Coldren, 1996; Pescara-Kovach, Fulkerson, & Haaf, 2000). Although the effect in Experiment 10 demonstrates greater orientation towards the familiar image when the context was different at test, there was still a novelty preference. Findings from Richmond et al. (2004) suggest that a longer delay may be necessary to impair the novelty preference when tested in a novel context.

In Experiment 11, a subset of predictions from previous experiments was tested by focusing on the long-term effects of spacing, using one long RI (2 minutes), and no longer testing short-term effects of spacing. The ISIs were also much more spaced (1, 10 or 30 seconds). There was also a different context presented when the stimuli were present, compared to when they were not present to allow the context to have the opportunity to recover and return to a state of inactivity between stimulus presentations, and allow for stronger context image associations to be formed with the longer ISIs.

Participants spent more time looking at novel images than familiar images, however, there were no differences across ISI conditions, suggesting the manipulations were unsuccessful.

It is possible that all of the retention interval conditions were too short to reveal spacing effects. According to the associative model, an effect of spacing during training may only be revealed when there is a long retention interval, as this reveals retrieval-generated priming, which is reliant on associations being formed during training. When tested shortly after training, effects may be observed because the stimulus may still be in the A2 activity state and self-generated priming is producing a novelty preference at test (Wagner, 1981). In other experiments that demonstrate spacing effects in humans, retention intervals are much longer. For example, Gatchel (1975) tested participants 15 minutes after training and were able to demonstrate an effect of ISI. It may be that the RIs included in this chapter were too short, as the longest RI tested was two minutes.

Chapter 4 was unable to provide evidence to support the associative model as the superior model to explain recognition memory effects. The experiments in this chapter did demonstrate a strong novelty preference and context-specific learning, however there were no spacing effects. Therefore, it is not possible to discriminate between the associative and the declarative models based on the experiments presented.

CHAPTER 5

5 General Discussion

5.1 Aim of Thesis

The aim of this thesis was to test the associative model of recognition memory using human participants to determine if humans show the same patterns of results that are observed in non-human animal recognition memory studies. In addition, this thesis sought to test if the associative account (Wagner, 1981) better explains recognition memory than other accounts (e.g. declarative account, Aggleton & Brown, 2006) by implementing associative manipulations that are known to affect learning, extinction and spacing. The associative account makes clear, detailed predictions about contextual learning, extinction and spacing interval manipulations. Other accounts do not clearly predict or explain these predictions, suggesting evidence of these effects would provide support for Wagner's (1981) SOP model.

5.2 Summary of Findings

5.2.1 Chapter 2

Chapter 2 tested OICL in human children and adults. Participants were first pre-exposed to two stimuli each in their own context; image A in context X and image B in context Y respectively. During a test phase, participants were shown images A and B in context X. Participants orientated more towards image B because it was unexpected in context X (e.g., Dember, 1956).

OICL can be explained by more than one account. The associative account (Wagner, 1981) explains that during the pre-exposure stage, participants are able to form image-context associations, as when presented together, the elements for the image and context can move into the A1 activity state, allowing an association to be formed. During the test stage, when context X is presented, image A's elements will be primed into the A2 state and only elicit weak responding due to the previously formed association, whereas image B is unexpected, so its elements will be able to move into the A1 activity state and elicit stronger responding. Therefore, participants will spend more time looking at the unexpected image, image B.

The declarative account can also be used to explain OICL (Aggleton & Brown, 2006). This account might say that during the training stage, participants are able to encode and familiarise both image-context pairs. This allows participants to store which image was presented in each context to memory for later recollection. During the test phase, the participants would be able to recognise both images as familiar, however would remember that

only image A was previously presented in context X. Image B would be recognised as unexpected in context X and therefore may receive more exploratory behaviour.

It is important to note that this phenomenon may also be explained by generalisation decrement. When the expected and unexpected images are presented during the test phase, there may be increased orientation towards the unexpected image because the image appears to be slightly different than when it was presented in the training context. Therefore, the participant may spend more time viewing the unexpected image because it could be perceived as a partially new stimulus (e.g. Hull, 1943; Lovibond, Preston, & Mackintosh, 1984; Wheeler, Amundson, & Miller, 2006). This account is very difficult to rule out. Although there have been some attempts to eliminate generalisation decrement (e.g. see Whitt et al., 2012), this account cannot be disregarded as a possible explanation for studies presented in this chapter.

All of these accounts offer valid explanations of OICL. Using the experimental designs for this thesis, experiments in Chapter 2 aimed to establish evidence of OICL in human participants so that manipulations could be later applied to test the associative account. Although there are some previous examples of OICL in humans, the majority of this research has been conducted using non-human animal participant samples. In addition, previous examples of OICL in humans (e.g., Hannula & Ranganath, 2009; Hannula et al., 2007) have demonstrated the opposite effect (i.e. orientation towards the expected image). It is important to note that previous studies used face stimuli, which have been considered to be special and do not

behave like normal cues. It has been suggested that performance is affected with the use of face stimuli compared to non-face objects (e.g. Yue, Tjan & Biederman, 2006; Biederman & Kalocsai, 1997; Galper, 1970; Leder & Bruce, 2000; Tanaka & Farah, 1993; Yin, 1969). Therefore, images of animals were used for experiments presented in this chapter to avoid effects observed with face stimuli. In addition, the experiments in this thesis administered studies in a more similar way to the non-human animal studies; two identical images were presented during training and two images, one expected and one unexpected, were presented at test.

Comparable to Alarcón and Bonardi (2020), who demonstrated that children and adults performed similarly in a learning task, results from the experiments in this chapter demonstrated that child and adult participants showed a similar pattern of results. Results were consistent with non-human animal OICL tasks (e.g. Whitt, Haselgrove & Robinson, 2012), meaning that both participant groups spent more time orienting towards the unexpected stimuli in the first block of trials, followed by the effect quickly decreasing. This rapid decline of response is also observed in animal studies (e.g. Dix & Aggleton, 1999) and is consistent with predictions made by Wagner's (1981) SOP account. It could be that there is a decline in novelty preference due to participants habituating to the unexpected stimuli. The associative account may predict that in the first block of trials, the elements for the unexpected object were able to enter the A1 activity state and elicit stronger responding. However, after several presentations of the unexpected object, it was able to form an association with the context, as both had elements in the A1 state. Therefore, on later trials, the context may be able to prime both the expected

and previously unexpected objects into the A2 activity state, causing the decreased novelty preference observed.

Results from Chapter 2 provided evidence that the experimental design used in this thesis was successful and therefore could be manipulated to test the associative account. Results from this chapter can be explained by the associative, declarative, and generalisation decrement accounts, so it cannot yet be determined which account best explains recognition memory tasks. Experiments in the next chapter applied extinction manipulations to test the associative account.

5.2.2 **Chapter 3**

Experiments in Chapter 3 aimed to test the associative model of recognition memory by applying a manipulation known to affect learning, extinction (Pavlov, 1927). In the OICL experiments in this chapter, image-context pairs were presented during the training phase. After this, participants were expected to demonstrate a greater dwell time towards the unexpected image in each context, as observed in the experiments in Chapter 2. During an extinction phase, the context was repeatedly presented alone, without the associated images, to allow extinction to occur before being tested.

The associative account predicts and explains extinction (Wagner, 1981). This account suggests that when the context is first presented without the associated image, the previously formed association will prime the elements for the associated image into the A2 activity state. When the elements for the context are in the A1 activity state and the elements for the image are in the A2 state, an inhibitory relationship is formed. This inhibitory association,

which prevents the image's elements from entering the A2 activity state, counteracts the excitatory association, which tries to prime the images elements into the A2 state, so the net effect is no change and results in no effect being observed. Therefore, if extinction is successful, when the previously expected and unexpected images are presented in a final test phase, it was predicted that there would be no looking preference.

The declarative account does not predict extinction, although it is possible to produce an explanation using the account (Aggleton & Brown, 2006). This account may suggest that when the contexts are presented without the previously associated images during the extinction phase, participants are introduced to a new episode to encode. Later, when the contexts are presented with previously expected and unexpected images in a test phase, participants may be faced with retrieval interference, as the context may be recognised as being presented with the expected image and being presented alone. They may remember that most recently that context was presented alone, so may be surprised that the image has reappeared, causing them to explore the expected image more than they previously would have.

Both accounts can explain extinction, however the declarative account does not do so naturally and requires assumptions to explain the effect post hoc. The SOP model makes clear and detailed predictions and does not require extra assumptions to discuss extinction effects. It is therefore possible to argue that any evidence of extinction is more likely to offer support for the associative model of recognition memory. However, it is important to note that non-associative accounts cannot be completely dismissed in this chapter.

Experiments in Chapter 3 tested several variations in the design of extinction in OICL tasks. Some experiments included an OICL test before the extinction phase and some did not, some included new images in the extinction phase and some presented the background alone, a new set of images were introduced in some experiments to increase salience, and individual differences were examined across all experiments using the O-LIFE questionnaire (see Table 9 in the Chapter 3 Chapter Discussion section). There were no extinction effects observed in any of the experiments reported in this chapter. First, it is important to note that there were no basic OICL effects demonstrated in any of the experiments, apart from Experiments 2/3 and 6, which only demonstrated an OICL effect in the first block of trials. In other experiments, pre-extinction effects were either insignificant, in the opposite direction or not present at all. In order for extinction to be successful, there must first be a reliable effect to extinguish. Therefore, the variable pre-extinction effects observed may have directly caused the lack of extinction effects observed in this chapter. Differences across experiments were examined to identify why varied results were observed.

In three of the experiments, Experiments 2/3, 6 and 7, there was an OICL test phase before the extinction training phase and extinction test phase. This test was included to test for pre-extinction effects to ensure basic OICL was achieved before attempting to extinguish learning. In Experiment 2/3, there was a basic OICL effect observed, however this effect was only present in the first block of eight trials. In Experiment 6, there was only an OICL effect in the first block of four trials and in Experiment 7, there were no pre-extinction

effects at all. Therefore, in Experiment 7, extinction may not have been observed simply because there was no basic effect to extinguish. In experiments that did demonstrate OICL effects (Experiments 2/3 & 6), the effect quickly declined after the first block of trials. It is predicted that the first test phase may have caused participants to form new associations with the unexpected dogs, making both the expected dog and previously unexpected dog expected in subsequent presentations. Therefore, in the final test of the experiment, the no extinction condition would be unable to truly test OICL effects, as both dogs may have been expected. This would explain the results demonstrating no differences in dwell time towards the two dogs in both the extinction and no extinction conditions.

In Experiments 4 and 5, there was no first test phase, so the issue observed in Experiments 2/3, 6 and 7 was no longer a concern. However, predicted OICL and extinction effects were not demonstrated in Experiments 4 and 5. Although the predicted OICL effects were not observed, there were pre-extinction effects. Results in both experiments demonstrated greater orientation towards the expected image; this effect was only statistically significant in Experiment 4. This is the opposite to what Wagner (1981) predicts. As previously stated, increased response towards the expected stimuli has been reported (e.g. Hannula et al., 2010) and there are no clear explanations to why these results differ from traditional associative OICL effects. Although it is possible for Wagner (1981) to predict and explain greater orientation towards the expected stimuli (e.g. Donegan, 1981), there is no reason why pre-extinction effects should vary across experiments in this chapter using the same stimuli and similar procedures. Greater orientation

towards the expected stimuli in Experiments 4 and 5 was not predicted but does demonstrate that participants had some pre-extinction learning. This pattern of learning was also observed in the extinction condition, suggesting that extinction training was not successful.

In addition, Experiments 2/3, 4 and 5 included more training trials (48 trials) than extinction trials (32 trials). Wagner's (1981) account predicts that excitatory learning requires less time than inhibitory learning. Therefore, when a pre-extinction effect was observed, there may not have been sufficient extinction training to produce an extinguished effect, as these experiments were designed to allow more time for excitatory learning. In Experiments 4 and 5, participants demonstrated greater orientation towards the expected image in both the extinction and no extinction conditions. It is possible that participants may not have had enough time to extinguish learning due to the lower number of inhibitory trials in these experiments.

In addition, this chapter examined individual differences in performance across all of the extinction experiments presented. Closer inspection of the data revealed that there was a lot of variability across performance in the extinction tasks. This was curious, so it was of interest to examine if any individual factors were linked to this effect. To do this, the O-LIFE questionnaire was sent out to all of the participants that took part in the extinction tasks. It was hypothesised that O-LIFE scores would be able to predict performance on the extinction experiments. It can be predicted that those who are high in schizotypy will not demonstrate expected extinction performance, as schizotypy has been linked to cognitive dysfunctions and deficits in working memory, executive function and attention (Dembińska-

Krajewska & Rybakowski, 2014). This hypothesis was not supported, as a multiple regression analysis demonstrated that O-LIFE scores were unable to predict performance in extinction experiments. It is important to note that only 24 of the 96 participants completed the questionnaire. As a rule of thumb, multiple regression analyses require a sample of 50 + (8*number of predictor variables) to obtain a medium effect size; the current analysis would therefore require 82 participants (Green, 1991). Therefore, this analysis may have been underpowered and unable to reveal any predictor variables significantly predicting extinction performance.

None of the experiments in Chapter 3 were able to provide evidence of extinction. This may be due to the pre-extinction effects; some experiments lacked pre-extinction effects and the effects were inconsistent in others. It is important to have a pre-extinction effect, otherwise there is no effect to extinguish. For studies that did have pre-extinction effects, there may not have been enough extinction trials, as previously noted. Another thing to consider is that the experimental designs may not have been ideal; these tasks had to be adapted for humans, so instead of being placed in different physical environments, computer backgrounds were used as contexts and images were used in place of physical objects. It could also be that individual differences affect performance in extinction tasks, however the analysis conducted was underpowered, so a higher response rate would be necessary to examine this.

There have also been failures to demonstrate effects of context-object extinction in a similar paradigm, latent inhibition. Latent inhibition tasks demonstrate that learning is slower when the CS is pre-exposed without the US (Lubow, 1973). This effect has been shown to be context-specific, as a

change in context between the pre-exposure and test phases interrupts latent inhibition (e.g. Bouton & Brooks, 1993; Honey & Good, 1993). These effects can be explained by the associative model (Wagner, 1981). Pre-exposure to the CS would allow context-CS associations to form. This allows the context to prime the CS into the A2 state at test, so the CS elicits little responding when the US is presented and learning about the CS→US relationship is retarded. When the context is changed at test, the CS is not primed into the A2 state and therefore CS→US learning may occur more quickly, as both may enter their A1 states and form an association. This suggests that latent inhibition should be affected by extinction if the context is presented alone after the CS has been pre-exposed in that context. Successful extinction should demonstrate reduced latent inhibition effects at test. However, studies with rats have shown that extinction has little or no effect on latent inhibition (Baker & Mercier, 1982; Hall & Minor, 1984). In an analogous version of this task with humans, results again demonstrated that extinction had no effect on latent inhibition (Zalstein-Orda & Lubow, 1995).

These results oppose SOP predictions, and therefore the failure to reduce latent inhibition by context extinction combined with the lack of extinction effects demonstrated in Chapter 3 may challenge Wagner's (1981) account. However, in all of the extinction experiments presented, only two were conducted without the first OICL test (Experiments 4 & 5), which likely affected results. In both of these experiments, participants did appear to demonstrate some form of learning, and although no extinction effects were observed, it may be that extinction training was not long enough to extinguish learning from training (Zalstein-Orda & Lubow, 1995).

Results from Chapter 2 can be explained by the associative, generalisation decrement and declarative accounts. Experiments in Chapter 3 aimed to specifically test the associative account by applying extinction manipulations, however these experiments were unsuccessful in providing evidence of extinction. Thus far, there is no evidence that the associative account is better than other accounts at explaining recognition memory. In the last experimental chapter, spacing manipulations were applied to SOR tasks to test the associative account.

5.2.3 **Chapter 4**

Chapter 4 tested spacing effects in SOR tasks. This chapter aimed to test the associative account, as spacing effects are not predicted or clearly explained by other accounts. Spacing effects have been demonstrated in animal studies (e.g. Sanderson & Bannerman, 2011; Whitt & Robinson, 2013), as well as in human studies (Crowder, 1976; Gatchel, 1975; Gatchel & Lang, 1974; Greene, 1989). These studies demonstrate that longer spaces between pre-exposures improve learning if the test is given after a delay. Spacing effects are clearly predicted and explained by the associative model (Wagner, 1981). The strength of an association can be affected by manipulating the time between pre-exposures. When spaces between pre-exposure trials are longer, the context's and object's elements have time to return to the inactive state between each presentation. Therefore, the elements for both the context and object can re-enter the A1 activity state on each pre-exposure, which allows a stronger association to be formed and greater learning is demonstrated at test. When spaces are short between pre-exposure trials, the elements for the context and object are unable to return to

the inactive state between presentations, preventing further learning from occurring, which results in lower retrieval-generated priming at test. In addition, manipulating the retention interval can determine the amount of self- and retrieval-generated priming at test. When tested immediately, it is likely that the object's elements will still be in the A2 activity state, which will increase self-generated priming and reduce responding to the object at test. However, if tested after a delay, the object's elements will have had enough time to decay from the A2 activity state to the inactive state, so retrieval-generated priming will be increased. When presented at test, if the ISIs were long and an association was formed, the context can serve as a retrieval cue and prime the object's elements into the A2 state, causing decreased responding to the object. Therefore, it is suggested that shorter ISIs result in greater short-term habituation when participants are tested immediately after training, and worse long-term habituation when tested after a resting period (e.g. Davis, 1970).

Spacing effects are not predicted or explained by other accounts; however, it is possible to suggest an explanation from the declarative account (Aggleton & Brown, 2006). This account may suggest that when shorter ISIs are used, the ISIs are so short that participants would be able to remember the pre-exposure phase as a single 'episode', making behaviour at test similar to single-trial learning. When there are longer ISIs, the declarative account may argue that there is time for memory consolidation, making the recall better with longer ISIs. However, it is also possible to suggest that increasing the ISI may make recollection and familiarity detection more difficult, as a longer ISI may allow for forgetting and possibly lead to decreased learning at test.

Although is it possible to suggest explanations from the declarative account, they must be forced out of the model and are not as clear or detailed as Wagner's (1981) SOP model.

There are some additional accounts that consider benefits of spaced over massed learning in humans. For example, one account suggests that items that have been presented in a massed fashion seem more familiar when repeated, causing subjects to spend less time exploring the item on subsequent presentations. In a study conducted by Zechmeister and Shaughnessy (1980), participants rated which items they would be able to better remember and falsely believed they would be able to better remember massed items over spaced items. Another account by Glenberg (1979) suggests that spaced training is superior because spaced training allows participants to associate more elements of the context with the item. It is argued that the longer the ISI, the more the context changes between item presentations. This allows for a greater number of contextual elements to be encoded, which facilitates retrieval during the test (Glenberg, 1979). Greene (1989) believes it requires both of the accounts proposed by Glenberg (1979) and Zechmeister and Shaughnessy (1980) to explain the benefit of spaced learning. Although explained in a different way, these theories are similar to the associative account. Two of the accounts (Glenberg, 1979; Greene, 1989) propose that spaced training allows for greater context-object associations to be formed, whereas massed training prevents stronger context-object associations from being formed.

Results from Chapter 4 demonstrated no spacing effects in human participants. This does not follow predictions from the associative account,

which suggests that longer ISIs would produce greater novelty preferences when tested after a delay. All of the experiments did, however, demonstrate strong novelty preferences regardless of the length of the ISIs or RIs.

Experiment 9 included 0-, 2-, 4- and 8-second ISIs and 1- and 10-second RIs. It was predicted that there would be greater short-term habituation when tested after the short, 1-second RI and greater long-term habituation when tested after the longer, 10-second RI. Results demonstrated no differences across conditions, although a strong novelty preference was observed in all spacing conditions.

Experiment 10 included new ISIs (1, 3, or 5 seconds) and RIs (1, 3, 5, 10, 15 or 20 seconds) to further explore spacing effects. The associative account does predict specific effects of spacing manipulations but does not specify the required length of time necessary. It was again predicted that there would be greater self-generated priming at shorter RIs and greater retrieval-generated priming at long RIs and that longer ISIs would produce stronger associations. Results suggested a strong novelty preference regardless of spacing condition, suggesting manipulations were unsuccessful. There was, however, an increase in dwell time towards the familiar stimuli when the context was different at test. This effect can be explained by the associative account. This account would state that during the test, the context was unable to prime the familiar image's elements into the A2 state, as the context was different to what it was during pre-exposure. This would mean that participants spent more time looking at the familiar stimuli in the different context condition than they did in the same context condition. It is also possible to suggest an interpretation from the declarative model (Aggleton & Brown, 2006). This

account may propose that the familiar image and context may be stored in memory during the pre-exposure phase. During the test phase, the participant may use familiarity detection and episodic memory recall to pair the previously presented image with the context and determine which image is novel. When tested in a new context, the participant may recall the familiar image, however, recognise that it was not previously presented in that particular context, so therefore the participant may explore this image more than in the same context condition. It is also important to mention that generalisation decrement may also explain this effect. It is possible that there is increased orientation towards the familiar image because the image appears to be slightly different than when it was presented in the training context and could be perceived as a partially new stimulus (e.g. Hull, 1943; Lovibond, Preston, & Mackintosh, 1984; Wheeler, Amundson, & Miller, 2006).

Greater orientation towards the familiar image when tested in a different context has also been observed in other studies (e.g. Richmond et al., 2004; Haaf, Lundy, & Coldren, 1996; Pescara-Kovach, Fulkerson, & Haaf, 2000). However, results from Richmond et al. (2004) demonstrated an impaired novelty preference when tested after a two-week delay; novelty preferences were not impaired when tested after a three-minute delay. The results in Chapter 10 did demonstrate greater orientation towards the familiar image when tested in a different context, however the novelty preference was still highly significant. It may be that a longer retention interval is needed to disrupt the novelty preference by context change.

Experiment 11 focused on testing the long-term effects of spacing by only including one, longer RI of two minutes. There were also more spaced out

ISIs (1, 10 or 30 seconds) included in this experiment. It was predicted that longer ISIs would demonstrate greater novelty preferences when tested after the two-minute RI due to retrieval-generated priming. Results indicated that participants had strong novelty preferences across all ISI conditions, suggesting no effects of spacing.

All three experiments presented in this chapter demonstrated strong novelty preferences across all spacing conditions. As previously mentioned, novelty preferences observed after a short break may be due to self-generated priming, as the image's representational elements may not have had enough time to decay back into the inactive state before the test. Consequently, all of the RI conditions tested in the experiments presented may have been too short. It may be possible that self-generated priming was able to reveal a novelty preference across all conditions. Longer RIs may be necessary to demonstrate increased learning in long ISI conditions due to increased retrieval-generated priming. The longest RI tested in the experiments in this chapter was two minutes. Other spacing tasks in human experimentation have shown spacing effects with an RI of 15 minutes (Gatchel, 1975).

Chapter 4 does not demonstrate effects of spacing in humans, and therefore, this chapter is not able to support the associative model. Results demonstrated were not consistent with previous non-human animal or human studies, which demonstrated a benefit of spaced learning when tested after a delay. Therefore, it is not possible to suggest the associative account is better at explaining recognition memory than other accounts based on the experiments presented.

5.3 Future Research

Experiments in this thesis are inconclusive, as no effects of extinction or spacing were demonstrated and it is not possible to state which account best explains recognition memory. Future research can further explore this area to determine which account can best explains these tasks.

Different experimental designs can be used to test these manipulations. Results from the experiments in Chapter 2 were assumed to support the experimental design used in this thesis, however this design may not have been ideal for extinction manipulations. As expressed by the participants who took part in the studies presented in Chapter 3, it was difficult to maintain alertness when presented with several trials displaying a background alone or several presentations of the same images. Therefore, it may be beneficial to do single trial learning, meaning that participants are presented with training (e.g. A:X; B:Y), extinction (e.g. A), and test (e.g. A:XY; B:XY) in trial one, and subsequent trials follow the same pattern with new images. This would allow participants to constantly see new images and prevent the boredom expressed when presented with the phase design used in this thesis, which caused participants to see the same images several times throughout the task.

In addition, the experiments in this thesis assumed that a computer background represented a context in the way that an apparatus represented a context in non-human animal studies. Human participants may not be experiencing context manipulation by changing a computer background in the same way as animals experience context manipulations. In fact, some participants from the experiments in this thesis reported that they did not

always notice when the computer background changed and failed to recognise which image was presented in each context. Therefore, it may be beneficial to use a different context manipulation. Although more complex, it could be useful to have participants physically move across laboratories. It would of course be difficult to maintain the same arrangement, lighting, smell, etc. when returning to 'same' contexts, as most laboratories are shared spaces. It could be possible to use a virtual reality eye-tracker to have participants experience 'being' in different contexts, which may be more similar to how the animals experienced context changes. However, these are expensive and not easily accessible. One simple change could be to use a context image presented next to the object image instead of a background image. This may make the context more salient, as it is an additional image to look at rather than in the background. In addition, a task could be included to test if participants noticed the different contexts during the experiment. For example, participants could be required to press different keys for each context when they are presented (e.g. Press X for Context 1 and Z for Context 2).

Due to the underpowered individual differences test in Chapter 3, it would be beneficial to retest this effect with a larger participant group. In addition, participants could be collected from one large extinction experiment to prevent task differences from affecting the results. It would be interesting if schizotypy affected performance in extinction tasks, as it also affects performance in other associative tests, such as blocking. Moran, Al-Uzri, Watson and Reveley (2003) tested healthy volunteers and patients with schizophrenia in a Kamin blocking task. In Kamin blocking, first stimulus A

is conditioned before conditioning to an AB compound occurs. Learning about stimulus B is retarded or blocked. Results demonstrate that the Kamin blocking effect is reduced in non-paranoid schizotypy patients (Moran et al., 2003).

Age effects can also be further explored. Similar patterns of results were found in child and adult OICL tasks; however, it is also important to test an older sample, as normal aging has been linked to memory impairments (Morrison & Baxter, 2012). Performance in recognition memory tasks can be used to compare age related changes in memory across the lifespan (Richmond et al., 2004), as these tasks do not require advanced skills, language or physical responding. It is suggested that the hippocampus is required for performance in recognition memory tasks (e.g. Bachevalier, Brickson, & Hagger, 1993; Zola et al., 2000) and the hippocampus has been linked to age related memory impairments. For example, cognitive aging has been linked to mild impairments in the medial temporal lobe, including the hippocampus, and age related memory impairments have been correlated with synaptic alterations in the hippocampus (Morrison & Baxter, 2012). Therefore, recognition memory tasks can be used on all ages and address interesting questions in aging. For example, it has been suggested that older adults have a decreased attention capacity and therefore demonstrate deficits in associating information, as it requires more attention than remembering a single feature. This limited attention capacity may be why older adults perform worse in some associative memory tasks (Kinjo, 2011; Mitchell, Johnson, Raye, & D'Esposito, 2000) and recognition memory tasks can be used to further investigate these age-related deficits.

Due to the many implications of recognition memory tasks discussed, it is important to further explore the aim of this thesis and further investigate whether recognition memory is better explained by the associative account. Although Chapter 2 suggested evidence of OICL, Chapter 3 demonstrated mixed pre-extinction results and no evidence for the associative test of extinction. A strong pre-extinction effect is necessary in order to demonstrate an effect of extinction, which may be the main issue in this chapter. In addition, it may be worth testing this phenomenon using a procedure more similar to non-human animal studies, which have well-established and robust effects of extinction. In chapter 4, there were no effects a second associative test, spacing. The experiments in this chapter all demonstrated novelty preferences but failed to demonstrate spacing effects. This may be due to the length of the retention intervals tested, as self-generated priming may have been able to reveal a novelty effect across all conditions. Future experiments should include longer retention intervals to further investigate this effect. As discussed, children and adults performed similarly in OICL tasks, however older adults have been shown to demonstrate age-related deficits in memory tasks, so future studies can be used to test recognition memory across the lifespan.

5.4 Conclusion

In conclusion, experiments in this thesis were able to find evidence of basic OICL and SOR, however extinction and spacing manipulations were unsuccessful. It is demonstrated that humans show a strong novelty preference in recognition memory tasks, however specific associative manipulations were ineffective. This may be due to the experimental designs, as conditions may not have been ideal to reveal extinction and spacing effects, or it may provide a basis to challenge the associative model. Based on the results presented in this thesis, it is not possible to say whether the associative account better explains recognition memory tasks than other accounts.

6 References

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7 Appendix

7.1 O-LIFE Questionnaire

Unusual Experiences

1. Do you believe in telepathy?
2. Do you ever feel sure that something is about to happen, even though there does not seem to be any reason for you thinking that?
3. Do you ever suddenly feel distracted by distant sounds that you are not normally aware of?
4. Do you often have days when indoor lights seem so bright that they bother your eyes?
5. Does your sense of smell sometimes become unusually strong?
6. Have you felt as though your head or limbs were somehow not your own?
7. Have you sometimes sensed an evil presence around you, even though you could not see it?
8. Have you wondered whether the spirits of the dead can influence the living?
9. On occasions, have you seen a person's face in front of you when no one was in fact there?
10. When in the dark do you often see shapes and forms even though there's nothing there?
11. When you look in the mirror does your face sometimes seem quite different from usual?
12. Are your thoughts sometimes so strong that you can almost hear them?
13. Can some people make you aware of them just by thinking about you?
14. Do ideas and insights sometimes come to you so fast that you cannot express them all?
15. Do the people in your daydreams seem so true to life that you sometimes think they are real?
16. Do you sometimes feel that your accidents are caused by mysterious forces?
17. Do you think you could learn to read other's minds if you wanted to?
18. Does it often happen that nearly every thought immediately and automatically suggests an enormous number of ideas?
19. Does a passing thought ever seem so real it frightens you?

20. Does your voice ever seem distant or faraway?
21. Have you ever felt that you have special, almost magical powers?
22. Is your hearing sometimes so sensitive that ordinary sounds become uncomfortable?
23. Do you ever have a sense of vague danger or sudden dread for reasons that you do not understand?
24. Do you feel so good at controlling others that it sometimes scares you?
25. Have you ever thought you heard people talking only to discover that it was in fact some nondescript noise?
26. Have you felt that you might cause something to happen just by thinking too much about it?
27. Have you occasionally felt as though your body did not exist?
28. Have you sometimes had the feeling of gaining or losing energy when certain people look at you or touch you?
29. Are the sounds you hear in your daydreams really clear and distinct?
30. Do your thoughts sometimes seem as real as actual events in your life?

Cognitive Disorganisation

31. Are you easily distracted when you read or talk to someone?
32. Do you ever feel that your speech is difficult to understand because the words are all mixed up and don't make sense?
33. Do you often experience an overwhelming sense of emptiness?
34. Do you often feel lonely?
35. Is it hard for you to make decisions?
36. Are you a person whose mood goes up and down easily?
37. Are you easily hurt when people find fault with you or the work you do?
38. Are you sometimes so nervous that you are ‘blocked’?
39. Do you dread going into a room by yourself where other people have already gathered and are talking?
40. Do you easily lose your courage when criticised or failing in something?
41. Do you find it difficult to keep interested in the same thing for a long time?
42. Do you frequently have difficulty in starting to do things?
43. Do you often feel that there is no purpose to life?

44. Do you often have difficulties in controlling your thoughts?
45. Do you often worry about things you should not have done or said?
46. Do you worry about awful things that might happen?
47. No matter how hard you try to concentrate do unrelated thoughts creep into your mind?
48. When in a crowded room, do you often have difficulty in following a conversation?
49. Are you easily confused if too much happens at the same time?
50. Are you easily distracted from work by daydreams?
51. Do you often feel 'fed up'?
52. Do you worry too long after an embarrassing experience?
53. Would you call yourself a nervous person?
54. Do you often hesitate when you are going to say something in a group of people whom you more or less know?

Introvertive Anhedonia

55. Can you usually let yourself go and enjoy yourself at a lively party? *negative*
56. Do people who try to get to know you better usually give up after a while?
57. Do you feel that making new friends isn't worth the energy it takes?
58. Do you find the bright lights of a city exciting to look at? *negative*
59. Do you like going out a lot? *negative*
60. Do you prefer watching television to going out with other people?
61. Do you usually have very little desire to buy new kinds of food?
62. Is it fun to sing with other people? *negative*
63. Are people usually better off if they stay aloof from emotional involvements with people?
64. Are there very few things that you have ever really enjoyed doing?
65. Are you much too independent to really get involved with other people?
66. Are you rather lively? *negative*
67. Can just being with friends make you feel really good? *negative*
68. Do you have many friends? *negative*
69. Do you like mixing with people? *negative*

70. Do you think having close friends is not as important as some people say?
71. Does it often feel good to massage your muscles when they are tired or sore? *negative*
72. Has dancing or the idea of it always seemed dull to you?
73. Have you often felt uncomfortable when your friends touch you?
74. Is trying new foods something you have always enjoyed? *negative*
75. On seeing a soft thick carpet have you sometimes had the impulse to take off your shoes and walk barefoot on it? *negative*
76. When things are bothering you do you like to talk to other people about it? *negative*
77. Do you feel very close to your friends? *negative*
78. Do you love having your back massaged? *negative*
79. Have you had very little fun from physical activities like walking, swimming, or sports?
80. Do you enjoy many different kinds of play and recreation? *negative*
81. Is it true that your relationships with other people never get very intense?

Impulsive Nonconformity

82. Do people who drive carefully annoy you?
83. Do you often feel like doing the opposite of what other people suggest, even though you know they are right?
84. Do you often feel the impulse to spend money which you know you can't afford?
85. Do you often have an urge to hit someone?
86. Do you sometimes talk about things you know nothing about?
87. Are you usually in an average sort of mood, not too high and not too low? *negative*
88. Do you at times have an urge to do something harmful or shocking?
89. Do you ever have the urge to break or smash things?
90. Do you often change between intense liking and disliking of the same person?
91. Do you stop to think things over before doing anything? *negative*
92. Do you think people spend too much time safeguarding their future with savings and insurance?
93. Have you ever blamed someone for doing something you know was really your fault?

94. Have you ever cheated at a game?
95. Have you ever felt the urge to injure yourself?
96. When in a group of people do you usually prefer to let someone else be the centre of attention? *negative*
97. When you catch a train do you often arrive at the last minute?
98. Would being in debt worry you? *negative*
99. Would you take drugs which may have strange or dangerous effects?
100. Do you consider yourself to be pretty much an average kind of person? *negative*
101. Have you ever taken advantage of someone?
102. Would you like other people to be afraid of you?
103. Do you often overindulge in alcohol or food?
104. Would it make you nervous to play the clown in front of other people? *negative*