AN EVALUATION OF HUMAN MEASURES OF KAMIN BLOCKING: IMPLICATIONS FOR SELECTIVE ATTENTION INVESTIGATIONS IN SCHIZOPHRENIA

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ABSTRACT

Title: An evaluation of human measures of Kamin Blocking: Implications for selective attention investigations in schizophrenia

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Kamin blocking occurs when learning to one conditioned stimulus is decreased when presented in compound with a conditioned stimulus pre-exposed with the outcome. The Kamin blocking procedure is central to current investigations of human learning processes. Additionally, it is said to reflect selective attention mechanisms and is utilised as an experimental model for underlying cognitive deficits in schizophrenia. Different experimental procedures have been independently developed to measure Kamin blocking effects. The relationship between these has important implications for the use of Kamin blocking as an experimental model.

Two approaches were employed to evaluate the relationship between blocking procedures: direct comparison of the association between blocking scores derived from different tasks (Experiments 1-3); and assessment of a trial order manipulation on different task formats (Experiment 4). Specifically, two types of procedure were evaluated: behavioural response and contingency judgement tasks.

These studies revealed no association between Kamin blocking demonstrated by different experimental formats. However, the different measures were similarly affected by a trial order manipulation. This indicates that a) different measures of blocking may not be driven by the same underlying processes and b) the use of experimental manipulation as assessment of procedural equivalence may not be valid. In Experiment 5, age and sex differences were observed in blocking effects measured by a task from the clinical literature. As this task is used as a model for attention deficits in schizophrenia such population factors would need to be taken into account when drawing conclusions about observations in clinical samples.

The present studies indicate that procedural and experimental factors need to be quantified when utilising the blocking model of attentional deficits in schizophrenia. Furthermore, dissociations across blocking procedures suggests that not all measures can be assumed to be models of selective attention, which should be accounted for in their application to clinical studies.

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OVERVIEW OF THESIS

The present thesis explores Kamin blocking as a research tool and specifically as an experimental analogue of attention deficits in schizophrenia. In line with these multiple applications of Kamin blocking, the thesis takes a multidisciplinary approach drawing on elements of both learning theory and clinical research.

First, it is necessary to a) describe the Kamin blocking paradigm and it's relationship to other selective attention procedures b) to discuss the theoretical background to the paradigm from an associative learning standpoint c) to describe the various procedures used to demonstrate blocking effects both in animals and in humans.

Following these discussions, the relationship of the Kamin blocking paradigm to clinical research, specifically schizophrenia and psychosis, will be considered. An overview is given of schizophrenia diagnosis, treatment and research. Then the role of experimental models in this clinical research will be considered with specific reference to the Kamin blocking paradigm.

The core of the thesis explores the utility of this research 'tool' in it's current form: that is, to consider whether the tasks currently used to measure Kamin blocking provide reliable and robust measurements to support a major role in future clinical research. The experimental work described examines some of the present methods for measuring Kamin blocking and investigates potential methodological and theoretical factors mediating the Kamin blocking effects observed. In the final chapter the present results will be summarised and the role of blocking as an experimental model for schizophrenia will be discussed in light of these findings.

CHAPTER ONE

GENERAL INTRODUCTION

1.0 Overview of Chapter One

As Kamin blocking has been a significant development in two separate fields of research a description of the presentation and application of Kamin blocking in *both* the associative learning and clinical contexts is necessary. By providing a comprehensive review of these parallel roles of Kamin blocking at this stage, the need for a consistent understanding of the presentation of Kamin blocking in humans is emphasised while the differences in the use and measurement of this phenomenon should become apparent. As this Chapter necessarily reviews such a wide range of issues, those areas which have directly informed the present studies have been highlighted in italic script.

The General Introduction has been divided into 3 parts to reflect these separate fields of research. **Part 1** aims to review the use of Kamin blocking in the field of associative learning. This includes a discussion of the relevant theoretical models of learning as well as the specific procedures that have been used to measure this phenomenon in different species. **Part 2** provides a general introduction to schizophrenia and the areas of research and theory in which cognitive processes such as Kamin blocking have been implicated. Finally, in **Part 3** the specific use of human and animal analogues in psychiatric clinical research is discussed. The aim of this Part is to highlight the current and future application of Kamin blocking in clinical research. It is this particular role which necessitates the evaluation of practical issues in Kamin blocking measurement which may moderate clinical findings and in turn theoretical conclusions.

Chapter One, Part One

1.1 Kamin Blocking and Learned Inattention Paradigms

The following sections introduce the concepts of selective attention and learned inattention. The close relationship between attention and learning is discussed leading to a description of the learning paradigms (such as Kamin blocking) thought to illustrate attentional mechanisms.

1.1.1 The relationship between selective attention and associative learning

The process of selecting what to attend to in the environment is fundamental not only to immediate perception and action but also to learning about the environment, society and associations between stimuli (Treisman, 1969; also discussed in Kruschke, 2001a; Oades & Sartory, 1997). The brain receives information continuously through the senses, yet only a small proportion of that information requires a response or conscious attention. Information is received in a constant stream but the brain has a "limited capacity" of resources with which to process this information (Broadbent, 1958). Therefore, as Broadbent proposed, the stream of information must be subject to a filtering system which delineates how far stimuli will be processed. In this way, irrelevant stimuli will be filtered out before processing (for example background noise); some stimuli may be processed at a non-conscious level (for example physiological responses), and others at a conscious level (for example complex problem solving). Therefore, conscious attention is the end product of this filtering system. The conceptual basis for this model is widely accepted although experimental evidence suggests unfiltered information is attenuated rather than completely deleted. Demonstrations of attentional switching phenomena such as the "cocktail party effect" (Cherry, 1953) illustrated that unattended information could be re-activated into conscious attention if necessary (Treisman, 1969). In either formulation, the allocation of resources will be based on perceived importance of the information to the organism in its current context. This selective aspect of attention is learnt through previous experience about what is relevant to the individual either for response to the immediate situation or by having personal meaning (Cherry, 1953). This then will depend on processing of learnt associations between stimuli. Therefore, the process of learning associations between stimuli is both driven by and influential to the perceived relevance of stimuli in the environment and in turn how much attention is allocated.

1.1.2 The Learned inattention paradigms

By directing attention to relevant stimuli, prior experience and learned associations must also dictate what can be ignored (Mackintosh, 1975). This concept is generally known as "learned inattention" (Oades & Sartory, 1997). By utilising the principles of classical conditioning, the learned inattention paradigm provides a model for investigating mechanisms within selective attention. Furthermore, if cognitive processing of information is *selective*, then the weakening of these filtering mechanisms would allow otherwise irrelevant information to reach the conscious awareness. This, in turn, could lead to the behavioural outcomes of hallucinations and delusions in people with schizophrenia (Frith, 1979; Gray, 1998). The theoretical links between learned inattention and schizophrenia are discussed in more detail in Part 2.

In particular, two associative learning phenomena have been described as models of learned inattention processing: Latent Inhibition and Kamin Blocking. Latent

Inhibition (Lubow, 1973 & 1997) is established if the learning of an association between a stimulus and a target response is delayed when the stimulus has been pre-exposed to no outcome. Kamin Blocking (Kamin, 1967), occurs when one stimulus (A) is pre exposed to the target response and then a second stimulus (B) is presented in compound with A to the same outcome: learning to B will have been weakened or 'blocked' by the presence of the already predictive stimulus A. In the related phenomenon known as Overshadowing, the naturally occurring salience bias for one stimulus over another when they are presented together is measured. This also reflects selective attention processes (Pavlov, 1955; Holland, 1999). The presence of overshadowing effects in compound stimulus learning are of relevance within the Kamin blocking procedure and many tasks measure these effects as part of an internal control for the Kamin blocking demonstration. See Table 1.1 for an illustration of these procedures.

Table 1.1: Experimental procedures in the learned inattention paradigm

		Kamin Blocking	**Latent Inhibition**	**Overshadowing**
Experimental group	**Learning phase 1**	CS-A +US	CS-A	....
	Learning phase 2	CS-AB +US	CS-A +US	CS-AB +US
	Test	CS-A, CS-B	CS-A	CS-A, CS-B
Control group	**Learning phase 1**	....	....	....
	Learning phase 2	CS-AB +US	CS-A +US	CS-A+US CS-B +US
	Test	CS-A, CS-B	CS-A	CS-A, CS-B

Key: letters denote individual stimuli; 'CS' describes a Conditioned Stimulus; 'US' an Unconditioned Stimulus; '+' denotes paired stimuli

The present research focuses primarily on the Kamin blocking paradigm. However, as these models are closely linked in the literature (Escobar, Oberling & Miller, 2002; Serra, Jones, Toone & Gray, 2001; Oades & Sartory, 1997; O'Tuathaigh & Moran, 2002; Holland 1999), comparisons will be made to both Latent Inhibition and overshadowing research when discussing the present results.

The use of Kamin blocking and Latent Inhibition as measures of attentional processes has met with some criticism however. In a commentary on the neuropsychological model of schizophrenia by Gray, Feldon, Rawlins, Hemsley, Smith (1991) (which emphasises the role of learned inattention paradigms in this research – explained in detail in Section 1.8), Smothergill & Kraut (1993) question the use of these (traditionally) associative learning paradigms as models of attention processes. They are wary of potential pitfalls for clinical research: they suggest that as Latent Inhibition and Kamin blocking have not been developed as models of attention, they could not be interpreted as such when investigating underlying deficits in clinical populations. Hemsley, Rawlins, Feldon, Jones & Gray (1993) disregard this criticism as these paradigms, though utilising learning procedures, are generally accepted as measures of attention mechanisms.

The relationship between Latent Inhibition and Kamin blocking has itself been a somewhat contentious issue in the literature (see Escobar et al., 2002 for discussion). Superficially, the procedures both reflect the process of learning to ignore a particular stimulus as irrelevant. The relationship is upheld in investigations showing that experimental manipulations will similarly affect both phenomena: for example Hippocampal lesions (Solomon, 1977) and amphetamine administration (Crider, Solomon, Macmahon, 1982; O'Tuathaigh, Salum, Young, Pickering, Joseph, Moran, 2003) in animals (see also Kruschke 2001a for theoretical support). Indeed, the demonstration of deficits in both processes in schizophrenic populations has led to the paradigms being similarly included in theories of underlying attentional deficits in the disorder. However, while Latent Inhibition reflects a direct example of learned inattention, in Kamin blocking it is embedded within cue competition effects of compound learning. That is, in Kamin blocking (but not Latent Inhibition) the added stimulus has itself a 100% contingency with the outcome and its irrelevance is inferred through comparison with the pre-exposed stimulus. Consequently, there are differences in experimental findings: for example amphetamine administration in humans differentially affects performance on Kamin blocking and Latent Inhibition tasks (Gray,1991; Gray, Pickering, Gray, Jones, Abrahams, Hemsley, 1997). These theoretical differences could be of relevance when extrapolating from behavioural demonstrations to underlying neurological and cognitive functions.

1.2 Associative Learning Theory

The following section reviews the role of Kamin blocking in investigations of human learning processes. The implications Kamin blocking has had for learning theory are discussed from initial demonstrations of the phenomenon in animals to more recent investigations of blocking effects in humans. The discussion highlights the ability of Kamin blocking paradigm to have continued utility for evaluating the parameters of human learning.

1.2.1 Associative accounts of Kamin blocking in animals

The Kamin blocking phenomenon (Kamin, 1967) was seen as a pivotal development for the field of associative learning: it indicated that temporal contiguity between the conditioned stimulus and unconditioned stimulus was not sufficient for learning to occur (Williams, 1999; also reflected in Kruschke, 2003) as had been previously assumed, thereby providing a new benchmark for the evaluation of learning theories. Kamin (1967) proposed that, beyond the purely temporal relationship, the conditioned stimulus must also be *relevant* to the organism (i.e. by signifying new information about the Unconditioned Stimulus) in order for it to be associated with the Unconditioned Stimulus and for learning to occur. In this way, blocking was initially conceived as a lack of any learning to the added stimulus due to the predictability of the outcome from the first stimulus (Kamin, 1967). This was formalised in the Rescorla-Wagner theory (Rescorla & Wagner, 1972) which stated that the strength of the association was led by a 'surprise' factor. That is, in Kamin blocking, as the added stimulus does not signal any new outcome it does not produce any element of surprise in the organism and therefore does not stimulate learning. This theory has been central to later investigations and remains one of the fundamental explanations of associative learning.

Following further investigations, Mackintosh (1975) argued that Kamin blocking could not involve a complete absence of learning but was better explained in terms of an *active* learning of stimulus *irrelevance* (later denoted as learned inattention). He proposed that the added stimulus becomes associated with inattention rather than attention. This concept of learned inattention is also reflected in the Conditioned Attention Theory of Latent Inhibition (Lubow, Weiner, Schnur, 1981).

1.2.2 Human contingency learning and blocking effects

Subsequent to these initial observations of Kamin blocking in animals, it was demonstrated that the perceived predictive value of a stimulus during human contingency learning procedures was similarly affected by the blocking phenomenon (Dickinson, Shanks, Evenden, 1984; Shanks, 1985). From this observation, the predictions of traditional learning models could be evaluated using procedural manipulations of contingency learning paradigms in humans. In particular, demonstrations of 'retrospective revaluation', post-training extinction and second order blocking effects in humans have led to the development of alternative accounts of human learning processes to accommodate the findings.

In retrospective revaluation the associative strengths of the stimuli are not stagnant but can be updated by later information. One of these procedures is referred to as backward blocking, whereby a blocking effect is still observed even when the compound learning stage precedes the elemental learning stage. See Table 1.2 for a summary of blocking procedure manipulations.

Table 1.2: Comparison of experimental procedures for different manipulations of the blocking paradigm

Procedure group	**Phase 1 learning**	**Phase 2 learning**	**Phase 3 learning**	**Test**
Control	CS-C + US	CS-AB+US	....	CS-B
Blocking	CS-A +US	CS-AB+US	....	CS-B
Backward blocking	CS-AB+US	CS-A +US	....	CS-B
Post training extinction	CS-A+US	CS-AB+US	CS-A+ **noUS**	CS-B
Training order	CS-AB+US,	CS-GB+US	CS-A+US	CS-B
2nd order backward blocking **(within design)**	CS-AB1+US CS-DE1+US	CS-B1B2+US CS-E1E2+US	CS-A+US CS-D+ **noUS**	CS-B2 CS-E2 **(CS-E2 rated lower than CS-B2)**

Key: letters denote individual stimuli; 'CS' describes a Conditioned Stimulus; 'US' an Unconditioned Stimulus

Although demonstrations of backward blocking in contingency learning have been notably weaker than in forward blocking procedures (Chapman, 1991; Williams, Sagness, Macphee, 1994; Lovibond, Been, Mitchell, 2003), the indication of more fluid learning processes in humans discredited the simpler associative learning theories. The Rescorla-Wagner (1972) model and to a lesser extent Mackintosh (1975) model cannot account for the influence of subsequent learning experience on original associative strength and learning only occurs in the presence of the stimulus. These earlier models are criticised for presupposing the passivity of the learner and assuming blocking effects become immediately concrete at the acquisition stage (Arcediano, Escobar, Matute, 2001). In addition, various other investigations have found evidence which is incongruent with a purely associative process. For example, in the learned irrelevance account the added stimulus gains a negative associative evaluation, which becomes independent of the pre-exposed stimulus. Therefore, post-training procedures on the blocking stimulus alone should have no effect on this evaluation in itself. However, Arcediano et al (2001) showed that post-training extinction of the pre-exposed, blocking stimulus does increase predictive value ratings of the added blocked stimulus and therefore reverses blocking effects. Specifically, this has led to a rebuff of these traditional explanations in favour of a more probabilistic view (for example see review by De Houwer & Beckers, 2002b).

1.2.3 Probabilistic models of blocking in humans

Examples of these newer models include the comparator hypothesis by Miller & Matzel (1988) and the probabilistic contrast model (Cheng & Novick, 1990, 1992), These models focus on *relative* differences in associative strength rather than discrete amounts of learning to the stimulus. Therefore, the Conditioned Stimulus-

Unconditioned Stimulus (CS-US) relationship is continuously updated as new information arrives and each stimulus is learnt but to different *strengths*. The blocked stimulus is noticed and learnt but will not elicit a response because it is not as strongly associated to the Unconditioned Stimulus (US) as the pre-exposed Conditioned Stimulus (CSA), this can then be reversed if CSA is subsequently extinguished and loses its dominant associative strength (Arcediano et al 2001; Blaisdell, Gunther, Miller, 1999).

In the Miller & Matzel (1988) model three associations are formed and compared: the first Conditioned Stimulus and Unconditioned Stimulus (CSA-US); the two Conditioned Stimuli in compound (CSA-CSB); and the second Conditioned Stimulus and Unconditioned Stimulus (CSB-US). Therefore, the CSB-US association is comparatively lowered due to the strength of the CSA-US and the CSA-CSB associations. The probabilistic contrast model (Cheng & Novick, 1990) maintains that information is gained about trials both when the target stimulus appears and when it is absent, thus the contingency judgement is based on a comparison of the contiguity of these two trial types.

This type of model is better able to explain learning in the absence of target cue representation as in backward blocking, however, it is still incompatible with the demonstration of training order (Dickinson & Burke, 1996) and recency effects (Lopez, Shanks, Almarez, Fernandez, 1998) on blocking measures. Dickinson & Burke (1996) showed that blocking effects (using a backward blocking procedure) were weakened if the blocked cue (CSB) were presented variously in compound with the blocking cue (CSA) and other cues. Therefore, backward blocking is dissociable from pure retrospective revaluation because it is not the result of an objective judgement based on a calculation of all the information presented, but rather is disrupted by inconsistent compound presentations. This was further explored in the Lopez et al. (1998) studies in which blocking was biased by the contingency presented in the most recent set of trials rather than in all learning trials.

1.2.4 Revised associative models of blocking in humans

Other authors have tried to update associative models to incorporate the experimental findings. For example, the Rescorla-Wagner (1972) model was revised to embrace retrospective revaluation (Van Hamme & Wasserman, 1993) by allowing for a negative associative value. That is, learning could occur when a cue was absent but this learning rate would be negative. This then allows for retrospective revaluation effects such as backward blocking. However, this revised model did not hold against further examination of retrospective procedures by Larkin, Aitken, & Dickinson (1998).

Another associative model, the Standard Operating Procedures model by Wagner (1981), was also revised to include backward blocking (Dickinson & Burke, 1996). In the original version, stimuli and outcomes can be in one of three representation states: primary active (A1 - present on the trial); secondary active (A2 - present on immediate past trials); or inactive (I - not presented at all, or presented in historic past trials). These are updated with each trial. As before, learning occurred only on surprising presentations and the representation of a stimulus could not be changed in trials when it is not directly activated (A2 or I state). The revised version allowed for learning on trials when the cue was absent (in A2 state) by stating that associations are formed between cues (CS) and outcomes (US) if they are in the same representative state, regardless of their overt presence on a trial (A1 state). That is, if one of the cues appears without the outcome, the strength of the second cue is increased because it has been absent *in conjunction with* the outcome. In the case of backward blocking, the second cue remains in A2 state while the first cue and the outcome are presented together and acquire an A1 state together. However, as backward blocking effects have not always been observable and seem to be mediated by other factors (Larkin et al., 1998), this model cannot account for all the research findings.

In general, the exploration of Kamin blocking and in particular the demonstration of backward blocking effects have led to a break from traditional associative models of human learning in which the learning is a passive process to more dynamic models in which associations are continuously moderated by new information.

1.2.5 Alternative models: selective attention and observer-belief models

In recent years models have focused more on the role of Kamin blocking within selective attention mechanisms. For example, the EXIT model developed by Kruschke (2001a) explains blocking as an acquired shift of attention away from the added stimulus (see also Kruschke, 2003).

Waldmann & Holyoak (1992) have proposed an extended probabilistic contrast model, which highlights an important shift for learning theories towards emphasising the *human* context. It has been shown in a number of studies that participants may perceive a causal relationship (rather than a predictive one) between the particular stimuli used. This is an important mediating factor in blocking effects of contingency judgements (Waldman, 2000). In this case, people may have an innate assumption of single-causes for each outcome. Therefore, when multiple cues are presented with a single outcome the person will automatically try to identify *which* of the two is the cause leading to blocking of the redundant cue through process of elimination. This was further illustrated in experimental manipulations including Mitchell & Lovibond's (2002; also Lovibond et al 2003) work on outcome additivity (where blocking effects can be increased by indicating that the outcome can vary in strength depending on how many causal cues are present); De Houwer & Beckers' (2002a) report on higher-order retrospective revaluation (where participants infer judgements about the target from relationships in which the target cue does not actually appear); performance differences observed from configural versus elemental factors (Williams et al., 1994; see also Shanks, Charles, Darby, Azmi, 1998); context consistency effects (Dibbetts, Maes, Vossen, 2002); and cause-effect beliefs (Waldmann, 2000). It seems that, at least in human contingency learning contexts, learning cannot be decoupled from innate understanding of real world associations.

Although the authors state that this theory was only developed to accommodate contingency judgements rather than as a general model for associative learning (Waldmann, 2000), the principle of incorporating human strategy into the equation certainly seems intuitive. Indeed others have come to similar conclusions about the necessity for a more inferential reasoning model to explain cue competition effects such as blocking in humans (Lovibond et al., 2003; Lopez et al., 1998). Interestingly, the evolution of learning models parallels the hierarchical account proposed for evaluating experimental models in clinical research. Wilner (1984) delineates clinical research models as having either basic (predictive) validity, somewhat phenomenological (face) or mirroring the human context (construct validity). Similarly, the original learning models (Rescorla-Wagner 1972) were purely objective and took the learner as passive and the learning as based on basic properties of contiguity. This has some predictive value for research findings but seems to have little intuitive equivalence to complex human processes. Following this the probability models saw the learner as proactive in updating decisions based on numerous factors of the relationships presented. But, these still viewed the learning process as abstract or neutral thereby reflecting face validity. Finally the recent shift to context based effects seems to reflect a construct validity for human judgement making and associative learning as it adds an element of strategy which may vary among people and between contexts. See Figure 1.1 for illustration of models.

Figure 1.1: Illustration of fit of learning theories to Wilner's (1984) hierarchy experimental models

Wilner (1984) level	Learning model description	Examples of model
Predictive	traditional associative models Based on animal experiments Learning is passive process	Rescorla-Wagner, 1972 Mackintosh, 1975
Face	Probability models Based on human studies Learning is active and flexible process	Cheng & Novick, 1990 Miller & Matzel, 1988
Construct	Context models Human processing Active, flexible and context-dependent	Waldmann, 2000 Kruschke, 2001

1.2.6 Summary of associative theory and Kamin blocking:

The demonstration of blocking indicated the deficiency in simple contiguity accounts of learning. Subsequent theories centred on associative processes, but following further investigation of cue competition effects in human contingency learning, the focus shifted to comparative-probabilistic models. The debate still continues over the strengths of purely associative versus probability models (Allan, 1993; De Houwer & Beckers, 2002b) and it seems none of the models have yet been able to explain all the research findings. Recently, some authors (Waldmann, 2000; Lovibond et al., 2003) have suggested the need to incorporate elements of participant strategy and knowledge to learning process accounts in humans.

This ongoing debate may be due, at least in part, to a more fundamental characteristic of the tasks being used: Waldmann (2000) discussed the fundamental difference between causal learning (as in human contingency learning) and non-causal (Pavlovian) contexts. He argues that these are not equivalent situations and as such are not approached in the same way by participants. Moreover, causal paradigms are fundamentally separate and thus associative learning models of any sort cannot explain both forms of learning. This possibility was also noted by Miller & Matute (1996) though not explicitly investigated. Therefore, it is conceivable that although blocking occurs in both predictive and causal settings, these may represent different forms of blocking stemming from different learning processes. Similarly, White (2001) argued for the fundamental dissociation between causal and correlational type judgements, again pointing to a need for separate explanations of the two mechanisms. Although this was not specifically applied to blocking effects, it is likely that blocking effects shown within different task contexts would also reflect these different processing mechanisms. If this is so, Kamin blocking could not be described as purely an associative learning process, rather it must represent a natural phenomenon that occurs whenever an organism is presented with two or more stimuli in the environment that are competing for attentional processing. This issue is a central element of the present research.

Notwithstanding this issue, the above discussion demonstrates the central role the blocking paradigm has played in learning research over the past thirty years. It has provided a link between animal and human investigations. Moreover, in light of the proposed dichotomy in human learning processes, blocking could also provide a link across learning contexts from pavlovian conditioning to contingency decision making and recently to social learning. *Finally, the above highlights the role which experimental manipulations such as backward blocking have had in refining our understanding of associative learning and assessing learning models. Consequently, this approach has been utilised in the studies that follow.*

1.3 Procedures used to Measure Kamin Blocking: Animal Experiments

Blocking has been successfully demonstrated in various animal species including rats (Kamin, 1967; Rickert, Lawden, Dawson, Smyly, Callahan, 1979; Garrud, Rawlins, Mackintosh, Goodall, Cotton, Feldon, 1984; Holland, 1999; Oades, Rivet, Taghzouti, Kharouby, Simon, Moal, 1987; Ohad, Lubow, Weiner, Feldon, 1987; Miller & Matute 1996; Rauhut, McPhee, Ayres, 1999; O'Tuathaigh et al., 2003 among others); pigeons (Schreurs & Westbrook, 1982; Good & Macphail, 1994); rabbits (Solomon, 1977, Marchant & Moore, 1973; Schreurs & Gormezano, 1982). In all these species, the Kamin blocking effect demonstrated has been during Pavolvian conditioning paradigms (see Section 1.2 for potential separation of learning processes). However within this paradigm, studies have utilised varying conditioned and unconditioned stimuli and response measures. The different procedures will be discussed below.

1.3.1 The Conditioned Emotion Response

The Conditioned Emotion Response (CER) procedure utilises neutral and aversive stimuli associations and measures behavioural suppression ratios as an indication of conditioned response. The conditioned stimuli include white noise and tones (Kamin, 1967; Ohad et al., 1987; Garrud et al., 1984; and Jones & Gonzalez-Lima, 2001) light and cessation of white noise (Rauhut et al., 1999); and a buzzer and clicks (Miller & Matute, 1996). Target response measures have ranged from bar press (Kamin, 1967; Ohad et al., 1987; Garrud et al 1984; Jones & Gonzalez-Lima 2001; Rauhut et al., 1999) and drink spout lick rates (O'Tuathaigh et al., 2003; Miller & Matute, 1996).

1.3.2 The Conditioned Avoidance Response

The Conditioned Avoidance response (CAR) measures the number of times the animal shuttled from a compartment during presentation of each CS. The US will be footshock with tones and lights as the conditioned stimulus (Crider et al., 1982; Oades et al., 1987).

1.3.3 The Appetitive Conditioning Procedure

Here, the animals learn to associate the conditioned stimuli (tones, lights) with the presence of food in a food cup. The frequency of food-cup directed behaviours during presentation of each of the conditioned stimuli is analysed during the test stage (Holland, 1999).

1.3.4 Conditioned discrimination

Schreurs & Gormezano (1982) and Goode & Macphail (1994) observed some blocking effects from a conditioned discrimination procedure in pigeons. The birds were taught to hop onto a key in order to gain a food reward. The food availability was signalled by a white dot (CSA) and a green light (CSB). The blocking measure was derived from the frequency of hopping to the food key during the CSB presentations.

1.3.5 The Nictating Membrane Response

Finally, the nictitating membrane response of rabbits was employed by Marchant & Moore (1973), Solomon (1977) and Schreurs & Gormezano (1982). In this approach, which is reflective of conditioned eye-blink responses seen in human studies, rabbits are trained using tones and lights as conditioned stimuli and air-puff directed at the eye as the unconditioned stimuli. During test presentations of the conditioned stimuli, the frequency of the nictitating response is measured using potentiometer devices connected through looped sutures to the membrane.

1.4 Procedures used to Measure Kamin blocking: Human Experiments

Numerous Experimental procedures have been developed to demonstrate the Kamin blocking effect in humans, which cover a variety of methods and dependent measures. These can be broadly grouped into four areas according to the type of measurement they use: physiological, contingency judgement, behavioural, and tasks involving different learning contexts.

1.4.1 Physiological measures

The first set of human Kamin blocking measures have aimed at directly transposing the animal paradigm by using equated physiological measures. For example, Davey &

Singh (1988) used both a within and between-subject design to show blocking effects in a human conditioned fear paradigm measuring electrodermal response. In their procedure, tones and pictures were used as the CS and a loud 115dB tone burst as the US. In both designs they found no evidence of a blocking effect and in fact found increased responding to the added stimulus. In a similar format, Lovibond, Siddle & Bond (1988) found no blocking in skin conductance response measures. However, Hinchy, Lovibond & Ter-Horst (1995) did report significant blocking effects using electrodermal conditioning in a between-groups procedure when they modified the original three phase paradigm (two learning phases and a test phase, see Table 1.1) to a single phase with intermixed trials. Here, they used purely visual stimuli as the CS with small electric shocks as the US. Kimmel & Bevill (1996) also demonstrated blocking during autonomic conditioning to electric shock using visual, auditory and vibratory stimuli though the effect was only apparent when the conditioned stimuli were from the same sensory mode and was demonstrated only in the latter test trials.

Martin & Levey investigated blocking using the human eye-blink response (1991) with a set of circular lights as the CS and air puff as the US. Here again, they were able to demonstrate a blocking effect but only after manipulation of procedural elements. In addition, the effect was very variable across participants and cannot be taken as a robust and consistent effect.

These studies indicate that, as seen in the animal literature, the blocking effect in human Pavlovian conditioning is highly dependent on procedural factors. Martin & Levey (1991) further conclude that the simple behavioural conditioning used in animal blocking procedures is not strong enough to control learning in humans.

However, Arcediano, Matute & Miller (1997) suggest that the difficulties in reproducing blocking in humans using direct analogues of the animal procedures reflect procedural inadequacy and high group variances leading to inconclusive statistical results rather than any fundamental difference in learning processes.

1.4.2 Human Contingency Judgement measures

The second and by far the largest group of blocking tasks are those using human contingency judgement procedures. In fact the first demonstration of blocking effects in humans involved a contingency judgement task in the form of a computer game where tanks were blown up by either shells or mines (Dickinson et al., 1984; see also Shanks, 1995; Baker, Berbirer, Vallee-Tourangeau, 1989; Baker. Mercier, Vallee-Tourangeau, Frank, Pan, 1993; Vallee-Tourangeau & Baker, 1994 Exp 1 using a slightly modified version). In this task, tanks were presented crossing the computer screen and could be destroyed either by mines in the field (the blocking cue, CSA) or by shells which the participants could fire at the tanks (the blocked cue, CSB) presented within the blocking procedure. The actual success contingency was the same for both stimuli, but the participants were asked to rate how effective they perceived each weapon to be in blowing up the tanks. Blocking would occur if exposure to the first stage (mines alone) lowered perceptions of effectiveness for the shells relative to a control group of participants with no pre exposure treatment. This task demonstrated significant blocking in student samples both in the original Dickinson studies and in numerous later studies by Baker et al., (1989) and De Houwer (2002; De Houwer & Beckers, 2003; De Houwer, Beckers, Glautier, 2002). However Jones, Hemsley, Ball & Serra (1997) report being unable to replicate blocking effects with this task in a non-student population.

Numerous other contingency tasks have been developed to investigate blocking effects. For example, Chapman & Robbins (1990; also reported in Williams et al., 1994) observed blocking effects in a computer game involving judgements about the efficacy of company share price rises in producing a whole stock market rise. In this game participants follow the daily activity of five company share prices and learn to associate certain share price rises with a rise in the whole market. They are led through the two learning stages of the blocking paradigm and after each are asked to rate between –100 and +100 the efficacy of each company. The use of a negative to positive rating scale was utilised to suggest a partitioning of companies into positive predictors, negative predictors or neutral, which is found to increase blocking effects. Dibbets, Maes & Vossen (2000) also utilised this task in their investigation of cue position preferences (although their scale ranged from 0-9). A similar task is described in Chapman (1991) but with medical symptoms as the conditioned stimuli and presence of particular diseases as the outcome (ratings on this task range from 0-100 only).

In their single stage task (i.e. the elemental and compound learning presented together followed by test stage), Price & Yates (1995) presented medical charts with either of two symptoms listed and were told whether the patient also had the target disease. Participants then judged the proportion (exp 1, 3 & 4) and absolute frequency (exp 2) of patients for whom the presence of the disease coincided with the presence of each symptom. This format was repeated in a later series of experiments by Kruschke & Blair (2000; Kruschke 2001a) (although with the more usual two learning stage design) where participants were asked to choose the outcome on each occasion (rather than a separate rating phase) and blocking was observed by a lower choice percentage of the target outcome to presentations of the blocked versus control cues (i.e. participants consistently failed to choose the correct outcome when presented with the blocked stimulus). Similarly, the tasks developed by Van Hamme & Wassermnan (1994), Dickinson & Burke (1996), Larkin et al. (1998) and Lovibond et al. (2003) use the scenario of foods as causal cues (conditioned stimuli) leading to allergies (the outcome) in both between and within-subject designs.

Various other storylines have been employed: for example, Waldmann (2000) had participants learn relationships between visible coloured lamps and an unseen light and Jones et al. (1997) associated names of fictitious actors with either successful or unsuccessful films. Glautier (2002) developed a contingency task in which stimuli were presented as part of a card game at a fictitious casino. Finally, Cobos, Canos, Lopez, Luque & Almarez (2000; Cobos, Lopez, Canos, Almarez, Shanks, 2002) developed a task in which participants acted as "inspectors at a nuclear plant" and had to predict substance leakages by various indicator lamps. This task was also used in both between and within-subject designs.

The majority of human contingency learning blocking tasks are presented as computer games requiring numeric rating responses along a designated judgement scale. This procedure may be more vulnerable to variations in instructions provided to the participants (Williams et al., 1994) and their subjective interpretation of the context (Waldmann, 2000) than behavioural or physiological measures. One such discrepancy is the rating scales used for the response and range from 0-100, –100 to +100, and 0-9. For example, using a scale which ranges from –100 to +100 inherently implies to the participant that some stimuli will be positive predictors while others should be negative. This focus of attention on *differences* between stimuli value is not so well indicated by purely positive value scales.

1.4.3 Behavioural measures

The third group of tasks involve behavioural responses. For example, Jones, Gray & Hemsley (1990) developed a simple, between-subject task involving presentation of coloured shapes on a computer screen (CSA) either alone or paired with computer generated tones (CSB) where the participants must predict the onset of a target shape (US) by learning what stimuli precede it: blocking was measured by the number of trials to learn at each stage. In later reports the program was modified so that blocking compounds were comprised of two visual stimuli (the tones being replaced by small horizontal flanker shapes appearing on screen either side of the central shape) (Jones, Gray, Hemsley 1992a & 1992b; Jones, Callas, Gray, 1994; Jones et al., 1997; Serra, et al., 2001). This task has been used in numerous clinical studies of schizophrenia populations and other clinical groups such as agoraphobic disorder (Jones, Gray, Hemsley, 1993) and Attention Deficit Hyperactivity Disorder in children (Jones et al., 1994) and in normal populations to investigate mediating factors such as gender (Jones et al., 1994) and age (Serra et al., 2001).

A more recent between-subject task was developed by Arcediano et al., (1997) and designed specifically to mirror the animal paradigm but avoid the physiological difficulties mentioned above by employing a response suppression measure. In this computer task participants complete a game in which they press the space bar of the keyboard to fire shots at "martian" icons on the screen. They must learn to predict the appearance of a "shield" (US) which will make their shots backfire: the shield is cued by coloured backgrounds on the screen (CSA) and tones in their headphones (CSB) according to the blocking paradigm. Blocking is measured by the rates of suppression of the keyboard pressing for the different cues. This has been used on several occasions to investigate forward and backward blocking conditions (Arecdiano, et al., 1997 & 2001).

The practicability of between-subject designs in clinical research, however, is limited as groups must be strictly matched which may not always be possible in clinical samples which are often at least partially opportunistic. Moreover, baseline differences in computer use and task strategy employed cannot be fully accounted for. For this reason, within-subject tasks give greater experimental control. One such task (Oades, Roepcke, Schepker, 1996) from the clinical literature takes the form of a computer game in which participants use a joystick to move an icon around the computer screen to find hidden locations (US), these locations are cued by coloured panels (CS). The participants are told they are playing a game in which they must move the "mouse" icon to locate hidden "cheese" squares and that they need to use the colour cues to know where the hidden cheese will be. Kamin blocking is assessed by comparing reaction times to locate the cheese when each colour is presented individually. This game was developed to be easy to use by adults, children and clinical groups and as such has been prolific in the clinical literature. (Oades, Roepcke, Schepker, 1996; Oades, Zimmerman, Eggers, 1996; Oades & Muller, 1997; Oades, Rao, Bender, Sartory, Muller, 2000; Oades, Bender, Muller, 2001; Moran, Al-Uzri, Watson, Reveley, 2003; Bender, Muller, Oades, Sartory, 2001).

Finally, a recent report has described a further behavioural demonstration of blocking effects in humans (Wills & Lavric, 2004). In this procedure, participants were asked to predict the presence of a particular "fever" (yes/no response) from presentations of pictures of "bacterium". Blocking was observed from both the proportion of correct responses during test stimuli presentations and the neural measurement of the event-related potential thought to represent visual attention (the N1 response).

1.4.4 Alternative procedures

Finally, a few tasks have been developed to investigate Kamin blocking effects in alternative learning contexts. Observations of blocking effects were reported by Westbrook & Harrison (1984) during a visual phenomenon known as the McCollough effect. In general, McCollough demonstrated that visual after-effects produced during presentation of horizontal or vertical lines in coloured lights were contingent on the orientation of the subsequent presentation in white lights (McCollough, 1965). Westbrook & Harrison (1984) showed that this visual effect could be attenuated during a between groups blocking procedure. This was further supported by Siegel & Allan (1985). However, Jones et al. (1990) have argued that effects observed during this procedure cannot be interpreted as true analogues of Kamin blocking as they do not involve learnt processes but are rather artefacts of the visual system itself.

Other aspects of human learning processes have been examined for blocking effects. For example, Kruschke (2001b) investigated blocking in a function learning context using an adapted contingency learning format. In this case, the cue-outcome (CS-US) association was not about absolute or discrete categories, but about magnitudes of attributes. For example the conditioned stimuli were attributes such as body temperature and hair length, each with eight levels and the outcome an overall level on a "mystery meter". Once presented with information about the fictitious people, the participants made a response by deciding that person's position on the "mystery meter" they then received feedback on the actual meter reading, which allowed them to learn the associations. Their responses during the test phase were recorded and used to demonstrate blocking effects (Kruschke, 2001b).

Similarly, Cramer, Weiss, William, Reid, Nieri & Manning-Ryan (2002, Exp 3 a,b) report blocking effects in social learning using a between subjects, contingency judgement design. Participants were presented with information about the relationships between employees (CS) and company productivity (US) and were asked to rate the efficacy of the employees on a 0-100 scale. Although these studies demonstrate the presence of blocking effects in a range of human learning situations, they are still in essence contingency judgement procedures.

One particularly original study by Cramer, Weiss, Steiglader & Banning (1985) demonstrated blocking effects in human interpersonal attraction contexts using a more naturalistic (though rather more complex) setting and a behavioural measure. In this study, participants were asked to sit in individual cubicles and take part in fabricated group conversations on social issues. The participants heard spokespeople from the pseudo-group assert either agreement or disagreement with their opinions and they were measured on how this influenced their attraction to each of the spokespeople (Cramer et al., 1985). The assumption being that people feel more socially attracted to those who share their opinions and manipulating the shared-opinion belief according to the blocking paradigm can moderate this attraction. In this between-subject task, the measure was the speed with which participants chose to open a line of communication with the external spokesperson after the two learning stages.

This group of tasks represent a break away from the somewhat artificial use of blocking purely to investigate simple learning processes, to a focus on how blocking may be observed in more naturalistic human contexts. They also suggest that blocking paradigms could be useful in investigations of learning and attention processes within other aspects of human cognition.

1.4.5 Summary of Kamin blocking measures in humans:

The above section describes the various tasks which have been used to measure Kamin blocking in humans. See Table 1.3 for summary of task measures. The Physiological tasks have tried to transpose the animal paradigm directly but have had little overall success. The Contingency Learning and Behavioural measures, on the other hand, have both demonstrated robust blocking effects in humans in a number of studies. However, a dichotomy exists in the literature between the applications of these different task formats: the contingency learning tasks have been reported within the learning theory literature to elucidate specific aspects of human learning processes in healthy populations while behavioural tasks are reported primarily in the clinical literature as a way of investigating learning differences between healthy and schizophrenia populations. Indeed the blocking phenomenon has been extensively investigated in the learning literature but does not seem to have informed development of tasks in the clinical arena. *Therefore, the following studies have explored commonalities and dissociations between the Kamin blocking tasks.*

There have been two exceptions to the above segregation: Jones et al. (1997) used a contingency learning task to show blocking deficits in people with schizophrenia and Arcediano et al. (1997) have developed a behavioural measure to investigate learning theories of normal learning mechanisms. *Furthermore, as in the discussion of blocking in animals, the above illustrates a large variability in the measures used across tasks. The present work aims to elucidate the effects these different task formats and procedural variations may be having on the clinical application of blocking tasks to investigate learning deficits in schizophrenia. Therefore, the present studies focus on the observation of blocking in four of these established measures: the Oades, Roepcke, Schepker (1996) and Jones et al. (1992, 1994) behavioural tasks and the Jones et al. (1997) and Chapman & Robbins (1990) human contingency learning tasks. The first three have all been developed for clinical studies while the fourth provides a comparative measure used widely within the human learning literature*

Tables 1.3 a-d: Summary of the tasks used to measure Kamin blocking in humans

Key: **overshadowing comparison** measures involve a comparison between the blocked stimulus and a control stimulus paired with a stimulus *not present* in the pre-exposure stage (i.e. no information is known about either element of the comparator pair, controls for arbitrary salience differences of elements paired in series).
Super-conditioning comparison measures involve a comparison between the blocked stimulus and a control stimulus paired with a stimulus which was *active but not predictive* of the outcome in the pre-exposure stage (i.e. a stimulus actively seen as not predicting the outcome).
Neutral comparison measures involve a comparison between the blocked stimulus and the *average* response of two predictors not active in pre-exposure stage (i.e. both elements of comparator pair are utilised, does not allow for overshadowing differences as above).

Significant Blocking Observations: This refers to a general Blocking effect in the study disregarding any study specific manipulations. The Table reports the alpha levels at which significance was observed. As the studies employ various statistical measures or may have inferred effects from grouped analyses it is not meaningful to report actual test results without recourse to the full content of each analysis.

Table 1.3 a:

Task Group	Task Author	Within/ Between design	Conditioned Stimuli	Unconditioned Stimuli or outcome	Blocking Comparison measure	Response measure	Study Sample Size	Significant Blocking Observed?
Physiological	Martin & Levey (1991)	Within (exp 1, 3, 4) Between (exp2)	Coloured lights	Air puff	Super-conditioning	Frequency of eyeblinks	Exp 1: 34	Yes; $p<0.05$
							Exp 2: 20	No
							Exp 3: 20	Yes; $p<0.05$
							Exp 4: 24	Yes; $p<0.05$

Task Group	Task Author	Within/ Between design	Conditioned Stimuli	Unconditioned Stimuli or outcome	Blocking Comparison measure	Response measure	Study Sample Size	Significant Blocking Observed?
Physiological (cont'd)	Hinchy et al. (1995)	Between	Coloured blocks	Electric shock	Overshadowing	Skin conductance level	30	Yes; p<0.05
	Kimmel & Bevill (1996)	Within (exp 3) Between (exp 1, 2, 4)	Tone, light or vibration	Electric shock	Overshadowing (between) Super-conditioning (within)	Skin conductance level	Exp 1: 36	No
							Exp 2: 24	No
							Exp 3: 48	No
							Exp 4: 60	Yes (end test trials only); p<0.01
	Davey & Singh (1988)	Within (exp 2, 3) Between (exp 1)	Low-intensity tone & shapes on screen	High-intensity tone	Super-conditioning	Skin conductance level	Exp 1: 30	No; p>0.1
							Exp 2: 10	No; p>0.05
							Exp 3: 12	No; p>0.1
	Lovibond et al. (1995)	Between	Pictures of natural objects	Electric shock	Overshadowing	Skin conductance level	32	Yes; p<0.05

Table 1.3 b:

Task Group	**Task Name (Author)**	**Within/ Between design**	**Conditioned Stimuli**	**Unconditioned Stimuli or outcome**	**Control**	**Response measure**	**Study Sample Size**	**Significant Blocking observed?**
Human Contingency Learning	Tanks computer game (Dickinson & Shanks, 1984)	Within	Shells and mines fired during game	Destruction of tank during game	Mixed (depends on participant actions)	Success rating of weapons Scale: 0-100	34	Yes
	Stock Market game (Chapman & Robbins, 1990)	Within	Names of Fictional Companies	A rise in Fictional Stock market	Super-conditioning	Causal rating of company Scale: -100-+100 (Chapman) 1-9 (Dibbetts) 0-100 (Williams)	Chapman: 16	Yes; p<0.01
							Dibbetts (exp 1): 20	Yes; p<0.05
							Williams (exp 1): 48	Yes (with pre-treatment only); P<0.05
	Symptoms of illness (Chapman, 1991)	Within	Names of symptoms	diagnosis of fictional disease	Overshadowing (exp1); Super-conditioning (exp 2)	Rating of symptom as predictive of disease Scale: 0-100	Exp 1: 24	Yes; p<0.01
							Exp 2: 24	Yes; p<0.01

Task Group	Task Name (Author)	Within/ Between design	Conditioned Stimuli	Unconditioned Stimuli or outcome	Control	Response measure	Study Sample Size	Significant Blocking observed?
Human Contingency Learning (cont'd)	Casino (Glautier, 2002)	Within	Background colour and coloured shapes on "casino cards"	Payout for each "card"	Super-conditioning	Rating of payouts for stimuli Scale: 0-100	Exp 1: 17	No
							Exp 2: 36	Yes (in one group only); p<0.01
							Exp 3: 16	Yes; p<0.01
	Lamps (Waldmann, 2000)	Within	On/off status of 4 visible lamps	Status of unseen lamp	Neutral	Predictive rating for unseen lamp being lit Scale: 0-100	24	Yes (only in predictive group); p<0.01
	Neuclear leakages (Cobos et al., 2000)	Within and Between	Indicator lamps	Leaking of nuclear substances	Super-conditioning	Predictive rating of lamps to leaking substances Scale: 0-100	Exp 1: 24	Yes; p<0.05
							Exp 2: 53	Yes; p<0.05
	Film stars (Jones et al. 1997)	Within	Names of fictional actors	Success of fictional films	Overshadowing	Success rating for actors Scale: 0-100	34 & 30	Yes; p<0.05
	Medical task (Price & Yates, 1995)	Within + 1 stage learning only	Symptoms	Presence of disease	Super-conditioning	Proportion judgment for disease presence	Exp 1: 16	Yes: p<0.05

Table 1.3 c:

Task Group	**Task Name (Author)**	**Within/ Between design**	**Conditioned Stimuli**	**Unconditioned Stimuli or outcome**	**Control**	**Response measure**	**Study Sample Size**	**Significant Blocking Observed?**
Behavioural	Mouse (Oades et al. 1996)	Within	Coloured squares	Floorplan locations	Overshadowing	Reaction time latencies	Exp 1: 25	Yes; p<0.05
	Flankers (Jones et al. 1990)	Between	Central shapes and horizontal flanker shapes	Onset of target shape	Neutral	Trials to learning criterion	Exp 1: 40	Yes; p<0.001
	Aliens (Arcediano et al. 1997)	Between	Background colours and tones	Onset of a "shield"	Super-conditioning	Suppression of key pressing behaviour	30	Yes; p<0.05
	Wills & Lavric (2004)	Within	Pictures of shapes (bacteria)	Presence of target disease	Super-conditioning	ERP and proportion correct responses	-------	---------------

Table 1.3 d:

Task Group	Task Name (Author)	Within/ Between design	Conditioned Stimuli	Unconditioned Stimuli or outcome	Control	Response measure	Study Sample Size	Significant Blocking Observed?
Alternative Learning Contexts	Function learning (Kruschke, 2001)	Within	Levels of various attributes	'Mystery meter' level	Neutral	Response frequencies	28	Yes; p<0.012
	Social learning (Cramer et al., 2002)	Between	Workers	Company productivity	Overshadowing (no pre-exposure stage in control group)	Ratings scale: 0-100	48	Yes; p<0.01
	Interpersonal attraction (Cramer et al., 1995)	Between	'Other People' in experiment (although fictitious)	Social reinforcer	Overshadowing (no pre-exposure stage in control group)	Attraction speed (i.e. speed of opening communication)	Exp 1: 32	Yes; p<0.1
							Exp 2: 40	Yes; p<0.02

Chapter One, Part Two

1.5. Schizophrenia and Kamin Blocking

The following sections provide an introduction to some of the areas of schizophrenia research which are of particular relevance to selective attention and Kamin blocking. The aim is to contextualise the role of Kamin blocking in schizophrenia and to highlight why and where it is an important paradigm for clinical research. Therefore, the following does not aim to provide a comprehensive evaluation of research and theory on schizophrenia.

1.5.1 General clinical description of schizophrenia

Schizophrenia occurs in all cultures and civilisations throughout human history (Crow, 1997) yet it still defies a thorough understanding of aetiology or definition (Crow, 1995) and continues to comprise a majority of clinical research. First classified as "Dementia Praecox" by Emil Kraepelin (1919 - cited in Bleuler, 1952) and as "Schizophrenia" by Manfred Bleuler (1952), the disorder is now known to affect approx 1% of the population (DSM-IV – American Psychological Association, 1994). In his original formulation Kraepelin described the disorder as a single psychiatric illness delineated by a specific set of symptoms and differentiated (primarily from manic-depressive psychoses) by its deteriorating prognosis. However, the diversity of symptoms seen across patients with schizophrenia has led to much debate about the true boundaries of the disorder. For example, Bleuler himself subdivided Kraepelin's dementia praecox into four categories of illness (Bleuler, 1952) while others since have argued for a group of differentiable syndromes (Crow, 1980; Liddle, 1987b). Regardless of ongoing debate among researchers, current diagnostic criteria (DSM-IV – APA, 1994; ICD-10 – World Health Organisation,

1994) define schizophrenia as a unitary illness which can manifest in several forms but which revolves around a central core of symptoms.

1.5.2 Current clinical classification of symptoms

Currently, patients will be diagnosed according to guidelines set out in either the DSM-IV or the ICD-10. These manuals provide criteria based on the presence of specific behaviours over time. The symptoms of schizophrenia tend to be subdivided into two groups: positive symptoms (behaviours which are gained) and negative symptoms (behaviours or functions which are lost). This dichotomy follows work by Crow (1980) and Lewine, Fogg, Meltzer (1983) although both Kraepelin and Bleuler made similar divisions.

Positive symptoms refer to the more overt and stereotypical behaviours that characterise the psychotic state. For example, Perceptual Distortions such as hallucinations are defined by sensory experiences with no external sensory cause. Delusions occur when the patient holds beliefs that are contrary to evidence or to reality itself: these are often persecutory in nature. Finally, Formal Thought Disorder refers to a general inability to organise ideas and thoughts indicated by speech distortions.

The negative symptoms involve behavioural deficits such as a general apathy in which there is no interest in basic daily activities such as personal grooming, or Alogia in which patients show a reduction in speech quality or quantity during conversation. Additionally, there are emotional symptoms such as Anhedonia (the inability to experience pleasure or interest in things formally enjoyed), and Flat Affect (showing no outward emotional response to any stimuli). Finally, patients will have a general withdrawal from social relationships and situations: they are awkward in social settings, show poor social skill, and are not interested in friendships (McKenna, 1997).

The diagnostic manuals categorise patients into schizophrenia subtypes according to the presence of particular symptoms. For example, Paranoid schizophrenia is marked by a prominence of delusions (most commonly of persecution) and often involves a distortion in "ideas of reference". That is, the patient places unnecessary attention and importance on environmental contexts and situations which are otherwise neutral or trivial. Other subtypes include the disorganised type in which the speech and behavioural incoherence is emphasised, and the rare catatonic disorder involving cycles of immobility and excitement.

1.5.3 Alternative classification systems utilised in research

The clinical classification system tends to view patients as belonging to separate and mutually exclusive illness subgroups. However, the heterogeneity of patient symptomatology makes such labelling difficult (Liddle, 1987b). Some researchers have attempted to overcome this by proposing only two separate subgroups: paranoid and non-paranoid patients. This particular dichotomy has received some support from cognitive studies (Oades, Bunk, Eggers, 1992; Oades, Zimmerman, Eggers, 1996; Oades, 1997; Moran et al., 2003). Other research identifies a separate "deficit syndrome" within patient samples (for example, Seckinger, Goudsmit, Coleman, Harkavy-Friedman, Yale, Rosenfield, Malaspina, 2004). This syndrome centres around the negative symptoms and particularly the social dysfunctions. Alternatively, much research suggests it is more useful to delineate syndromes *or phases* of schizophrenia which are not as mutually exclusive. For example, although the clinical diagnostic criteria reflect the symptom dichotomy suggested by Crow (1980), he himself sees this division as two syndromes of the illness which are observable in a single patient at different stages during the course of illness: Type I comprising positive symptomatology is seen at the acute stage of the illness, and Type II dominated by negative symptoms manifests more in chronic patients. Research also suggests this distinction is reflected in structural abnormalities (more ventricular enlargement in Type II), response to treatment (better in Type I), and prognosis (better in Type I).

Independent of Crow's model, the acute/chronic distinction has itself been employed in illness descriptions (Rascle, Mazas, Vaiva, Tournant, Raybois, Goudemand, Thomas, 2001; Jones et al., 1992). In the acute stage, patients show a florid psychosis in which positive symptoms predominate. Such behaviours are temporary and can be treated with antipsychotic medication leading to a short period of illness. In contrast, patients in the chronic stage of schizophrenia will have negative symptoms and a greater intellectual impairment. These deficits and behaviours will be long-term and indicate a poor prognosis for the patient. The distinction between patients at the acute or chronic stage of the illness has proved useful for research into the cognitive and neuropsychological features of the disorder (Jones et al., 1992; Serra et al., 2001).

Other research focussing on dissociations of purely *cognitive* deficits in patients suggests a two-way distinction may be too simplistic. Liddle (1987a, 1987b, 1999) argues that the classification of patients according to behavioural symptom profiles is not etiologically informative. He questions the accuracy of the inherent implication that these symptoms are chronologically exclusive and represent a mutation of the disorder over time (see Liddle, 1999 for review). He proposes instead that patients should be distinguishable by their underlying cognitive pathologies (Liddle, 1987b). Thus, Liddle describes three syndromes based on distinct neuropsychological performance deficits: psychomotor poverty (linked to poverty of speech, movement and expression), disorganisation (linked to derailment of speech and inappropriate affect), and reality distortion (primarily hallucinations and delusion symptoms). Based on factor analysis of symptom clusters and cognitive performance (for example see Pritchard, 1986 and Bassett, Bury, Honer, 1994 for support), these syndromes represent different facets of the disorder which can variously affect individual patients at different times in the course of their illness. Liddle further suggests that in order to account for the full spectrum of schizophrenia-form disorders, there would need to be a 5-syndrome distinction (Liddle, 2000). See Figure 1.2 for illustration of Illness Models.

Figure 1.2: Summary of models used to describe patient groups

Symptom Categories

Positive: hallucinations (perceptual disorders), delusions, formal thought disorder (disorganised speech)

Negative: avolition (apathy), alogia (negative thought disorder), anhedonia, flat affect, social withdrawal

Illness Categories

Subtypes of Illness / Categories of patients

Bleuler (1950) – Hebephrenic, Paranoid, Catatonic, Simple

DSM-IV (1994) - Disorganised, Catatonic, Paranoid

Oades et al. (1996/7) - Paranoid/Non-paranoid

Seckinger et al (2004). – Deficit/Non-deficit

Dimensional models

2-way models

Crow (1980)– Type I / Type II

Jones et al. (1992) – Acute / Chronic

Rascle et al. (2001)

3-way models

Liddle (1987) – Psychomotor poverty, Disorganised, Reality distortion

1.6 Etiological Issues in Schizophrenia

1.6.1 Schizophrenia and sex effects

There has been much debate about the role of sex in the occurrence and manifestation of schizophrenia. Although most recent research agrees that the overall lifetime occurrence of the disorder is equal among males and females (although see Aleman, Kahn, Stelten, 2003 for alternative view), many differences have been found in the particular course of illness seen between the sexes. In general, there seem to be significant sex differences in age of onset – males tend to present with symptoms between 16 -24 yrs and females from their later twenties onward; symptomatology – males show more negative symptoms and usually require more hospitalisations than females; and course of illness - males tend to have a more chronic course than females (see Castle, McGrath, Kulkarni, 2000 for review of gender in schizophrenia). Although other authors have noted that the issue is complicated by sampling methods which may lead to a bias against the 'typical' female schizophrenic patients in previous epidemiological studies (Maric, Krabbendam, Vollebergh, Graaf, Van Os, 2003). One way to circumvent potential bias in patient groups is to study schizophrenic symptom correlates in the normal population. Indeed, in a study of psychotic traits and sex differences among the general population Both Raine (1992) and Maric et al. (2003) have found significant support for the increased negative symptom typology in males (also reported by Miller & Burns, 1995) and positive typology in females.

The role of sex in patient samples may be important not only for illness presentation but also when studying the underlying cognitive dysfunctions in schizophrenia. That is, there may be innate differences in cognitive functions between the sexes which consequently moderate results observed in clinical samples, particularly where the sex of the patients has not been equally matched. Indeed there is much psychological research to suggest such sexual dimorphism in brain function exists (e.g. Maccoby & Jacklin, 1974). Moreover, where cognitive deficits are found to link to particular manifestations of schizophrenia, it is potentially unclear whether this is a genuine link between the illness and cognitive anomalies or is mediated by otherwise "normal" sex effects. Of particular relevance for the present thesis is the observation that the Latent Inhibition relationship to schizotypal measures is also manifest differentially across the sexes (Lubow & De La Casa, 2002). *It is important therefore, to have an understanding of underlying sex differences on cognitive tasks before they can be accurately applied in clinical research. This area is further discussed in Chapter 6, where Experiment 5 aims to address this issue in Kamin Blocking.*

1.6.2 Schizophrenia and genetics

Schizophrenia is generally recognised as a neurodevelopmental disorder (for example see Cannon, 1998). That is, one in which the neurological abnormalities develop during brain maturation (both pre and post natal) as opposed to degeneration following a period of normal functioning. Epidemiological observations also indicate the strong genetic component in the disorder in that relatives of patients are at increased risk for schizophrenia itself and also related disorders such as schizotypal personality disorder. (Kety, Wender, Jacobsen, Ingraham, Jansson, Faber, Kinney, 1994; Cadenhead & Braff 2002; Gottesman & Erlenmeyer-Kimling, 2001).

However, genetic studies show no more than a 50% concordance among monozygotic twins, and the increased risk in relatives of probands still only lies at 10-15% (in

Cadenhead & Braff, 2002). Therefore it is likely that the schizophrenic genotype manifests as a predisposition to the disorder which may or may not be realised in later maturation. This stress-diathesis model indicates the significance of hormonal changes during adolescence as well as environmental stressors and life events in the eventual development of the disorder. Moreover, the underlying genetic vulnerability for schizophrenia could itself be marked by cognitive or behavioural anomalies which are present before the key symptoms appear (Gourion, Goldberger, Olie, Loo, Krebs, 2004). It has been proposed that selective attention mechanisms could be susceptible to the genetic predisposition and thus measures of learned inattention such as Kamin blocking could be important indicators of the schizophrenia genotype (Meehl, 1990; Claridge, 1997).

1.6.3 The psychopharmacology of schizophrenia

The dominant psychopharmacological theory for the past two decades has focused on hyperactivity of the Dopamine system in the brain (Carlsson, 1988 – cited in Carlsson, Waters, Waters, Carlsson, 2000). Early observations reported that a psychosis-like state could occur following chronic amphetamine (a dopamine agonist) use in humans (Ellinwood, 1967) and acute administration in animals (Ellinwood, Sudilovsky, Nelson, 1973). This has led not only to the development of the 'typical' anti-psychotic medications (Haloperidol and Chlorpromazine) but also the widespread use of amphetamine-induced psychosis as an animal model for investigating new treatment compounds for schizophrenia (See McKenna, 1997 chapter 8 for review).

However, it has been argued that an overemphasis on dopamine dysfunction alone is too simplistic and overlooks key issues. For example, 'atypical' compounds

(Clozapine and Risperidol) are also found to be effective as anti-psychotics. These medications work as serotonin (5-HT) receptor antagonists (decreasing serotonin activity). Additionally, observations from LSD-induced psychosis and post mortem studies suggest that the underlying pathology in schizophrenia (in particular the positive symptoms) is an increase in serotonin receptor activity. (see Abi-Dargham & Krystal, 2000 for review).

Recently, interest has moved to investigate the possible role of glutamate in schizophrenia (for example Goff, 2000). This stems from reports of patients demonstrating acute psychotic symptoms after recreational use of Phencyclidine (PCP) and Ketamine – chemicals known to block NMDA (N-methyl-D-aspartate) receptor activity in the brain. Of potential interest is Glutamate's natural interaction with Dopamine (Carlsson et al., 2000) and its role in brain development which may underlie the structural anomalies seen in schizophrenia. It may be of interest to investigate the activity of this system in non-clinical populations such as high schizotypes and relatives of patients. Although much debate continues, it is likely that these systems are either indicative of different subtypes of schizophrenia or that the underlying pathology requires an interaction of these systems to create the behavioural symptoms.

1.7 Schizophrenia Personality Dimensions and Schizotypy

The current thesis looks at the presentation of Kamin blocking in healthy human participants and therefore aims to support and confirm clinical observations rather than add directly to them. However, the concept of schizotypy and its relationship to clinical symptoms has indicated the utility of investigations in the general population to inform schizophrenia research. Therefore, the relationship of schizotypal traits to measures of Kamin blocking is assessed in the present research. This concept of schizotypy is introduced below.

Research into the psychology of schizophrenia has been aided in recent years by a renewed interest in the concept of schizotypy. Originally used to describe the genetic predisposition to the full disorder (Meehl, 1962; Rado, 1953), it was later modified to describe the observable traits or phenotype (Meehl, 1990) and has now been redefined in light of a continuum theory of schizophrenia symptoms (Claridge, 1997). That is, the idea that schizophrenia symptoms lie at one extreme end of a continuum of personality traits which can be measured in the general population. To this end, there is a dichotomy in the use of this term in the literature: one refers to a categorical construct indicating a sub-clinical form of mental disorder (Meehl, 1990 definition) while the other refers to a dimensional view of psychosis (Claridge, 1997 definition). This second conceptualisation is controversial as it suggests that psychosis can be generalised from the psychiatric illness to the healthy population and therefore is more a deviation of traits than a separate pathological state as understood by the traditional medical model. However, this idea is already accepted for other areas of mental illness such as anxiety or depressive states and the inclusion of schizoptypal personality disorder in the DSM-IV at least partially acknowledges the presence of schizophrenia-like traits among personality variables. Aside from the ongoing philosophical debate, many scales have been developed to measure psychotic personality traits and evaluate these in the general population (discussed below). Importantly, schizotypal dimensions have been found to differentiate psychotic disorders (schizophrenia and bipolar disorder) from depression spectrum disorders (Rossi & Daneluzzo, 2002). Furthermore, studies have shown higher scores on these schizotypal measures not only in patients but also in their first-degree relatives compared to the general population (Serra et al., 2001 among others). Finally, the cognitive anomalies found in patients have been similarly correlated to measures of schizotypal personality: for example, atypical handedness (Shaw et al., 2001), and executive functions (Lezenweger & Korfine, 1994 although not in Lezenweger & Gold, 2000). This evidence then suggests not only that psychometric scales for schizotypal dimensions are linked to schizophrenic disorders but also that investigations of these dimensions in the general population can potentially inform us about relationships in clinical populations. Of particular relevance to the present studies is the investigation of schizotypy in a student sample by Dinn et al. (Dinn, Harris, Aysicegi, Greene, Andover, 2002). This study identified neuropsychological profiles for positive and negative schizotypal groups within the sample which mirror findings for patient sub groups. *Therefore, in the present studies the dimensional view is taken and schizotypy is psychometrically measured in the student samples as a potential analogue of psychotic traits.*

The dimensions of schizotypy are usually measured through self-report questionnaires, which incorporate a number of scales relating to aspects of schizophrenia spectrum disorders. For example, the Chapman scales measure 'perceptual aberration' and 'magical ideation' based on clinical descriptions of symptoms (Chapman, Chapman, Raulin, 1978; Chapman, Chapman, Kwapil, Eckbald, Zinser, 1994) while the Oxford schizotypy scales developed from Eysenck's (normal) personality dimension of Psychoticism. (For a review of the measurement scales see Claridge, 1997). One of the most widely used published scales for measuring schizotypal traits in the healthy population is the Oxford-Liverpool Inventory of Feeling and Experiences (O-Life – Mason, Claridge & Jackson, 1995).

Research using Schizotypal traits has given support to the proposed links between psychosis proneness and selective attention deficits. That is, investigations have shown that those people in the general population who score highly on measures of schizotypal traits also demonstrate weaker performance on measures of both Latent Inhibition (Baruch, Hemsley, Gray, 1998; De La Casa, Ruiz, Lubow, 1993; Braunstein-Berkowitz, Rammsayer, Gibbons, Lubow, 2002; Lubow & De La Casa, 2002) and Kamin Blocking (Jones et al., 1990, 1992). This highlights the possibility that these measures may be behavioural markers for "psychosis-proneness" or the genetic predisposition to schizophrenia.

1.8 Cognitive Models of Schizophrenia

The origin of the behavioural abnormalities seen in patients with schizophrenia is still unclear, but information processing and attentional abnormalities have featured prominently since early observations of the disorder. More recently, the observation of cognitive anomalies in patients has become a prominent focus for schizophrenia research (see section 1.5.3). For example, differences in performance on cognitive tasks such as sustained attention (e.g. Cornblatt, Lezenweger, Erlenmeyer-Kimling, 1989 among others) and executive functions (see Antonova, Sharma, Morris, Kumari , 2004 for review) indicate the role of such underlying processing deficits in psychotic behaviours. Furthermore, this has been paralleled by findings of structural abnormalities in patients (see Antonova et al., 2004 for review). Another indication of processing abnormalities has come from the measurement of handedness in schizophrenia. Handedness has been found to exist along a continuum ranging from fully right-handed to fully left- handed (Annett, 1970) and this is thought to reflect the laterality of processing in the brain. That is, most of the population naturally favour their right hand for actions such as writing and throwing a ball and this behavioural preference denotes a natural dominance of the left hemisphere of the brain in many aspects of cognition. However, higher levels of atypical (non-right) handedness are seen in the schizophrenic population compared to the general population. This is postulated to represent an increased shift away from left-hemisphere dominance (Annett, 1970 & 1998) and an increase in "mixed" hemisphere use (described as the "indecisive brain") or right hemisphere dominance in the schizophrenic brain. Both of these could mean a decline in normal cognitive functioning. Furthermore, this shift away from right-handedness in schizophrenia is mirrored by a similar increase in high schizotypes in the general population (Shaw, Claridge, Clark, 2001). *As handedness is of relevance both in schizophrenia and in general cognition, it has been measured in the present series of studies.*

In contemporary literature, four neuropsychological models have been proposed which variously develop from this central theme. The model proposed by Braff & Geyer (1978, in Braff & Geyer, 1990) states that inherited and inefficient information processing systems in schizophrenic patients are unable to cope when the environment presents multiple stimuli together requiring rapid processing. This "stressed "(Braff & Geyer, 1990) system results in thought disorder and other behavioural symptoms seen in psychoses. In contrast, the models by Anscombe (1987) and Frith (1979) focus more on"instability of attention" (Anscombe, 1987, pp256). In Anscombe's hypothesis, it is the internal focussing of attention that becomes pathological and leads to an inability to organise perception within a continuous frame of reference. Of particular relevance for the learned inattention paradigm and this thesis are the model's put forward by Frith (1979, revised in Frith, 1992a,b) and Hemsley (1987), which will be discussed in more detail below.

Frith (1979) proposed that many of the behavioural symptoms of schizophrenia such as hallucinations, delusions and thought disorder could stem from underlying cognitive deficits in basic information processing in which otherwise automatic and subconscious processes are attended to by consciousness. This indicates a deficit in which information that would otherwise not reach consciousness, is processed to a higher level than necessary: specifically he conceptualises a "defective filter" system. Information is selectively funnelled on its way to consciousness so that only information directly relevant to the current situation reaches higher-level consciousness. It is a deficit in this selection mechanism that is seen in schizophrenia. This cognitive theory encapsulates both clinical observations of schizophrenia (Kraepelin, 1919 - in Bleuler, 1952; McGhie & Chapman 1961) and prevailing information processing theories (Broadbent, 1958). The defective filter theme is also expressed in the neuropsychological model described by Hemsley (1987) which emphasises the role of selecting relevant past experiences stored in long term memory for use in the present situation and action sequence (i.e. the correct use of learned associations from the past in making a response in the present).

Support for an information filter deficit has come from neurological (Pritchard, 1986) and cognitive (Braff & Geyer, 1990; Braff, Geyer, Light, Sprock, Perry, Cadenhead, Swerdlow, 2001) evidence. This model has been criticised primarily for its limited scope (see commentary by Gray, Hemsley, Feldon, Gray, Rawlins, 1991). That is, it can be applied only to the positive symptoms and acute psychotic episodes of the disorder and does not explain the negative symptoms seen in the long-term syndrome of chronic patients (as described above). Although it could be argued that the negative affective symptoms are simply a reaction to the positive psychosis, most research suggests the negative aspects are an independent and often primary part of the syndrome (for example Davidson, Reichenberg, Rabinowitz, Weiser, Kaplan, Mark, 1999; Seckinger et al., 2004). However, Hemlsey's model (1987) maintains that the negative symptoms could appear prior to positive psychosis as a response to the underlying neural changes linked to the positive symptoms.

Frith (1992b; also see Frith, Blakemore, Wolpert, 2000) has revised his original hypothesis to explain schizophrenia symptoms not as deficits to initial attention or the filtering of information *coming in* but of overseeing actions *going out*: as a "loss of reflexivity" (Frith 1992a, pg. 438). That is, positive symptoms occur when a person is unable to oversee or identify with their own actions leading to perceptual changes and hallucinations (misidentifying one's own thoughts as external). In this conception, there is a break during the process of having an intention to act and deciding (using past experience) how best to implement that intention. Therefore, when the action takes place, the person with schizophrenia no longer recognises the action as derived from their own initial intention. In this model, the negative symptoms are explained by an inability to follow through on intended actions which leads to the observed motor and behavioural deficits (Frith, 1992b). By this account, the negative symptoms are explained in terms of their behavioural outcome rather than their psychological significance as in the earlier formulation.

Gray, Feldon, et al. (1991) have proposed a bottom-up description of schizophrenia pathology which incorporates neuropsychological evidence with the models of both Frith and Hemsley. In particular, they emphasise a disruption to the normal interaction between a system which monitors action (in septohippocampal regions) and a motor programming system (in striatal regions). This break leads to an inability to use past experience and associations to control present behaviour (as in Hemsley's model) and to recognise "willed intentions" (Frith's revised theory). Specifically, this deficit occurs in the neural pathway carrying output from the subiculum in the limbic system to the nucleus accumbens in the basal ganglia (known as the subiculo-accumbens pathway). Although the defective filter concept of Frith's original formulation is not directly described in this model, the idea that behavioural aberrations occur as a product of an inability to select relevant from irrelevant material is maintained, albeit as part of long-term memory retrieval rather than external stimuli processing.

1.9 Early Intervention in Schizophrenia

The general acknowledgment that schizophrenia is a developmental disorder implies that there are neurological (and potentially behavioural) anomalies present prior to onset of the clinical disorder. This assertion has been supported by the finding of cognitive deficits in learning and attention in first-degree relatives of patients and in high schizotypal groups within the normal population. This evidence suggests that there is an identifiable phenotype for the genetic predisposition to schizophrenia (for example see Gourion et al., 2004). Additionally, neuropharmacological evidence indicates that anti-psychotic medication increases efficacy with earlier intervention (for example Bottlender, Strauss, Moller, 2000). In accordance, there has been a focus shift in recent years towards distinguishing and potentially treating individuals at much earlier stages of illness including first episode, prodromal stage (defined as that immediately preceding first episode); and entirely pre-psychotic individuals.

The prodromal stage of schizophrenia has been found to involve observable cognitive changes in working memory and attention (Hawkins, Addington, Keefe, Christensen, Perkins, Zipursky, Woods, Miller, Marquez, Breier, McGlashan, 2003). Others have also reported behavioural changes (relating to more negative symptoms) such as social withdrawal at this stage (Olin, Mednick, Cannon, 1998). Other reports highlighting the negative impact of the "duration of untreated psychosis" on both short term (Bottlender et al., 2000; Melle, Larson, Haahr, Friis, Johannessen, Opjordsmoen, Simonsen, Rund, Vaglum, McGlashan, 2004) and long term (Bottlender, Sato, Jager, Weggener, Wittmann, Strauss, Moller, 2003) prognosis further implicate this prodromal phase as an important treatment point.

Alternatively, others argue that the prodromal phase should itself be considered as an early stage of the illness implying that treating patients at this stage could not stop the inevitable onset of the disorder (and the health and financial costs that ensue). Instead, in accordance with the stress-diathesis model, emphasis should be placed on strategies to prevent the progression of the schizophrenic genotype into clinical illness. This approach is supported by studies indicating that the transition to psychosis and the onset of first episode itself has additional toxic effects on the brain (see Schaffner & McGorry, 2001; McGorry, Yung, Phillips, 2001; Caspi, Reichenberg, Weiser, Rabinowitz, Kaplan, Knobler, Davidon-Sagi, Davidson, 2003). Thus, onset of the clinically diagnosable illness may be reversible *up until this point.* The neurological soft signs already found to indicate the underlying phenotype could be measured in childhood and adolescence to identify those who may go on to develop schizophrenia. Treatment programs, both medical and behavioural could be developed to "buffer" the vulnerable neural systems against stressors and illness onset (see McGlashan & Johanessen, 1996 for review of this approach).

The issue of pre-psychotic intervention is the focus of much controversy in the literature due to the sensitive ethical questions it raises (see articles in special issue of *Schizophrenia Research, Vol. 52*). The main arguments against this line of treatment are the high risk of false positives and the damage that may be caused from unnecessary drug intervention (McGorry et al., 2001; but see Bak, Delespaul, Hanssen, Vollebergh, Graaf, van Os, 2003 for argument against false positives). However, no such negative impact was seen in a preliminary study of pre-morbid individuals by Cannon, Huttunen, Dahlstrom, Larmo, Rasanen & Juriloo (2002). Over and above the harmful effects of pharmacological treatments in high-risk children, there are issues about unnecessary stigmatisation. Moreover, the occurrence of schizotypal traits in the general population itself indicates the potential for false positives to be identified. Questions then arise as to how one could differentiate high schizotypals from true 'pre-psychotics'.

The key to overcoming such ethical controversy is in the accuracy of the methods used to identify this 'dormant' psychosis. Most likely the identification of such individuals would be a multiple-stage process involving both family history and neurocognitive indicators. For example, Erlenmeyer-Kimling, Rock, Roberts, Janal, Kestenbaum, Cornblatt, Adamo, Gottesman (2000) found attention deviance and verbal memory both correctly predicted psychoses-related illness in children with high genetic risk for schizophrenia. Other reports also support this approach (Yung, Phillips, Yuen, McGorry, 2003; McGlashan, Zipursky, Perkins, Addington, Miller, Woods, Hawkins, Hoffman, Linborg, Tohen, Breier, 2003). In general, such methods have demonstrated around 40% psychosis-prediction rate. A considerable weakness of this approach is that the majority of new schizophrenic cases do not, in fact, have a schizophrenic first degree relative (Erlenmeyer-Kimling et al., 2000) which would lead to pressure on the cognitive markers to accurately predict pre-psychotics among the wider population.

As interest continues to grow in the potential to identify and treat psychosis before it fully appears, an understanding in the precursors of schizophrenia has a central role. *It is as part of this ongoing search for accurate markers of schizophrenia predisposition that learned inattention paradigms such as Kamin blocking could have an essential application. Indeed, a report from the New York High Risk Project has concluded that the attentional deficits in schizophrenia are the most likely candidates as pre-morbid indicators for psychosis (Cornblatt, Obuchowski, Roberts, Pollack, Erlenmeyer-Kimling, 1999). Consequently, with this potential role in mind, the importance of evaluating and understanding the task measures involved becomes clear.*

Chapter One, Part Three

1.10 Experimental Models as Research Tools for Psychiatric Illness

In the above discussion the clinical characteristics of schizophrenia have been described and current theories regarding the potential underlying mechanisms have been detailed. A key aspect of this research has been the use of experimental models. Indeed, the use of experimental, laboratory-based procedures to mimic illness symptomatology is an integral part of research into the aetiology and treatment of all human illness. These models are required both in testing for new treatment compounds and in evaluating theoretical proposals about the underlying pathology.

The following section opens with a discussion of the controversy surrounding the use of such models in human psychiatric illness. Specifically it describes an assessment of validity for such models proposed by Wilner (1984). This has been used to evaluate experimental analogues of depression and schizophrenia. As such it provides a conceptual framework in which selective attention paradigms, in particular Kamin blocking, can be assessed. Following this, consideration is given to specific studies in which Kamin blocking deficits have been implicated in schizophrenia. In light of these findings, the theoretical validity of Kamin blocking as a research model for schizophrenia is evaluated.

1.10.1 Experimental models and Wilner's (1984) hierarchy

Using Experimental models for research into *psychiatric* human illness is a complex and controversial issue (see Lipska & Weinberger, 2000 for review). Questions arise about the underlying rationale and practical ability for simple behavioural and pharmacological models (in animals) to replicate human mental disorders. Thus, experimental models are often rated against a three-tier hierarchy according to their validity as reflections of the human illness: Predictive, face, and construct validity (Willner, 1984).

The most basic level is that of predictive or pharmacological validity in which the accuracy of the model for identifying clinically useful pharmacological compounds is assessed. Such models are based primarily on neurochemical and anatomical changes. These models can be useful in testing for new compounds for treatment, but are probably more applicable to medical rather than psychological illness (Lipska & Weinberger, 2000). Models with face validity will demonstrate "phenomenological similarities" (Wilner, 1984) to the disorder. Models with face validity may not necessarily demonstrate the predictive, pharmacological validity: if they do it suggests the behaviours in the model are a true analogue of the actual disorder, but if they don't it can help in identifying different neural substrates involved in the disorder and lead to new lines of treatment. Finally, the construct validity combines the anatomical and behavioural elements with added consideration for the etiological patterns of the illness. By Wilner's (1984) formulation, models with construct validity have an underlying "theoretical relationship" to the disorder.

Although experimental models are widely employed in physical medicine, for psychological illness it is more difficult. Pharmacological models will be based on the *current* theories about the pharmacology and neural structure of the disorder and are therefore open to the criticism that they merely serve as self-fulfilling hypotheses (i.e. designed to evaluate the same theory from which they have been derived). In addition, development of models with face or construct validity relies heavily on our knowledge of animal behaviour and is by nature a subjective rather than objective technique. Models which have achieved an element of face validity for psychiatric illness are in disorders which themselves arise from a dysfunction to a basic response mechanism which can be seen in all species (e.g. anxiety or depression). In disorders such as schizophrenia many of the symptoms involve changes to executive functions and uniquely human processes. Therefore, the behaviours tested within the animal models are not naturally occurring analogues of the disorder. It can be argued, because of this, that the behaviours seen as part of these models cannot reflect the naturally occurring human state in the disorder (see Lipska & Weinberger, 2000 for review). Therefore the validity of models of schizophrenia is an issue of ongoing debate and controversy (for example see Kilts, 2001; Ellenbroek & Cools, 1990; Hert & Ellenbroek, 2000).

The primary source of experimental models for schizophrenia comprise of simple pharmacological tests using animals which, as mentioned before, involve an inherent bias in support of rather than independent testing of current pharmacological theories and may miss out on other potential factors. For example the dopamine hypothesis for schizophrenia led to the amphetamine model as a key research tool, however later evidence suggests a role for glutamate and serotonin systems in the disorder which cannot be incorporated into the original experimental model (see Section 1.6.3). Furthermore, using these simple models for schizophrenia can produce a separation of research into the positive and negative symptom clusters. For example the amphetamine model reflects purely positive symptoms while a second pharmacological model, the PCP model (involving glutamate systems, see Section

1.6.3), is required for investigations on negative symptomatology. This then discounts the holistic experience of the disorder and leads to a dichotomy in treatment efficacy. Other models are proposed to have face validity in terms of simple behavioural attributes such as Pre-pulse Inhibition of the startle response which can be demonstrated in animals and is seen in schizophrenia patients (see Kilts, 2001). However, this still models only a single observable behaviour in patients. Timothy Crow has argued that, from an evolutionary perspective, schizophrenia may be "the price we pay for language" (Crow, 1997) and is therefore inherently tied to our language ability. It would follow from this view that experimental models based on animal behaviour are fundamentally precluded from attaining face or construct validity for this particular disorder.

1.11 The Selective Attention Paradigm as an Experimental Model for Schizophrenia

It has been noted that experimental models form a central part of research into human illness and have been successfully applied to both biological and psychological disorders. However, the above discussions indicate a fundamental dilemma for schizophrenia research: it is clear that our current level of understanding about the description and underlying mechanisms involved in schizophrenia is far from definitive yet the development of experimental analogues of a psychiatric disorder such as schizophrenia are theoretically questionable. As schizophrenia research continues to rely on the use of experimental models, and with these inherent problems in mind, it is vital that models are developed and employed which at least *aim* at face or construct validity (Wilner, 1984).

The cognitive models of Frith (1979) and Hemsley (1987) focus on selective attention and filtering mechanisms thereby highlighting the potential for learning based paradigms such as Latent Inhibition and Kamin blocking to be used as valid experimental analogues in schizophrenia research. These procedures represent naturally occurring functions in both humans and animals. Furthermore, they are disrupted during increased dopamine activity (induced by amphetamine administration). In addition, they have been shown to be deficient in clinical groups (Lubow & Gewirtz, 1995; N. Gray, 1991; Jones et al., 1992b; Oades, Zimmerman, Eggers, 1996; Oades et al., 2000; Moran et al., 2003; Williams, Wellman, Geaney, Cowen, Feldon, Rawlins, 1998) and their first-degree relatives (Serra et al., 2001) indicating that they may be behavioural markers of underlying genetic predisposition to the disorder. In animals, learned inattention models have been used to show the latent effects of developmental interventions such as prenatal stress (e.g. Shalev & Weiner, 2001) reflecting the neurodevelopmental aspect of schizophrenia in humans. Therefore, this paradigm may have the construct or at least reliable face validity described in Wilner's (1984) model. This conclusion is further supported in a review of models for schizophrenia by Ellenbroek & Cools (1990).

However, the role of selective attention is not emphasised in all cognitive models of schizophrenia, and in turn the theoretical role of Kamin blocking within these cognitive models is somewhat unclear. The revised Frith model (1992a,b) as well as that of Gray, Feldon, et al. (1991) focus on action control mechanisms rather than stimulus processing. There is still controversy over what elements of information processing are represented by blocking procedures, and this is of relevance to its compatibility with these prevailing hypotheses of schizophrenia deficits. For example, original theories of Kamin blocking describe it as a filtering out of the added stimulus (Rescorla & Wagner, 1972) which would exclude it from the current models of cognitive deficits in schizophrenia. However, later investigations of Kamin blocking indicate that the added stimulus is learnt and attended to but does not have the strength to control response actions (Mackintosh, 1975; Cheng & Novick, 1990). In this case, the association between the added stimulus and outcome is retrievable from long-term memory such that, while in normal processing the association is deemed irrelevant and does not control current responses, in schizophrenia this association is inappropriately retrieved. However, there is evidence to support both these definitions of Kamin blocking as has been discussed in previous sections.

It would seem then that the compatibility of Latent Inhibition and Kamin blocking to current theories of the underlying cognitive deficits in schizophrenia is open to some debate. However, Kamin blocking and Latent Inhibition are also important tools in schizophrenia research because they demonstrate a way to directly transpose cognitive processes disrupted in schizophrenia patients into an animal model. This provides consistency across pharmacological and genetic investigations of underlying dysfunctions in the disorder. At the very least these paradigms can be used as behavioural markers in other potential neurodevelopmental (such as neonatal lesions) or genetic models. The utility of Kamin blocking in this respect, though, is dependent on the equivalence of the human and animal procedures. In humans, Kamin blocking is measured not only in Pavlovian conditioning set-ups would be utilised in animal studies, but also using contingency learning paradigms. Moreover, as mentioned above, it is often the contingency learning paradigms in humans which have demonstrated the most consistent blocking effects. This lack of comparability between blocking procedures is one of the issues addressed by this thesis.

1.12 Blocking Research I: Findings with Animals

Various lines of evidence support the use of Kamin blocking as an animal model for deficits in schizophrenia. For example, the haloperidol-reversed disruption to Kamin blocking with d-amphetamine treatment (Crider et al., 1982) and a disruption following hippocampal lesions: general lesions (Solomon, 1977, Marchant & Moore, 1973); selective frontal/septal lesions (Oades, et al., 1987). Moreover, the more complex cue competition in Kamin blocking may reflect an animal model with better construct validity for schizophrenia deficits than Latent Inhibition (Crider et al., 1982).

Furthermore, administration of amphetamine at stage two seems to be similarly critical to its disruptive effects on both Kamin blocking (O'Tuathaigh et al., 2003 - although this differs from Crider et al., 1982) and Latent Inhibition (Moser, Hitchcock, Lister, Moran, 2000 – although this differs from Solomon, Crider, Winkelman, Turi, Kamer, Kaplan, 1981). These findings can be interpreted as a disruption to stage one learning on stage two responses such that the target stimuli are now learnt effectively. Importantly, this concurs with the hypothesis that the deficits experienced in the disorder are focused at the response control stage rather than learning per se (Frith, 1987; Gray, Feldon, et al., 1991).

However, the response mechanism account of Kamin blocking would contradict many of the prevailing associative learning theories such as Rescorla-Wagner (1972) and Mackintosh (1975) in which the blocking effects are driven by learning processes (see Section 1.2 for review). Although other theories such as the comparator model (Miller & Schachtman, 1985) in which blocking is a response-expression competition between the cues after the compound learning stage (see Rauhut et al., 1999) could accommodate the amphetamine findings.

Evidence from a number of studies has indicated that Kamin blocking in animal set-ups is highly sensitive to context and procedural parameters (Ohad et al., 1987; Holland, 1999; O'Tuathaigh et al., 2003; Schreurs & Westbrook, 1982; though contrary findings cited in Crider et al., 1982 and Maleske & Frey, 1979) as well as control conditons used (see Garrud et al., 1984) and the biological significance of the stimuli (Miller & Matute, 1996). This sensitivity to procedural factors may also affect human blocking paradigms (see Section 1.13) and the large variety of methods employed in blocking investigations raises the possibility that the blocking observed across studies involves different types of processes (Holland, 1999).

Finally, a recent study attempted to record more directly the processes involved mapping blocking effects onto the brain using fluorodeoxyglucose autoradiography in the rat (Jones & Gonzalez-Lima, 2001). They found a decrease in activity in the medial prefrontal cortex, an area previously implemented in selective attention and relevant to observed abnormalities in schizophrenia. In light of the above discussion it would be of interest to repeat this technique across different blocking procedures to clarify the issue of consistency across studies.

1.12.1 Summary of blocking research I

Kamin Blocking is found to be disrupted by acute administration of amphetamine during stage two learning, and by hippocampal lesions supporting the dopamine hypothesis of schizophrenia dysfunction. However, several factors have been seen to mediate blocking effects such as biological significance of the stimuli and type of measurement used and these may be the cause of the discrepancies in the literature. The context sensitivity of blocking effects underlies the present thesis: it is of prime importance for clinical applications of blocking that the differences between tasks in the literature are understood and that consistency is maintained in the experimental paradigm such that drug and genetic manipulations can be explored.

1.13 Blocking Research II: Findings in Clinical Populations

A decrease in Kamin blocking measures in clinical samples has been reliably reported in a number of studies (Jones et al., 1990 exp 2; Oades, Zimmerman, Eggers, 1996; Jones et al., 1992b; Jones et al., 1997; Oades et al., 2000; Moran et al., 2003; Watson, Al-Uzri, Reveley, Moran, 2001). Moreover, Kamin blocking measures have demonstrated differential deficits in schizophrenia and Attention Deficit Hyperactivity Disorder (Oades & Muller, 1997) but not Obsessive-Compulsive Disorder (Oades, Zimmerman, Eggers, 1996) or Tourette's Syndrome (Oades & Muller, 1997) indicating their specificity as models of the attention dysfunction seen in schizophrenia.

In healthy participants, a disruption to Kamin blocking following amphetamine administration would parallel earlier findings with Latent Inhibition. Indeed, such a relationship was tentatively demonstrated (Serra, 1995; Jones et al., 1997 – though not conclusive evidence), although later research has not upheld this finding (Gray et al., 1997). However, the relationship between blocking and dopamine measures in humans has been indirectly investigated in other studies involving dopamine metabolism measures in humans (Oades et al., 1992; though not Oades, Roepcke, Schepker, 1996). The results from these are unclear due to differences between patient subgroups, but putatively suggest Kamin blocking in normal participants links more to dopamine increase than that seen in patients. In general though, measures of Kamin blocking in humans has not shown expected relationships to amphetamine administration (Gray et al., 1997) as seen in animals (Crider et al., 1982) and with human Latent Inhibition tasks (Gray, 1991). This finding is discordant with the Gray, Feldon et al's (1991) model of schizophrenia which postulates dopamine systems to have a primary role in mediating attentional deficits (see also Gray, 1995), and consequently questions the theoretical equivalence of the human and animal Kamin blocking procedures. However, Gray et al. (1997) point out that Kamin blocking has demonstrated the expected differences in schizophrenia groups and deficits following hippocampal lesions as would be predicted by the model. Furthermore, they argue that the findings in animal studies of blocking are also not as robust as with Latent Inhibition. This strengthens the links between the animal and human measures of Kamin blocking but suggests a fundamental distinction between Kamin blocking and Latent Inhibition in terms of their underlying mechanisms. Following this, caution must be used when predicting results between the two functions.

The possible use of Kamin blocking in investigating differences not only between clinical and healthy populations but to differentiate within clinical sub groups is an important issue for its future study. It is as yet unclear whether Kamin blocking can differentiate between these separate patient subgroups. For example, Jones et al. initially reported the Kamin blocking deficit in acute but not chronic patients (Jones et al., 1992b), which is discrepant with later demonstrations of Kamin blocking deficits in chronic patients (Serra et al., 2001; Jones et al., 1997). Moreover, Bender et al. (2001) found no significant effect of illness duration on Kamin blocking measures using the Oades Task (although they did find a relationship with an earlier age of onset which is often cited as indicative of a worse illness outcome).

A variation between paranoid and non-paranoid sub groups in terms of the pattern of blocking over the test period has been shown (Oades, Zimmerman, Eggers, 1996). That is, while both groups showed an immediate deficit in blocking, this remained low for the non-paranoid group but not paranoid groups during the first five (out of twelve) test trials. However, the issue is somewhat confused by a later study in which the Kamin blocking deficit was reported only in non-paranoid groups - the paranoid patients had high levels of Kamin blocking at the start which remained high throughout the test phase (Oades et al., 2000, 2001). Bender et al. (2001) also noted that the Kamin blocking deficit in their clinical sample was only apparent when the non-paranoid patients were analysed on their own and not in the sample as a whole. This has repercussions for previous findings reporting deficits in non-specific samples as the ratio of paranoid to non-paranoid groups were not reported in previous studies it is unclear whether this reflects a contradiction to previous work or not. Evidently though this distinction is an important factor for interpreting Kamin blocking deficits in schizophrenia and for guiding future research.

Furthermore, the maintenance of high blocking levels by paranoid patients throughout the 24 trial test phase in the blocking task (Oades et al., 2000, 2001; Bender et al., 2001) suggests a deficit in unblocking rather than blocking itself. That is, although paranoid patients have initially acquired the necessary automatic processing such that the added stimulus is blocked, they are subsequently unable to go back to override this and learn the correct response to the added stimulus. In healthy participants blocking and conditioning paradigms in general are often extinguished rapidly. It would seem from this that, in paranoid patients, there is an inability to override initial learning and change response actions according to new information and this was further investigated by looking at the association between the Kamin blocking patterns and stimulus dimension shift measures: in the non-paranoid group their impaired Kamin blocking was linked with faster inter-dimensional shifts while the paranoid group who, in this study, recovered Kamin blocking after the first test trial also linked faster attention shifts to recovered Kamin blocking. This was said to reflect earlier findings of differences in "cognitive style" and task strategy between the two groups (see Bender et al., 2001) on other cognitive tasks.

Those authors suggest that the finding of normal levels of Kamin blocking in paranoid groups supports the previous finding of no disruption to Kamin blocking with amphetamine since the amphetamine administration is a pharmacological model for the positive symptoms of the disorder only. However, it cannot be concluded that the Kamin blocking observed in paranoid groups reflects normal processing as there was no evidence of the unblocking expected in healthy participants. While it could be argued that unblocking is a separate function on which paranoid patients (but not non-paranoid) are consequently deficient, by definition unblocking must be at least functionally linked to the blocking mechanisms. This difference is especially so when the differences in performance are described in terms of "cognitive strategy" (see above): it is plausible that there are many strategy options and more than one may lead to "normal" blocking measures on the task.

Finally, these authors report that Kamin blocking deficits relate more to the negative symptoms such as poor rapport and attention and enhanced Kamin blocking with the positive symptoms such as thought disorder (which reflects the dichotomous syndromes seen in paranoid/non-paranoid subtypes) (Bender et al., 2001). Similar relationships were seen in an earlier study (Oades, Zimmerman, Eggers, 1996) where correlations were found between Kamin blocking impairment and particular symptoms in the schizophrenia group. For example, in the paranoid group delusions were negatively correlated and hallucinations positively correlated with Kamin blocking while thought disorder correlated more with normal levels of Kamin blocking in the whole sample.

The potential for Kamin blocking effects in patients to be paralleled in their first-degree relatives would implicate Kamin blocking as a trait marker for Schizophrenia and add to its utility in clinical research. This has been investigated by Serra (1995; see also Serra et al., 2001), who report a deficit to Kamin blocking in first-degree relatives of schizophrenia probands. However, the authors note that these results are not unequivocal as the Kamin blocking deficit was compounded by general learning deficits on the task in all groups. Other studies have evaluated the potential relationship between Kamin blocking and schizotypal personality: Jones et al. (1992) demonstrate a tentative link between lower Kamin blocking scores and factors of magical thinking and unusual perceptual experiences; and Moran et al. (2003) report associations with O-Life measures of Cognitive disorganisation and STA scores using the Oades, Roepcke, Schepker (1996) behavioural blocking task.

1.13.1 Summary of blocking research II

There are three Kamin blocking procedures reported in clinical investigations: a simple rule-learning format with a between subjects design (Jones et al., 1990); a human contingency learning task using a within subjects design (Jones et al., 1997); and a more complex, within subjects task involving visuo-spatial cue-location associations (Oades, Roepcke, Schepker, 1996). Together these groups have shown a consistent and differentiable deficit in blocking in schizophrenic groups. However, there are numerous discrepancies in the literature leaving questions over the role of mediating factors such as illness duration and symptom subtype. Furthermore, at present the literature does not report a consistent amphetamine effect in healthy participants or a clear relationship with measures of schizotypal traits.

1.14 The Theoretical Validity of the Kamin Blocking Model for Schizophrenia

As discussed above, models of clinical disorders can be validated against a three-tier hierarchy (Willner, 1984). It is of interest then to evaluate the formal validity of Kamin blocking as an experimental model of the disorder.

In terms of predictive validity, there is evidence of dopamine involvement in Kamin blocking processes from studies in animals. Amphetamine administration at stage two learning is seen to disrupt Kamin blocking and this can be linked to the current model of underlying schizophrenia pathology (Gray, Feldon, et al., 1991). And indirect support comes from studies showing a disruption in Kamin blocking with hippocampal lesions. However, evidence of this amphetamine disruption is not consistent in the animal literature and has yet to be unequivocally demonstrated in humans. A possible explanation for this discrepancy is the strong bias for amphetamine to model only the positive symptoms of the disorder. Thus, Kamin blocking may be an analogue more for the negative aspects of the disorder and so does not fully reflect the dopamine hypothesis. Indeed, there is some evidence suggesting Kamin blocking deficits link more to negative symptomatology (see above) and for Kamin blocking deficits to be absent in chronic patients (Serra et al., 2001; Jones et al., 1997). To date however, the Kamin blocking model has not been used to investigate glutamatergic or serotonergic system activity, which may have more relevance for models of the negative syndrome. Conversely, the cognitive models of schizophrenia neuropathology, which postulate underlying attention deficits as would be measured in Kamin blocking, themselves pertain more to the positive symptom aspects.

With regards to face validity, Kamin blocking has demonstrated a stronger profile. The Kamin blocking paradigm can be translated across species, and as a human function is seen to be disrupted in schizophrenic patients. Furthermore, this deficit is specific to psychotic populations over other clinical groups. There is also some evidence of a relationship between Kamin blocking disruptions and high schizotypal traits in the general population. This evidence suggests that Kamin blocking reflects a naturally occurring cognitive aspect of the schizophrenic disorder and therefore that it demonstrates some face validity for the human psychiatric illness.

Kamin blocking has been described by various authors as having construct validity as a model for schizophrenia (Crider et al., 1982). However, it could be queried whether there is enough experimental evidence at this stage to support this contention. As discussed, Kamin blocking does reflect a cognitive dysfunction in schizophrenia which is behaviourally measurable, but the key element for construct validity is whether the Kamin blocking model follows a similar etiological pattern to the cognitive abnormalities in the disorder. Although there is theoretical potential for Kamin blocking to reflect the underlying schizophrenia genotype, evidence for Kamin blocking disruptions in first-degree relatives of patients or in pre-morbid probands is yet to be properly demonstrated. Furthermore, the theoretical fit of Kamin blocking into cognitive models of schizophrenia pathology is unclear and depends largely on how blocking itself is to be defined. This symbolises the inherent problem which the present thesis is trying to address – namely, that the validity of Kamin blocking as a model in future research cannot be fully assessed until a full understanding of the mechanisms involved in human Kamin blocking is known. Importantly, this understanding must involve a practical knowledge of the manifestation of Kamin blocking in humans. The role of population parameters such as sex and IQ must be accounted for when drawing conclusions about deficits seen in performance from patient samples. In addition, the *development* of Kamin blocking is of interest. Indeed, if it is found to be a function that develops during childhood it would provide added support to its ties with the neurodevelopmental changes that occur in schizophrenia. Alternatively, if Kamin blocking is found to decrease naturally after a certain age, it may be of little use in patient samples which exceed this criteria. As noted in the discussion of sex effects (section 1.6.1), evidence from psychological research does suggest the role of age in attentional abilities (Ridderinkhof & Van der Stelt, 2000) and this field of research could help to inform clinical investigations. The issue of the development of Kamin blocking in humans is assessed as part of Experiment 5 and discussed further in Chapter 6.

Cognitive theories of associative learning phenomena such as Kamin blocking may never be fully resolved, but this need not mean Kamin blocking is of no use in the clinical realm. It is sufficient for a standard interpretation and measurement of Kamin blocking as it is applied in the clinical sphere to enable clear research conclusions to be drawn.

1.15 Aims of This Thesis

The above sections have reviewed the Kamin blocking paradigm in the context of associative learning theories and in schizophrenia research. The discussion of schizophrenia research and issues surrounding the underlying pathology involved in the disorder has highlighted the areas in which the learned inattention paradigm and Kamin blocking have been utilised as experimental analogues of schizophrenia. The theoretical validity of this role has also been considered. Finally, the discussion of future research investment in schizophrenia in terms of prevention has indicated the potential importance of Kamin blocking in future clinical research. However, the above also demonstrates the discordance across Kamin blocking procedures, not only between the animal and human paradigms, but also across human measures of this function.

This, then, is the context for the present thesis: to take into consideration the findings from *both* the associative learning and clinical fields of literature in order to investigate the practical issues within blocking measures which may be affecting the clinical findings and therefore must be accounted for if blocking is to be a useful tool for schizophrenia research.

The studies reviewed in this thesis have centred on three main aims:

a) Are blocking tasks from the literature measuring the same underlying process?
b) Are these tasks similarly affected by experimental manipulations?
c) How do population variables such as age and gender affect observations of blocking?

CHAPTER TWO

2.1 General Introduction to Comparison Studies

Following the original demonstrations using animal learning procedures, some problems have been encountered in trying to demonstrate the blocking phenomenon in human participants. Attempts to directly transpose the original experimental approaches into human tasks have been largely unsuccessful (Davey & Singh, 1988; Hinchy et al., 1995; Martin & Levey, 1991) and differences in blocking effects in both healthy (e.g. Jones et al., 1994 versus Oades, Roepcke, Schepker, 1996) and clinical (e.g. Jones et al., 1992b versus Serra et al., 2001) populations have been observed. As discussed in Chapter One (Section 1.4), many different methodologies exist and there is little agreement on the types of measurements used in the tasks. To date no studies have explored the possibility that these varied methods for Kamin blocking may not be measuring the same cognitive process.

This series of experiments was carried out a) to establish Kamin blocking using a number of tasks that have been described in the literature and b) to investigate the association of the blocking effects measured across these experimental approaches.

In order to control for potential mediating factors across participants, measures of general intelligence (IQ) and handedness were taken in each study. As discussed in the Introduction (see section 1.8) an increase in non-right handedness has been found in patients with schizophrenia. As handedness is thought to reflect processing patterns in the brain, a shift away from right-handedness (the standard in general populations) could indicate underlying differences in information processing. Therefore, it is of relevance to measure handedness in the present studies not only for it's association with schizophrenia and schizotypy, but also as a potential variable which could affect cognitive functioning.

Differences in IQ could affect learning of the task as well as blocking processes. General IQ was estimated from scores on the National Adult Reading Test, which has been standardised against population norms. This particular test was also chosen because it is used in clinical research as a primary indicator of pre-morbid intelligence (e.g. Kondel, Mortimer, Leeson, Laws, Hirsch, 2003; and see Bright, Jaldow, Kopelman, 2002 for discussion).

2.2 Experiment 1: Kamin Blocking Effects in a Within-Subject Task

2.2.1 Introduction

In this experiment we investigate Kamin blocking effects in the healthy population using the task reported by Jones et al. (1990 – termed Jones A Task here). This task has previously shown robust blocking in healthy populations (Jones et al., 1990, 1992a, 1994; Gray et al., 1997; Serra et al., 2001) as well as the expected blocking deficits in schizophrenic populations (Jones et al., 1992b, Serra et al., 2001) and their first-degree relatives (Serra et al., 2001). Furthermore, there is some evidence for decreased blocking on this task in high schizotypals (Jones et al., 1992a, but not conclusively in Serra et al., 2001). As such this task seems to provide a consistent and reliable measure of blocking effects in humans.

The task is a between-subject design in which participants learn compounds of visual shapes and auditory tones which predict the onset of a target visual stimulus (usually a second coloured shape) and blocking is measured by a greater number of trials to learn the blocked stimulus alone in the experimental compared to the control group. However, parameters of the task have been moderated in different reports in order to maintain blocking effects. For example, the original description used a mixture of lights and tones in the compound stimulus (Jones et al., 1990), but a bi-modal design makes the results less reliable and this was modified to a wholly visual compound in later studies (Jones et al., 1992b, 1994, 1997; Serra et al., 2001). However, this later version still presented the noises to add complexity. Although this change resulted in robust blocking effects, the authors report that the introduction of bi-sensory processing in stage two could still lead to changes in perception of the learning context (for a discussion of the potential effects of this see Jones et al., 1992b, 1994).

Furthermore, the use of a between-subjects design is also cited as being unreliable particularly in clinical studies where patient samples would need to be matched between groups (Jones et al., 1997). Therefore, blocking effects demonstrated using this approach may have been due to these extraneous factors. Investigation of blocking produced by this version in which potential mediating factors from previous reports have been removed will demonstrate the reliability of this particular blocking procedure.

A within-subject version of the task has been developed by the original authors in which only visual stimuli are presented. However, this version has not yet been reported in the literature. The present study looks at the blocking effects produced in healthy participants by this version of the task.

2.2.2 Methods

Participants: 30 psychology undergraduates completed the test as part of a course requirement. Of these, two participants were unable to pass the learning criteria for the task (see below) and were discarded. The data sets from the remaining 28 participants (7 Males; 21 Females) were analysed. The average age of this sample was 18.87 yrs (std dev 0.6); the average IQ (as estimated by the NART) was 108.33 (std dev 4.42); and the average Annett handedness score was 2.07 (std dev 1.56).

<u>Materials & Procedure:</u>

1) Jones A Task

This blocking task was based on that reported in Jones et al. (1990 - and with minor modifications in 1992b, 1994, 1997, 2001) but with some significant differences, which are discussed below. In this task, participants are presented with a series of coloured shapes on the computer screen and must learn a simple rule predicting the onset of the target stimulus. The task is presented on an Atari computer with an attached button response box. In the present form, compound stimuli consisting of coloured squares and horizontal flanker shapes appear in all trials. The target (outcome) stimulus is presentation of a yellow square and the series of shapes is presented pseudo-randomly such that a particular shape always precedes this target.

The within-subject version comprises of *two learning stages and a test stage*: in all three stages participants are instructed to watch the series of screens and press a response button when they believe the yellow square will appear next. They must press the button during the two seconds inter-trial period. Button presses outside of this screen are not registered. If the participant has made a correct response, the words "well done, the next square is yellow" would appear on the screen for 1.5 seconds before the yellow square appeared. If the participant has incorrectly pressed the response button, the words "wrong, the next square is not yellow!" would similarly appear. If the yellow square appeared without the participants response, the words "bad luck, you missed this one!" would appear on the screen above the yellow square. See Table 2.1 for breakdown of stimuli in each stage and Appendix 1 for screen layout.

In learning stage 1, one of six coloured squares appears in the centre of the computer screen. Smaller shapes in grey appear horizontally either side of the main square (known as flankers). In this stage the dark blue square is paired randomly with the flanker shapes such that only the appearance of the blue square can be predictive of the yellow target square. Participants complete 60 trials during this stage.

In learning stage 2, the coloured squares in the trial series are always paired with particular flankers. In particular, the blue square and triangle flankers always appear together and always precedes the yellow target square. Additionally, the circle flankers only appear paired with a green square: this pair also predicts the target stimulus and acts as the novel control measure. All other pairings of flankers to squares are random. In this stage participants must compete 120 trials.

In the test stage, compounds of squares and flankers appear as before except that the central blue and green predictor squares are now absent. The triangle and circle flankers are now paired randomly with all other squares from stage two and remain predictive of the yellow square regardless of the central square pairing. All other flankers appear on random trials as before. There are a total of 120 trials in this stage.

Modifications to task from Jones 1990

The present study uses a modified version of the Jones et al. (1990) behavioural computer program, obtained from the original authors. In particular this task differs from the original version in three areas: the visual compounds are used of squares and flankers rather than shapes and tones; the within-subject design means participants are evaluated for blocking against their own control stimuli; and there is no criterion for learning at each stage and all participants complete a set number of trials. Consequently, the blocking measure is calculated as the frequency of correct responses during stage three rather than the number of trials to learn reported in previous versions.

Learning in this task is observed from the number of correct hits in the first learning stage. In the original task a measure of speed of learning could be taken from the number of trials to pass the criterion but in this case it is not speed of learning but total learning that can be compared across individuals. Also participants are asked to make a response at all stages of the task rather than the first learning stage being merely observational.

Table 2.1: Stimuli presented during the Jones A Task

Stage	**Coloured squares**	**Flanker shapes**	**Target stimulus**	**Cue for target**
Learning stage 1	Purple White Red Light Blue Dark Blue Yellow	Squares Crosses	Yellow Square (paired with any flanker)	Dark Blue Square (paired with any flanker)
Learning stage 2	Purple White Red Light Blue Dark Blue Yellow **Green**	Squares Crosses **Triangles** **Circles**	Yellow Square (paired with any flanker)	Dark Blue square + triangle flankers **AND** Green square + circle flankers
Test stage	Purple White Red Light Blue Yellow	Squares Crosses Triangles Circles	Yellow Square (paired with any flanker)	Triangle flankers (with any square) **AND** Circle flankers (with any square)

2) National Adult Reading Test

The National Adult Reading Test (NART - Nelson & Willison, 1992) was completed by all participants. This is a word reading test involving a list of 50 English words of varying frequency. See Appendix 2a. Participants are asked to read aloud each word in their own time. They are reminded that they may not be familiar with every word but to attempt to pronounce each as accurately as possible (See Appendix 2b for full instructions). Participants are scored according to the number of incorrect pronunciations.

3) Annett Handedness Questionnaire (Annett, 1970, 1998)

This is a short self-report questionnaire (paper and pencil) consisting of a list of 12 common actions. See Appendix 3a. Participants are asked to mark which hand they would use to perform each activity. They are instructed to actively imagine themselves performing each action to ensure accurate reporting. They are also reminded that people do not necessarily use their writing hand for all actions and so they should consider each activity independently. The scores are calculated based on the importance of each action using a flow-chart as reported in Annett (1998) see Appendix 3b.

4) Demographics Questionnaire

Finally, participants were asked to complete a pre-test questionnaire providing general information which may be of use when interpreting the data. Questions included date of birth, education level, family history of psychiatric disorders, visual problems, and frequency of computer use in daily life. See Appendix 4.

Note that participants were not excluded on the basis of answers to the general questions or from their NART and handedness scores. Data from these questionnaires was taken in the event of anomalies in the results which may have been mediated by these factors.

<u>Data analysis:</u>

1) Jones A Task-

Learning is demonstrated by participant's making more responses to the correct predictor stimulus than to other stimuli (i.e. more hits than false positives) at the end of learning stage one. The maximum number of hits would be 15 as this is the total number of trials in which the blue square appears. Individual variation in learning rate can be compared from the number of correct responses in this stage or by the average reaction time to the correct predictor at this time. That is, a greater number of correct responses or a faster response time to correct stimuli would indicate more consistent learning (and perhaps earlier learning) of the correct predictive rule during the learning stage.

Blocking is demonstrated by a lower number of correct responses (hits) to the blocked stimulus (the triangle flankers) than the control stimulus (the circle flankers) during the test stage. Additionally, blocking can be assessed from a faster average response time to the control stimulus compared to the blocked stimulus. This would indicate stronger learning to the control stimulus.

Overshadowing cannot be measured in this task as the two stimuli from the control compound are not tested separately during the test stage.

2.2.3 Results

The following section describes the pattern of scores observed from (1) the learning and (2) blocking elements of the Jones A Task. The distribution of scores is reported followed by the mean and variance of the scores and the significance of these effects.

Learning Scores:

The learning scores from Jones A Task did not follow a normal distribution either from the graph (see Figures 2.1 & 2.2) or in a statistical test for normality (Kolmogorov-Smirnov statistic was 0.207 hits and 0.334 reaction time, $p<0.001$ for both). The mean number of correct responses in the first learning stage of Jones A is 12.04 (std dev 2.10; median 12.50). However, there was a large ceiling effect for this measure with 37% of participants scoring 14 hits. The mean reaction time for correct responses in the learning stage was 0.48 seconds (std dev 0.52; median 0.33).

Figure 2.1: Distribution of learning scores Jones A Task
(Bar labels represent bin range)

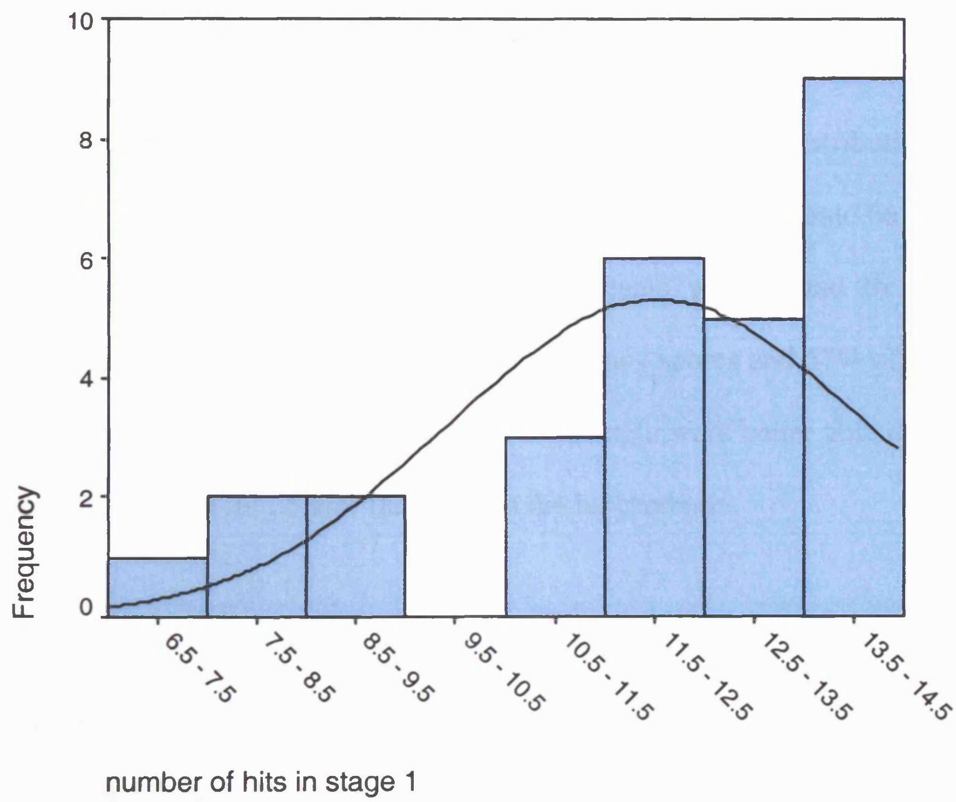
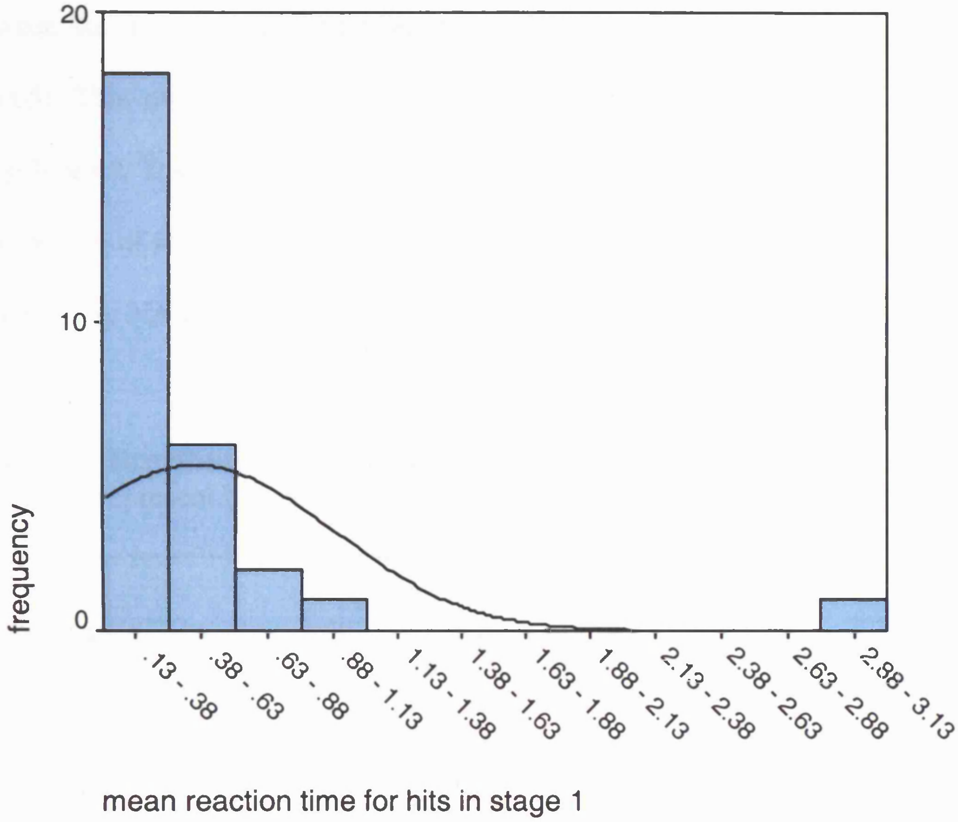


Figure 2.2: Distribution of learning scores in Jones A Task
(Bar labels represent bin range)



Blocking Scores:

The blocking scores were generally found to follow a normal distribution from the Histograms (see Figures 2.3 & 2.4) such that parametric analysis could be carried out. The individual difference scores in the participants were found to be positive (indicating a blocking effect) in 46% of the frequency scores and 57% of the reaction time scores. This suggests that only half of the sample were better able to predict the target stimulus from the control flanker than the blocked one.

The mean blocking scores for Jones A were 0.04 (hit difference) and 0.01 (reaction time difference). Neither of these was found to be a significant blocking effect above zero in a one-sample T-test ($t(27)=0.062$, $p=0.95$ for number of hits; $t(27)=0.467$, p=0.64 for reaction times). Furthermore, only 32% of participants showed positive blocking scores in both measures and analysis revealed no significant relationship between the frequencies of positive scores on the two measures (Chi Sq (1)=1.448; p>0.05). This evidence suggests that blocking did not occur in the present sample using Jones A Task.

The absence of reliable blocking effects in Jones A precludes analysis of any potential mediation by NART or handedness scores.

Figure 2.3: Distribution of blocking scores in Jones A Task
(Bar labels represent bin range)

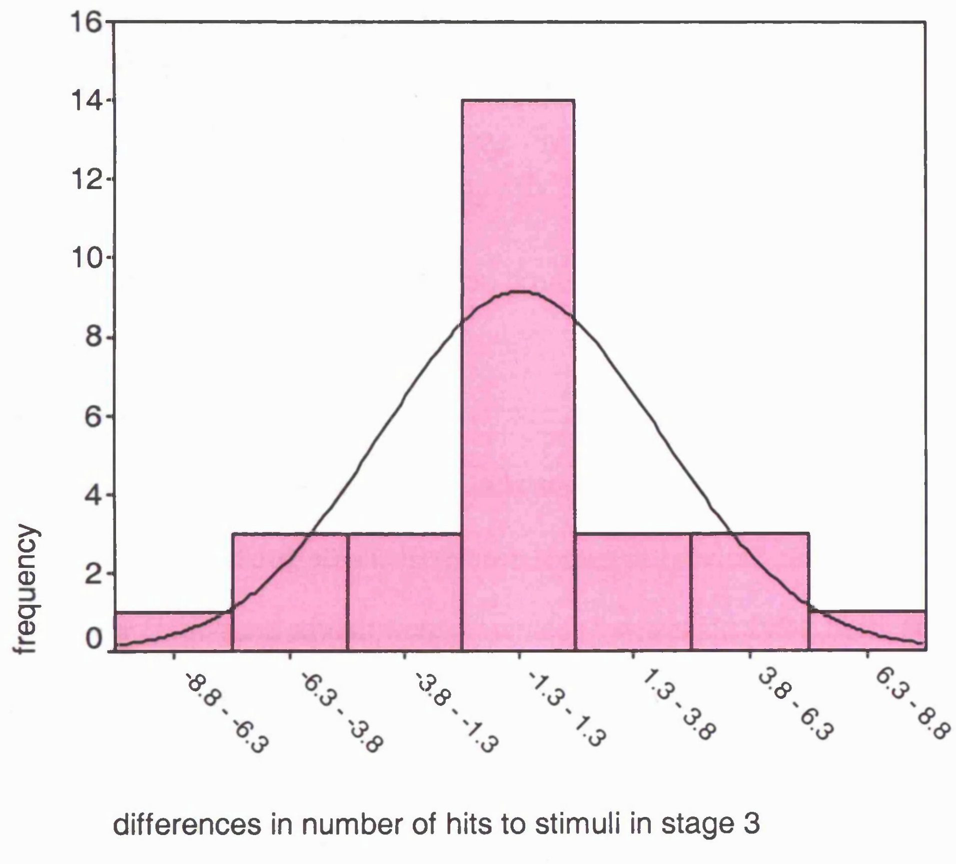
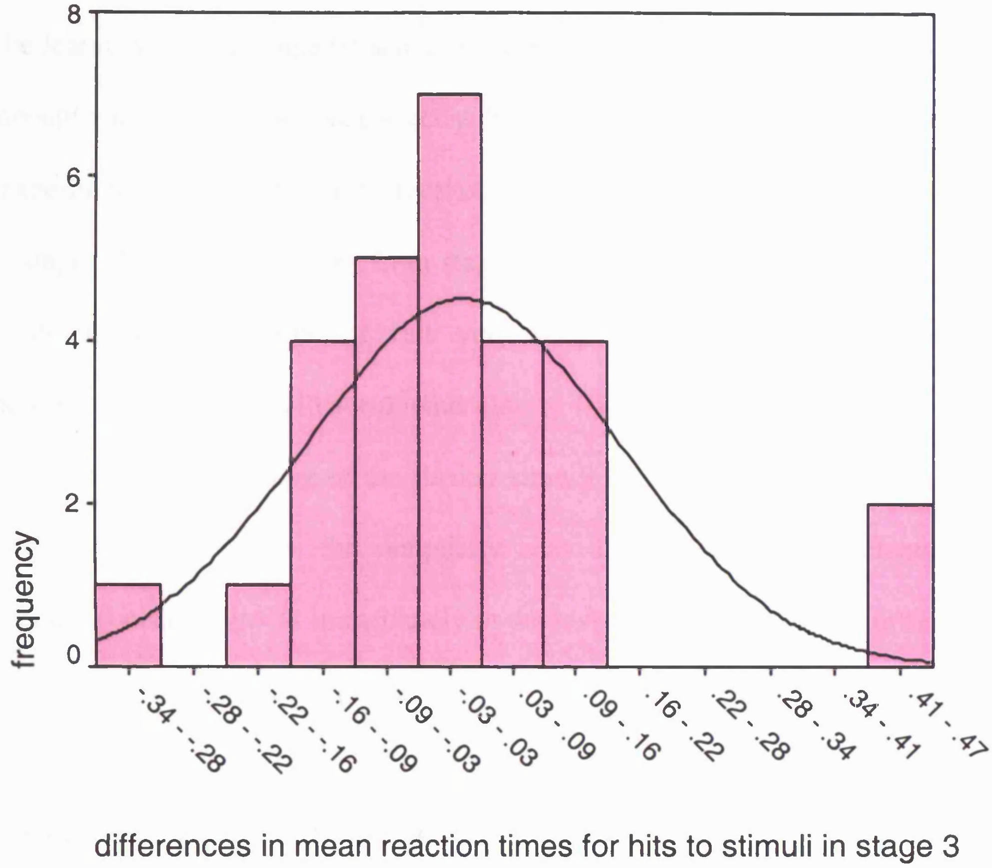


Figure 2.4: Distribution of blocking scores in Jones A Task
(Bar labels represent bin range)



2.2.4 Discussion

The present study failed to reveal any indication of blocking effects using Jones A Task. As reliable blocking effects have been shown in previous reports of this task in which similar format and stimuli were presented (Jones et al., 1994; Serra et al., 2001) the primary explanation for the present findings must lie in the transformation of the original task to a within-subject design. It is of note that similar problems have been encountered in previous attempts to modify a between-subject task to a within-subject equivalent in Latent Inhibition studies (Serra, 1995). In this case the within subjects version was assessed in a series of studies in which no significant effects were observed and the task was eventually abandoned.

The key features of the task which may have obstructed demonstrations of blocking are the considerable length and simplicity. That is, the ease at which the associations can be learnt (within a single presentation) leads to boredom in participants and a loss of incentive to perform the task correctly. Informal observations of participants during the experiment indicated a general level of frustration with the high number of trials at each stage. The learning scores from stage one indicate a high ceiling effect, which suggests participants learnt the rule very early on and were then subjected to numerous trials which would seem unnecessary. The high number of trials would also lead to increased processing of the flanker stimuli which decreases the likelihood of observing blocking. Also the simplicity may obscure blocking effects as the 'unblocking' occurs almost immediately in the test stage and cannot be differentiated by measures taken at the end scores.

Perhaps a continuous measure of blocking during the test stage rather than a single overall measure would be better able to assess potential learning differences between the stimuli. However, the reaction time data already collected should have been sensitive to such small differences at the start of the test stage. That is, if blocking had occurred but been subsequently followed by 'unblocking' (or re-learning the relevance of the blocked stimulus) differences in reaction time to the stimuli would be recorded from the first few trials and then equal out to zero as unblocking occurs: the overall measure taken at the end would then still indicate the early differences in responding. Indeed, for there to have been no differences observed overall, initial response differences in the blocking direction would have been overridden by equal differences in the opposite direction. Therefore, if anything, the present results would indicate a form of 'reverse blocking' effect. A more likely explanation is that any differences in reaction times between the stimuli are merely random effects and not driven by underlying learning differences.

The blocking scores indicate that most participants had no difference between correct responses to the control and blocking stimuli. However there are differences between individuals on the number of correct responses overall during stage three. It is probable, then, that once participants had learnt the general rule 'the flankers from stage two are predictive in stage three' they then used this equivalently on the relevant shapes – and the only difference between participants is the number of trials it took to realise this general rule *not* in the number of trials it took to learn one shape over another.

The present study demonstrates the sensitivity of this particular blocking measure to procedural changes and suggests the between-subject design may have been a fundamental element in previous observations of blocking in this task. Given the limitations of between-subject designs in clinical studies (discussed above) it was decided not to pursue this experimental approach through assessment of the original between-subject version. Furthermore, the comparison approach invoked for these studies requires similar designs as a comparison of within-subject to between-subject designs would present practical difficulties as well as producing less reliable comparative data. Therefore, two Kamin blocking tasks of within-subject designs were identified from the literature for comparison in the following experiments.

CHAPTER THREE

3.1 Experiment 2: Oades and Jones B Tasks Comparison

3.1.1 Introduction

This experiment compared measures of blocking observed in two within-subject Kamin blocking tasks: Oades, Roepcke, Schepker (1996) and Jones et al. (1997) (Oades and Jones B Tasks respectively). The Oades Task measure has shown robust blocking effects both in the reports of other groups and in our own laboratories. Jones B Task was also identified from the clinical literature following unsuccessful attempts to demonstrate blocking in Jones A.

In the present study, both tasks have been used with clinical and healthy populations and have both demonstrated the expected blocking deficit in people with schizophrenia (Jones et al., 1997; Oades et al., 2000; Oades et al., 2001; Serra et al., 2001). However, these two tasks reflect different approaches to learning measurement: the Oades Task involves a visuo-spatial computer task with reaction time as the blocking measure; Jones B Task is a contingency judgement task whereby participants must make overt judgements about the relative predictive values of each stimuli. Therefore, in Oades Task, blocking rises from unconscious efficiency strategies in the brain, while blocking in Jones B Task is due to an active and logical deduction of the relative predictive values of the stimuli.

As part of the comparison of the blocking tasks, neuropsychological measures were taken involving either memory or executive functions. If the tasks are found to differ, these measures may then help to elucidate what different processes are involved in each task. Previously, blocking on the Oades Task has been found to correlate with performance on visual reproduction, verbal fluency, Stroop interference and holistic perceptual strategies (Oades et al., 2001). Jones B Task has not been directly studied with these measures, however putatively the contingency judgement task could be associated with cognitive processes such as working memory (indicated in Chapman, 1991). Therefore, in the following experiment we included measures of Stroop interference, verbal fluency, and Weschler scales of visual and logical memory.

Finally, the Oades Task was found to be negatively associated with measures of schizotypal traits such as cognitive disorganisation, unusual experiences and the schizotypy scale (Moran et al., 2003). That is, people scoring higher on these personality measures were found to have lower blocking effects. However, this study involved a comparison between clinical and control groups. The present study will, therefore, investigate the replicability of this finding in a healthy population sample. Jones B has not yet been investigated with regards to schizotypy, but as it has shown deficits in clinical populations (Jones et al., 1997), a similar decrease in high schizotypy groups could be hypothesised. Schizotypal measures have been included in the present study to replicate previous findings with Jones A Task and to further cross-validate these associations in the two blocking tasks.

Therefore, this study looks at a) the associations between measures from two blocking tasks b) the relationships between these tasks and measures of schizotypal traits and c) the relationships of the blocking to neuropsychological processes of Stroop interference, verbal fluency and working memory. As before, general IQ and handedness of the participants was obtained as potential mediators for cognitive performance.

3.1.2 Methods

Participants:

74 people were recruited from the University of Leicester (as part of a course requirement) and local area (as unpaid volunteers). Of these, 62 people (42 Females; 20 Males) reached the learning criteria for both Kamin blocking tasks (described below). The mean age for the sample was 22.42yrs (std de 8.23yrs); the mean estimated IQ (as calculated from the NART) was 110.16 (std dev 7.10); and the mean handedness, as measured by the Annett handedness scale (Annett, 1970, 1998), was 2.05 (std dev 1.42).

Participants were randomly assigned to an order group:

Group 1- 29 participants (18 Females; 11 Males) completed the Oades Task, followed by all other cognitive tests, and finally Jones B Task

Group2 – 33 (24 Females; 9 Males) completed Jones B Task followed by all other cognitive tests and finally Oades Task.

The order groups did not differ significantly in age, NART, or handedness.

Jones B Task was run as one of four possible versions to counterbalance across stimuli. Mean age, NART score, and handedness did not differ significantly between the version groups. See Table 3.1 for breakdown of demographics.

Table 3.1: Break down of Age, IQ and Handedness scores for each participant group

	Mean Age yrs (std dev)	Difference test value	Mean IQ (std dev)	Difference test value	Mean Handedness (std dev)	t-test value
Order Group 1	21.62 (7.38)	----------	110.00 (6.94)	----------	2.17 (1.54)	---------
Order Group 2	23.13 (8.96)	t(60)=-0.717	110.30 (7.35)	t(60)=-0.166	1.94 (1.32)	t(60)= 0.642
Version Group 1 (N=14)	22.56 (10.64)	----------	111.71 (5.65)	---------	2.43 (1.45)	---------
Version Group 2 (N=15)	22.07 (5.36)	---------	111.71 (5.65)	---------	2.07 (1.44)	----------
Version Group 3 (N=17)	22.31 (3.90)	---------	108.35 (7.26)	----------	1.65 (1.54)	----------
Version Group 4 (N=16)	22.76 (11.58)	F(3,61)= 0.654	109.94 (8.19)	F(3,61)= 0.654	2.13 (1.26)	F(3,61)= 0.796
Totals	22.42 (8.23)	-------	110.16 (7.10)	---------	2.05 (1.42)	---------

Key: Order Groups refer to which Blocking Task was performed at start and end of session; Version Group refers to version of Jones B Task completed.

Materials & Procedure:

See Table 3.2 (page 109) for blocking set-up in each Task.

1) The Oades Task

A computer based task written in turbo Pascal and described in full in Oades, Roepcke, Schepker (1996) and in the format of a game called "the mouse in the house". The participants are asked to move an icon (the "mouse") around a floorplan (the "house") using a joystick (see Appendix 5a for screen layout). On each of a series of trials, they must move the icon to the target locations. These locations are invisible but are cued by panels of particular colour blocks appearing at the top of the screen for 1 second at the start of the trial. The participant thus learns the associations between the target locations and the colours which predict them. Participants complete two sessions of the game, each of which involves a series of learning and test stages of trials:

The Conditioning Session

For both sessions the computer screen depicts a floorplan divided in half by a partial wall (i.e. the mouse icon may still move between the two sides) and with each side further divided into four sections or "rooms". See Appendix 5a for illustration.

Instructions: Participants were asked to sit facing the computer and hold the joystick in a comfortable position. They were instructed that they would be playing a computer game about a "hungry mouse in a big house". They should use the joystick to guide the mouse to find invisible "cheeses" as quickly as possible in order to win points. They were told the mouse would start on either the right or left side of the house and the cheese would always be hidden in the opposite side. As the cheese was invisible, colours would appear at the start of each trial to help them. These would "tell" them which hiding place to go to each time. Successful location of the cheese results in fifteen points added to their score (shown at the bottom of the screen). However, if they took too long to find the cheese they would have points subtracted from their score at a rate of minus two per second. Participants are not told that there will be two hiding places per side or that the locations on each side are reflections of each other through the central wall. See Appendix 5b for full instructions.

Learning phase: The mouse icon starts alternately in the top left hand corner (the target location will be on the right side of the house) and in the top right hand corner (target location will be on the left side of the house). A panel of colours appears above the house for one second at the start of each trial. The colour panel consists of three colours presented in series: CSA, a neutral colour, and CSB. There are two colour sets to be learnt. During each trial, participants have a grace period of seven seconds before any point decrement is incurred. Progression from this phase is conditional on completing a set number of trials without point deductions (88% over 8 trials).

Test phase: In this phase individual colours from the previous colour sets are shown at the top of the screen in each trial. This phase begins with presentations of the two neutral colours to control for surprise effects due to the change in stimulus number. Then the conditioned stimuli are presented in partial random order (the two colour sets always appear one after the other, but colour presentations within each set are randomised). All other aspects of the game remain unchanged. A total of 24 trials are completed: 12 presentations each of the first and third colours from each of the two colour panels. In this way, the test phase can be broken down into 12 trial pairs (first and third colour pairs), which can be further divided into 6 pair groups (each group consisting of one trial pair from each colour set).

The Blocking Session

Instructions: Participants are told they will play another game with the mouse, very similar to the first. They are reminded of the general rules stated in session one.

Learning phase one: In this phase, a pair of colours appears at the start of each trial: CSA (to the left) and a neutral colour (to the right). There are two sets of colours and the game is played in the same way as in session one. Again, progression from this stage is as for session one.

Learning phase two: Here, a third colour (CSB) is added to the colour pairs to the right of the neutral colour. All else remains the same.

Test phase: Again, the test phase consists of individual presentations of the colours as described in session one.

2) Jones B Task

A computer based contingency learning task written in visual basic (Jones et al., 1997). Using the keyboard to make a response, participants are presented with a series of trials ('films'), for each they are given the name of the starring actor and asked to rate how successful they think the film will be. All names are fictitious and ratings can be any number between 0-100. The task involves completion of a single session with two learning stages and two test stages. In the first learning stage each film has a single starring actor and only two actors appear overall (one associated with successful films and one with unsuccessful films). Therefore, there are 36 trials: 12 of each single star presentation and 12 control trials where "no famous actors" are presented. This is followed by a test stage, of a single trial, where the participant is asked to rate the predicted success of each of six actors including the two from the learning stage and four novel actors. In the second learning stage each film has two stars and all actors are associated with successful films. Therefore, there are 36 trials: nine of the previously successful star with another actor; nine of the unsuccessful star with another actor; nine of a pair in which both actors are novel; and nine of "no famous actors". This is then followed by a final test stage (as above). See Appendices 6a and 6b for screen layout, Appendix 6c for the full instructions.

3) Neuropsychological measures

a. Weschler memory scales (logical and visual) (Weschler, 1987). In the logical memory test, participants listen to two short stories and after each are asked to repeat back verbatim. This is performed immediately and again at the end of the test session for delayed recall measures. The visual memory test consists of short (10 seconds) presentation of simple line drawings (series of four) which must subsequently be drawn from memory (immediate and delayed as before). On both tests participants are scored for number of accurately recalled aspects of the stories/pictures to give total visual and logical scores for both immediate and delayed memory. See Appendix 7a for example of stories for logical memory scales; Appendix 7b for drawings in visual memory scales.

b. The Stroop Test (paper version – Trenerry, Crosson, DeBoe, Leber, 1989). In this version, participants read aloud colour words (RED, BLUE, GREEN, TAN) written in discordant colour ink. The words are presented on a sheet of 100 words divided into four columns. Participants must complete as many word as possible in the time limit. Guidelines for clinical use suggested a two minute time limit: this was decreased to one minute for the healthy sample used here to counteract potential ceiling effects. Scores are allocated by the number of words completed out of 100.

c. The FAS verbal fluency test (Benton & Hamsher, 1974). In this test participants are instructed to say aloud as many words as possible that begin with a particular letter within a given time limit of one minute. The score is allocated as the total words produced over three letter trials (letters F,A,S respectively).

4) The O-Life Questionnaire (Mason et al., 1995; Claridge, 1997) was also completed. This consists of a list of 160 yes/no questions presented individually on a computer screen. Participants are instructed to work through the questions in their own time, but not to deliberate too much on any question and go with their first, impulse answer. This collects data on six scales: Unusual Experiences (items pertaining to positive symptoms of schizophrenia such as perceptual hallucinations), Introverted Anhedonia (relates to negative aspects of schizophrenia such as social withdrawal and lack of social enjoyment), cognitive disorganisation (items describing attention, decision-making and concentration problems), impulsive nonconformity (refers to reckless or non-conformist behaviours), the general schizotypy scale (STA – constructed from clinical symptoms of schizotypal personality disorder). These scales are designed to measure schizotypal traits within the normal population. Additionally the questionnaire includes items on extroversion and Lie dimensions as filler items and internal validity measures (Mason et al., 1995).

5) General Measures

Finally, participants completed the National Adult Reading Test, the Annett Handedness questionnaire, and Demographics Questionnaire as described in Experiment1. Participants were also asked a few questions about the strategies used on each of the blocking tasks (See Appendix 8a and 8b).

Table 3.2: Experimental procedure and target comparison for blocking in the Oades, Jones B and Chapman Tasks

Experiment	Task	Session	Learning 1	Test 1	Learning 2	Test 2	Comparison	
2 & 3	Oades et al., 1996	Control	AOB+	....	....	A, B	A minus B = **X**	
		Blocking	CO+	....	COD+	C, D	C minus D = **Y**	**X minus Y = blocking**
2	Jones et al., 1997	Single session	A+, B-	A, B, C, D, E, F	AC+, BD+, EF+	A, B, C, D, E, F	**F minus C = blocking**	
3	Chapman & Robbins, 1990	Single session	A+, B-, C-	A, B, C, D, E	AD+, BE+, C-	A, B, C, D, E	**E minus D = blocking**	

Table shows blocking set up in the all three Blocking tasks used in Experiments 2 and 3. Letters represent colours in Oades Task, names in all other Tasks.

Data Analysis:

1) Kamin blocking calculations

a. The Oades Task:

Learning is measured by the number of trials to criterion (88% over 8 trials) completed in the learning stage of session one (control/conditioning session) up to a maximum of 60. Participants not reaching criterion were excluded from the data analysis. In this calculation, better learning is signified by lower scores. In order to clarify the relationships found with other measures (whereby higher scores define better performance), this scale was reversed for the correlation analyses.

Kamin blocking scores are calculated by subtracting an index Y (reaction times to the first colour subtracted from the reaction time to the third colour during the test stage of the blocking session) from an index X (reaction times to the first colour subtracted from the reaction time to the third colour during the test stage of the Control/conditioning session). As greater associative strength would result in faster reaction times to the first over the third colour in the blocking session, a positive score from this calculation indicates that blocking has occurred. That is, the difference between learning of the first and third colours is greater after the blocking stages than in the control session (See Table 3.2). This formula can be further broken down to look at blocking across the test phase by applying the above formula to each of the **6 pair groups of the test phase** (Bender et al., 2001; Moran et al., 2003). This may aid demonstration of blocking effects which may otherwise be obscured by subsequent learning of the blocked stimulus (a process known as unblocking). Additionally, it has been shown that schizophrenic deficits in Kamin blocking are dependent on pair group (Bender et al., 2001; Watson et al., 2001).

Overshadowing is calculated as the average difference between the first and third colours in the stimuli panels for the conditioning session only. That is, during the session in which the participant is equally exposed to both stimuli, overshadowing would be demonstrated by a large difference between learning to the colours during the test phase (Oades, Roepcke, Schepker, 1996).

b. The Jones B Task:

Learning is measured by the difference between ratings for the two actors after the initial, pre-exposure stage: during this stage, one actor is always associated with successful films and a second actor with no success, therefore learning is demonstrated if one actor is correctly rated above the other.

Kamin Blocking is measured from the comparison of ratings after the blocking stage. Blocking is indicated by a lower rating for the star paired with the initially successful star than a novel control. (i.e. the pair consisting of two stars neither of which appeared in the first learning stage). For each participant, the rating for the 'blocked' star was subtracted from the rating for the second star of the novel control pair (to control for stimulus position effects) so that a positive score indicates blocking.

Super-conditioning can also be measured in this task as the star paired with the initially unsuccessful star should be rated relatively high at the second rating stage. Therefore, super-conditioning can be measured by subtracting the rating for the novel control (second name in the novel control pair as above) from this star. Again, a positive score indicates super-conditioning. This measure further indicates active differentiation between stimuli ratings. Additionally, the super-conditioned stimulus has been used to indicate blocking effects in other contingency learning tasks instead of a novel control (Chapman & Robbins, 1990).

Overshadowing is measured as the difference between ratings for the individual actors comprising the novel control pair which appears in the second learning phase only. Therefore, as these two actors are equally presented with a successful outcome, overshadowing would be demonstrated by a significantly higher rating for one over the other (Jones et al., 1997).

Rationale for calculation deviation from Jones et al. (1997)

In the original report of this task Jones et al. (1997) calculates blocking as a difference between the mean rating for the control and blocked stimuli from the sample as a whole. Indeed this measure is often used in calculations of contingency judgement blocking effects. However, the Oades Task provides blocking scores for individual participants by calculating within subject differences between stimulus response times. In the present study individual blocking scores have been calculated in Jones B Task primarily for comparison to scores derived in Oades Task. However, measuring blocking effects within individuals can in some cases be a more informative evaluation of blocking effects in a sample. That is, if most participants score both stimuli equally (around +100), and a few score the blocked stimulus much lower than the control the overall means will be artificially differentiated by these few scores. Although statistical analysis of the overall blocking effect will be equivalent for these methods, the proportion of positive blocking scores in the sample ('blockers') can provide an additional assessment of the presence of blocking. Therefore, while analysis of the means may report a significant difference between the ratings and a significant blocking effect, in fact only a few participants have actually been actively influenced by the blocking paradigm in the task.

In the all studies in this thesis those participants demonstrating blocking scores above zero on the Tasks have been denoted as 'blockers' (as opposed to non-blockers). As mentioned above, this is primarily for use as a secondary description for the amount of blocking within the sample or across groups. Although not specifically mentioned in his original reports, this definition of 'blockers' has been derived from the Oades Task calculation (Oades et al., 1996) in which scores are obtained along a continuum where positive scores indicate the occurrence of blocking within the individual. Indeed, the proportion of participants demonstrating a blocking direction (regardless of amount) is similarly noted by Chapman (1991) when comparing forward and backward blocking effects. It is acknowledged that the use of such a discrete 'cut-off' point is somewhat arbitrary and may lead to over-inclusive groups. However, with this caveat it is still a useful description of the pattern of blocking scores in the sample.

Finally, the learning measure described above has been developed specifically for the present study and was not mentioned in the original report of the task. However, using the logic of the contingency learning blocking calculation (in which a greater difference between target ratings indicates greater blocking) it follows that learning strength can be similarly evaluated from the rating differences.

2) Statistical Analysis

One Sample T-test analyses were used to establish blocking effects different from zero where positive scores indicate the presence of blocking. In addition the proportion of positive blocking scores in the sample are reported as discussed above.

Bi-variate correlation analysis was performed to investigate the relationships between the learning and blocking scores from each Kamin blocking task.

In addition, two separate Hierarchical Multiple Regression analyses were conducted to investigate the influence of the schizotypal and neuropsychological measures on each of the two Kamin Blocking scores. For each analysis: Block One included the neurocognitive measures of Stroop, Verbal Fluency and Logical Memory; and Block Two included the O-life scales of STA, COGDIS, and UNEX. These predictors were chosen on the basis of previous reports (see discussion above). Moreover, It was decided to enter the neurocognitive measures as Block One so that the specific involvement of schizotypal traits in the two blocking measures could be assessed over and above differences in cognitive functions involved in the tasks.

Previous reports in which the effect of schizotypal traits on blocking scores have been investigated have utilised the median split technique to divide participants into high and low schizotypal groups (e.g. De La Casa et al., 1993). It has been argued that this is a less reliable measure of putative relationships and may lead to false positives (MacCallum, Zhang, Preacher, Rucker, 2002). In addition, the use of this technique somewhat opposes the dimensional conceptualisation of schizotypy which is encompassed by the O-life scales. That is, this technique necessarily categorises participants rather than analysing the various strengths of the schizotypal trait. However, it should be noted that the groups produced by this analysis are understood to refer to high*er* and low*er* scores along the continuum and are therefore descriptive rather than diagnostic. In order to compare our results with those in the published literature, the differences between high and low schizotypes (following a median split) in the present sample was additionally evaluated through independent t-tests.

Finally, participants achieving Kamin blocking scores of two or more standard deviations from the mean on either task were removed from the analysis as outliers. Six data sets were removed by this criterion. Therefore, the reported analysis is from the remaining 56 participants only (25 Order Group 1; 31 Order Group 2).

3.1.3 Results

The scores from the Weschler visual memory scales (immediate and delayed) demonstrated high ceiling effects with most participants achieving maximum scores on both scales. Therefore it was decided to remove this from the analyses as it could not provide any meaningful information between participants. Table 3.3 describes the means, variance and range of scores observed for the remaining neuropsychological and O-life measures in this study.

The following section is divided into reports for (1) the learning measures and (2) the blocking measures from the Tasks. For each measure, the distribution of scores is described along with the mean and variance and the significance of these effects. Following these descriptions, statistical analysis of the data is reported as discussed above.

Table 3.3: Description of observed scores from the neuropsychological and O-Life scales

	Mean (std dev)	Minimum score	Maximum score
UNEX	9.24 (6.53)	0	28
COGDIS	13.22 (5.93)	0	24
INTAN	4.26 (3.71)	0	15
IMPNON	11.11 (3.84)	3	21
STA	15.24 (7.02)	0	35
Stroop	65.32 (13.00)	44	94
Logical memory immediate	26.14 (4.77)	19	39
Logical memory delayed	22.00 (5.53)	5	34
Verbal fluency	39.95 (10.92)	18	67

Learning Scores:

Measures of learning from the Jones B Task clearly do not follow a normal distribution (see Figure 3.1; for Oades Task distribution (normal distribution) see Figure 3.2) as many participants obtained the maximum learning score. Therefore, spearman's rank correlation was employed to analyse the relationship between the learning scores. The learning measures from the two tasks were found to correlate significantly with each other: r(s) = 0.29; n=56; p=0.03 (although this effect size is small – Cohen, 1988).

Learning measures from the Tasks did not differ across order or version groups.

Order: Mann-Whitney U = 365.5, N=56, p=0.72 Oades Task; Mann-Whitney U=304, N=56, P=0.12 Jones Task.

Version: Kruskall-Wallis chi-sq=1.03, df=3, p=0.79 Jones Task

As multiple regression analysis is not appropriate for this data, Spearman's correlations were performed between the two learning measures and the neuropsychological (four measures) and O-Life measures (seven measures) in turn. Due to the number of analyses being performed, a corrected alpha level was used so that variables must reach (0.05/11) 0.005 level to be considered significant. Using this value, Oades Task learning correlated positively with verbal fluency only (r(s)=-0.41; n=56; p=0.002). Jones B learning did not correlate significantly with any measures using this more stringent alpha level. However, trends (outside the corrected alpha levels) were found for this measure to correlate positively with verbal fluency (r(s)=0.30;n=56; p=0.03), and negatively with Unusual Experiences (r(s)=-0.30; n=56; p=0.04) and Cognitive Disorganisation (r(s)=-0.30; n=56; p=0.03). See Appendix 13 for full correlation matrix of learning scores and other measures.

Figure 3.1: Distribution of learning scores in Jones B Task
(Bar labels represent bin range)

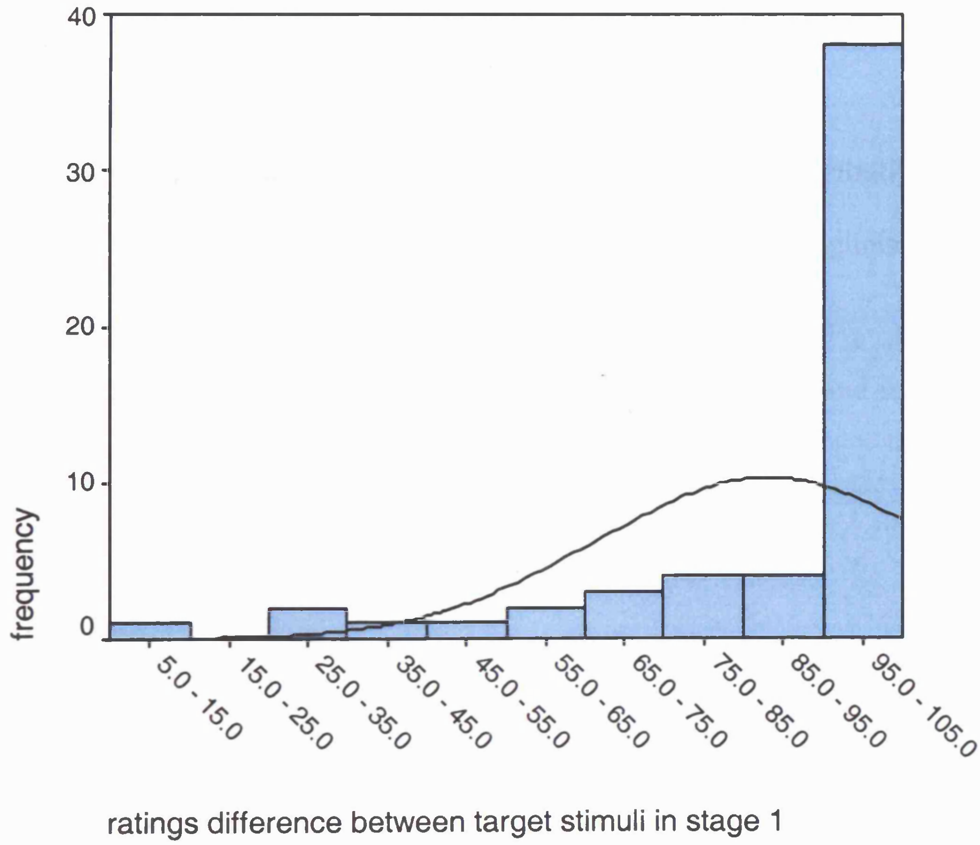
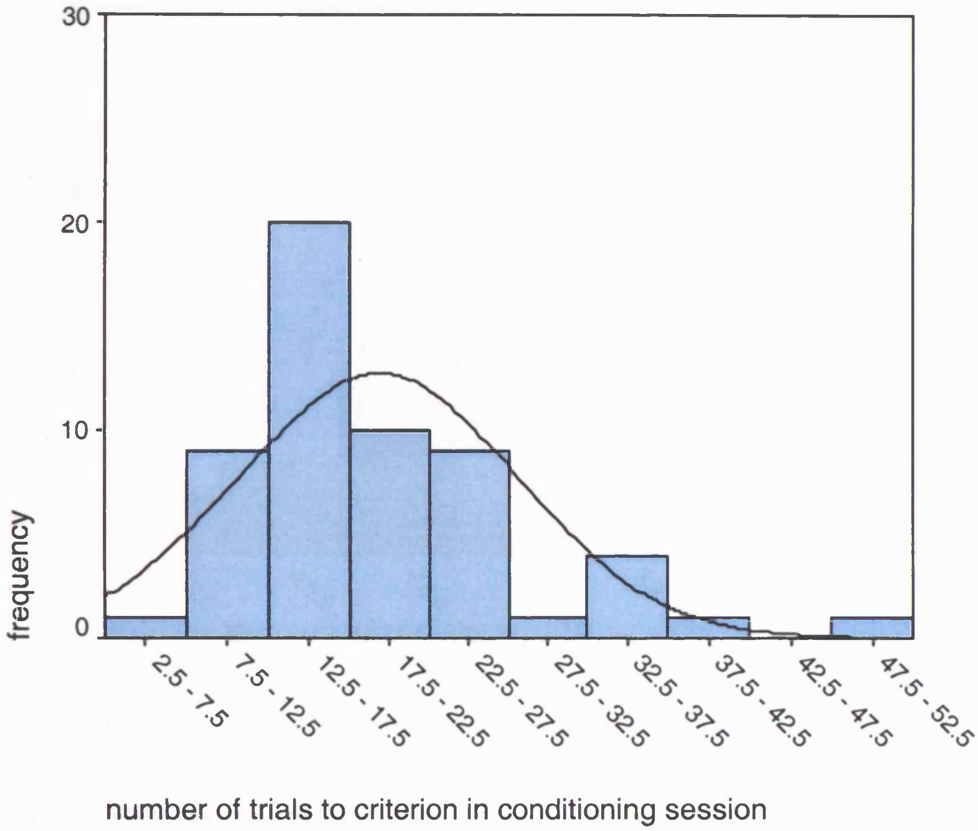


Figure 3.2: Distribution of learning scores in Oades Task
(Bar labels represent bin range)



Blocking Scores:

The task score distributions were found to follow a normal distribution such that parametric analysis could be carried out on the data (see Figures 3.3 & 3.4 Kolmogorov-Smirnov = 0.47 Oades; 0.72 Jones B; p>0.10 for both).

Positive blocking scores were found in 73% of the Oades scores and in 45% of the Jones B scores.

Figure 3.3: Distribution of blocking scores in Jones B Task
(Bar labels represent bin range)

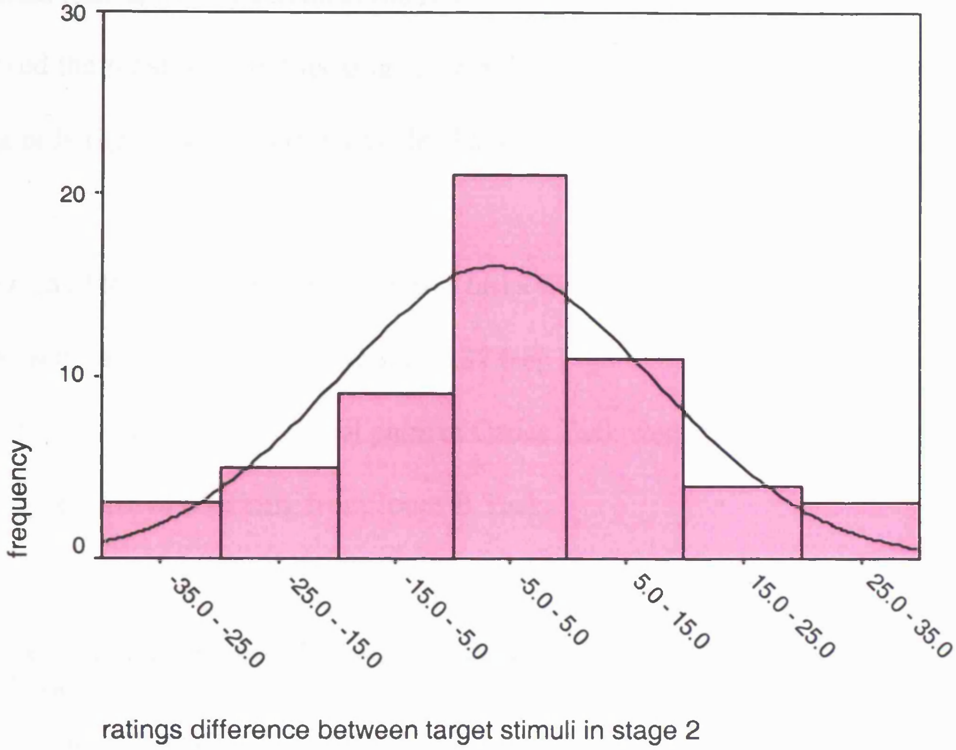
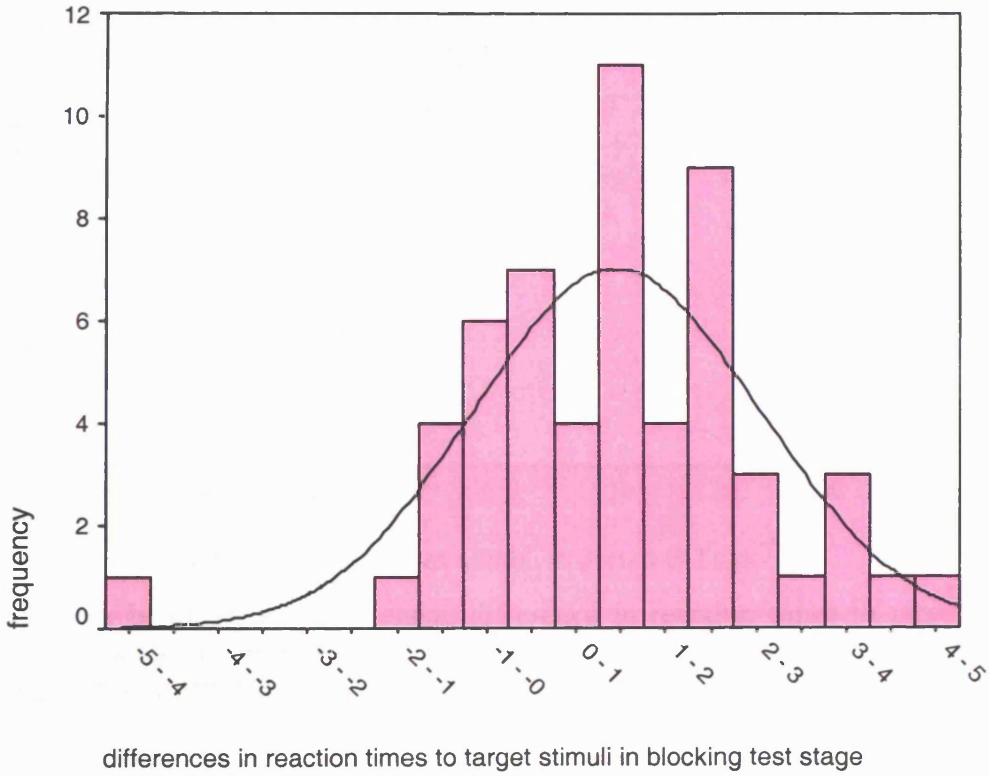


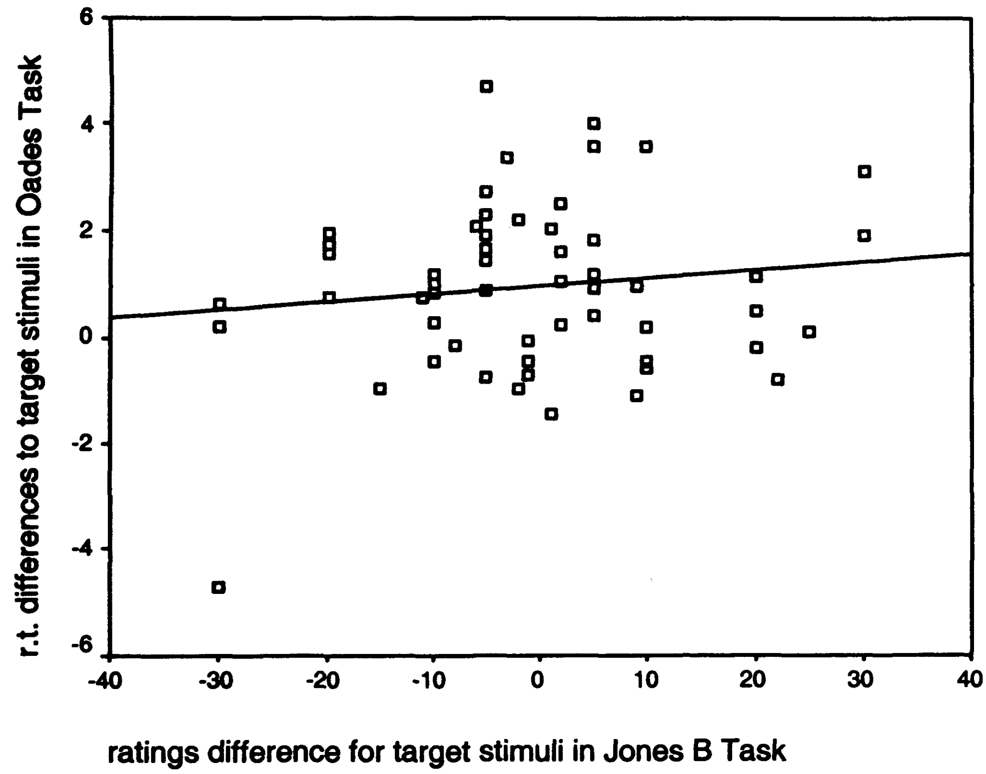
Figure 3.4: Distribution of blocking scores in Oades Task
(Bar labels represent bin range)



The mean blocking score for the individual participants on Oades Task was 0.95 seconds (std dev 1.59) and on Jones B Task was –1.16 (std. dev 13.90). T-test analysis showed the mean Kamin blocking score to be significantly greater than zero in Oades Task only ($t(55)=4.48$, $p<0.001$ Oades Task; $t(55)=-0.63$, $p=0.53$ Jones B Task).

The mean blocking scores from the two tasks were not found to correlate significantly with each other: $r(p) = 0.14$; $n=56$; $p=0.32$ (see Figure 3.5). None of the scores derived from the individual trial pairs in Oades Task were found to correlate with the single measure of blocking from Jones B Task.

Figure 3.5: Relationship between blocking scores on the Oades (Y) and Jones B (X) Tasks



Key: Oades blocking scores = mean difference in reaction times to target colour stimuli, blocking session test stage; **Jones B blocking scores** = differences in ratings for target stimuli, stage 2

A post hoc analysis was performed on those participants who showed positive blocking scores on both tasks (N=19) in which significant blocking effects were observed in both tasks ($t(18)=5.75$, $p<0.001$ Oades; $t(18)=4.54$, $p<0.001$ Jones B). In this group the null relationship was upheld ($r(p)=0.04$; $n=19$; $p=0.86$). However, this supporting evidence is tentative as Jones B Task scores were not significantly greater than zero, the positive blocking scores of these participants may not reliably reflect active 'blocking' phenomena over and above random effects.

Multiple Regressions

Table 3.4 shows correlations between the O-Life and neuropsychological measures. The relationships between O-life variables in this sample are very similar to those reported by other authors (Mason et al. 1997; Moran et al. 2003) indicating a degree of internal reliability in these scales.

Oades Task: Block one explained 16.3% and block two 10.2% of the variance in the Oades blocking scores. The addition of the predictor set in block two was not significant ($p=0.110$). The overall model was significant $F(7,53)=2.37$, $p=0.04$. Individual coefficients revealed only STA scores to significantly predict Oades scores (ß unstand. = 0.170, ß std = 0.750; $p=0.02$). However, this finding is tentative given the lack overall of correlation between the STA and blocking scores ($r(p)=0.10$; $N=56$; $p=0.46$. See Appendix 14a for full analysis information.

Jones B Task: Block one explained 22.9% and block two 11.9% of the variance in the Jones B blocking scores. The addition of the predictor set in block two showed a just significant change in the model ($p=0.05$). The overall model was found to be significant $F(7,53) = 3.50$, $p=0.004$. Individual coefficients revealed Stroop (ß unstd =

-0.595, ß std = -0.556, p<0.001) and Verbal Fluency (ß unstd = 0.454, ß std. = 0.357, p=0.01) measures to be significant. See Appendix 14b for full analysis information.

Table 3.4: Relationships between neuropsychological and O-life measures (Pearson's correlation coefficients; N=56)

	UNEX	*COGDIS*	*INTAN*	*IMPNON*	*STA*	*Stroop*	*Logical memory immediate*	*Logical memory delayed*
UNEX								
COGDIS	0.523**							
INTAN	0.233	0.421**						
IMPNON	0.479**	0.366**	0.071					
STA	0.834**	0.726**	0.269*	0.513**				
Stroop	-0.007	0.292*	0.019	0.134	0.159			
Log.mem immediate	-0.138	-0.068	0.158	-0.140	-0.068	0.166		
Log. mem delayed	-0.149	-0.068	0.138	-0.103	-0.063	0.180	0.825**	
Verb flu	0.028	-0.167	-0.283*	0.149	-0.124	0.251	-0.172	-0.157

*denotes significant relationship at p<0.05
** denotes significant relationship at p<0.01

Comparison of High and Low Schizotypes

T-test Analyses of High (N=28) and Low Schizotypes (N=26) by means of a median split on STA scores (median = 14, equal scores classed as low) revealed a significant difference on Jones Task scores, but not the overall or trial pair scores from the Oades Task.

Oades Task: Mean blocking scores Low Schizotypes = 0.79 (std dev 1.25); High Schizotypes = 1.14 (std dev 1.91); t(52)=-0.80; p=0.43

Jones B Task: Mean blocking scores Low Schizotypes = 2.43 (std dev 15.66); High Schizotypes = -5.54 (11.00); t(52)=-2.15; p=0.04.

See Figures 3.6 and 3.7

Order and Version Effects

Table 3.5 shows the breakdown of blocking scores across order and Jones Version groups. Version was not found to have a significant effect on the scores. However, Order group 2 (Jones Task first) was found to have lower blocking scores on both tasks and this was a significant difference in the Oades Task scores (see Table). As the groups do not differ on any other measures of IQ, handedness or Task learning it is unclear why this difference has occurred. However, the Oades Task results discussed above were upheld in subsequent partial correlations controlling for order. See Appendix 15.

Table 3.5: Break down of blocking scores in each Task by participant group

	Mean Blocking score Oades Task (std dev)	**Difference Test**	**Mean Blocking score Jones Task (std dev)**	**Difference Test**
Order Group 1	1.48 (1.37)	------------	1.36 (13.93)	------------
Order Group 2	0.53 (1.64)	t(54) = 2.31*	-3.19 (13.77)	t(54) = 1.22
Version Group 1	0.65 (1.05)	------------	-5.33 (11.59)	------------
Version Group 2	0.22 (1.20)	------------	-1.25 (13.39)	------------
Version Group 3	1.54 (2.10)	------------	2.12 (17.17)	------------
Version Group 4	1.11 (1.38)	F(3,55) = 1.902	-1.47 (12.16)	F(3,55) = 0.666

Key: Order Groups refer to which Blocking Task was performed at start and end of session; Version Group refers to version of Jones Task completed

Overshadowing scores

Positive overshadowing was not found to be significant on either task as indicated by analysis of the mean scores in one-sample t-tests: t(55) = 0.94, p=0.35 Oades Task; t(55) = 0.66, p=0.51 Jones B Task. Overshadowing scores for individual participants did not correlate across the two tasks (r(p)=0.21; N=56; p=0.13). However, the

Overshadowing scores from the tasks did correlate significantly with their relative blocking scores (Oades, r(p)=-0.50; N=56; p<0.001, Jones B r(p)=0.44; N=56; p=0.001). In Oades Task, from the graph (Figure 3.8), it is clear this result is due to an outlying overshadowing score, but in Jones B Task (Figure3.9) this relationship is visibly consistent throughout the sample.

Figure 3.6: Difference in mean blocking scores on Oades Task between low and high schizotypy groups (from median split on STA scores)

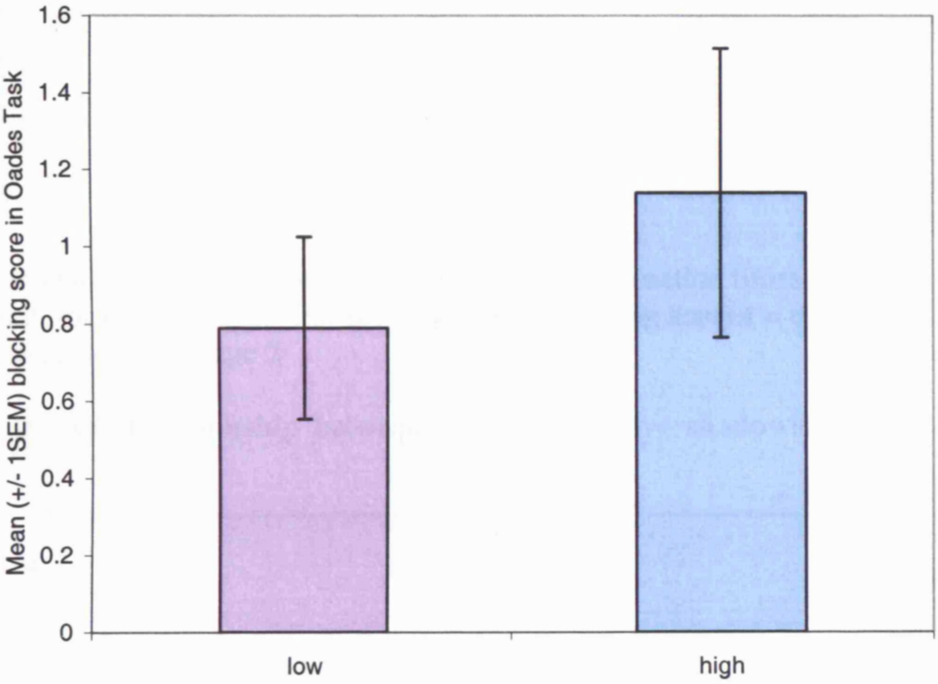
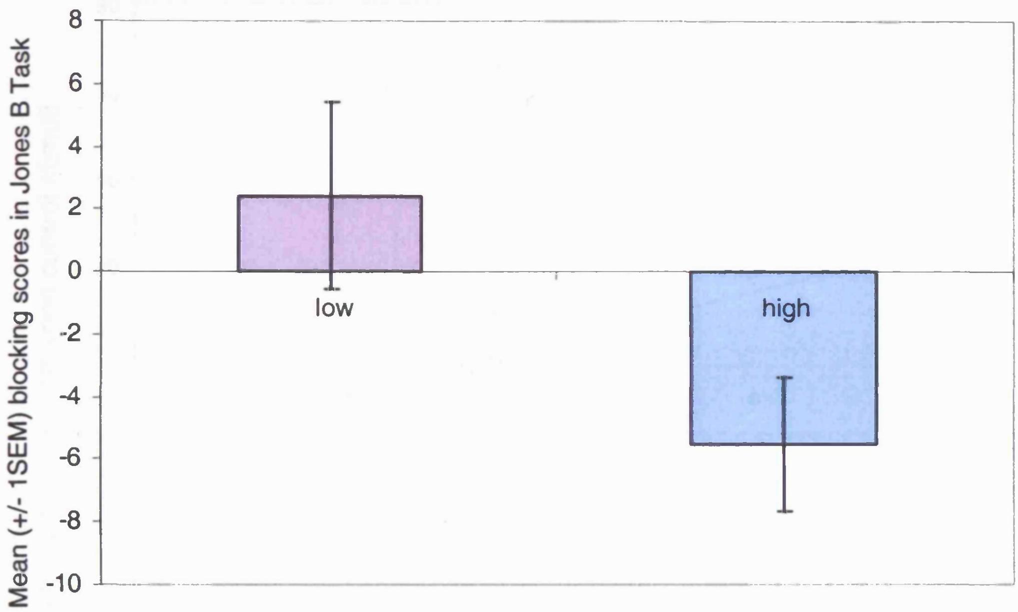
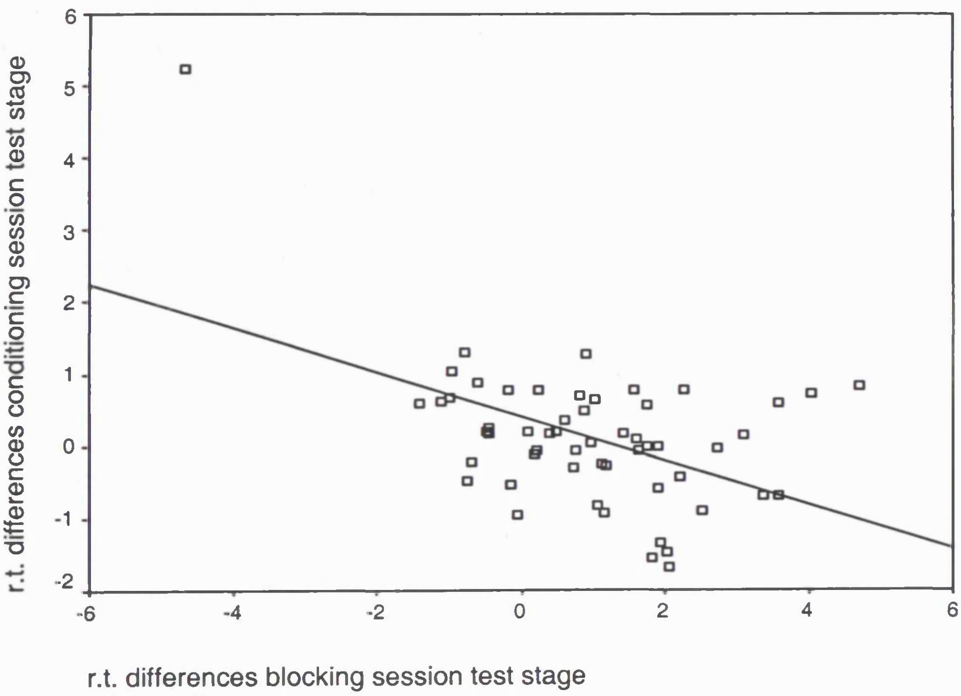


Figure 3.7: Difference in mean blocking scores on Jones B Task between low and high schizotypy groups (from median split on STA scores)



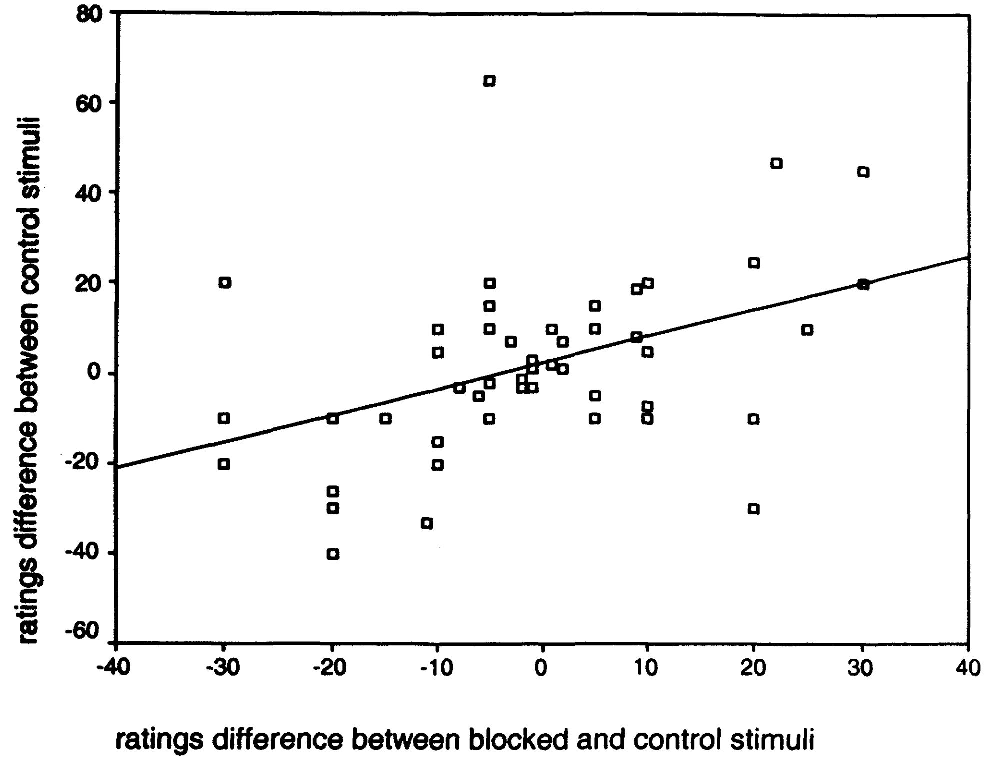
Key: Oades blocking scores = mean difference in reaction times to target colour stimuli, blocking session test stage; **Jones B blocking scores** = differences in ratings for target stimuli, stage 2

Figure 3.8: Relationship between blocking and overshadowing scores in Oades Task



Key: Blocking (X axis) = mean difference in reaction times to target stimuli, blocking session test stage; **Overshadowing** (Y axis) = mean reaction times to stimuli in conditioning session test stage

Figure 3.9: Relationship between blocking and overshadowing scores in Jones B Task



Key: Blocking (X axis) = difference in ratings for blocked and novel control stimuli in second rating stage; **Overshadowing** (Y axis) = difference between ratings for two novel control stimuli in second rating stage

3.1.4 Discussion

Experiment 2 aimed to investigate relationships between measures of blocking from different tasks and other measures of neuropsychological function and schizotypal traits previously found to interact with Kamin blocking. Importantly, our findings indicate no overall correlation between blocking scores derived from two within-subject tasks. This was also indicated in the analysis of those participants who showed positive blocking scores on both tasks. Measures of learning from the two tasks did however demonstrate a positive relationship, suggesting that these findings are likely to be specific to blocking effects and not a function of general differences in ability to understand or perform the tasks correctly. This is further supported by the indication that both learning measures have a positive relationship with verbal fluency (although this was not significant in the Jones B Task under the more stringent alpha levels).

Overall, the demonstration that blocking measures derived from different task formats are not associated could account for some of the discrepancies found in the literature (e.g. Jones et al., 1994 versus Oades, Roepcke, Schepker, 1996; Jones et al., 1992b versus. Serra et al., 2001), and is particularly relevant to clinical studies that use these tasks. The findings raise the possibility that the deficits previously reported in patients with schizophrenia using the Oades Task and Jones B Task may reflect independent phenomena.

The findings from the multiple regression analyses also suggest a dissociation between the tasks. That is, there was tentative evidence to suggest that O-Life measure of STA were predictive of blocking in Oades Task but not in Jones B Task. However, this finding would differ from the literature: in the present sample, higher STA scores were predictive of higher blocking scores in the Oades Task while previous evidence has indicated the opposite (Moran et al., 2003; Jones et al., 1992a). In addition, the median split analysis contradicted this by indicating a significant difference between high and low schizotypal groups in the Jones Task scores but not the Oades Task. Conclusions drawn about blocking scores in the Jones Task are however, tentative given the overall lack of a significant blocking effect. Nonetheless, these findings illustrate that the links between schizotypy and blocking deficits are inconsistent and may depend on contextual factors such as population used. Indeed, a previous study by Serra et al. (2001) has reported problems replicating this link.

A further discrepancy is found in the neuropsychological measures: verbal fluency and Stroop interference were not found to be predictive of blocking in the Oades Task as has previously been reported (Oades et al., 2000). In contrast, these variables were predictive for the Jones B Task (negative relationship with Stroop, positive for verbal fluency).

One of the main differences of the present sample compared to previous studies is in the use of a predominantly student or university-based population. Previous reports of Kamin blocking correlates have been from healthy control groups for patient samples: these were recruited to match patient samples on IQ and age variables and will therefore have most likely been of a higher age and lower IQ range than the sample used here. For example, in Oades et al. (2001) the mean age of the 62 control participants is 32.5 yrs (std dev 10.9 yrs) with a mean number of years in education of 13.8 suggesting that most participants did not reach University level. Similarly, in Moran et al. (2003) the 30 control participants had a mean age of 28.50 years (std dev 9.84). It is possible that differences in these sample parameters has led to the differences in our observations.

A positive association was found between overshadowing scores and blocking scores in the Jones B Task. One possible explanation of this is the method by which the blocking scores are derived. That is, the second name in the neutral pair (i.e. the pair in which both names only appear in the second learning phase) is used as a baseline rating in both overshadowing and blocking calculations. Therefore, people scoring this name higher than the others will indeed show both positive blocking and overshadowing scores (likewise for those scoring it lower) while those scoring this name in the middle are more likely to show small differences which will not significantly affect the correlation analysis.

The mode of calculating blocking scores could also be said to be vulnerable to false positives in the Oades Task. That is, positive blocking scores would be obtained if associative strength were higher to the first colour in the blocking session regardless of any active weakening of association to the third colour. However, Oades, Roepcke, Schepker (1996) argue that the inclusion of the control session provides a measure of the basic difference between colours learnt in a three-colour panel and any subsequent blocking is calculated above this baseline measure. While there is still the potential for false positives through a salience difference between the first and third colours of the blocking session only, this is unlikely to account for all of the numerous blocking effects published with this task.

Finally, it is apparent that Jones B Task did not produce robust blocking effects as has been reported previously (Jones et al., 1997). In their original report of this task, Jones et al mention two individual samples of (34 and 30 participants) in which significant blocking effects were observed. This was further replicated in a sample of 12 participants used as a control group within an amphetamine investigation. The failure to replicate these findings in the present study could be due to the predominantly student sample used: in all three samples reported by Jones et al. (1997) participants were drawn from a general population with a predominantly non-university background (Jones et al., 1997 and personal communication). However, findings from the control group of an ongoing clinical study taken from a non-student population

(Moran – unpublished) have also pointed to weak blocking effects in Jones B Task. In general, this finding questions the replicability of blocking measures from this task.

Moreover, it precludes definitive conclusions being drawn about the relationship between blocking phenomena across tasks. Therefore, a further comparison study was undertaken using a more robust contingency judgement task taken from the associative learning literature.

CHAPTER FOUR

4.1 Experiment 3: Oades and Chapman Task Comparison

4.1.1 Introduction

In Experiment 2, the relationship between Kamin blocking scores measured using either the reaction time task (Oades Task) or the contingency judgment task (Jones B Task) was evaluated. Although both these tasks have previously demonstrated a decrease in performance in schizophrenia patients, no correlation was found between Kamin blocking scores from these tasks. As discussed, the observation of no relationship between blocking scores from two published measures could explain some of the discrepancies in the applied literature and would call into question the utility of Kamin blocking in schizophrenia research.

However, the contingency judgement task used (Jones B Task) did not produce clear blocking effects as previously reported in the literature. Therefore, a second study was carried out to investigate the association between the Oades Task and a second contingency learning task that has been more widely reported in the literature. The present study uses a version of the "stocks" task originally reported by Chapman & Robbins (1990) (denoted Chapman Task here). Although this task has not been employed in a clinical setting, it has been widely utilised in investigations of associative learning processes in healthy humans has demonstrated significant Kamin blocking effects with different authors (Chapman & Robbins 1990; Williams et al., 1994).

In a series of experiments the stocks task format was used to investigate the specific factors which mediate observed blocking effects in human contingency judgement tasks (Williams et al., 1994). It was found that blocking in contingency judgement requires specific cues that highlight an elemental differentiation of the stimuli. This has been incorporated into the present study: the potential for cues to be either positive, negative or neutral predictors of the outcome was reinforced both by the instructions themselves and by the scale used (-100 to +100); the need to judge independently the elements within the compound was further highlighted in the instructions given to participants at the judgment stage.

The present experiment aims to replicate Experiment 2 using a different contingency judgement task (the Chapman Task). The tasks will again be compared to evaluate the relationship between the blocking scores themselves, and regression analyses will be used to evaluate the role of neuropsychological and schizotypal measures in the blocking scores. Note that, the neuropsychological measures of logical and visual memory were removed from this study as, in Experiment 2, these measures had not indicated any potential association with the blocking measures and were prone to ceiling effects in the healthy sample being investigated. The Indication from Experiments 1 and 2 is that there will be no relationship between measures of blocking across the two task formats.

To begin, the results from a small pilot study describing and testing blocking effects from the new task are reported followed by the method and results from the main study.

4.1.2 Pilot study of Chapman Task

As our version of the stocks task was derived from descriptions given in the literature and following the problems found with the Jones contingency task, an initial pilot study was carried out to confirm the stocks task as a robust measure of blocking effects.

Method

Participants:

30 participants (27 Females; 3 Males) were recruited from the local student population. Eight participants did not meet the learning criterion of the task and were removed from the analysis, and the data from 1 participant was lost due to a technical error. This left 21 data sets for the analysis. Participants were paid £3 for completion of the task. Participants were randomly allocated to complete one of the five versions of the task.

Materials & Procedure:

1) Chapman Task Description

A computer based contingency learning task written in E-Prime software and based on details described in Chapman & Robbins (1990). Participants are told to take the role of a "stockbroker" who must predict the movement of the stock market at the end of each day based on the movement of five fictional company's stocks. The company names used were those of characters from the "Simpson's Cartoon": Bart, Homer, Marge, Maggie, and Lisa. These names were previously used in the experiments by Williams et al. (1994).

The game comprises two types of trial: learning and judgment. In the *learning stages* participants work through a series of trials in which they are presented with a list of the company names and information stating whether the individual share values had gone up or stayed the same on that day. They were asked to predict (yes/no) whether the stock market would also have gone up on that particular day and to indicate how confident they were of their answer (rating 1-5). They were then given feedback about the actual outcome of each day. This information stayed on the screen until the participant pressed a key to continue. The cumulative percentage of correct answers was always displayed in the top right hand corner of the screen as an incentive. The participants would thus learn that a rise in the shares of one of the companies is always associated with stock market rises while rises in the shares of other companies is not predictive of this outcome.

In the *judgement stages*, participants are asked to provide ratings for each company on how predictive it is of the whole market rise. Ratings can go from –100 to +100. Participants were reminded at this stage that a company could be a positive, negative or neutral predictor of the outcome, they are also told that they may not give the same rating to two companies which aims to ensure a differentiation between the ratings. There are five stages to the task: stage one is the elemental learning trials; stage two the first judgement trial on which the learning criterion is based; stage three is the paired learning trials; stage four a second judgement trial at which time participants are further reminded that the stock market is changed by single company activity and so they should think about the independent value of each company using all information gathered so far; and stage five a short set of learning trials in which all company are negative predictors and the associations previously learnt are extinguished. See Table 3.2 (page 109) for task layout.

During the learning stages there are four sets of 12 trials to reinforce the associations. For example, in stage one, there may be 12 trials of 'Bart' + a market rise; 12 of 'Lisa' with no market rise; 12 of 'Maggie' with no market rise; and 12 trials in which no company stocks went up and there was no market rise (background trials). This gave a total of 48 trials in the learning stages. Note that all company names are present on the screen in every trial. In stage three, the two companies which had not been active during stage one (i.e. Homer and Marge) are now paired with either the positive or negative predictor company from stage one. This meant that there were 12 trials of a blocking pair (neutral paired with the positive predictor), 12 of a super-conditioning pair (neutral paired with the negative predictor), 12 of the single, consistent negative predictor (negative predictor throughout), and 12 of the background trials. The roles played by the company names are counterbalanced across five versions of the task.

See Appendices 9a and 9b for example of Screen Layout and 9c for full instructions.

2) Data Analysis for Chapman Task

Learning on this task is confirmed by a correct direction of ratings at stage two according to associations learnt in stage one. That is, the company which was always associated with a market rise is rated highest and the company which never predicted a stock market rise is rated lowest with all other companies being rated in the middle range. Participants not meeting this requirement were removed from the data analysis.

Although the original authors did not evaluate learning strength, it was of interest to measure learning on a continuum in order to compare with learning scores from Oades Task. A learning scale can be identified within the task: the original authors suggest that participants showing greater differences between ratings at stage two are demonstrating higher strength of blocking therefore by this logic, a higher strength of learning can similarly be calculated from the difference between ratings at stage one. In this way the learning score for participants in the present study was calculated by subtracting the mean rating for the two neutral predictors after Stage one from the rating for the positive predictor.

Blocking is measured by the difference in ratings at stage four between the blocked stimulus (paired with the positive predictor from stage one) and the super-conditioned stimulus (paired with the negative predictor from stage one). This measure of blocking follows that used by both Chapman & Robbins (1990) and Williams et al. (1994), but differs from the type of rating comparison in Jones B in which the blocked stimulus is compared to an entirely novel control pair.

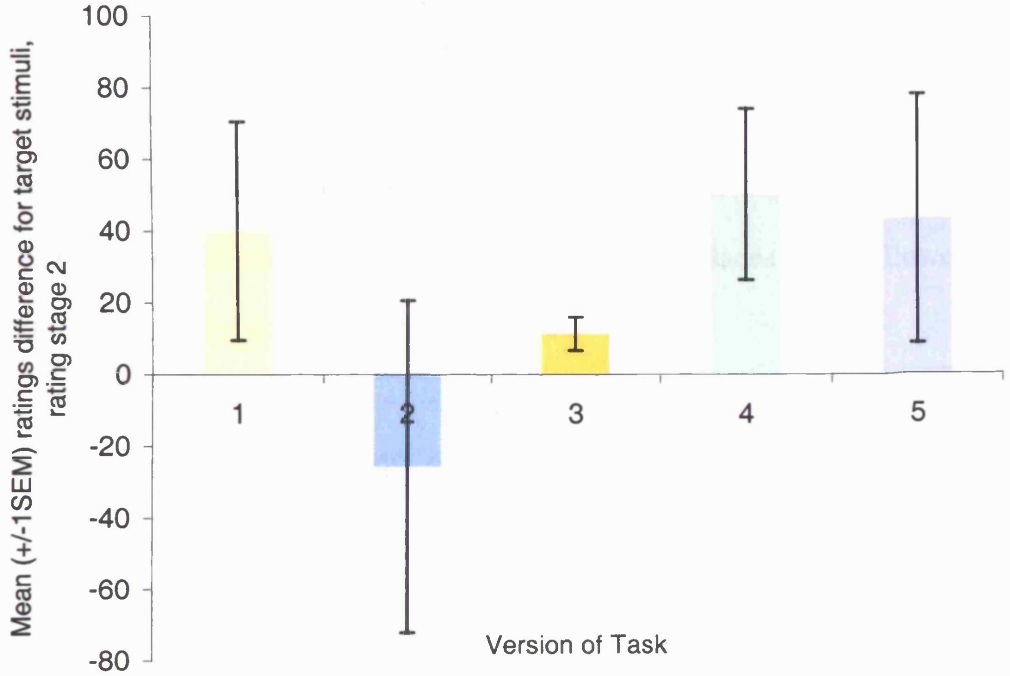
It could be argued that this measure does not reflect the specific activation of blocking effects as the blocked stimulus is not compared to a wholly neutral stimulus. Although Chapman & Robbins denote this comparison as blocking, Williams et al. (1994) suggest it may be better referred to as "selective processing" as it demonstrates the overall activation of selective judgements both in a super-conditioned and blocked direction. However, both authors have employed this measure for blocking evaluations and described significant blocking effects resulting from it. Table 1.3b (page 45) also illustrates the use of this comparison in other contingency judgement tasks. Therefore, we have not modified this original measure in the present study. However, as discussed in Experiment two, the core analyses here assess individual blocking scores rather than overall mean stimuli ratings. The arguments for this approach are described in Section 3.1.2.

Overshadowing and Super-conditioning – due to the absence of an entirely novel control pair in stage three, it is not possible to calculate a measure of overshadowing or super-conditioning in this task. Overshadowing as measured in Oades and Jones B Tasks refers to a natural bias for one stimulus over another when presented in a neutral pair (where neither stimulus has been pre-exposed). Similarly, super-conditioning in Jones B Task refers to the comparison of the stimulus paired with the negative predictor from stage one with a neutral control.

Results & Discussion:

The mean blocking score was 20.52 (76.15 std dev) with the frequency of positive blocking scores at 76%. However, this was not significantly greater than zero in a one-sample t-test due to the large variability of the scores ($t(20)=1.24$; $p=0.23$). The version with the lowest mean blocking was version 2 – this version calculated blocking as a comparison between the "Marge" and "Maggie" companies (see Figure 4.1). When this version was removed from the analysis, the overall mean Kamin blocking score did reach a value significantly greater than zero (mean 39.07, std dev 48.74; $t(14)=3.10$, $p=0.008$). It was decided from this that the differentiation between these two names may not have been as salient as between other names and consequently participants were less able to remember which part each had played in the blocking paradigm. Therefore, the name "Krusty" was substituted for "Maggie" in the main experiment Also, instructions were modified to reinforce the elemental strategy during ratings following the paired learning stage (see findings from Williams et al., 1994). Finally, the number of stimulus trials in the learning stages was reduced from 12 to 9 (48 to 36 in total) as participants were found to be achieving a high percentage of correct predictions of outcome from early into the stage and reported boredom and decreased motivation by the higher number of trials.

Figure 4.1 Mean blocking scores for participants in each Chapman Task version group (pilot study)



4.1.3 Main study

Method

Participants:

44 participants were recruited through advertisements around the University. Participants were each paid £7.50 for taking part. As in Experiment two, only those participants who met the learning criteria on both tasks were used in the analysis, this left, 41 participants (21 Males; 20 Females). The mean age for the sample was 22.69 yrs (std dev 0.68 yrs); the mean predicted IQ, taken from the NART, was 112.83 (std dev 0.78); and the mean handedness score, from the Annett Handedness Questionnaire was 2.39 (std dev 0.23).

Participants were assigned to either of the two order groups:
Order Group 1 – 21 participants (10M; 11F) completed Oades Task followed by the Stroop, O-life, FAS, and finally Chapman Task.
Order Group 2 – 20 participants (11M; 9F) completed Chapman Task, followed by the Stroop, O-life, FAS, and finally Oades Task.
The order groups did not differ significantly in mean age, predicted IQ, or handedness (see Table 4.1).

Participants were randomly assigned to one of the five Chapman versions. Mean age, predicted IQ and handedness did not differ across these version groups. See Table 4.1 for full demographics breakdown.

Table 4.1: Break down of Age, IQ and Handedness scores for each participant group

	Mean Age yrs (std dev)	Difference test value	Mean IQ (std dev)	Difference test value	Mean Handedness (std dev)	t-test value
Order Group 1	23.82 (5.64)	----------	112.19 (5.21)	----------	2.33 (1.39)	---------
Order Group 2	21.50 (1.81)	t(39)=1.79	113.50 (4.74)	t(39)=-0.84	2.45 (1.54)	t(39)= -0.26
Version Group 1 (N= 9)	25.57 (8.10)	----------	112.78 (3.49)	---------	1.67 (1.12)	---------
Version Group 2 (N= 9)	21.28 (1.42)	---------	115.44 (6.75)	---------	2.78 (1.30)	---------
Version Group 3 (N= 8)	22.80 (3.03)	---------	111.38 (4.60)	---------	2.88 (1.81)	---------
Version Group 4 (N= 7)	22.36 (1.40)	---------	112.14 (5.21)	--------	2.00 (1.00)	--------
Version Group 5 (N= 8)	21.23 (1.95)	F(4,40)= 1.54	112.83 (4.97)	F(4,40)= 0.87	2.63 (1.77)	F(4,40)= 1.15
Totals	22.69 (0.68)	--------	112.83 (0.78)	--------	2.39 (0.23)	--------

Key: Order Groups refer to which blocking task was performed at start and end of session; Version Group refers to version of Chapman Task completed.

Materials & Procedure:

See Table 3.2 (page 109) for blocking set-up in each Task.

1) **Oades Task:** As described in Experiment two.

2) **Chapman Task:** As described above

3) All other measures including the Neuropsychological tests, O-life scales, handedness questionnaire and the NART are as described in previous Experiments. However, it was felt that the test session had been quite long (approximately 1.5 hours) which may have affected the motivation to perform on the tasks towards the end of the session. Therefore, in the present study, the Weschler memory scales

(visual and logical) were removed from the test session as they had not provided any informative comparisons to either task in Experiment 2

Data Analysis:

1) Kamin blocking calculations

a. Oades Task: *Learning and Blocking* calculations were as described in Experiment two. As discussed in Experiment two, blocking effects were measured using both the overall test stage reaction times and from individual trial pairs throughout this stage.

b. Chapman Task: *Learning and Blocking* calculations are as described above

2) Statistical Analysis:

Analyses were performed following those described in Experiment two. Multiple regression analyses have been repeated here in line with statistical methods from Experiment two, however, it is acknowledged that the power of this form of analysis is weakened due to the smaller sample recruited in this study given the number of predictor variables involved. (see Pallant, 2003, Chapter 13 for discussion).

4.1.4 Results:

Table 4.2 describes the means, variance and range of scores observed for the remaining neuropsychological and O-life measures in this study. In addition, the corresponding values from Experiment 2 are included (values in italics) for comparison across samples.

Table 4.2: Description of observed scores from the neuropsychological and O-Life scales

	Mean (std dev)	Minimum score	Maximum score
UNEX	9.93 (7.18) *9.24 (6.53)*	0 *0*	28 *28*
COGDIS	12.22 (5.53) *13.22 (5.93)*	1 *0*	22 *24*
INTAN	5.78 (4.44) *4.26 (3.71)*	0 *0*	17 *15*
IMPNON	11.00 (4.21) *11.11 (3.84)*	1 *3*	19 *21*
STA	15.98 (7.84) *15.24 (7.02)*	3 *0*	32 *35*
Stroop	64.24 (8.83) *65.32 (13.00)*	48 *44*	89 *94*
Verbal fluency	42.49 (10.68) *39.95 (10.92)*	20 *18*	77 *67*

The following section is divided into reports for (1) the learning measures and (2) the blocking measures from the Tasks. For each measure, the distribution of scores is described along with the mean and variance and the significance of these effects. Following these descriptions, statistical analysis of the data is reported as discussed above.

Learning Scores:

From the Histogram, learning scores on the Oades Task seem to follow an uneven distribution (see Figure 4.2), however, statistical analysis does show this to follow a normal curve such that parametric analysis could be performed (Kolmogorov-Smirnov = 0.87, p>0.05). In the Oades Task the number of trials to learn were found to have a significant positive correlation with NART IQ: r(p)= 0.36; N=41; p=0.02 (see Figure 4.3). However, this did not remain once the outlying NART score was removed (r(p)=-0.18; N=40; p=0.10). Oades Task Learning scores did not show any significant relationship to verbal fluency as seen in Experiment two (r(p)= 0.22; N-41; p=0.17) or to Stroop Interference (r(p)= 0.21; N=41; p=0.19).

The Chapman Task learning scores showed very little variation (std dev 45.6) with 37% of participants scoring the maximum rating difference (+199.5) (see Figure 4.4). As discussed in Experiment two, this indicates that little information about learning differences between participants can be ascertained and thus precludes any analysis of associations with other variables.

Figure 4.2: Distribution of learning scores in Oades Task
(Bar labels represent bin range)

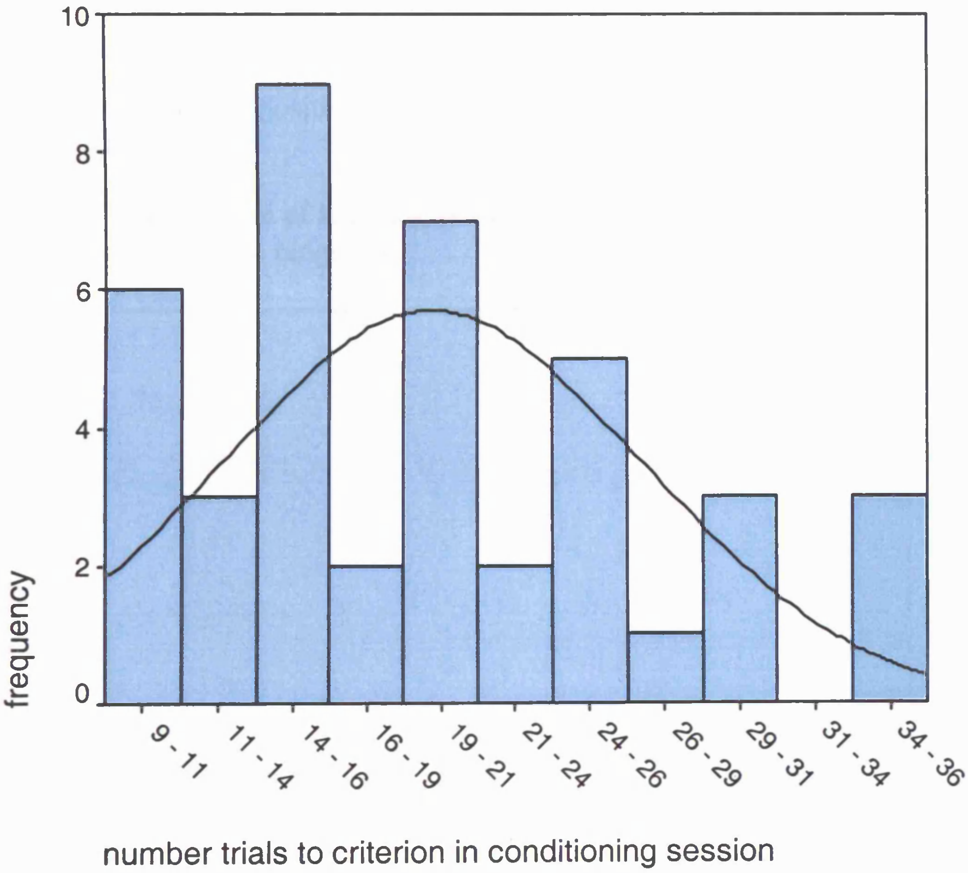
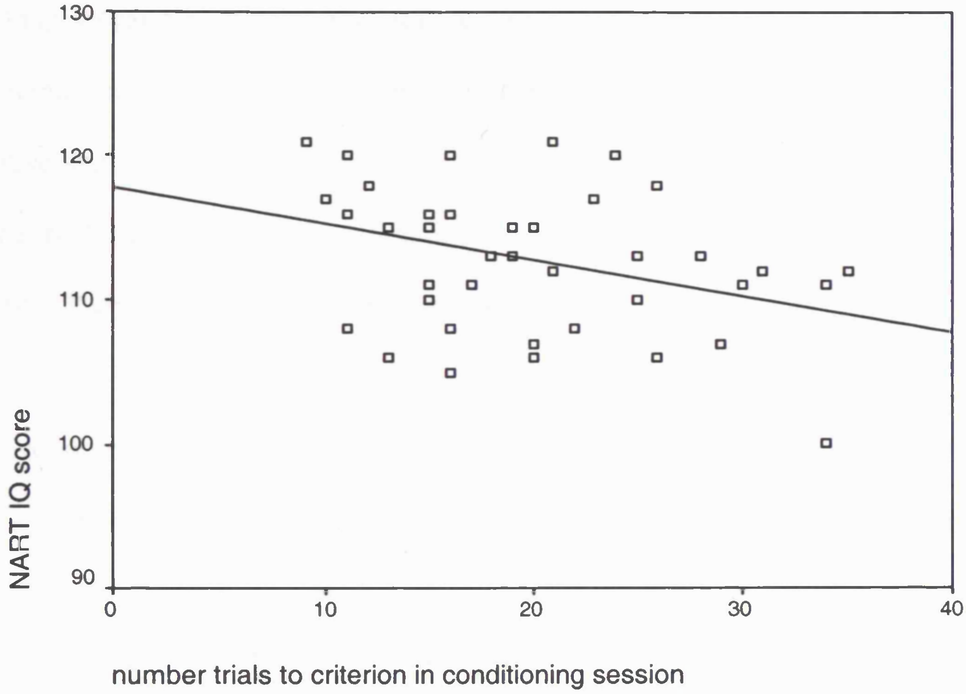
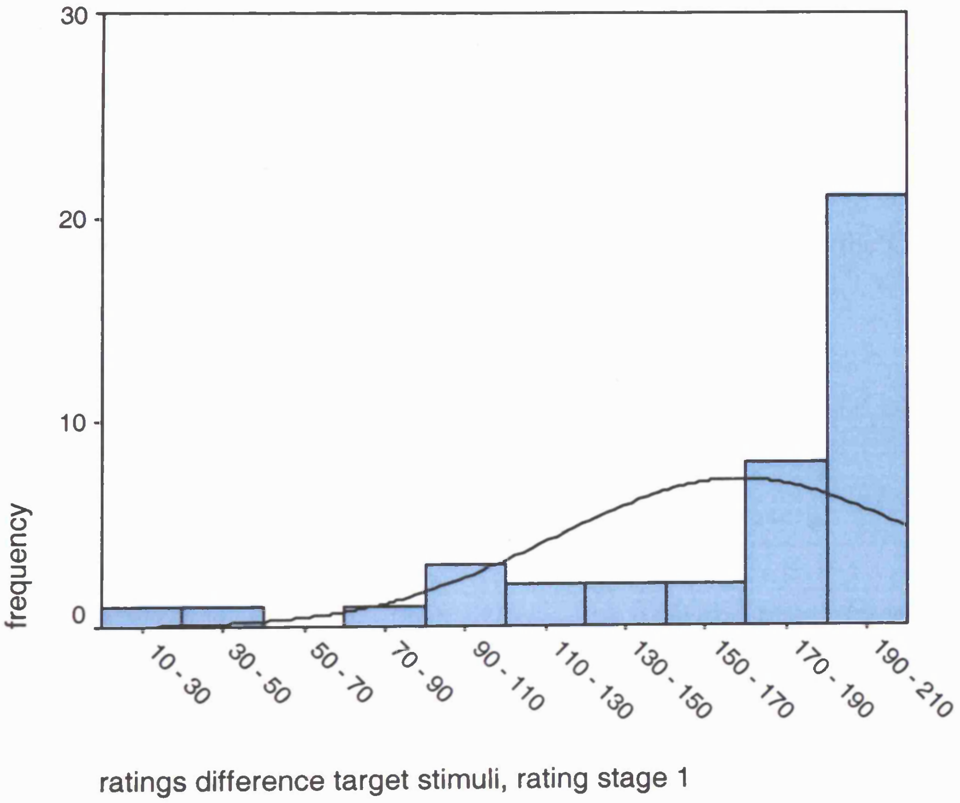


Figure 4.3: Relationship between learning scores in Oades Task and NART IQ



Note: this illustrates a positive relationship as lower learning scores indicate better learning on the task.

Figure 4.4: Distribution of learning scores in Chapman Task
(Bar labels represent bin range)



Blocking Scores:

Blocking scores from Oades Task follow a normal distribution from inspection of the Histogram (see Figure 4.5). Although the Chapman Task blocking scores showed a negative skew in the Histogram (see Figure 4.6), the Kolmogorov-Smirnov test for normality did not find this deviation to be significant (Kolmogorov-Smirnov =0.128; $P>0.05$). Therefore, parametric analyses were performed on this data.

Positive blocking scores were observed in 73% of participants on the Oades Task and 85% of participants in the Chapman Task. The mean overall blocking scores were 1.62 (std dev 2.39) Oades Task and 50.51 (std dev 62.02) Chapman Task. These values were both found to be significantly greater than zero in One sample t-tests (Oades $t(40)=4.33$, $p<0.001$; Chapman $t(40)=5.22$, $p<0.001$). The measures of Kamin blocking scores did not differ across order groups or with Chapman version (see Table 4.3).

The overall Kamin blocking scores from the two tasks were not found to correlate with each other ($r = -0.119$, $N=41$, $p=0.46$) (see Figure 4.7). However, Chapman Task blocking scores were found to correlate negatively with trials 7-8 of the Oades Task ($r(p)=-0.368$; $N=41$; $p=0.02$).

Table 4.3: Break down of blocking scores in each Task by participant group

	Mean Blocking score Oades Task (std dev)	**Difference Test**	**Mean Blocking score Chapman Task (std dev)**	**Difference Test**
Order Group 1	1.63 (2.45)	------------	44.10 (60.50)	------------
Order Group 2	1.61 (2.39)	t(39) = 0.03	64.44 (14.41)	t(39) = -0.67

Version Group 1	2.51 (2.25)	-----------	32.78 (62.56)	-------------
Version Group 2	1.06 (3.14)	-----------	88.33 (86.22)	--------------
Version Group 3	1.91 (2.45)	-----------	48.25 (53.46)	---------------
Version Group 4	2.16 (2.42)	-----------	53.71 (33.98)	-------------
Version Group 5	0.48 (1.13)	F(4,40) = 1.01)	27.38 (47.91)	F(4,40) = 1.35

Key: Order Groups refer to which Blocking Task was performed at start and end of session; Version Group refers to version of Chapman Task completed.

Figure 4.5: Distribution of blocking scores in Oades Task
(Bar labels represent bin range)

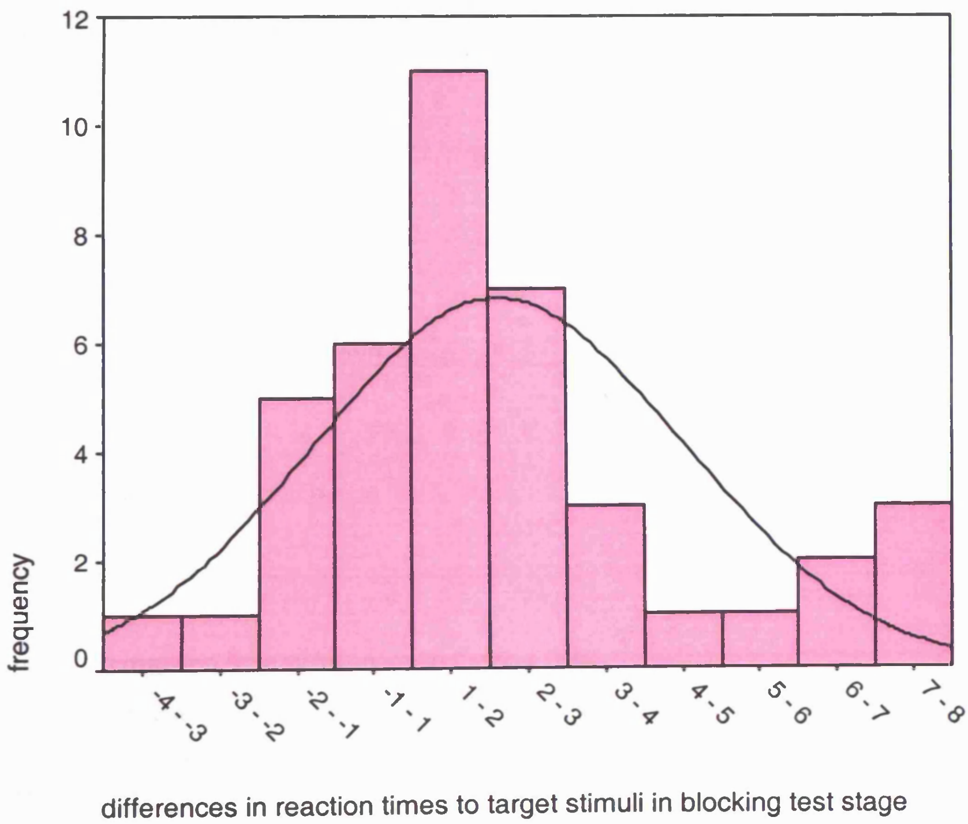


Figure 4.6: Distribution of blocking scores in Chapman Task
(Bar labels represent bin range)

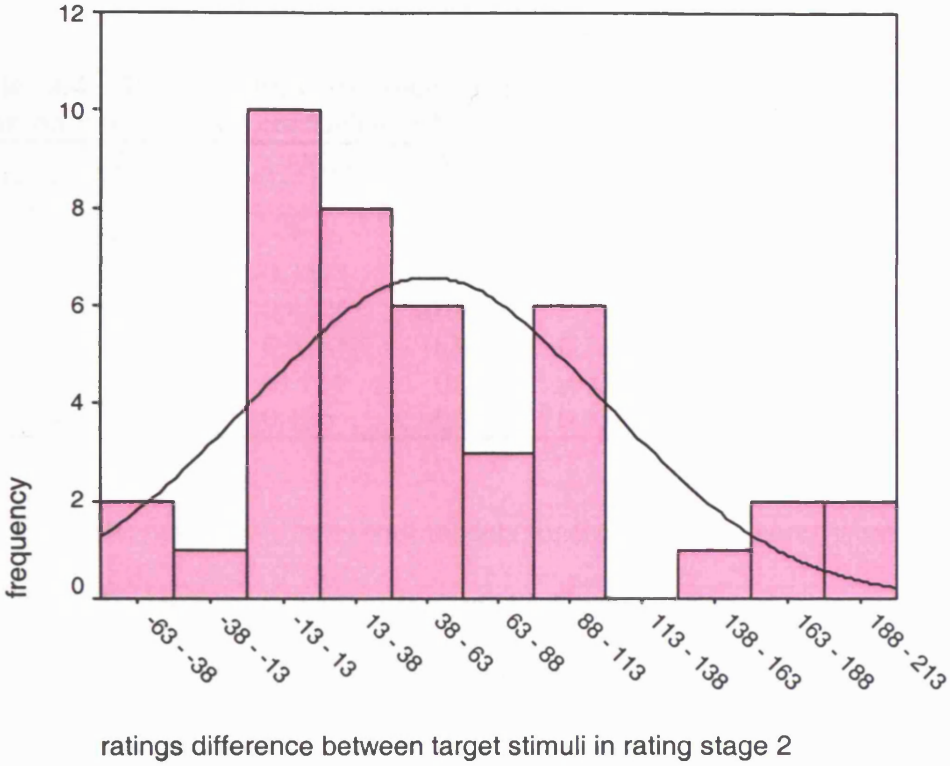
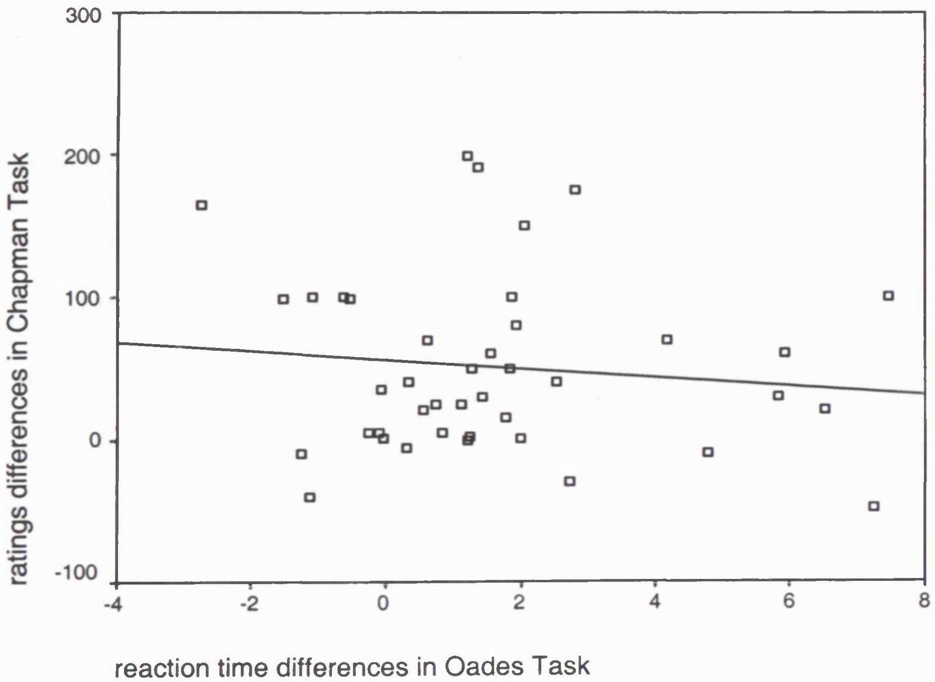


Figure 4.7: Relationship between blocking scores in Oades and Chapman Tasks



Key: **Oades Task blocking** (X axis) = differences in mean reaction times to stimuli in blocking test stage; **Chapman Task blocking (Y axis)** = differences in ratings of blocked and super-conditioned stimuli in rating stage 2

Multiple Regressions

Table 4.4 shows correlations between the O-Life and neuropsychological measures.

Table 4.4: Relationships between neuropsychological and O-life measures (Pearson's correlation coefficients; N=56)

	UNEX	*COGDIS*	*INTAN*	*IMPNON*	*STA*	*Stroop*
UNEX						
COGDIS	0.388*					
INTAN	0.276	0.357*				
IMPNON	0.264	0.489**	0.201			
STA	0.888**	0.578**	0.377*	0.387*		
Stroop	-0.138	-0.114	-0.281	-0.072	-0.140	
Verbal fluency	-0.070	0.136	-0.129	0.339*	-0.039	0.023

In this sample, neither of the overall models for the blocking scores were found to be significant (Oades Task F(5,40)=1.01, p=0.42; Chapman Task F(5,40)=1.12, p=0.37). In addition, none of the individual predictors were found to be significant. See Appendix 16a and 16b for full reports. This result could be confounded by the relatively small sample size in this study however, further analyses using the single predictors found to relate to each task in Experiment 2 also failed to reveal any significant relationships. This indicates that the present results are real and cannot be accounted for by sample size.

Comparison of High and Low Schizotypes

Participants were recoded as either High (N= 19) or Low (N= 22) Schizotypes relative to the median STA score of 16 (scores of 16 were treated as low). Independent T-tests revealed no significant differences between the groups on mean blocking scores from either task.

Oades Task: Mean blocking scores Low Schizotypes 2.18 (std dev 0.97); High Schizotypes 0.97 (2.27); t(39) = 1.65, p=0.11.

Chapman Task: Mean blocking scores Low Schizotypes 47.00 (std dev 62.78); High Schizotypes 54.58 (std dev 62.59); t(39) = -0.39, p=0.70.

(see Figures 4.8 & 4.9)

However, the analysis did indicate a significant difference between these groups on early trial blocking scores from the Oades Task (trials1-2 t(39)=2.168; p=0.04). The Low schizotypal group had a mean blocking score of 6.05 (std dev 9.17) and the high group a mean of 0.76 (std dev 5.80).

Figure 4.8: Difference in mean blocking scores on Oades Task between low and high schizotypy groups (from median split on STA scores)

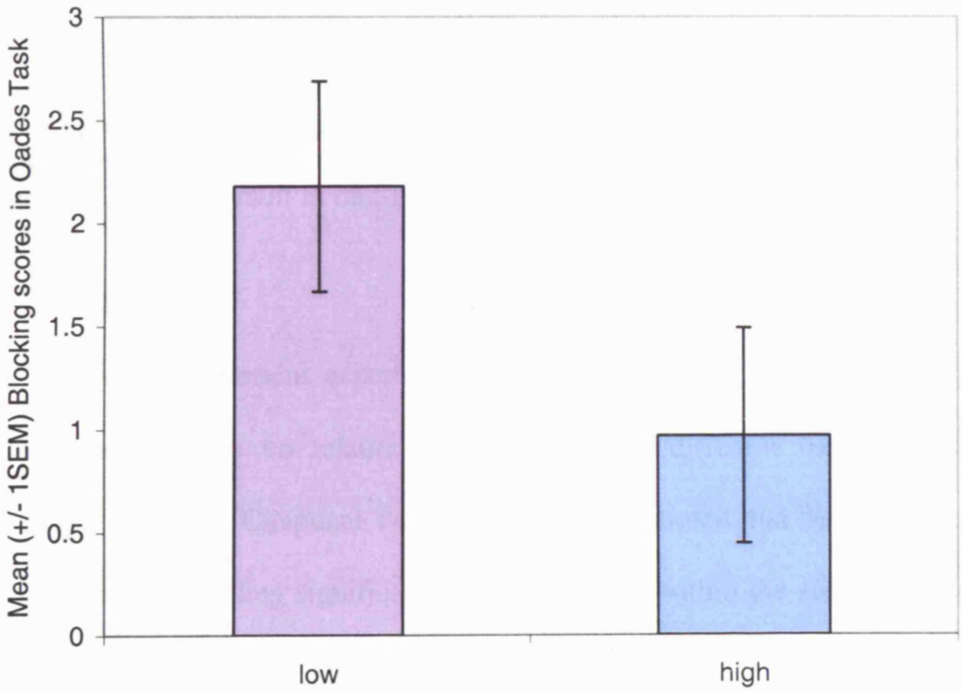
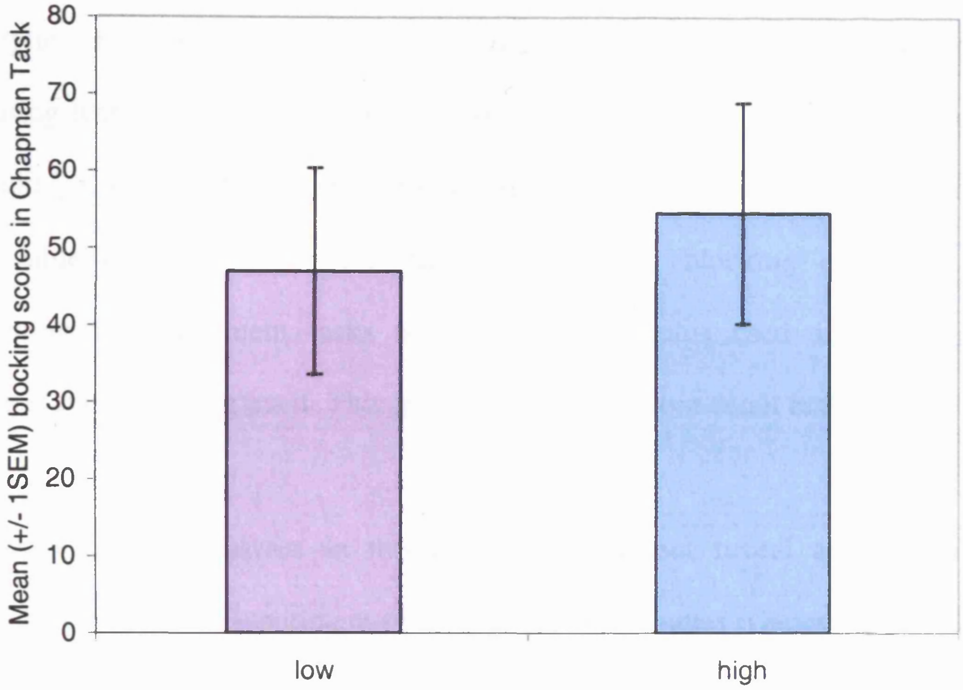


Figure 4.9: Difference in mean blocking scores on Chapman Task between low and high schizotypy groups (from median split on STA scores)



Key: **Oades Task blocking** = differences in mean reaction times to stimuli in blocking test stage; **Chapman Task blocking** = differences in ratings of blocked and super-conditioned stimuli in rating stage 2

4.1.5 Discussion

The results of the present experiment serve to confirm findings from the previous studies that there is no relationship between two different measures of Kamin blocking. The use of Chapman Task here has demonstrated that despite the two tasks independently producing significant blocking effects within the sample, these effects are not due to equitable or associated underlying processes.

In contrast to the Jones B contingency judgement task in Experiment two, the Chapman Task did demonstrate significant blocking effects replicating findings from the literature (Chapman & Robbins 1990; Williams et al., 1994). This supports earlier suggestions that blocking effects in contingency judgement tasks are dependent on the inclusion of cues for an elemental blocking strategy (Williams et al., 1994). For example in the present study the Chapman Task, benefits from a rating scale which implies that cues may be positive or negative predictors; the presence of all cues during learning trials in which they do not necessarily predict the outcome; and the inclusion of specific instructions to differentiate between the stimuli. One other possible explanation for the difference between blocking effects in the two contingency judgement tasks is the control stimulus used and the method for calculating blocking itself. This issue is covered in more detail in Section 4.2 below.

The regression analyses in this experiment did not reveal any of the reported relationships from Experiment two or from earlier studies (Oades et al., 2000; Moran et al., 2003). Although this could have been confounded by the smaller sample size in this study compared to the number of variables in the model, further analyses of the relationships between the variables did not suggest this to be the case. However, the relationship between STA and blocking scores in the Oades Task was, in fact, replicated as a difference between high and low STA groups was found in the early stages of the blocking test. Indeed, it is this early stage of the test phase which has demonstrated the strongest blocking differences in the past (Moran et al., 2003). This still contrasts with the findings from Experiment 2 in which the STA-Oades Task relationship was in the opposite direction and there was some suggestion of a link between STA and blocking on the contingency judgement task. Although there is some replication of findings from previous reports, the discrepancies illustrated here indicate that the relationship between schizotypal traits and blocking measures is not yet robust.

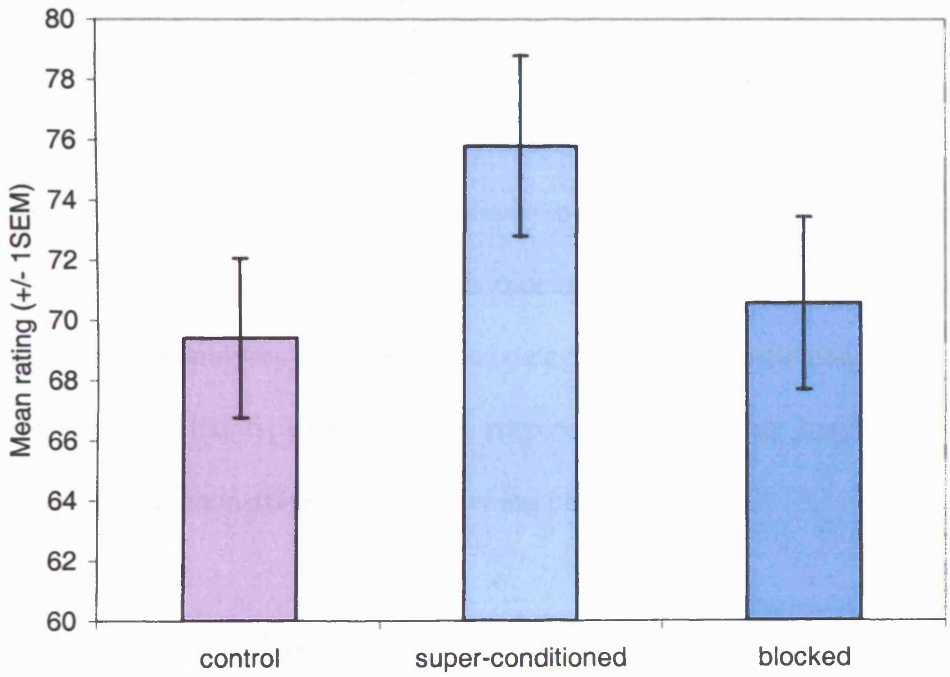
4.2 General Discussion to Comparison Studies

The preceding experiments aimed a) to investigate the replicability of blocking effects from Tasks reported in the literature and b) to compare blocking measures derived from these different experimental procedures. It was found that blocking effects can be difficult to replicate and two of the tasks described in the clinical literature failed to produce blocking effects in the present samples. This is further illustrated by the changeable results regarding the relationships between blocking measures and neuropsychological and schizotypal measures which have previously been reported.

One explanation for the present inability to demonstrate blocking effects in the Jones A and B Tasks is the sensitivity of human blocking measures to experimental parameters. For example, Jones A Task has been reported on numerous occasions in the literature, however in Experiment 1 modifying the task design from between to within subjects failed to reproduce these blocking effects. In Experiments 2 and 3 only one of the two contingency judgement tasks demonstrated significant blocking effects. It was suggested that this discrepancy was due to specific parameters within the Chapman contingency judgement Task which guide participants attention toward a blocking strategy (see Williams et al., 1994).

A second issue relevant to this discrepancy is the method for calculating blocking within these tasks: that is, the use of the super-conditioned stimulus (Chapman Task) rather than a novel control as the blocking comparison (Jones B Task) may artificially inflate the blocking effects. This issue has been raised by previous authors (Williams et al., 1994) but the use of this calculation has so far been maintained. In light of this, the ratings from the Jones B Task were re-analysed along these lines. Indeed, the proportion of positive blocking scores rose to 70% and there was evidence to suggest that the difference between the mean ratings for the blocked and super-conditioned stimuli were larger than between the blocked and novel control (see Figure 4.10). However, this difference did not reach significance ($t(55) = -1.27$; $p=0.21$). This questions the strength of blocking effects obtained from tasks employing a blocked / super-conditioned comparison method.

Figure 4.10: Differences in mean ratings for main stimuli in Jones B Task



Importantly, the present investigations indicate that Kamin Blocking measures derived from two different procedures are not associated. This could be due to differences in task format or strategy used by the participants, and could symbolise some of the fundamental differences in the theoretical accounts of associative learning mechanisms.

In the present studies the Jones B and Chapman Tasks are verbal based with contingency ratings as the measure of blocking while the Oades Task involves spatial awareness and measures behavioural learning through reaction times. It has been proposed that these different formats involve different underlying learning systems in the brain (Arcediano et al., 1997). This would mean previous conclusions from the literature need to be acknowledged as task specific rather than universal. This parallels findings from another paradigm of selective attention, the Stroop test, where various authors have concluded that different formats of the standard cognitive Stroop task may not be mediated by similar attentional mechanisms (Edwards, Brice, Craig, Penri-Jones, 1996; Kindt, Bierman, Brosschot, 1996). The potential link between the differing response requirements on the tasks and the dissociation we have found between the blocking measures, is unlikely to be an artefact of overt differences in ability to perform the tasks correctly as blocking is calculated over and above basal learning and the analyses were performed using only those participants who had learnt on both tasks. That is, differences in response requirements may have a specific influence over demonstration of the blocking phenomenon

To this end, it would be of interest to investigate the relationship between two behavioural measures of blocking as would have been covered in Experiment 1. Unfortunately the within subjects modification to this task was unsuccessful and such a comparison could not be pursued in the present studies. However, as new tasks are being developed this may be something that could be considered for future research.

One possible explanation of these findings may be that there are differences in the performance strategies employed by participants on each task, which may have led to a dissociation of the blocking measures. The use of films and stock markets as stimuli in Jones B and Chapman Tasks inevitably introduces an element of 'real world', contextual bias which may work against the required associative learning strategy. Although blocking has been demonstrated in associative learning of social contexts (Cramer et al., 1985; Cramer et al., 2002), it is difficult to predict the participant's subjective view of this type of causal relationship. For example, It is assumed in Jones B Task that the participant is learning an association between a star and successful films and then carrying that through to a judgement of the intrinsic success of the star themselves which may not be the case. Indeed, participant's subjective perception of the stimuli in contingency judgement tasks has been found to moderate blocking effects in a medical judgement task (Waldmann, 2000). Alternatively, in any task, the participant may view each new stage as a new context and thus re-learn the associations without bias as proposed by Hinchy et al. (1995). This would follow work on Latent Inhibition demonstrating that participants must *believe* the context is unchanged from pre-training to blocking stages, regardless of whether the physical context actually does change (Gray, Williams, Fernandez, Ruddle, Good, Snowden, 2001).

The fact that blocking effects measured in humans are inherently confounded by the participants' response to the experimental context is highlighted in a study on negative priming where cognitive inhibition effects were found to be influenced by participants expectations and "strategic awareness" of the situation (Everett & Lajeunesse, 2000). This may not be such a problem in animal models of blocking as this heightened situational awareness, and the potential to consider more possible performance strategies may be specific to human cognition. Human blocking measures, then, are dependent on the participant's perception of the stimuli used, the contiguity between stages within the task and the strategy they use to complete the tasks. The present results further suggest that this may be of increased importance in contingency judgement type tasks as the present sample demonstrated robust blocking effects on the contingency judgements on Chapman Task, where the strategy cues were overtly highlighted, but not Jones B Task. Differences in context and strategy, then, could be a factor in the lack of relationship between the behavioural and contingency judgement formats seen here.

Finally, the differences in performance on the tasks may derive from a more fundamental dissociation. That is, blocking effects in the Oades Task can be defined in terms of learning differences between stimuli at the *acquisition and pre-conscious stage* as described by associative models such as Rescorla-Wagner (1972) and Mackintosh (1975). However, contingency learning tasks as in Jones B and Chapman Tasks are about *relative* predictive *values* of the stimuli and therefore involve conscious, decision-making mechanisms at the *response stage.* It has been argued that models such as Rescorla-Wagner view participants as passive learners which can explain blocking on human behavioural tasks such as the Oades Task, but are inconsistent with findings from human contingency tasks where the active learning and encoding is a necessary feature of blocking (De Houwer & Beckers, 2002b). Although there is recent evidence of learned inattention (as suggested by the Mackintosh model) on a medical contingency judgement task (Kruschke & Blair, 2000), there remains the suggestion that the two types of task used here are representative of wholly different and incompatible theoretical standpoints. Indeed, our results serve to symbolise the dichotomous separation within learning models and theories. Recently, some authors have sought to resolve this difference through the configuration of 'hybrid models' incorporating essential features of both associative and inferential based theories (Le Pelley, 2004). Such models are being developed specifically to provide a holistic account of the range of blocking effects that have been described in the literature. However, the present results suggest that learning processes in humans change with the procedural context. Therefore, any holistic model would need to illustrate how and when these processing shifts occur to be of any predictive use as accounts of human learning systems. On a practical level, our data clearly suggest that data from differing blocking methodologies cannot be considered interchangeably, as is frequently the case in the literature, as they may not be measuring comparable processes.

The finding that there is little correlation between blocking measures derived from different within-subject formats has important implications for clinical investigations in which such tasks are utilised to assess attentional abnormalities in schizophrenia. Many of the disparities in the clinical literature may be due to differences in task methodology rather than any 'real' differences in underlying blocking mechanisms. Therefore, conclusions about clinical patient deficits and sub group differences made to date would need to be reconsidered in light of these methodological issues. Although this finding does not directly contradict the general observation of selective attention dysfunction in schizophrenia which is indicated by a number of different lines of evidence, the present results do undermine conclusions based primarily on studies using current Kamin blocking measurements: for example, sub-group differences and links to schizotypal measures (Oades, Zimmerman, Eggers, 1996; Moran et al., 2003, Jones et al., 1992b). Moreover, our results question the future utility of Kamin blocking in this research path without a more concrete understanding of human processes engaged during these tasks.

Furthermore, the suggested influence of performance strategy used by the participant on blocking scores has other implications for clinical populations: there is evidence that schizophrenic patients use different task solving strategies not only in comparison to healthy controls but also when compared across symptom sub groups (Erkwoh, Sabri, Schreckenberger, Setani, Assfalg, Sturz, Fehler, Plessmann, 2002). Therefore, it cannot be ruled out that the proposed Kamin blocking deficit in schizophrenia patients is due to inappropriate strategic approach to the tasks, rather than actual underlying dysfunctions in attentional mechanisms. Most importantly, the present results highlight the need for cross validation addressing blocking processes in humans. It is clear that more standardised forms of measurement are necessary if Kamin blocking and by implication related paradigms such as latent inhibition are to be understood either as fundamental stimulus selection strategies or as models for investigating attention deficits in people with schizophrenia.

CHAPTER FIVE

5.1 Experiment 4: Backward Blocking Manipulation in Two Tasks

5.1.1 Introduction

The previous series of studies has demonstrated that there is no relationship between blocking scores achieved from different measures. This has suggested that the different procedures used in the blocking tasks are not measuring equivalent cognitive processes. As discussed previously, this may account for some of the discrepancies in the literature and importantly questions the strength of conclusions drawn about deficits in clinical populations using such tasks. Not only does it preclude the ability to synthesise findings from different studies in the literature to draw general conclusions about underlying cognitive abilities, but it also potentially indicates that at least one of the proposed tasks is in fact not a measure of underlying 'blocking' phenomenon as has been assumed in the literature.

There are a number of procedural manipulations within the associative learning literature which have been found to produce different effects on blocking measures. For example, modifications to the stimulus-outcome relationship such as "outcome additivity" (Lovibond et al., 2003) and causal / predictive (Waldmann, 2000) factors change the observed blocking effects. Moreover with both Kamin blocking and Latent Inhibition the use of such manipulations has been employed to directly assess the association between blocking measures (human versus animal paradigms – Miller & Matute, 1996; Gray et al., 2001; Lubow, in press). Therefore, this approach was similarly employed in the present study to attempt to dissociate further the Kamin blocking tasks from Experiment 3.

'Backward blocking' (Shanks, 1985) is the observation of blocking effects on stimuli learning even when the compound and elemental learning stages are presented in reverse order. The maintenance of blocking effects under this trial order manipulation has been observed by a number of different authors (Chapman, 1991; Williams et al., 1994; De Houwer & Beckers, 2002c; Kruschke & Blair, 2000). The observation of such retrospective blocking indicates that the associative strength of stimuli can be changed in trials when they are not themselves present as some models have assumed. Therefore, as blocking itself first indicated weaknesses in the learning models of the time, so backward blocking later suggested that the purely associative accounts of blocking as learned inattention were unable to account for these new findings. Models of blocking which focus on comparative strengths of predictive value of the stimuli such as the probabilistic contrast model (Cheng & Novick, 1990, 1992) and comparator model (Miller & Matzel, 1988) allow for changes to the learning procedures as blocking is based on a post learning comparison based on all information gathered rather than a phenomenon activated during (and thus dependent on) the specific parameters of the learning procedure itself.

In the present study, a backward blocking manipulation of the task procedures was utilised to elucidate the comparability of the blocking functions being measured by each task. The literature suggests that both in theory and practice such a change to the blocking paradigm should not affect observations of blocking effects and thus should not change blocking scores observed in each task.

However, backward blocking effects and the models of learning which developed to accommodate it are based on observations primarily from contingency judgement tasks. Indeed the contrast and comparison based models of learning are derived from contingency judgement procedures. In these tasks the instructions positively encourage participants to activate a post-learning comparison of the stimuli based on all information presented throughout the task, regardless of presentation order. Certainly, Williams et al. (1994) observed backward blocking (as well as forward blocking) effects in a contingency task *only* in participants who had been pre-treated with an explicit cue to this blocking strategy. In behavioural tasks such as the Oades Task the procedure itself fits much better with these associative accounts in that it assumes blocking occurs as part of an efficiency learning strategy and therefore occurs online during the learning stages and the test stage merely acts to illustrate the blocking which has already occurred.

Therefore, just as the associative accounts of learning were unable to account for the blocking effects observed in human contingency procedures, so human behavioural procedures may also not be able to replicate the backward blocking effects. Miller & Matute (1996) report backward blocking in animal Pavlovian conditioning but only when the stimuli were of low biological significance. That is, if the US was highly relevant to the animal the conditioned stimulus become resistant to extinction. Therefore, after the initial compound learning stage blocking of the CSB will not occur retrospectively. In the Oades Task, although not strictly an example of Pavlovian conditioning procedures, there is certainly low biological significance and incentive which could suggest the potential for backward blocking to occur.

In contrast, Mitchell & Lovibond (2002) have argued that backward blocking in humans is dependent on the assumption of "outcome additivity". That is, when two elements are said to predict the same outcome, if they are presented together (as in compound trials) the subsequent outcome would be double that experienced if only one predictor was presented. Consequently, when the compound is presented and the predictor is of a "single" intensity it is assumed that one of the elements in the compound must *not* be predictive of that outcome. They demonstrated backward blocking in Pavlovian conditioning procedure in humans but only when this outcome additivity had been instructed. In this way, when participants subsequently experienced the same level of shock on both the compound and elemental trials, they would deduce that only one element of the compound was causal and therefore make a predictive judgement similar to those seen in contingency paradigm. In the Oades Task outcome additivity is not indicated to the participants which suggests that backward blocking may not be possible. There are as yet no published reports of backward blocking in a behavioural paradigm such as the Oades Task and in an unpublished study by Helena Matute's group using their "martian" behavioural task they were unable to find any evidence of backward blocking in this format (personal communication). However, of note is the successful backward blocking task reported by Kruschke & Blair (2000) which involved participants choosing between outcomes given the stimuli rather than rating the predictive value of the stimuli. By removing the numerical element the preference response could be argued as somewhat behavioural in essence.

The demonstration of backward blocking has become a key issue not only for evaluating models for human learning processes, but also for investigating potential divisions between animal and human learning processes. For example, Miller & Matute (1996) argue that the observation of backward blocking in animals (provided the biological significance was low) illustrated the equivalence of animal paradigms to human learning mechanisms. However, Mitchell & Lovibond (2002) have stated that their later demonstration of backward blocking in human Pavlovian conditioning and when biological significance is putatively high has re-iterated the fundamental differences between animal and human learning. These authors go on to argue that their "outcome additivity" factor is fundamental to all demonstrations of blocking in humans and as the assumptions of animals in this respect cannot be instructed, animal demonstrations of blocking are not based on the same processes. In particular, they describe all human learning processes in which blocking is a feature as reducible to deductive reasoning or "the manipulation of propositional information" (pp327).

On the other hand, they argue that learning in non-human animals utilises trial-by-trial error correction processes which can be more easily modelled within the original associative accounts such as Rescorla-Wagner (1972). This sentiment is echoed in a recent review of human associative learning by De Houwer, Vandorpe, & Beckers (in press) which argues for the central role of "controlled processes" (i.e. deductive reasoning and hypothesis testing) in all human associative learning contexts. However, the evidence they review centres once again on contingency judgement and physiological task procedures. The assimilation of blocking effects from the seemingly automatic learning in behavioural response procedures is not explained. In light of the previous finding of no association between blocking measures, it is conceivable that perhaps the human behavioural response tasks are independent of *both* traditional Pavlovian conditioning and contingency judgement contexts. In contrast, Kruschke & Blair (2000) have argued in support of learned inattention mechanisms in backward blocking rather than comparative models.

However, blocking observed in the Oades Task and other human behavioural measures does not fit this account: these measures involve 'online' learning without recourse to post-learning reasoning processes or outcome additivity. As discussed, they seem to be examples of human learning processes which would more intuitively match to the early associative learning models such as Rescorla-Wagner (1972) and Mackintosh (1975) rather than the later comparative models. Therefore, the demonstration of backward blocking in these tasks would contradict the standpoint proposed by Mitchell & Lovibond (2002; also Lovibond et al., 2003) and further add to the ongoing debates.

The present study aims to investigate backward blocking effects in the contingency and behavioural tasks used previously. According to current models of human learning processes, blocking effects should be impervious to changes in learning stages and so if both tasks are in fact measuring the same function (i.e. "blocking"), both tasks should continue to demonstrate significant blocking effects under the changed learning regime.

5.1.2 Methods

Participants:

45 participants were recruited from the university population. Participants either completed the study as part of a course requirement or were paid volunteers recruited from advertisements in the student's union building. Participants were randomly assigned to one of the two task groups: 20 participants completed the modified Oades Task and 25 the modified Chapman Task. See Table 5.1 for demographics breakdown.

Table 5.1: Break down of Age, IQ, and handedness for each participant group

	Mean Age years (std dev)	Difference Test	Mean NART IQ	Difference Test	Mean Handedness	Difference Test
Oades Task Group 12F; 8M	19.52 (1.15)	----------	112.75 (4.54)	----------	2.30 (1.59)	----------
Chapman Task Group 23F; 2M	20.79 (4.56)	t(43) = -1.22	112.60 (5.11)	t(43) = 0.10	2.40 (1.50)	t(43) = -0.22

The Groups did not differ significantly in age, NART IQ or Annett Handedness.

Materials & Procedure:

1) The Kamin Blocking Tasks:

The Oades and Chapman Tasks described in previous experiments were employed here. The task procedures and instructions are as previously described except for the change in learning phase order. The modified versions of the tasks are denoted by a 'back' suffix.

a. The Oades-back Task:

For general details of format and screen layout please refer to Experiment 2. Note that, as before, participants must learn two separate CS-US associations during each session of the task (i.e. they effectively encounter two individual blocking paradigms in a single game). This is for added complexity and has been shown to aid the demonstration of blocking effects in humans.

Conditioning session – One learning stage and one test stage presented and performed as described in Experiment 2.

Blocking session – Two learning stages and one test stage as described for the Oades task. However, the first learning stage now comprises the compound learning stage in which a three-colour panel is presented as predictive of the target locations. Once the learning criterion has been reached for this stage, participants are automatically moved to the elemental learning phase (in which the two-colour panels appear and the third colours are completely absent). Again, once the learning criterion has been achieved participants are moved on to the test stage. This consists of 26 trials of the individual colours as described in the original version.

b. The Chapman-back Task:

General details of the task can be found in Experiment 3. Participants again completed one of five versions of this task in which the predictive roles played by each company were alternated. Participants complete two learning phases of 36 trials as before. Each learning stage is again followed by a rating (test) stage in which they must rate the predictive value of each company individually (-100 to +100).

The backward blocking manipulation means that participants are first presented with trials in which the daily stock movement of the companies may be paired on a single day. After the first rating stage, the second learning stage then only comprises trials in which the daily stock movement is from single companies. Finally, there is the second rating stage from which blocking measures are taken.

Note that, following comments from initial participants that they were unable to recall the pairs given in stage one during stage two rating, latter participants were presented with a card prior to the final rating stage which reminded them of these pairs. See Appendix 10

2) Other Measures:

Participants also completed the NART and Annett Handedness Questionnaires (described in Experiment 1 and employed in all previous Experiments) as well as providing demographic information on age, education level, and a self-report history of family psychiatric illness.

Data Analysis:

1) Kamin blocking calculations

Learning for the Oades-back Task is calculated as for the original version (number of learning trials in the conditioning session). For the Chapman-back Task learning is said to have occurred if the participant has correctly rated the company which was never paired with a market rise in the first learning stage as lower than all other companies which had been presented with stock market rises. Note that this measure provides a nominal criterion for learning on the task rather than scaled individual learning scores.

Blocking in both tasks is measured as reported in Experiment 3.

As in other experiments, participants not reaching the learning criterion on either task were removed from the analysis. 5 participants from Group 2 were removed from the analysis on this basis. This left 20 participants (19 Females, 1 Male).

2) Statistical Analysis

One Sample T-test analyses were used to establish blocking effects different from zero where positive scores indicate the presence of blocking. In addition the proportion of positive blocking scores in the sample are reported as discussed above.

5.1.3 Results

The following section is divided into reports for (1) the Oades-back Task measures and (2) the Chapman-back Task measures. For each Task, the distribution of scores is described along with the mean and variance and the significance of these effects.

Oades-back Task:

See Figures 5.1 and 5.2 for learning and blocking score distributions. Although, these distributions deviate somewhat from the normal curve in the histogram, normality analysis indicated both distributions to be within the normal range (Kolmogorov-Smirnov = 0.59, $p>0.05$ on both).

Mean number of learning trials was 22.05 (std dev 9.99).

Mean Blocking score was 2.57 (std dev 2.42). This was found to be significantly above zero in a one-sample T-test: $t(19)=4.74$; $p<0.001$.

The frequency of positive blocking scores across individual participants in the group was 90%.

Figure 5.1: Distribution of learning scores in Oades-back Task
(Bar labels represent bin range)

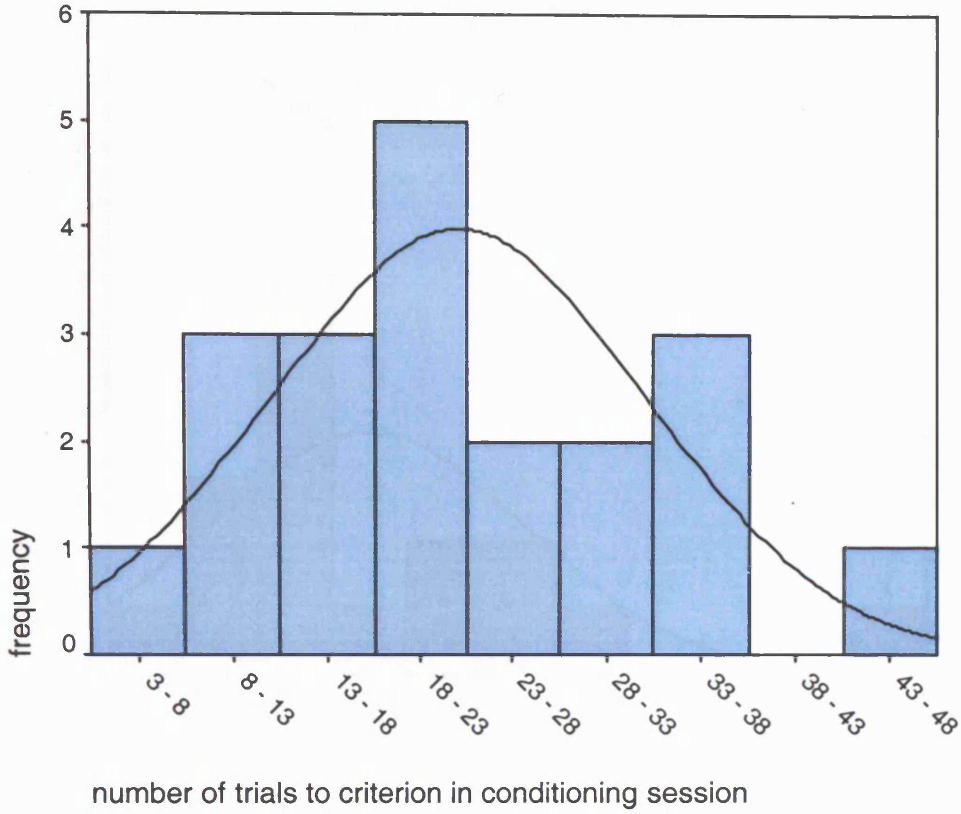


Figure 5.2: Distribution of blocking scores in Oades-back Task
(Bar labels represent bin range)

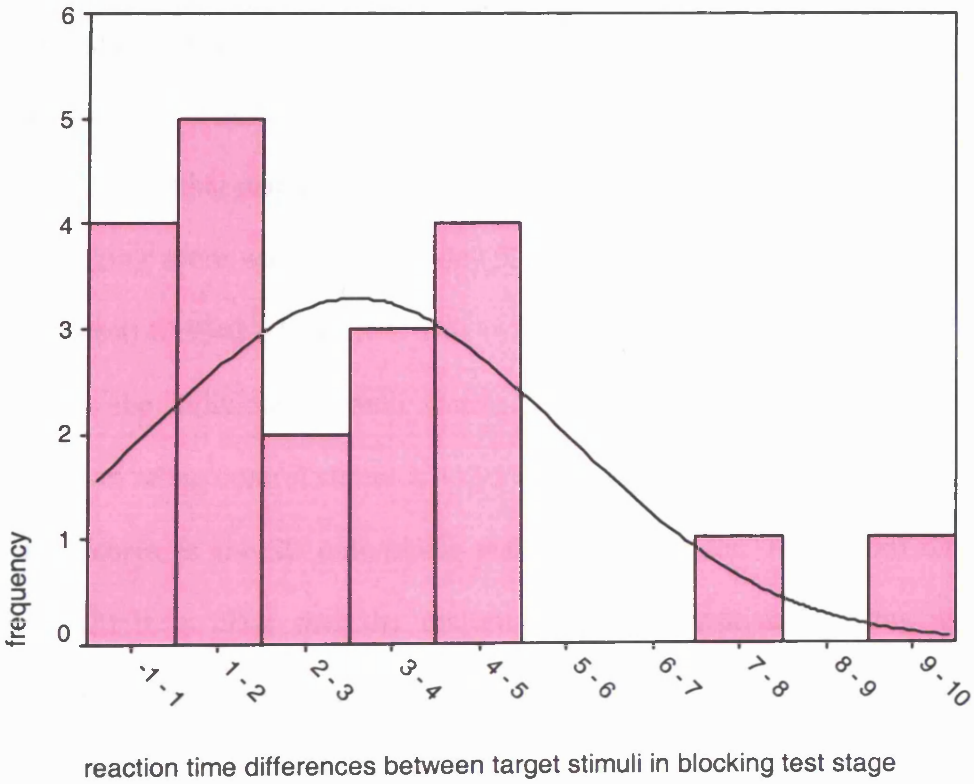
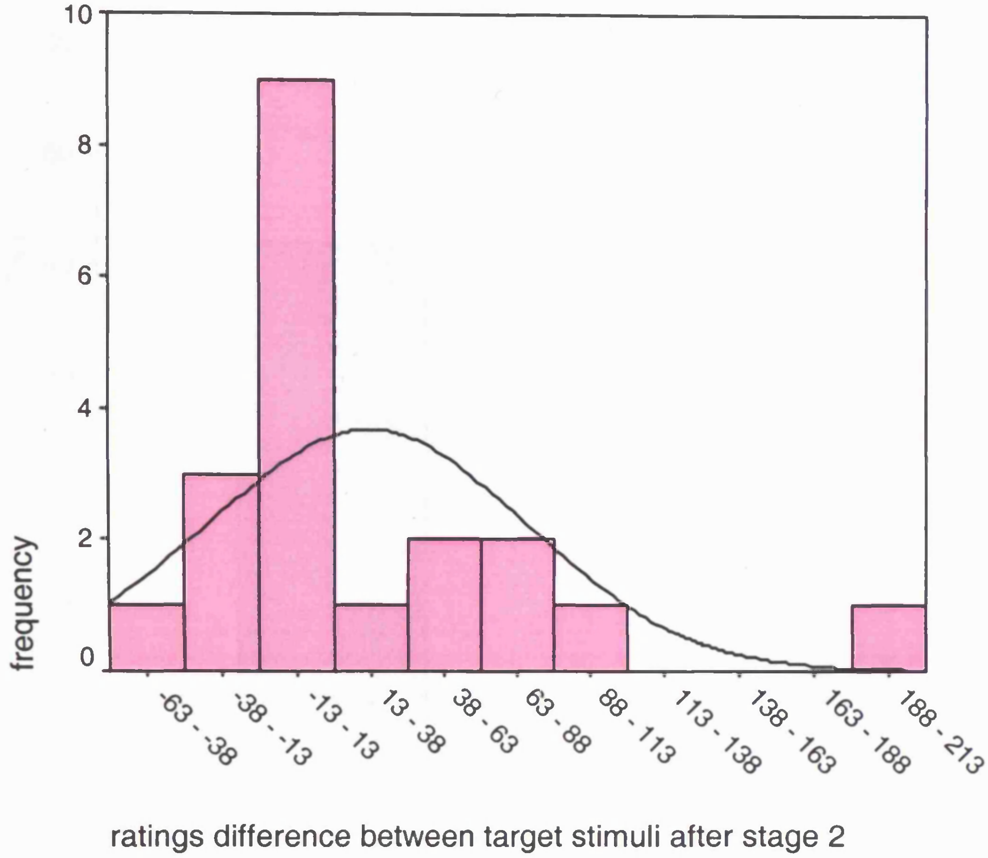


Figure 5.3: Distribution of blocking scores in Chapman-back Task
(Bar labels represent bin range)

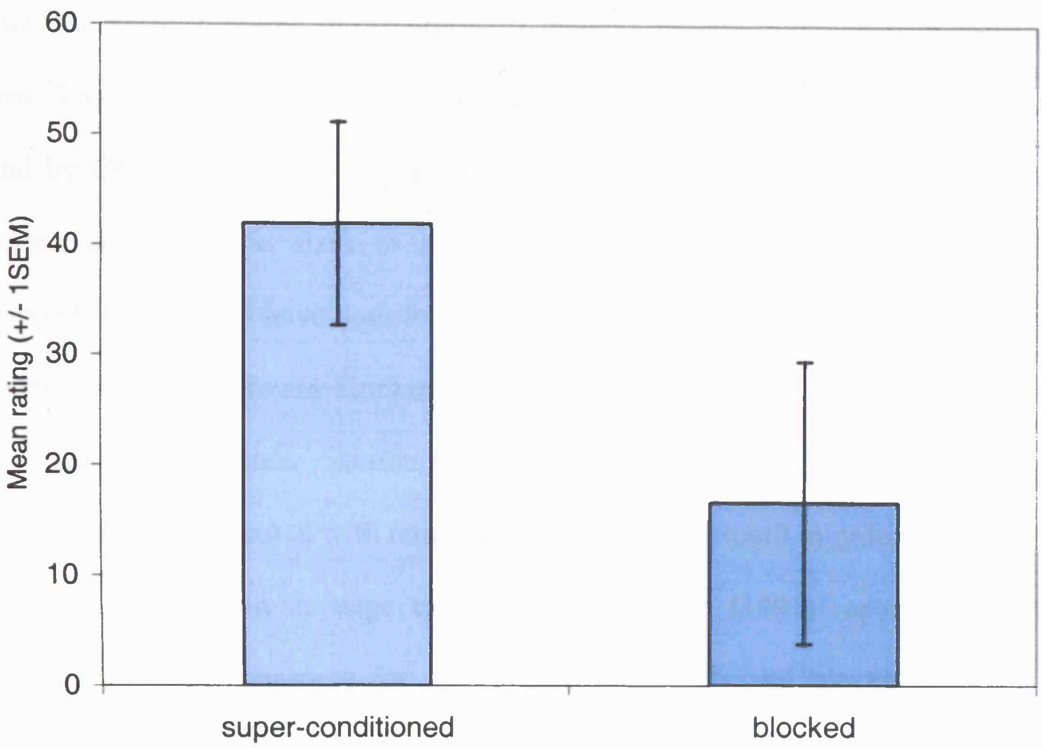


Chapman-back Task:

The Histogram (Figure 5.3) indicates the blocking scores followed a normal distribution such that parametric analysis could be performed.

Mean blocking score was 25.35 (std dev 53.27). This effect was significant in a one-sample T-test: $t(19)=2.13$; $p=0.04$. This is further illustrated in Figure 5.4 comparing ratings for the individual stimuli (mean rating blocked stimulus 16.60 (std dev. 57.40); mean rating control stimulus 41.95 (std dev. 41.33). The frequency of positive blocking scores in the 20 individuals was 75%. From the Task score distribution (Figure 5.3) it is clear that the majority of these positive blocking score (i.e. differences between stimuli ratings) were relatively low.

Figure 5.4: Difference between mean ratings for super-conditioned and blocked stimuli in Chapman-back Task



5.1.4 Discussion

The present study reveals significant blocking effects in both the Oades-back and Chapman-back Tasks. In fact, the blocking effect was stronger in the behavioural response task than in the contingency judgement procedure. This is somewhat surprising given the numerous reports of successful backward blocking effects in contingency judgement tasks and the limited evidence for such effects in alternative procedures.

Although previous accounts of backward blocking effects in contingency judgement have been replicated here, these effects are clearly weaker than those found in the forward procedure of Experiment 3. Many of the differences between ratings, although in the right direction, were small and only five scores were greater than 50 (where the maximum possible difference was 198). A comparison of forward and backward blocking effects in the Chapman and Oades tasks both from the present studies and those reported in the original Chapman reports is provided in Table 5.2 below. The Table illustrates that a similar decrease to the blocking effect was also found by Chapman (1991 – experiment 3) who found that a backwards procedure required larger sample sizes to reach significance. Williams et al. (1994) and Lovibond et al. (2003) have both found the necessity for additional parameters in the demonstration of backward blocking. In the present study the role of memory for compound pairs seems particularly important: following initial comments, participants were presented with reminder cards of these stimuli in order to accurately utilise this information in stage two. Indeed Chapman (1991) reports significant correlations between memory for the compound pairings and blocking effects. In addition, the observations of Lopez et al. (1998 – exp 1 & 2) that contingency ratings are more affected by the most recent information presented, could help account for the present results.

With regards to the Oades-back Task, the present study serves as the first clear demonstration of successful backward blocking manipulation in a human behavioural task. Indeed, as Table 5.2 shows, this effect is somewhat stronger in the backward procedure than the forward blocking effects found in the previous experiments. Mitchell & Lovibond (2002) have previously reported backward blocking in Pavlovian physiological conditioning (human electrodermal response) but only with outcome additivity manipulations. Therefore, the present finding is somewhat surprising given other reported difficulties in past studies and in some way contradicts the proposal of Mitchell & Lovibond (2002) that outcome additvity is essential for backward blocking. Although, these authors have also made the stronger assertion that this factor was important for all demonstrations of blocking which has already been violated by the robust blocking effects (forward) using behavioural (though not physiological responses as Mitchell & Lovibond discuss in their argument) response procedures reported in the clinical literature. Indeed, this incongruity perhaps serves to highlight a key theme for this thesis: the lack of acknowledgment between procedures and findings across the clinical and learning research areas.

Table 5.2: Comparison of Forward and Backward blocking effects in previous studies for the Chapman and Oades Tasks

		Forward Procedure		**Backward Procedure**		
		Mean Blocking score	*% positive blocking scores*	*Mean blocking score*	*% positive blocking scores*	
Oades Task	*Exp. 2*	0.95* (1.59)	73%	2.57** (2.42)	90%	*Exp. 4*
	Exp. 3	1.62* (2.39)	73%	----------	--------	
Chapman Task	*Exp. 3*	50.51* (62.02)	85%	25.35* (53.27)	75%	*Exp. 4*
	Chapman &Robbins 1990	Wilcoxon T(9)=0**	69%[1]	----------	----------	
	Chapman 1991	Wilcoxon T(24)=61**	---------	Wilcoxon T(52)=462.5*	54%[2]	*Chapman 1991*

*denotes significance at $p<0.05$
** denotes significance at $p<0.01$
[1] frequency of positive blocking was calculated from pooled rankings of stimuli given during learning stage 2
[2] frequency of positive blocking scores calculated from number of participants rating CSB lower than control as in present studies

The finding of backward blocking effects in the Oades Task may shed light on the explanatory value of learning models for this format. As discussed previously, these behavioural task formats seemed best served by the more traditional associative models of Rescorla-Wagner (1972) and Mackintosh (1975). While the procedure in the Oades Task still does not intuitively correspond to the relative value assessments described by the comparator models developed from contingency judgement contexts, the present findings now suggest it is also incongruent with the Rescorla-Wagner associative model which cannot account for backward blocking effects. But, the later associative formulation by Mackintosh of an active 'learned irrelevance' process does allow for such effects. That is, while CSB is learnt equally well after stage one, this learning subsequently decreases when the presentations of CSA alone indicate the post hoc redundancy of CSB. Although this model can account for the backward blocking effects seen here, it has been criticised as unable to hold up against other experimental manipulations such as post-training extinction effects (see Chapter One) which cannot be evaluated by the present study. Similarly the Standard Operating Procedures model (Wagner, 1981), although criticised for a number of other issues, also seems able to explain the backward blocking found in this "passive" learning context by positing that the absence of CSB in stage two reduces it to a latent activation state (A2) while elevating CSA to an immediate activation state (A1) and this status is carried into the test stage resulting in longer response times to CSB.

The finding that trial order manipulation does not affect blocking in the Oades Task could suggest that blocking in this task is similar to that reported in associative learning and particularly contingency judgement contexts. However, as shown in Experiments 2 & 3, direct comparison of the two blocking procedures reveal that the blocking measures are *not* associated. Therefore, the present finding in fact demonstrates that finding similar effects of procedural manipulation is not necessarily indicative of an association between the task measures. At the very least, the present results indicate that this approach is not enough to evaluate similarity across the measures as has been described in the past (Gray et al., 1991; Miller & Matute, 1996; Lubow, 2004). In particular, the Miller & Matute study argues for the equivalence of human (contingency judgement) and animal (behavioural) procedures based on demonstration of backward blocking in animals. However, the present findings demonstrate that this result can be obtained in the absence of association between measures.

It could be argued that the backward blocking effects seen in the Oades Task are simply an artefact of recency effects from the modified trial order: CSA is the most current stimulus in working memory. This would suggest that backward blocking has not yet been reliably demonstrated in the behavioural format and debate over the comparability of the task procedures remains. However, such recency effects would be similarly activated in the forward blocking procedure and blocking would not occur. As robust blocking is seen in this task, recency effects are likely not central to the underlying mechanisms involved.

In the present study, a backward blocking manipulation of the task procedures was employed to assess the comparability of 'blocking' effects in the two task measures. The backward blocking effects previously reported in contingency judgement tasks were replicated here (although not in all analyses). Additionally, robust blocking effects were found in the behavioural task format of the Oades Task. This suggests that procedural similarity does not necessarily reflect underlying association between task measures.

CHAPTER SIX

6.1 Experiment 5: Age and Sex Effects on Kamin Blocking

6.1.1 Introduction

A number of tasks have been utilised in the investigations of clinical populations (Jones et al., 1990, 1992b; Jones et al., 1997) of which the most prolific has been the "mouse in the house" task (Oades, Zimmerman, Eggers, 1996; Oades et al., 1997; Oades et al., 2000; and used here in the preceding studies). The present study aims to investigate population factors which may mediate Kamin blocking effects and may be relevant to the findings and conclusions reported in the clinical literature. For this reason, the Oades Task will be employed in the present evaluation.

Inconsistency in the clinical literature on Kamin blocking effects:

The Kamin blocking paradigm has been identified as an important tool in human research into schizophrenia (see Sections 1.11-1.14 for review). Moreover, it has demonstrated reliable and specific group differences between healthy and clinical populations (Jones et al., 1997; Jones et al., 199b2; Serra et al., 2001; Oades et al., 2000 among others). Critical to the understanding of the neuropsychological changes that occur in schizophrenia is the precise definition of the Kamin blocking phenomenon in the normal population. Associative learning investigations in the general population as well as the preceding studies in this thesis have revealed factors and parameters of the task which mediate Kamin blocking effects in humans (see Section 4.2 for discussion). In general, the associative learning literature suggests that there are specific task parameters which need to be in place in order to demonstrate robust Kamin blocking effects in humans. Although these investigations have invariably studied contingency learning paradigms rather than the behavioural response tasks used in clinical research, the potential pitfalls of methodological parameters within clinical research was discussed in an editorial review of measuring attention deficits in patient populations (Oades & Sartory, 1997). However, the potential for task parameters to mediate differences in blocking effects found in clinical studies is not generally addressed within individual Kamin blocking studies. That is, in the overall clinical literature there *is a lack* of consideration for the particular experimental parameters surrounding human analogues of Kamin blocking. Many studies make reference to Kamin blocking in healthy humans *only in comparison* to performances from clinical populations. Such a comparison demonstrates differences on task performance between clinical and healthy groups, but does not rule out co-variables within each population which may be moderating the effects seen. There may be elements of the experimental and task context which themselves cause differences between groups.

Perhaps more relevant to the between group investigations in clinical studies is the potential for demographic variables to play a role in Kamin blocking abilities and hence the differences between study populations. Although the age, gender and social class of clinical and control groups are usually matched there has been little research on how these individual variables may actually be influencing Kamin blocking effects seen in the study. Again, little consideration is given to demographic variables when discussing results. With little understanding or consideration for potential mediating factors of Kamin blocking in humans both within the task used and from the sample chosen, definite conclusions about the role of Kamin blocking attentional abilities in schizophrenia cannot be made.

Indeed, an overview of the data drawn from healthy control groups in clinical studies indicates disparate results. For example, Gray et al. (1997) found no decrease in the blocking effect in humans following amphetamine (as seen in animals) using a between-subject task, while in the same year, Jones et al. report the opposite when using a within subjects design. On investigations into children diagnosed with Attention Deficit Hyperactivity Disorder, Jones et al. (1994) found no blocking deficit while Oades & Muller have reported the opposite with this population (Oades & Muller, 1997). The influence of age on learned inattention abilities also requires clarification: Jones did not find any age effects in studies on children (Jones et al., 1994) or 18-55 year old adults (Jones et al., 1990) while the research by Oades disagrees with this finding (Oades, Roepcke, Schepker, 1996). It is also worth noting that a review of two Latent Inhibition studies on children reported the phenomenon to be present in younger children (4-5 years) but actually decreases in older children (11-12 years) without the use of a masking task (Kaniel & Lubow, 1986).

Findings relating to sex differences on task performance are also unclear. For example, Jones et al. (1990), reports no significant sex differences between 58 healthy adults but the same task in 1994 renders highly significant differences between males and females on a smaller study of 8-10 year old children (Jones et al., 1994). However, Oades' within-subject design *does not* give any significant sex related divergence either in children (Oades, Roepcke, Schepker, 1996) or, on a slightly modified design, in a sample of 62 healthy adults (Bender et al., 2001). These difficulties may stem from methodological issues (Oades & Sartory, 1997) as well as the heightened conscious control and experimental awareness found in humans compared to animals (Lubow, 1997 and Oades & Sartory, 1997 for reviews).

Age effects on cognitive processing relevant to Kamin blocking:

There is much evidence from cognitive literature to indicate developmental changes in attention function. For example, in their 1994 review of the literature, Plude, Erris, & Brodeur conclude that three out of the four components they identified in selective attention showed developmental changes both at the start and end of the life span. This is supported further in a recent review by Ridderinkhof & Van der Stelt (2000) who state that, regardless of task modality and structure, the majority of research argues for a significant increase in the efficiency of selective attention mechanisms from childhood into adolescence leading the authors to suggest that "age-related improvements in the ...deployment of attentional selection are among the most profound advances in information processing efficiency that take place as children grow older." (pp. 105)

There has been only one Kamin blocking study in recent years which has aimed specifically at investigating blocking and its development in healthy humans (Oades, Roepcke, Schepker, 1996). Here, four age groups were tested between 6 and 25 years with 11 subjects in each group. This study found a non-significant trend for Kamin blocking to increase with age which has been replicated by Bender et al. 2001 and with the control group in the Oades & Muller (1997) study. The authors suggest that Kamin blocking first appears at age 8 and continues to increase in the brain during adolescence reflecting development of frontal areas of the brain (Oades, Roepcke, Schepker, 1996). This theory is highly relevant in light of recent models of schizophrenia which emphasise post-natal, neurodevelopmental changes. For example, results from post-mortem and MRI studies indicate that schizophrenia involves an abnormal rate of neuronal loss in areas such as the frontal cortex stemming from prenatal pathogenesis and continuing throughout the first two decades of life (McGlashan & Hoffman, 2000; Woods 1998). Moreover, such cell 'pruning' is known to be involved in the normal process of learning (Woods, 1998), thus it is plausible that abnormal performances on psychological tests related to attention and learning function could be indicative of such aberrant neuronal processes. The Oades, Roepcke, Schepker (1996) study was used as a basis for the current investigation and the first aim of the present work was to provide a comprehensive investigation into the development of blocking in humans.

Sex effects on cognitive processing relevant to Kamin blocking:

The variations between males and females in Kamin blocking performance may reflect differences in cognitive function and/or strategies employed by the participants. Again, evidence from other cognitive literature has illustrated sex differences in cognitive style, especially relating to spatial-location tasks as seen in the Oades game (Maccoby & Jacklin, 1974; Halpern & Tan, 2001; Postma, Izendoorn, de Haan, 1998). Therefore, it is the second purpose of this study to investigate sex differences on learned inattention in humans using the Kamin blocking paradigm. There has been inconsistent evidence for sex differences on blocking abilities, but findings from other areas of research do suggest fundamental divergence between males and females. Furthermore, epidemiological differences in the occurrence and diagnosis of schizophrenia (Lewine, Walker, Shurett, Caudle, Haden, 1996; Goldstein, Seidman, Goodman, Koren, Lee, Weintraub, Tsuang, 1998) which have also been shown in general population correlates of psychosis (Maric et al., 2003) could reflect underlying sex differences in cognitive abilities such as selective attention. The potential role of sex factors in cognitive performance is also illustrated by a comparison of two studies investigating the effects of caffeine on cognitive (stroop task) performance: here wholly opposite results were found in student samples of differing sex (see Foreman, Barraclough, Moore, Mehita, Madon, 1989 versus Kenemans, Wieleman, Zeegers, Verbaten, 1999).

6.1.2 Methods

Participants:

270 people were recruited from local schools, businesses and from the University Psychology department on a voluntary (unpaid) basis. For recruitment of school children, permission was gained from the head teachers of the schools during initial interviews and parents were notified of the research by the schools (See Appendix 11 for example of recruitment letter sent to schools). From these participants a total of 222 (113 Males; 109 Females) reached the learning criterion and went on to complete the tasks. There were no significant sex differences among the participants who were unable to learn the task adequately (55% female; 45% male), however 50% of the non-learners were from the 6-7yrs age group and 77% from the lowest two age groups. The remaining participants were divided into five age categories as shown in Table 6.1.

Male and female participants did not differ significantly in age with the average female being 17.54 (std dev 11.52) years and the average male 15.46 (std dev 9.21) years. IQ scores, as estimated from standard reading tests, also did not differ significantly between males and females (BAS scores: mean males = 113.94 (std dev.

13.52, mean females = 112.86 (std dev. 12.50); NART scores: mean males = 113.52 (std dev. 5.89), mean females = 112.11 (std dev. 5.55)).

10% of the sample was recorded as left-handed (40% male and 60% female).

Table 6.1: Break down of age, sex and ability score by age group

Age group	Mean age (years)	Number males	Number females	Total number of participants	Ability score
6-8 Years	6.98 (0.67)	16	18	34	117.29 (14.09)
9-12 Years	10.24 (0.90)	39	29	68	115.47 (12.34)
13-17 Years	14.70 (1.22)	27	17	44	107.41 (11.36)
18-21 Years	19.61 (1.11)	12	21	33	111.62 (4.72)
22+ Years	34.0. (11.19)	19	24	43	113.49 (6.27)
Total	**16.47 (10.44)**	**113**	**109**	**222**	---------

Materials & Procedure:

1) The Oades Task was used as described in Experiment 2 (Chapter 3).

2) Ability Scales

Participants were given simple word reading tests relevant to their age to obtain a prediction of their ability on standardised scales. For the children (under 17 years) this was taken from the British Ability Scales 2 (BAS) for ages 6-17 years, and for the Adults the National Adult Reading Test (NART) was used. The standardised scores for the BAS are measured on a scale with mean 100 (std dev 15) while the NART calculates an estimate on a standard IQ scale. Both tests involve the participant reading a list of words and the responses marked by the experimenter for pronunciation accuracy. See Appendix 2a for NART word list and Appendix 12 for BAS 2 word list.

3) General Questionnaires

Participants completed a general questionnaire on demographic details as described in previous experiments (See Appendix 4). They also answered questions at the end of the session regarding the strategies they used on the blocking task, their memory for the colour stimuli and their feelings about task difficulty (See Appendix 8a). Note that the Annett Handedness Questionnaire was not completed in this study as some of the items were felt to be irrelevant for younger age groups. Instead a simple measure of handedness was obtained from the participants' writing hand.

Participants completed two sessions of the computer game separated by the word reading test. The demographics questionnaire was completed at the start of the session and the strategy questionnaire at the end. In the case of the younger age groups, the questionnaires were administered verbally by the experimenter.

<u>Data Analysis:</u>

1) Kamin blocking calculations

Learning and Blocking on the Kamin blocking task were calculated as described in Experiment 2. As in previous experiments, participants reaching the upper limit of sixty learning trials during session one were excluded from the data analysis.

As before, the formula for calculating the overall Kamin blocking score was further broken down to look at blocking across the test phase by applying the Kamin blocking formula to each of the six pair groups of the test phase. It has been shown that schizophrenic deficits in Kamin blocking are dependent on pair group (Bender et al., 2001; Watson et al., 2001).

2) Statistical analysis

Analysis carried out on the learning data consisted of a one-way ANOVA with post-hoc Tukey tests using age group and gender as the independent variables. Analysis of the blocking scores involved a univariate ANCOVA with age group and sex as the primary factors and learning as a covariate. A Chi-squared test was also performed on the frequency of a positive blocking score across age and sex groups. A further ANCOVA was performed on the partial blocking scores obtained from the trial pair groups.

6.1.3 Results

The following section is divided into reports for (1) the learning measures and (2) the blocking measures from the Tasks. For each measure, the overall distribution of scores is described and is then broken down to analyse the effects of age and sex (and their interaction) on the scores.

<u>Learning Scores:</u>

The overall scores were not found to follow a normal distribution either from the graph (see Figure 6.1) or in statistical analysis (Kolmogorov-Smirnov = 0.161, $p<0.001$) therefore non-Parametric comparisons were performed.

Measures of learning were compared across age groups (Figure 6.2). Significant age differences were found using Kruskall-Wallis comparison of the means: Chi-sq

(4)=63.40; p<0.001. Post hoc analysis using Mann-Whitney tests revealed that the two youngest age groups required significantly more trials to learn than all other groups, but that by early teens learning became consistent. See Table 6.2.

There was a tendency for females overall to require more trials than males during the learning phase (Mann-Whitney U = 5157; N=222; p=0.04) (see Figure 6.3). This difference was seen in all age groups, most markedly in the 9-12 year olds (see Figure 6.4). Measures of learning did not correlate significantly with either the BAS reading scores or the NART IQ estimate scores (r(s) = 0.04, N= 146, p=0.07; and r(s) = -0.02, N=75, p=0.86 respectively).

Figure 6.1: Distribution of learning scores in Oades Task
(Bar labels represent bin range)

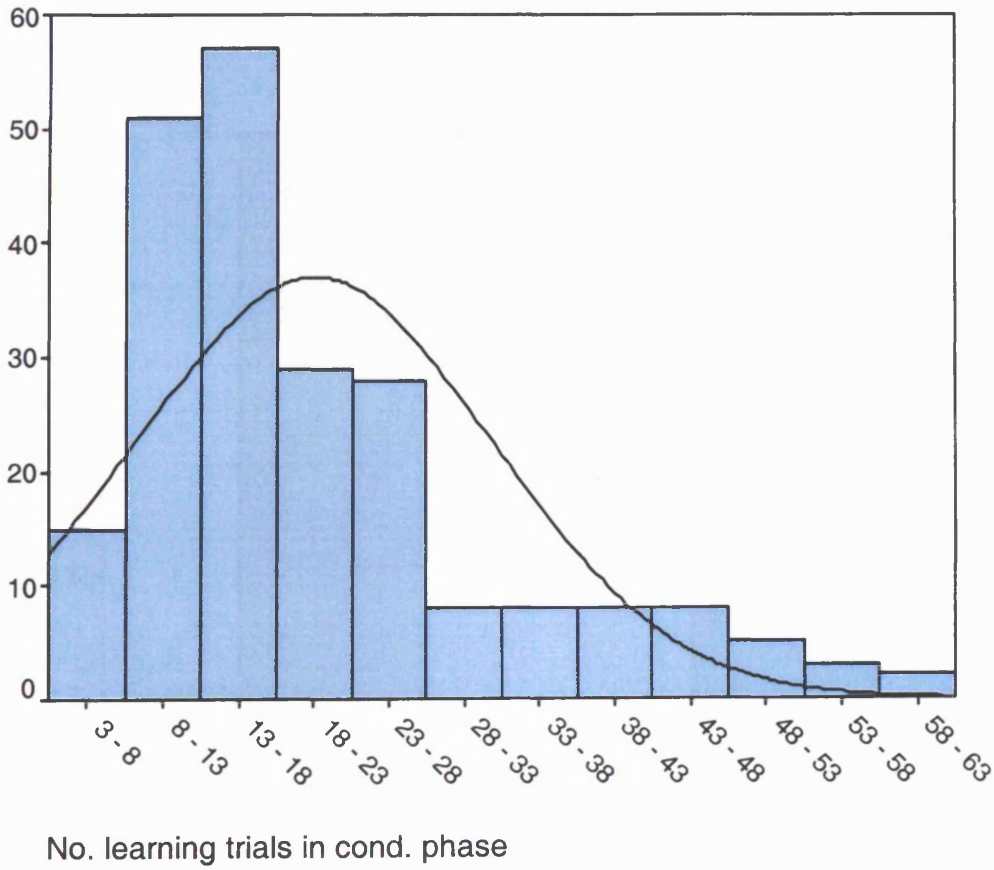


Figure 6.2: Difference in Oades Task learning scores between age groups

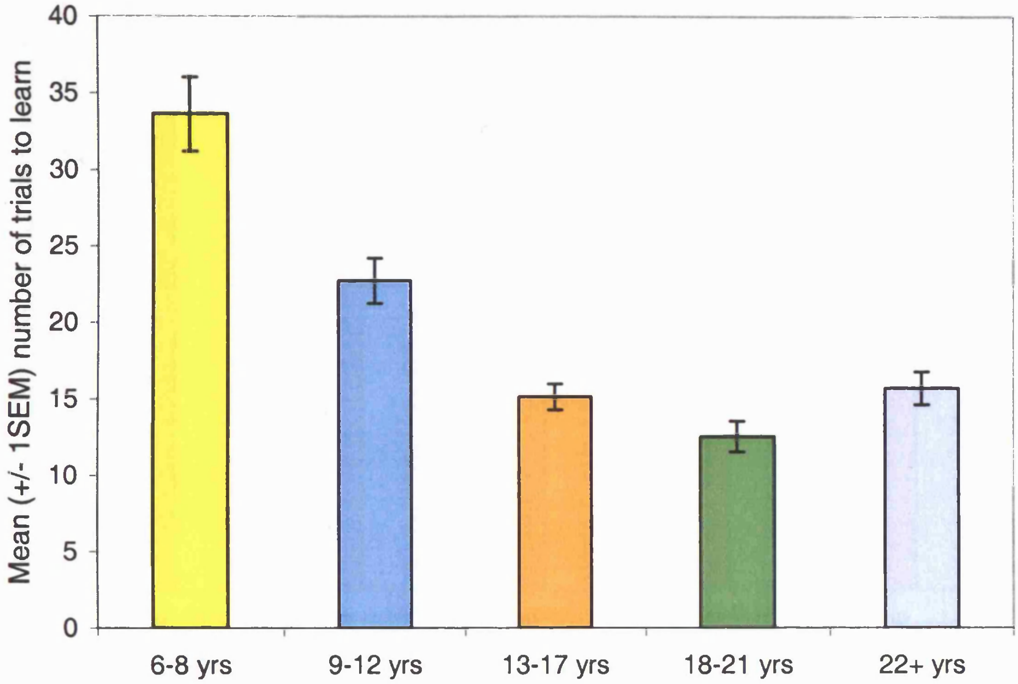


Figure 6.3: Difference in Oades Task learning scores between males and females

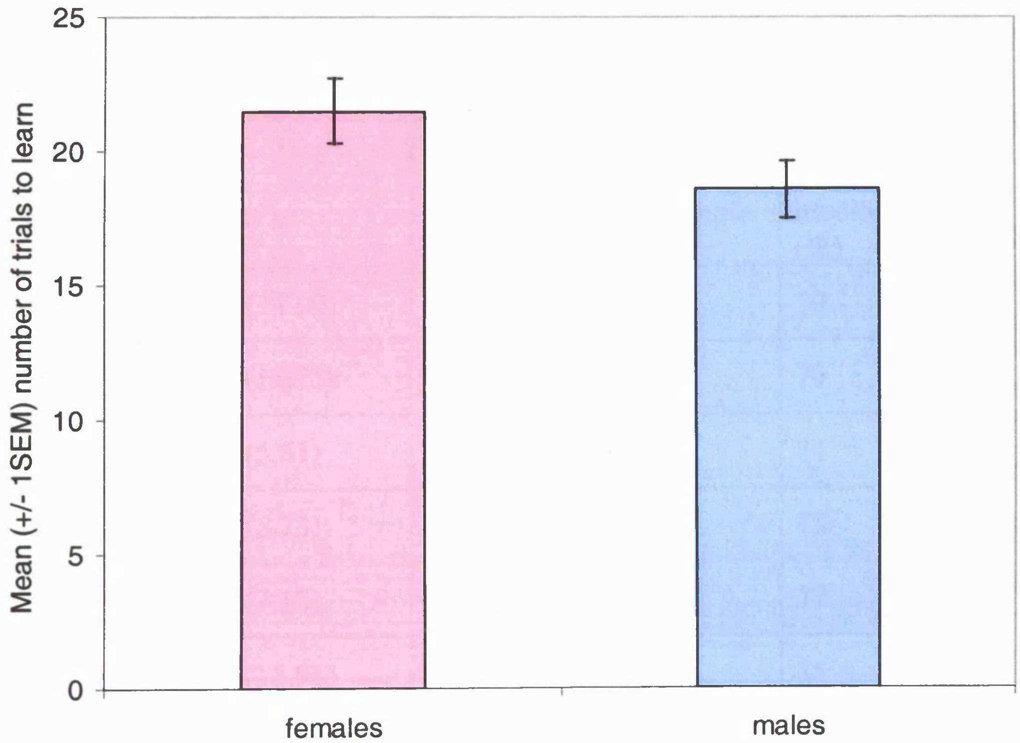


Figure 6.4: Distribution of Oades Task learning scores across age and sex

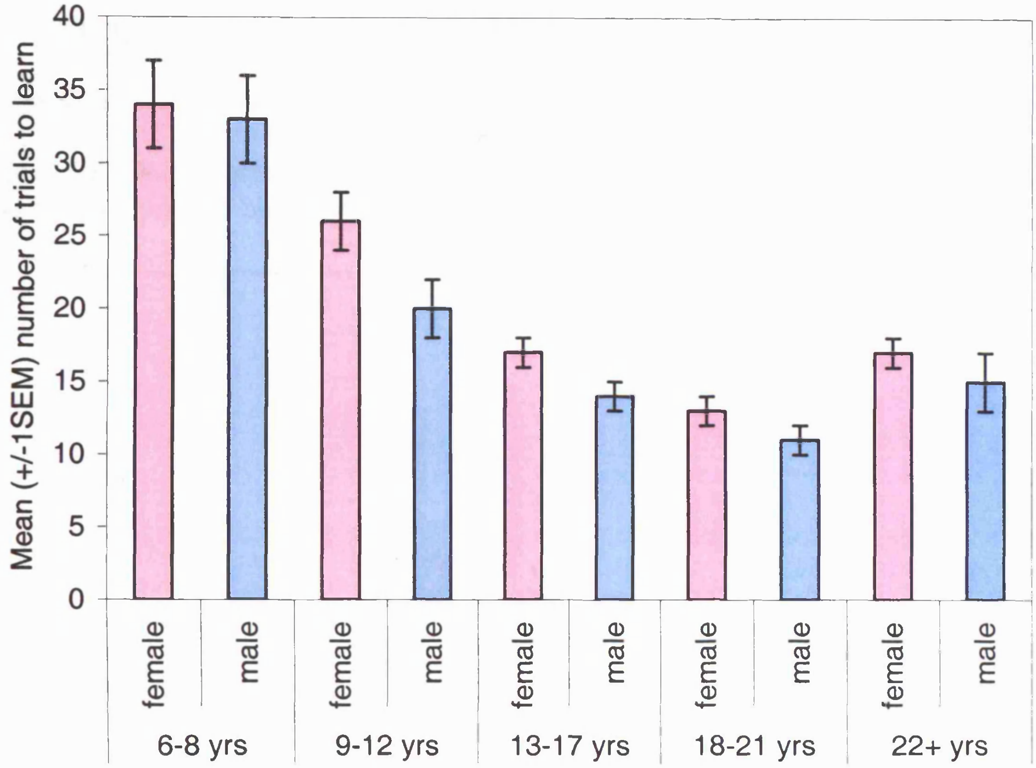


Table 6.2: Break down of Oades Task learning and blocking effects in each age group

	Learning scores	**Blocking scores**		
Age Group	Mean (std dev)	Mean (std dev)	Blocking effects > 0 (one-sample t-test)	Proportion positive blocking (%)
6-8 yrs	33.62 (14.09)	0.68 (3.62)	t(33) = 1.09	50
9-12 yrs	22.72 (12.23)	1.40 (1.95)	t(67) = 5.95**	79
13-17 yrs	15.14 (5.61)	1.42 (1.58)	t(43) = 5.97**	84
18-21 yrs	12.52 (5.73)	1.20 (2.32)	t(32) = 2.98**	78
22+ yrs	15.70 (7.10)	1.99 (2.28)	t(42) = 5.74**	77
Total	20.01 (11.96)	1.38 (2.35)	t(221) = 8.76**	75

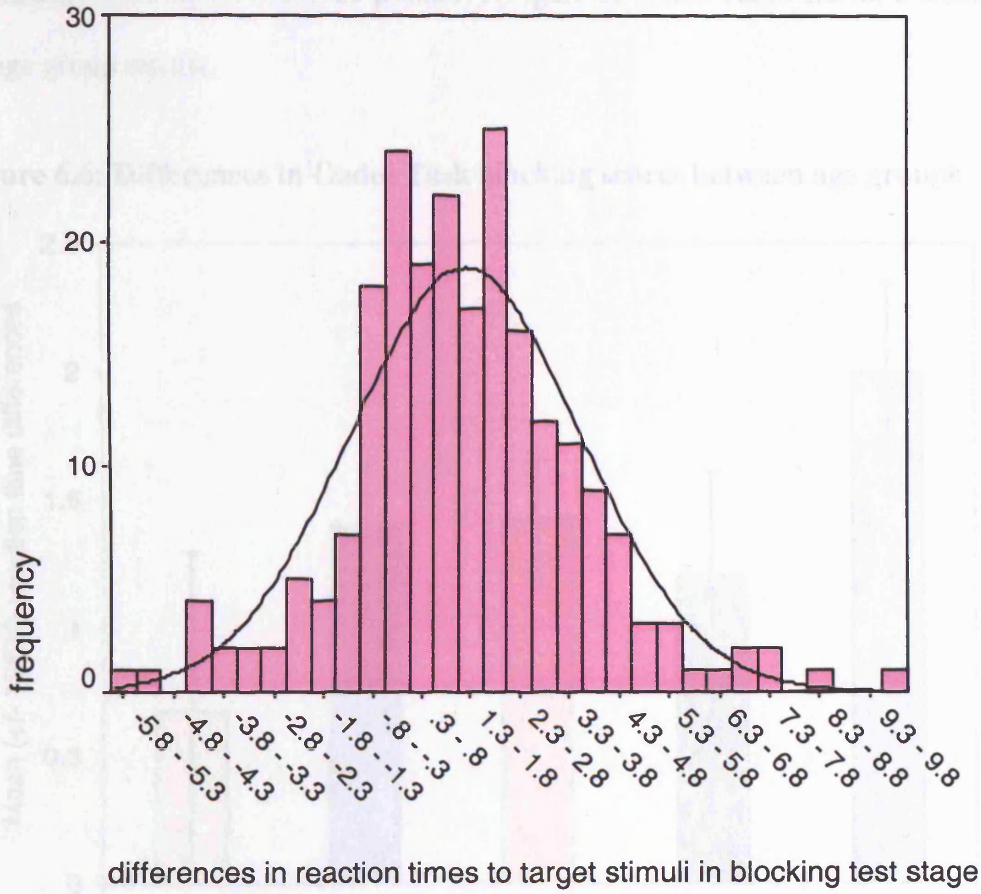
** denotes significance at p<0.01

Key: **Learning scores** = number of trials to criterion in conditioning session, stage 1; **Blocking scores** = difference between reaction times to target stimuli in blocking session test stage

Blocking Scores:

The blocking scores were found to follow a normal distribution such that parametric analysis could be performed. (See Figure 6.5, Kolmogorov-Smirnov = 1.02; p>0.10).

Figure 6.5: Distribution of blocking scores, Oades Task
(Bar labels represent bin range)



Comparisons of Kamin blocking scores across age (Figure 6.6) revealed no significant main effect for age group F(4,221) = 1.189; p=0.32. There was also no evidence of a correlation between an individual's age in months and their Kamin blocking score (r(p)=0.109; N=222; p=0.11). However, Kamin blocking effects were not significantly greater than zero in the 6-8yrs group (only). See Table 6.2.

This result is probably due to the high degree of variability within the group scores, most notably in the youngest age group. Examination of the number of 'blockers' (positive blocking scores) to 'non-blockers' in each age group reveals a highly significant difference across ages. A Chi-squared test shows this comparison to be significant (Chi-sq (4) = 13.969 p=0.007) (Figure 6.7). See Table 6.2 for a breakdown of age group results.

Figure 6.6: Differences in Oades Task blocking scores between age groups

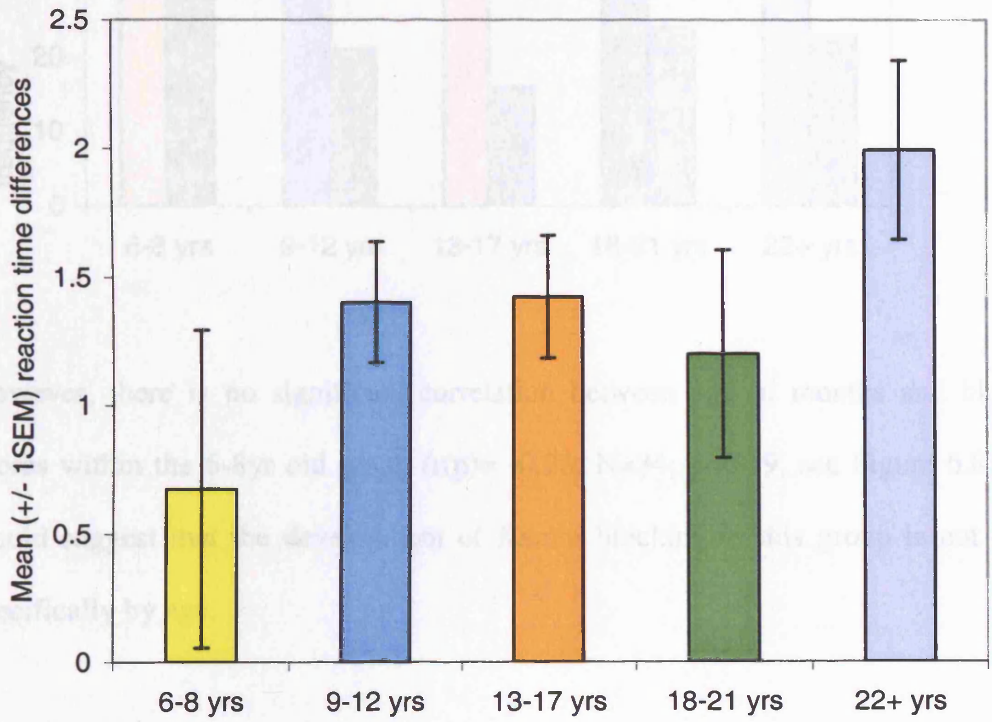
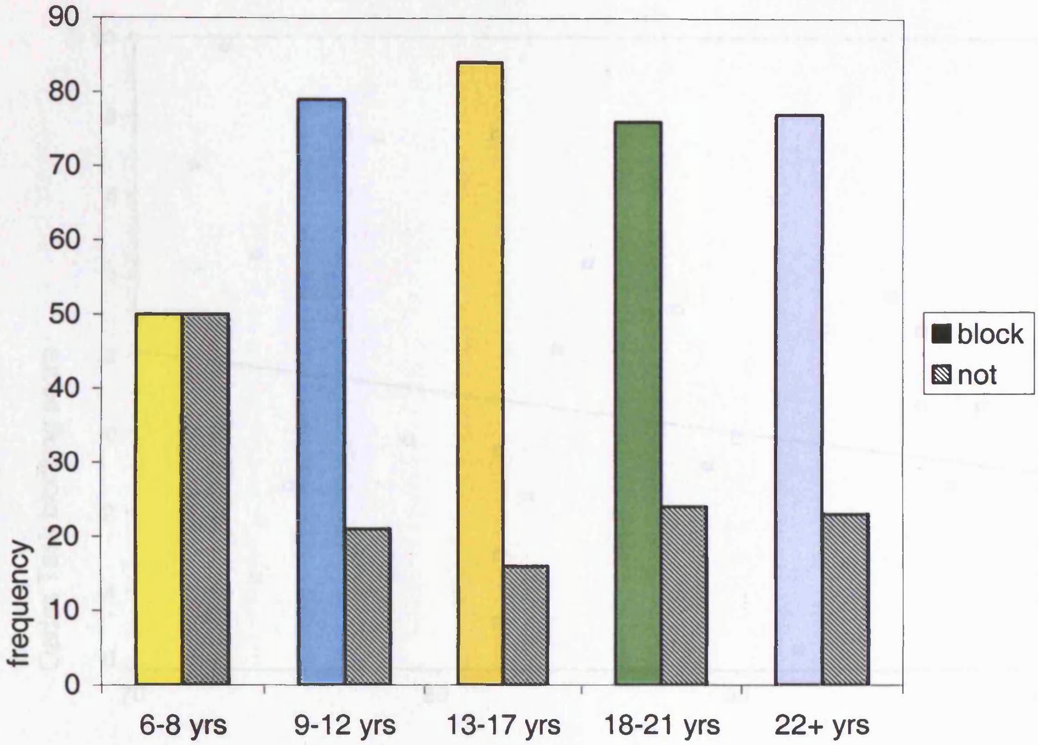


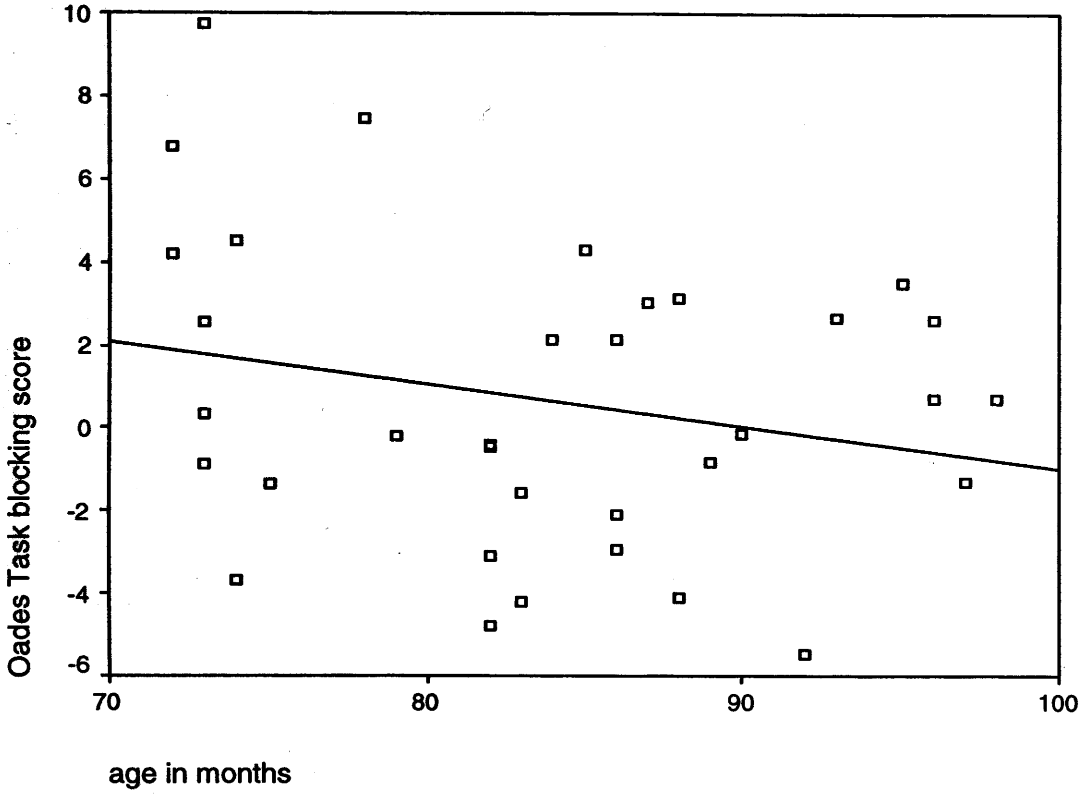
Figure 6.7: Proportion of positive blocking scores in each age group



However, there is no significant correlation between age in months and blocking scores within the 6-8yr old group (r(p)= -0.23; N=34; p=0.19, see Figure 6.8). This would suggest that the development of Kamin blocking in this group is not driven specifically by age.

There were no significant correlations between the ability scores and Kamin blocking scores: r(p)=0.02; N=146; p=0.78 for the BAS standard scores and r(p)=0.07; N=75; p=0.54 for the NART IQ estimate.

Figure 6.8: Relationship between blocking scores (Oades Task) and age (in months) for the 6-8yrs age group



There was an overall effect of sex: F(1,221) = 5.381, p=0.02, with higher scores in females (female mean = 1.74 (std dev 2.73); male mean = 1.03 (std dev 1.86); see Figure 6.7). This was not reflected in the actual number of males and females who showed Kamin blocking (75.23% of females and 74.34% of males positive blocking scores; Chi-Sq (1) = 0.023; p=0.88). This main effect was seen in all age groups (see Figure 6.9) but was most marked in the 13-17 years group.

No significant interaction was found between sex and age group on Kamin blocking scores (F(4,221) = 0.346; p=0.85).

Figure 6.9: Difference in Oades Task blocking scores in males and females

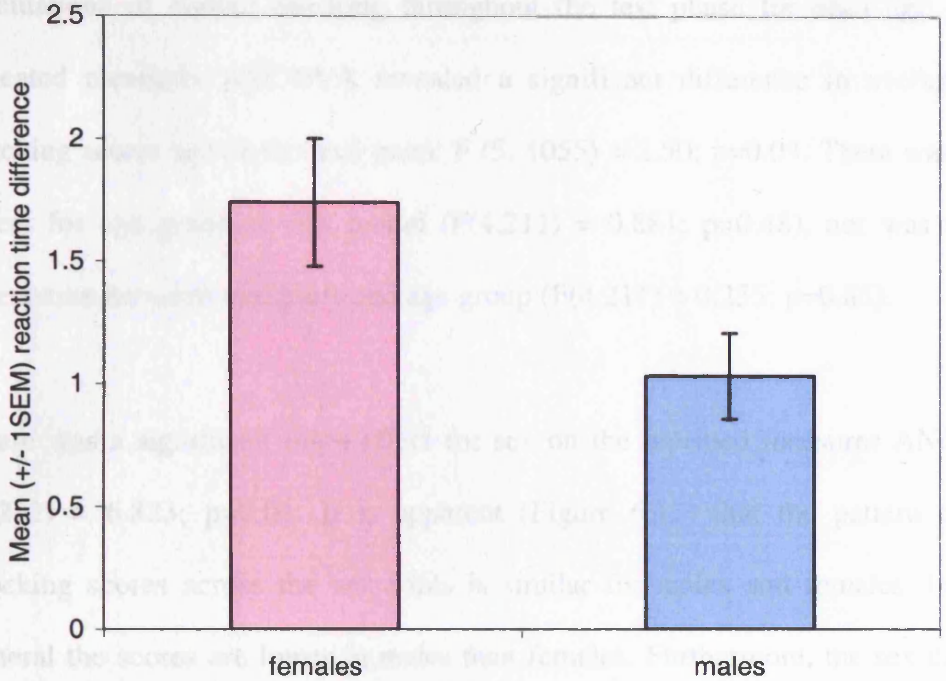
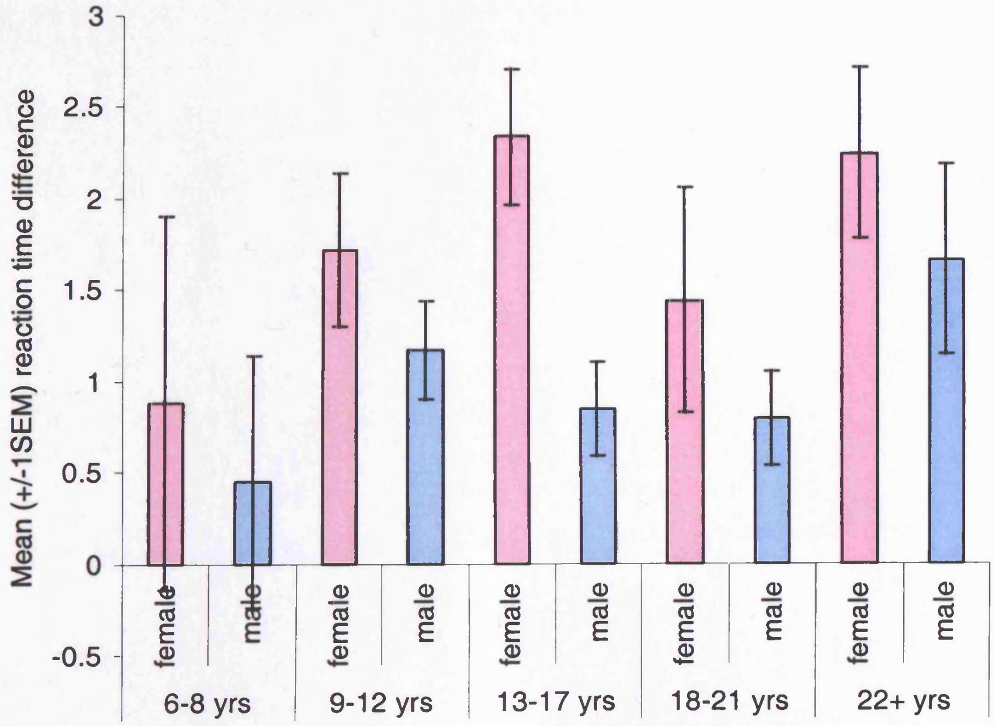


Figure 6.10: Distribution of Oades Task blocking scores by age and sex



Kamin blocking scores were calculated for the six pair groups: Figure 6.10 shows the fluctuations of Kamin blocking throughout the test phase for each age group. A repeated measures ANCOVA revealed a significant difference in average Kamin blocking scores across the trial pairs: F (5, 1055) = 2.50; p=0.03. There was no main effect for age group in this model (F(4,211) = 0.881; p=0.48), nor was there any interaction between trial pairs and age group (F(4,211) = 0.235; p=0.85).

There was a significant main effect for sex on the repeated measures ANCOVA: F (1,212) = 6.823; p=0.01. It is apparent (Figure 6.12) that the pattern of Kamin blocking scores across the test trials is similar for males and females, but that in general the scores are lower in males than females. Furthermore, the sex differences in Kamin blocking scores are concentrated in the beginning of the test phase. There was no interaction between age group and sex (F(4,211)=0.348; p=0.85).

Figure 6.11: Distribution of Oades Task blocking scores by trial pair and age group

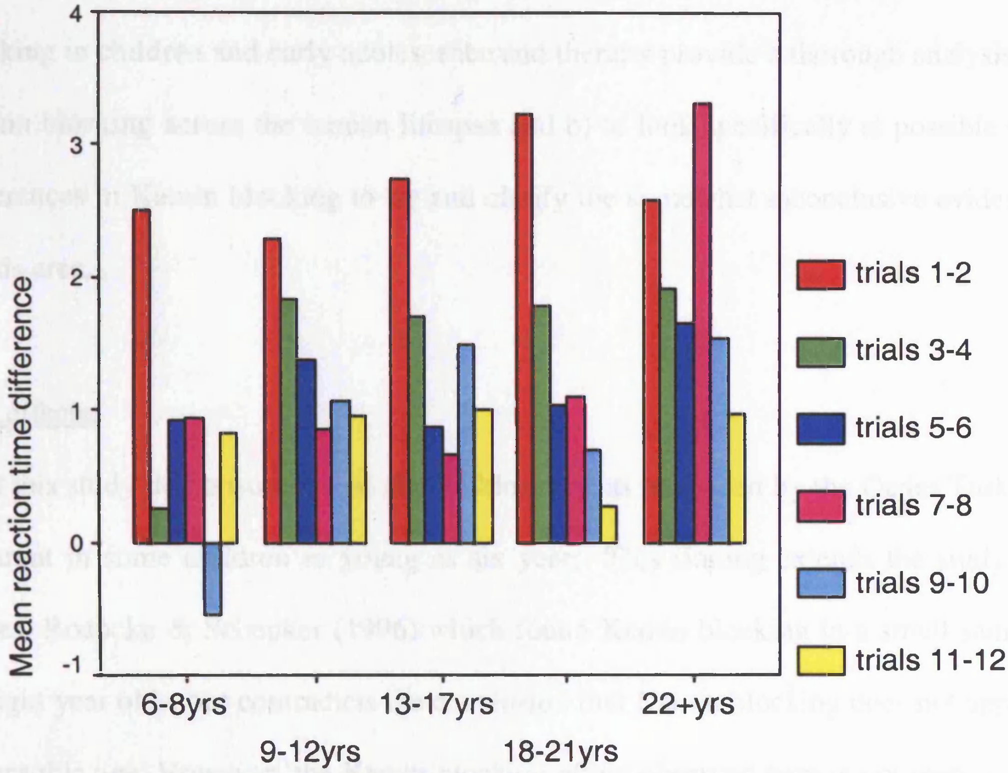
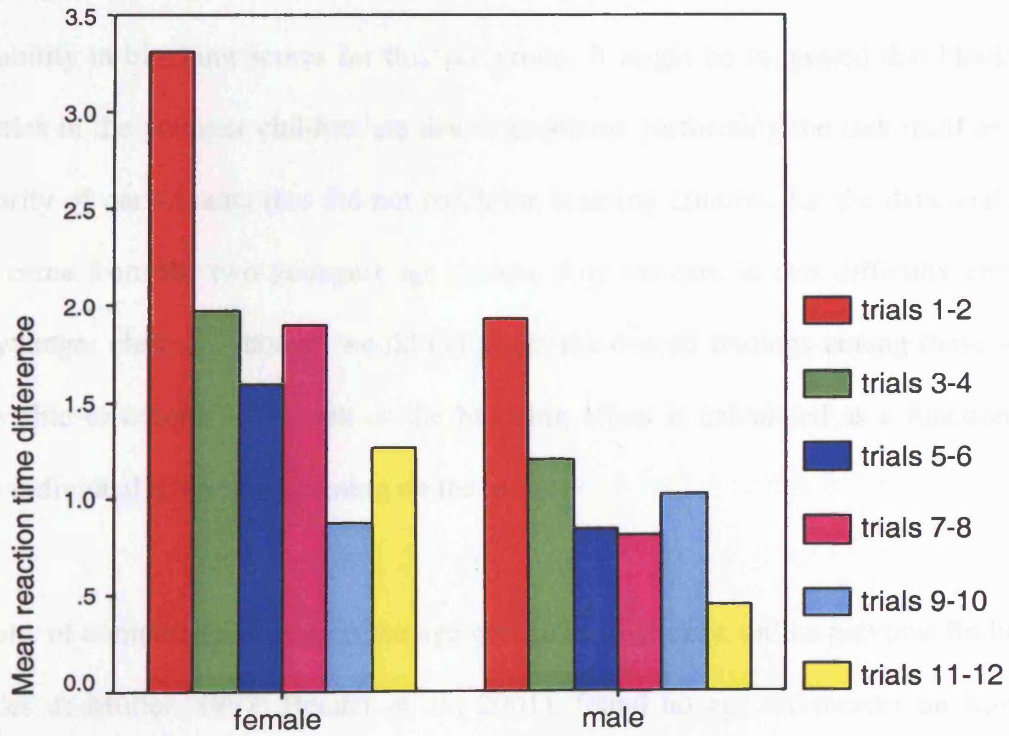


Figure 6.12: Distribution of Oades Task blocking scores by trial pair and sex



6.1.4 Discussion

The main aims of the present study were a) to investigate the development of Kamin blocking in children and early adolescence and thereby provide a thorough analysis of Kamin blocking across the human lifespan and b) to look specifically at possible sex differences in Kamin blocking to try and clarify the somewhat inconclusive evidence in this area.

Age effects:

First this study demonstrates that Kamin blocking, as measured by the Oades Task, is apparent in some children as young as six years. This finding extends the study by Oades, Roepcke & Schepker (1996) which found Kamin blocking in a small sample of eight year olds, but contradicts the conclusion that Kamin blocking does not appear before this age. However, the Kamin blocking effect observed here is not seen in the majority of participants below nine years of age. This is reflected in the increased variability in blocking scores for this age group. It might be suggested that blocking abilities in the younger children are due to problems performing the task itself as the majority of participants that did not reach the learning criterion for the data analysis also came from the two youngest age groups. Any increase in task difficulty among the younger children, though, would not affect the overall findings among those who were able to complete the task as the blocking effect is calculated as a function of each individual's baseline learning on the task.

Results of comparisons between the age groups in this study, unlike previous findings (Oades & Muller, 1997; Bender et al., 2001), found no age differences on Kamin blocking scores. However, an analysis of the ratio of 'blockers' to 'non-blockers' in the sample indicates a significant increase in the occurrence of blocking after age eight. Therefore it is agreed that Kamin blocking is established in childhood but this study suggests that it plateaus in early rather than late adolescence as had been previously suggested (Oades, Roepcke, Schepker, 1996). The factors that influence age of onset and early versus late appearance have yet to be established. Although, further analysis of the blocking scores in the 6-8yr olds suggests that this development is not specifically related to age itself. However, if Kamin blocking represents the *habitual or automatic* filtering of unnecessary information and therefore the increasing automacity of associative learning, then it is possible that this may differ in younger versus older children as a product of increased experience and memory load. That is, by using past regularities to moderate associative learning, a more efficient information processing strategy can be acquired. Therefore, this may develop with age as children gain more experience of past regularities thus necessitating the introduction of these learning strategies.

One other possibility is that cognitive functions such as Kamin blocking become robust internal strategies for mediating attention and learned associations at a stage when formal education becomes more rigorous and fact based. For example, although the National Curriculum in the United Kingdom (from which this sample was drawn) does set out standardised tests from age seven, subjects such as science and mental arithmetic are not formally tested until age eleven. It is also in this second Key Stage that subjects such as History and Geography are introduced. It is of interest to note that the Oades, Roepcke, Schepker (1996) study was carried out in Germany where children begin formal schooling at a later age.

Sex effects:

The study also demonstrates that females show higher Kamin blocking scores than males, a clear finding observed both overall and in each of the five age groups. This was not reflected in the incidence of Kamin blocking per se, but the degree and strength of blocking was higher in females. This contrasts with a previous study using a different task which found Kamin blocking to be absent in females (Jones et al., 1994) and with studies in healthy adults no sex differences are observed (Jones et al. 1990; Oades, Roepcke, Schepker, 1996; Bender et al., 2001). It is possible that task design might influence the observed Kamin blocking effect. For example, Bender et al. (2001) used a modified version of the present task, yet found no significant sex differences among healthy adults (though sex did affect blocking scores in a corresponding patient population). Furthermore, this research in adults was carried out as part of large scale clinical studies with comprehensive testing batteries using a range of cognitive tasks, it is possible that order effects on learning history may play a role in the discrepancy between the present findings and prior studies in adults (see Williams et al., 1994 for discussion).

A breakdown of the overall Kamin blocking scores into six trial pair groups found that the age and sex differences were focussed at the beginning of the test phase. Furthermore, it was not the *pattern* of Kamin blocking scores across trial pairs but the *magnitude* of the effect, which differed with age and sex. This finding parallels the blocking differences seen in people with schizophrenia, which are concentrated at the early test trial pairs (Bender et al., 2001; confirmed by Watson et al., 2001). The progressive decrease in blocking over time that we have observed has been reported previously and may indicate a separate process of 'unblocking' where the participant learns to respond correctly to the second stimulus (Oades, Roepcke, Schepker, 1996; Bender et al., 2001).

The sex differences found in this study may be an artefact of sex differences on the individual skills required to perform the task: differences in these skills may influence superficial task parameters which would arbitrarily moderate the blocking effects derived from the latency calculation. For example, the task involves aspects of joystick control and computer use to locate the target objects. Indeed, informal observations taken during the investigation note that male participants were more proficient at controlling the mouse icon and reported having significantly more experience with computer games (though not specifically with a joystick) than females. Although this may not directly affect their final Kamin blocking scores (as the within-subject design controls for these experiential differences) a shorter learning phase in the second session (where CSA is being pre-conditioned) could mean that the preconditioning of CSA is not of equal strength across all subjects which could in turn lead to less filtering of CSB and less Kamin blocking during the test stage. Therefore, if the males in the study were generally more familiar with computer games and equipment, this could lead to a difference in scores between males and females in the direction found.

Furthermore, a male advantage has been found on target directed spatio-motor tasks that involve integrating movement and visual information (Watson & Kimura, 1991; Hall & Kimura, 1995) which could relate to moving an icon around a screen using an external joystick. The within-subject design is used to control for individual differences in baseline joystick skill. However, if males *as a group* have better control and can move the icon faster, then they are able to correct their mistakes quicker. This consequently, makes their overall reaction time latencies much lower (which in turn are used to calculate the Kamin blocking score) hence providing lower scores without less 'blockers' (participants with positive blocking scores) per se. Alternatively, if males are very proficient at using the joystick it may lead to a different *strategy* in the game as the loss of time due to a misinterpretation of the colour cue is not as detrimental to their point score (i.e. the incentive) as for the females. In addition sex differences in strategy to perform these types of tasks seems to develop early in adolescence (Pezaris & Casey, 1991) and so might have been a factor in the present study.

Alternately, the sex differences could be due to differences in underlying cognitive skills utilised in performing the task (as opposed to Kamin blocking itself). Although not fully supported in Experiments 1-3, Oades et al. (2001) found a number of neuropsychological indices which may be important in this Kamin blocking task. It was found that the speed of learning on the task correlated with problem solving abilities and visual perception while Kamin blocking itself correlated with measures of verbal fluency, immediate visual reproduction and picture completion as well as performance on Stroop interference and the Mooney faces closure test. Measures on the Stroop task emphasise the problems of shifting between automatic and controlled processing and the Mooney faces test involves a need for holistic perceptual abilities (Oades et al., 2001). Sex differences have been explored on the Stroop task: a study (Owens & Broida, 1998) using a manual response version of the Stroop task found a male advantage (i.e. that males experienced less interference) which supports the current findings as it is the *increased* Stroop interference as seen in females that correlates to higher Kamin blocking scores, according to Oades et al. (2001). However, the Owens and Broida finding was not replicated in a later study by Daniel, Pelotte, & Lewis (2000) who found no sex effect on Stroop interference using a verbal response. Here, again, the influence of task design is cited as a possible factor.

Verbal fluency was shown to correlate positively with Kamin blocking scores and for a long time, females have been shown to outperform males on measures of verbal ability from puberty and continuing throughout adulthood (see Maccoby & Jacklin, 1975 and Burstein, Bank, Jarvik, 1980 for reviews). Although in the present study, no overall significant differences were seen in the standardised reading task scores themselves, ability in verbal fluency skills could relate more directly to differences in Kamin blocking scores.

Block design performance and perceptual flexibility (i.e. the ability to see beyond the specific context and situation variables) are cited as advantageous at least when learning the present Kamin blocking task (Oades et al., 2001) and these too seem to show sex differences in other areas of research. Males are reported to be much more 'field independent' than females which gives them an advantage on spatial tasks such as block design and which in turn could help them learn during the Kamin blocking task (see Burstein et al., 1980 for review). Concordantly, the present results do show a non-significant trend for females to require more trials to learn the task. However, according to Maccoby & Jacklin (1975), field independence relates more to analytic than spatial abilities and should reflect an *increased* ability to ignore irrelevant stimuli in the environment during a task, which for our purposes would indicate *increased* Kamin blocking scores for the males. In their review, however, the evidence is confined to purely visuo-spatial tasks and so may not reflect on the mechanisms involved in Kamin blocking.

It should be noted that in a review of meta analyses on sex differences in verbal and spatial abilities (Hyde & Mckinley, 1997), overall effect sizes were small and the authors concluded that no sex differences exist in most areas of verbal function (except in speech production) nor in any measures of spatial function except mental rotation (a view supported by Linn & Peterson, 1985)

Stemming from sex differences in information processing and cognitive functions is the growing body of evidence to suggest that males and females approach these cognitive tasks with different *strategies*. It has been proposed that females process tasks both verbally and on a more holistic/global level (Meurling, Tonning-Olsson, Lavender, 2000; Pezaris & Casey, 1991 among others) while males use spatial and localised processing to solve the tasks. This has been cited as a major factor in the observed differences on spatial tasks. Moreover, the use of less efficient verbal strategies on spatial tasks by females could be a direct cause of their observed deficit in spatial ability (see Linn & Peterson, 1985 for review). Unlike many differences in general cognitive functioning, differences in strategy seem to develop early in adolescence (Pezaris & Casey, 1991) and so could be a factor in the present study.

Findings on computerised maze tasks with and without target information show that boys utilise a speed preferring strategy while girls tended to be more cautious (Klinteberg, Levander, Schalling, 1987). The authors suggest this reflects an impulsive strategy by the boys and a sequential one by the girls. However, in the present task, the impulsive strategy could implicate the use of more automatic processing, thus filtering out unnecessary information and resulting in higher Kamin blocking scores for the males.

On a choice reaction time study, it was hypothesised that observed differences arose from females using a serial strategy when processing visual stimuli (i.e. they process left to right) while males use a binary type method (i.e. they would split the stimulus string into two halves and process as chunks) (Adam, Paas, Beukers, Wuyts, Spijkers, Wallmeyer, 1999). This reflects the verbal versus spatial strategies used in spatial tasks. If the colour panel (in which the target stimuli appeared) was perceived in this way in the present study, it could have led to the results described.

Meurling et al. (2000) found that, in a range of neuropsychological tests, males seemed to use a "speed-preferring" strategy while females tended to be more cautious. These authors also concluded that perhaps females overall used a less definitive strategy and showed more flexibility in problem solving methods. Here again, the speed strategy could lead the males in the present study to be more impulsive and therefore show more Kamin blocking. Alternatively, by being overly cautious, the females could spend more time at the learning stages and hence be more pre-exposed to CSA leading to higher Kamin blocking effects. While the present data are unable to confirm the approach used during the game, it would seem that differences between males and females on the strategies used in neuropsychological tasks are consistent and could lead to differences in overall performance, and hence blocking scores, as was seen here.

There are two factors that may moderate sex differences in cognitive functions. First, a fundamental difference in brain lateralisation has been proposed by a number of authors as the cause of the observed sex differences not only in overall performance on neuropsychological tasks but also in the strategy used to solve the tasks. Spatial tasks such as mental rotation and visuo-spatial memory as well as mathematics and science at school in which boys traditionally outperform girls, are activities predominantly arising in the right hemisphere. Females, on the other hand, seem to have an advantage on predominantly left hemisphere tasks such as language at school and specifically verbal fluency and articulation speed tasks (Pezaris & Casey, 1991; Meurling et al., 2000; Davidson, Cave, Sellner, 2000). It has been concluded from these investigations, as well as imaging studies and observations on behavioural deficits following head injuries, that males have a more lateralised brain organisation than females. Thus, in females both hemispheres are activated during verbal and other tasks which increases language abilities but has a detrimental effect on spatial skills. In males however, we find asymmetrical activity between the hemispheres during spatial and verbal tasks indicating increased lateralisation of cognitive functions (Burstein et al., 1980 for review; Davidson et al., 2000).

A second influence on cognitive performance may be the pharmacological effects of hormones and specifically the sex steroids oestrogen and testosterone (see Burstein et al., 1980 for review). The Geschwind-Behan-Galaburda model (Geschwind & Galaburda, 1987), although criticised by some authors as being somewhat inconsistent with research findings (Bryden, Mcnamus, Bulman-Fleming, 1994), indicates how masculinising hormones such as testosterone could have an organising effect on the developing brain during gestation (Halpern, 1994). Testosterone, it is hypothesised, inhibits the size of the left cerebral hemisphere, which modifies (left hemisphere) functions such as language. Moreover, it subsequently increases growth in the right cerebral hemisphere which influences right hemisphere functions such as spatial ability (Geschwind & Galaburda, 1987). Importantly, it is this notion of a sexually dimorphic hemispheric development which is generally reflected in more current research on brain development (see Castle et al., 2000 for review).

Other evidence for hormonal influence on cognition comes form studies on women at different stages of the menstrual cycle. Hampson (1990) found hormonal changes during the cycle produced consistent effects on performance in a range of cognitive tasks. The authors suggest that oestradiol and progesterone aid "female-like" abilities such as verbal fluency and articulatory skills but provide detrimental effects on "male-like" abilities such as spatial cognition and abstract reasoning. The cyclical nature of hormonal influence is not confined to women either: evidence suggests that male hormones also vary during the day and can lead to variations in spatial skills performance similar results are found across different cultures and throughout the lifespan (Halpern & Tan, 2001). Further support comes from studies of female to male transsexuals where performance on spatial tasks is seen to improve after the start of androgen treatment (Van Goozen, Cohen-Kettenis, Gooren, Frijda, Van De Poll, 1994). Finally, experimental evidence on animals supports the innate importance of steroidal hormones on the brain both during and after development (Kanit, Taskiran, Yilmaz, Balkan, Demirgoran, Furedy, Pogun, 2000; Halpern & Tan, 2001 for review). Though the present study found sex differences in pre-pubertal aged children, the above evidence suggests a role for hormonal influence brain organisation and function even prior to the hormonal changes occurring at puberty.

Implications for clinical research:

The finding of sex differences among the normal population in cognitive functions such as Kamin blocking raises important issues for schizophrenia research. It is well documented that male and female schizophrenia patients differ in age of onset (Cowell, Kostianovsky, Gur, Turetsky, Gur, 1996; Lewine et al., 1996), symptomatology (Goldstein et al., 1998; Nopolous, Flaum, Andreasen, 1997) and course of illness (see Castle et al., 2000 for review of gender differences in epidemiology). A recent review of the literature further argues for an overall male bias in the epidemiology of schizophrenia (Aleman et al., 2003). Such differences in manifestation of the illness leads to problems in equating the level of dysfunction in males and females within a schizophrenia patient population. Differences in the occurrence of psychiatric disorders may be mediated by underlying differences in cognitive function. Studies often do not account for these differences in the samples and analyses they use (see Wahl & Hunter, 1992 for review), and many authors have cited this sampling bias as problematic when drawing clear conclusions from the literature (Nopoulos et al., 1997; Lewine et al., 1996; Goldstein et al., 1998; Cowell et al., 1996). Although, it should be noted that sex differences in neuropsychological tasks have not been found in actual patient samples (Goldberg, Gold, Torrey, Weinberger, 1995; Hoff, Wieneke, Faustman, Horon, Sakuma, Blankfield, DeLisi, 1998) once pre-morbid cognitive factors are removed. More specifically though, if experimental paradigms such as blocking are to be used to investigate the level of dysfunction in people with schizophrenia, any fundamental sex differences in this ability must be accounted for when interpreting results from clinical studies.

One interesting implication of the present finding is that the increased Kamin blocking scores of females might relate to an increase in normal functioning and filtering abilities (i.e. decreased Kamin blocking is observed in clinical populations such as schizophrenia). If this is so, then perhaps this more robust filtering process in some way protects females from these disorders. A recent study by Weiser, Reichenberg, Rabinowitz, Kaplan, Mark, Nahon & Davidson (2000) on pre-morbid cognitive functioning in patients with schizophrenia found that females had a lower pre-morbid IQ than males. Thus if, in a non-clinical population and controlling for IQ differences, females have increased Kamin blocking abilities compared to males (as shown in the present study), it follows that for Kamin blocking function to decrease to the levels seen in patients with schizophrenia (both males and females), the IQ of females at-risk for schizophrenia would indeed be decreased further than that of similarly pre-disposed males. This would further account for the observed epidemiological differences in schizophrenia (Castle et al., 2000). As mentioned above, sex differences in Kamin blocking could be due to sex-typed hormonal influences on the brain. In addition, it has previously been suggested that oestrogen may underly the later onset of schizophrenia in women (Seeman, 1997). Therefore, Kamin blocking may be a behavioural consequent of this neuro-protective system. In this way it is important to further investigate the mechanisms involved in Kamin blocking and other measures of learned inattention.

Anomalous findings in student groups:

Finally, it is of interest to note the trend for females in the 19-21 years group to have much lower Kamin blocking scores than both their older and younger counterparts. As this is not seen to the same extent in the male participants there may be a particular characteristic in females of this age that is affecting their scores. One possibility is that the females sampled in this age group have a bias towards the 'male-like' visual-spatial strategy described in the above discussion. In the Pezaris & Casey (1991) study, they identified a population of females who were "high math/science" achievers with non right-handed immediate relatives and consequently illustrated such a "male-like" performance. While it is unlikely that the present group of females fit this profile exactly, it is possible that by recruiting from a population of specifically *Psychology* (BSc) undergraduates, there was a bias towards females with higher maths and science abilities. It may follow that these females were able to utilise more visual-spatial strategies when completing the Oades Task and thus obtaining a different pattern of scores to the other females in this study.

Conclusion:

In summary, the present findings demonstrate that the ability to perform the attentional filtering required for Kamin blocking first appears around age six in humans and is consistent by early adolescence. We have demonstrated a clear sex difference in Kamin blocking scores (on the Oades Task) that is present from the earliest age group tested. These effects are concentrated in the first two trials of the test phase, which corresponds to the specific trials where Kamin blocking deficits are seen in people with schizophrenia (Bender et al., 2001; Watson et al., 2001). The existence of a clear early sex difference in Kamin blocking abilities has particular implications for neurodevelopmental theories of schizophrenia.

Data and conclusions from the preceding study were published during completion of the present thesis. See Crookes & Moran (2003) for details.

6.2 Re-analysis of sex effects in Experiments 1-4

In light of the finding of a significant sex difference in Kamin blocking scores in the present study, the blocking scores from previous experiments were re-analysed to evaluate this difference. In the present study, the females demonstrated higher blocking scores than the males across all age groups. This effect was confined to absolute mean blocking scores rather than the proportion of positive blocking score ('blockers') and was concentrated in the initial trial pairs of the test stage.

Method:

For each study (where possible) and for each blocking measure, t-tests were performed to analyse the differences between male and female group scores. In addition, a chi-sq analysis was performed (again where blocking measures permitted) to analyse the frequency of positive blocking scores in each group.

Note that for all Tables below 'blockers' refers to participants demonstrating a positive blocking score from the Task calculation and thereby suggesting the presence of blocking effects

Experiment 1:

Participants: 7 males; 21 Females. All participants were drawn from a student sample as part of a course requirement.

Results: No differences observed at $p<0.05$ level, see Table 6.3.

Table 6.3: Results of sex analyses in Experiment 1

	Mean blocking: reaction times (std dev)	Difference Test	**Mean blocking:** number of hits (std dev)	Difference Test	**Frequency blockers:** reaction times	Chi-square test	**Frequency blockers:** number of hits	Chi-square test
Males	0.05 (0.17)	-----------	-1.00 (1.63)	-----------	5 (71%)	------	1 (14%)	-------
Females	0.001 (0.15)	t(26) = 0.72	0.38 (3.35)	t(26) = -1.04	12 (57%)	Chi-sq (1) = 0.78	11 (52%)	Chi-sq (1) = 3.88

Experiment 2:

Participants: 18 males; 38 females. Participants recruited from University population either as paid volunteers or as part of a course requirement.

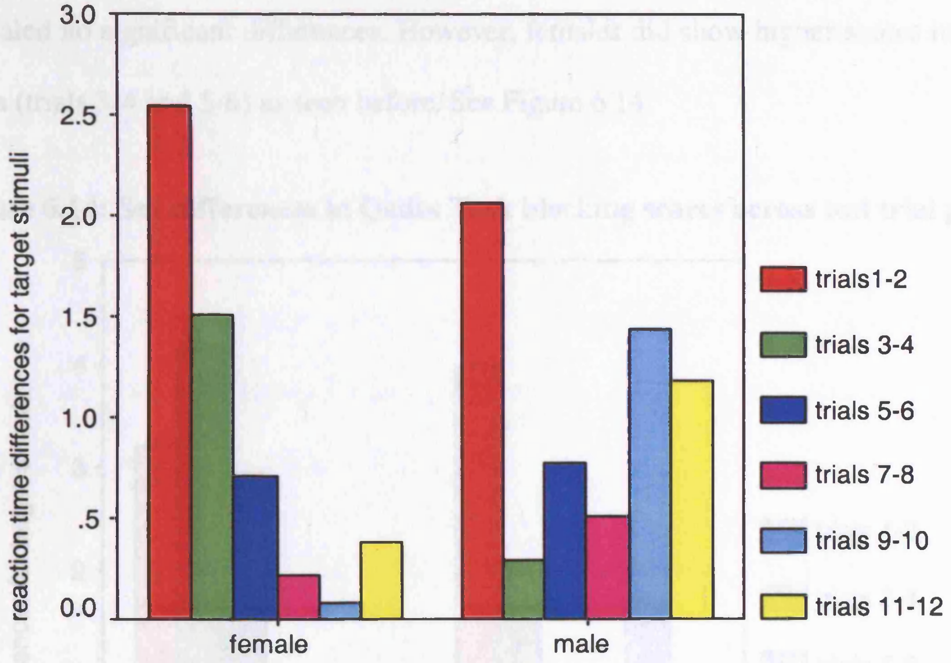
Results: No differences observed at $p<0.05$ level, see Table 6.4.

Table 6.4: Results of sex analyses in Experiment 2

	Mean Blocking: Jones Task (std dev)	Difference Test	**Mean Blocking:** Oades Task (std dev)	Difference Test	**Frequency blockers:** Jones Task	Chi-squared test	**Frequency blockers:** Oades Task	Chi-squared test
Males	-1.39 (9.52)	-----------	1.03 (1.60)	----------	10 (56%)	--------	12 (67%)	--------
Females	-1.32 (15.65)	t(54) = 0.02	0.91 (1.60)	t(54) = -0.26	14 (37%)	Chi-sq(1) = 1.75	29 (76%)	Chi-sq(1) = 0.58

An analysis of group differences of blocking scores on individual Oades Task trial pairs also revealed no significant differences. However, the females were seen to have higher blocking scores at the start of the test stage which tentatively supports the pattern found in Experiment 5. But, this pattern was reversed in the later trial pairs leading to little overall difference. See Figure 6.13

Figure 6.13: Sex differences in Oades Task blocking scores across test trial pairs



Experiment 3:

Participants: 21 Males; 20 Females. Participants recruited from University population as above.

Results: A significant sex difference was found on the frequency of positive blocking scores, see Table 6.5.

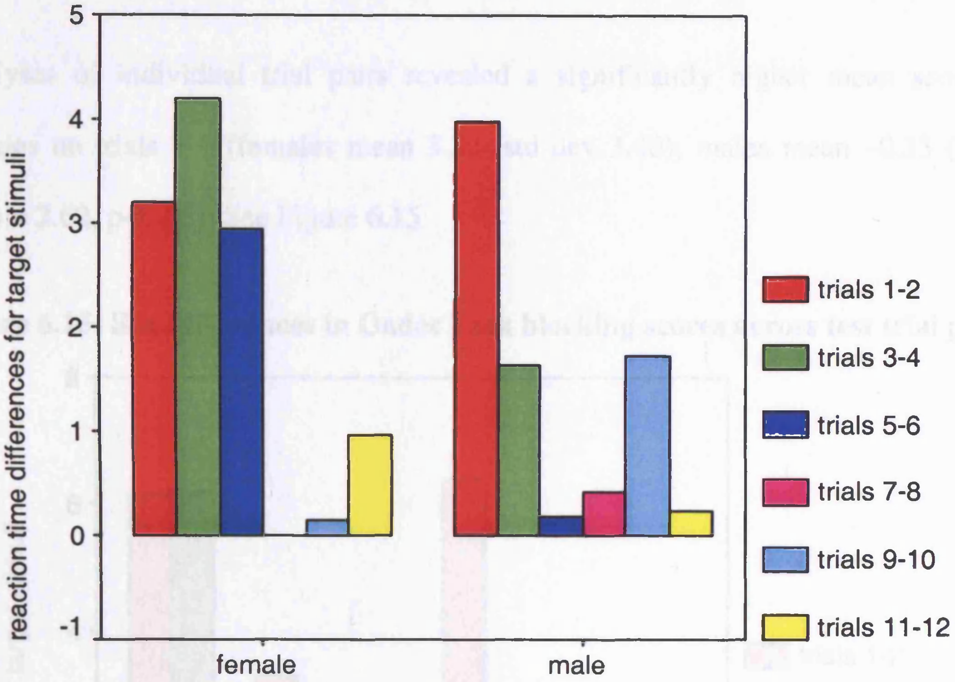
Table 6.5: Results of sex analyses in Experiment 3

	Mean Blocking: Chapman Task (std dev)	Difference Test	**Mean Blocking:** Oades Task (std dev)	Difference Test	**Frequency blockers:** Chapman Task	Chi-squared test	**Frequency blockers:** Oades Task	Chi-squared test
Males	55.71 (58.68)	-----------	1.36 (2.80)	----------	19 (90%)	--------	12 (57%)	--------
Females	45.05 (66.43)	t(39) = 0.55	1.89 (1.91)	t(39) = -0.70	16 (80%)	Chi-sq(1) = 0.90	18 (90%)	Chi-sq(1) = 5.63*

* denotes significance at p<0.05 level

An analysis of group differences on individual trial pairs of the Oades Task also revealed no significant differences. However, females did show higher scores in early pairs (trials 3-4 and 5-6) as seen before. See Figure 6.14

Figure 6.14: Sex differences in Oades Task blocking scores across test trial pairs



<u>Experiment 4</u>

Chapman-back Task – There was only one male participant in this group which precludes any analysis of sex differences.

Oades-back Task –

Participants: 8 Males; 12 Females. Participants recruited from University population as before.

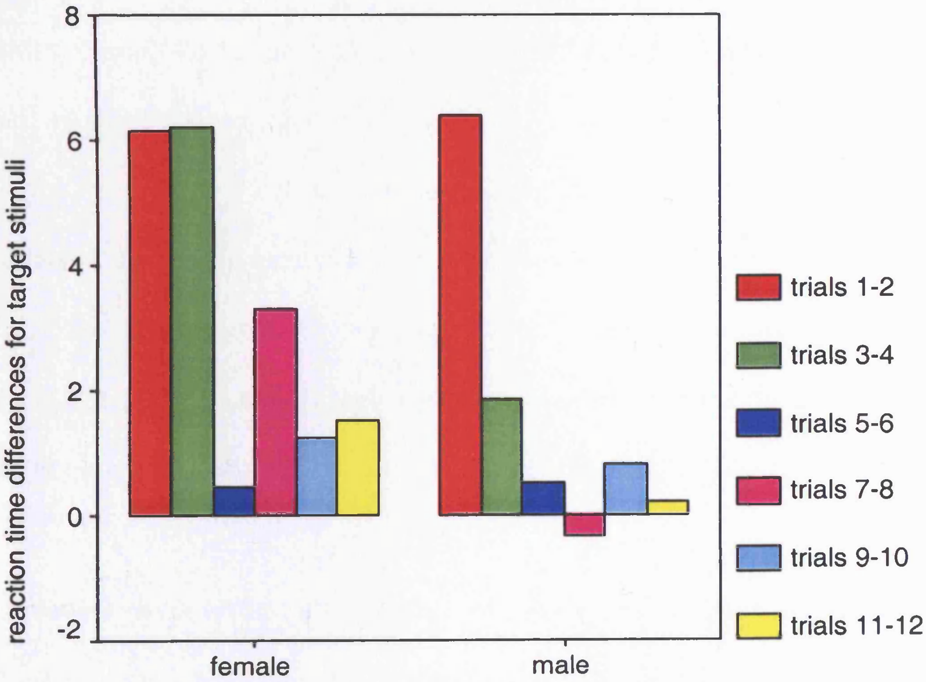
Results: No differences observed at p<0.05 level, see Table 6.6.

Table 6.6: Results of sex analyses in Experiment 4

	Mean Blocking: Oades Task (std dev)	Difference Test	**Frequency blockers:** Oades Task	Chi-squared test
Males	1.71 (1.52)	----------	7 (88%)	--------
Females	3.15 (2.79)	t(18) = 1.32	11 (92%)	Chi-sq(1) = 0.09

Analyses of individual trial pairs revealed a significantly higher mean score for females on trials 7-8 (females mean 3.32 (std dev 3.40); males mean –0.33 (2.80); $t(18) = 2.62$, $p<0.05$). See Figure 6.15

Figure 6.15: Sex differences in Oades Task blocking scores across test trial pairs



Summary and Conclusions

Analyses of sex differences in the previous samples has suggested some parallels with the sex effects found in Experiment 5. On the Oades Task, although there were no consistent effects reaching significance, the pattern of results does indicate higher blocking in females particularly in trial pairs 3-4. In addition, Experiment 3 revealed a significantly higher proportion of positive blocking scores in females. No sex differences were found for either Jones A, B, or the Chapman Tasks. This suggests that such sex effects may be peculiar to the visuo-spatial nature of the Oades Task. However, conclusions drawn from the preceding analyses should be tempered with the caveat that the male to female ratio in previous Experiments was not controlled.

CHAPTER SEVEN

GENERAL DISCUSSION

7.1 Introduction

As discussed in the introduction, Kamin blocking and other learned inattention phenomena have been found to be deficient in major psychiatric disorders such as schizophrenia. Consequently, these paradigms have taken a central role in studies of the underlying cognitive and pharmacological deficits seen in schizophrenia. Furthermore, Kamin blocking in particular has potential to be useful as a pre-morbid indicator of schizophrenia and as such could be importantly utilised as part of high-risk assessment batteries for pre-morbid treatment. The present work has aimed primarily to evaluate the particular measures of blocking in humans which have been utilised in clinical research.

Specifically, the main aims for this thesis were a) to investigate the association between blocking tasks from the literature b) to assess whether these tasks were similarly affected by experimental manipulations c) to evaluate the role of population variables such as age and sex in the mediation of blocking effects.

These issues arose from observations of discrepant findings across the Kamin blocking literature and in particular when looking at clinical populations. Of specific interest were the differences between blocking measures used in the associative learning domain and those applied to clinical research. The importance of these issues derives from the current employment of Kamin blocking as an experimental analogue of attentional deficits seen in schizophrenia and it's potential importance to future research. However, a promoted role for Kamin blocking in clinical research and in particular as a behavioural marker of pre-psychotic adolescents is dependent upon a clear understanding of the human manifestation of Kamin blocking and a reliable method for studying these mechanisms.

Two approaches were used to investigate the relationship between task parameters: a direct comparison of two different procedures described as measures of Kamin blocking in a within-subject design and an investigation of the effects of a procedural manipulation on these measures. In the main (and due to an initial inability to demonstrate blocking in one of the behavioural tasks), the blocking scores compared were those from a contingency judgement and a behavioural response task. In addition measures of neuropsychological function and schizotypal personality were taken to investigate the underlying cognitive mechanisms which may be involved in each task. Finally, to examine population variables which could affect blocking observations reported in clinical studies, the behavioural task from the clinical literature was measured in a wide range of age groups and between male and female participants. By undertaking these investigations the thesis aims more generally to assess the utility of these blocking measures with a view to their increasingly important potential in schizophrenia research.

The findings from these investigations along with the questions that remain and the future research that they suggest will be summarised below.

7.2 Summary of Findings

7.2.1 Replication of Kamin blocking effects

As a precursor to the main comparison studies, Experiment 1 looked at the effects of a design manipulation on one of the most cited tasks from the clinical literature (Jones et al., 1990). With a view to the potential comparison of blocking measures within individual participants, the Jones flankers task (Jones A) originally developed in a between-subject design had been modified to within-subject and the effects of this modification were assessed in this study. The results indicated that the revised task failed to produce blocking effects in the present sample. The most likely explanation for this was in the simplicity of the task such that learning differences across stimuli were too minute to be observed by the blocking measures. Perhaps the between subject design is better able to amplify these differences such that they are observable. Moreover, the within-subject design led to an increase in trials which consequently increases the speed of 'unblocking' (extinction of blocking as blocked stimulus is re-learnt) which would further obscure blocking effects. It was decided not to pursue the assessment of blocking with this task as a comparison between two within-subject blocking designs was preferable for the following evaluation of the equivalency of blocking procedures than to introduce between group factors. Therefore, another within-subject task from the clinical literature was acquired for use in Experiment 2

7.2.2 Comparison studies

Experiment 2 compared blocking measures obtained on the Oades (behavioural) Task (Oades, Roepcke, Schepker, 1996) with those from the Jones (contingency judgement) Task (Jones B; Jones et al., 1997). This is an important comparison in itself because it highlights a key practical division in blocking research: clinical investigations which demonstrate blocking deficits in schizophrenia and other clinical populations have primarily employed measures with behavioural responses similar to Pavlovian conditioning in animals (the single exception being that reported in Jones et al., 1997); while models of human learning processes derived from investigations on healthy participants primarily utilise contingency judgement tasks. The present study also assessed performance on Kamin blocking tasks against measures of neuropsychological functions and schizotypal personality traits. No relationship was found between the measures of blocking from the two tasks. Importantly, this was over and above the measures of learning on the tasks which themselves demonstrated a positive relationship. This suggested that blocking from the two task formats was not equivalent. However, the contingency judgement task did not in itself show robust blocking effects in the present sample. The ratings for the target stimuli were not significantly different in this sample indicating no active cognitive process had been involved. Therefore, no definite conclusion could be drawn about the relationships between the scores.

Experiment 3 sought primarily to verify the results indicated in the previous study by repeating the comparison with a more robust contingency judgement task. Although the Chapman task has not directly been involved in clinical studies, it represents a contingency judgement format which has been found to show robust blocking effects on numerous occasions. This study, therefore, repeated the previous procedure with this alternative task. The findings confirmed those from Experiment 2 that no relationship exists between the blocking measures from the different task formats.

Taken together, the results from the first three studies indicate that there is little relationship between the calculated blocking scores from different task formats. It also highlights the difficulty in replicating blocking effects and the sensitivity of these measures to changes in task parameters and sample demographics. The indication could be that the cognitive functions involved in these tasks are not comparable and moreover may not all index 'blocking' and learned inattention as has been implied particularly by the clinical literature.

7.2.3 Backward blocking manipulation effects

In Experiment 4, the question of whether the tasks were in fact measuring a similar cognitive function, namely blocking, was assessed by investigating the effect of a trial order manipulation on blocking measures from the two tasks in Experiment 3. This followed an approach implemented by previous authors in the comparison of animal and human procedures. Specifically, the effect of a backward blocking manipulation on the contingency judgement and behavioural response tasks from Experiment 3 was explored. In Section 4.2, it was argued that the dissociation between measures could be accounted for by an underlying dichotomy in accounts of human learning. That is, the behavioural tasks seem more fitted to an associative explanation of learned inattention as modelled by Rescorla-Wagner (1972), Mackintosh (1975) and more recently in the attentional models of Kruschke (2000) while the contingency judgement tasks have proven to be less applicable to these accounts and more related to probabilistic and comparative accounts of learning processes.

One of the fundamental differences between these theoretical models is their ability to cope with retrospective revaluation and trial order effects as seen in backward blocking. In particular, backward blocking has been seen primarily in contingency type formats (including the Chapman Task used presently) and only observed in animal studies when the biological significance is low (Miller & Matute, 1996) and in human Pavlovian conditioning when outcome additivity is indicated (Mitchell & Lovibond, 2002). However, it could be argued that by indicating outcome additivity in the instructions this form of conditioning is essentially reduced to a probabilistic judgement similar to contingency judgement set-ups. Backward blocking has not previously been successfully demonstrated in wholly behavioural response procedures such as the Oades Task.

The results from Experiment 4 replicated previous reports of blocking effects in backward contingency judgement procedures and importantly, also revealed significant blocking effects in the behavioural task regardless of the trial order manipulation. The fact that backward blocking effects can be observed in both procedures regardless of the previously found dissociation between them questions the reliability of this approach in determining procedural equivalence.

This study presents the first successful demonstration of backward blocking in a behavioural task. However it is somewhat unexpected as it suggests the Oades Task is not accurately portrayed by purely associative accounts of learning such as the Rescorla-Wagner models as was considered in Experiment 3. Yet the procedures of this task still do not intuitively fit the blocking modelled by the alternative probabilistic or comparator systems: this requires further explanation. However, revisions of the associative accounts as well as the more contemporary models of Kruschke which focus on attentional mechanisms and are also able to incorporate backward blocking effects may be able to account for the backward blocking found in this behavioural task. Indeed, Kruschke (2000) has argued that backward blocking is a result of learned inattention mechanisms from studies using a forced choice task. As Waldmann (2000) discussed, there may be fundamental differences between learning processes in causal and non-causal contexts. The present findings, then, provide support for proposals discussed in Chapter One – that blocking may be a natural phenomenon in animals, including humans, which is utilised as a strategy for selecting between competing stimuli across environmental contexts.

In particular, the Oades Task could be described as an example of blocking of non-conscious attentional processes and contingency judgements as blocking of conscious, deductive processes. From the present findings it seems likely that the blocking seen in contingency judgments reflects more logical reasoning processes than associative or attentional mechanisms. De Houwer & Beckers(2003) also provide support for this position and following a recent investigation have concluded that deductive reasoning processes must be "at least partially" involved during blocking of contingency learning procedures (pg 354). There is evidence that schizophrenic patients may also have deficits in logical reasoning processes (Goel & Bartolo, 2004) which would account for findings of decreased blocking in patients during contingency learning tasks (Jones et al., 1997). However, this consequently suggests that such findings should be considered separately from those acquired during blocking of behavioural procedures.

7.2.4 Age and sex effects on Kamin blocking

Experiment 5 moved from procedural factors involved in blocking effects to assess population parameters. The Oades Task has been used on numerous occasions in the clinical literature to explore group differences in clinical and normal populations. This has been done in both children and adults. However, the effects of population demographics such as age and sex have not been fully explored either on the blocking measures from this task itself, or more fundamentally on the development and manifestation of blocking functions. This has important implications for drawing conclusions in clinical studies. For example, sex is known to affect onset, symptoms and potentially prevalence of schizophrenia. The samples used in clinical studies are often opportunity samples taken from in-patient populations, which may bring inherent sex bias to the study. It is important, therefore, to understand how these factors may affect blocking in themselves in order to reliably extrapolate the results of the experimental manipulation of interest. Furthermore, the development of blocking processes in the brain is of interest not only for current research but also if this model were to be used as part of early intervention strategies and assessment batteries which would inevitably rely on childhood identification of the neurological soft signs. In general, it has been argued here that we require a full understanding of the development and parameters of blocking functions in healthy humans as part of reliable and valid investigation of clinical population deficits.

The present results of this large scale study found that blocking functions begin to develop at age six and become concrete cognitive functions in early adolescence. Moreover, females were found to have higher blocking scores than males across all age groups. The age effects seen here support the putative role for blocking as part of pre-psychosis identification assessments as it should be observable in healthy, non-psychotic children by early adolescence. However, although studies suggest blocking deficits represent underlying genetic anomalies and therefore are likely developmental in aetiology, it remains to be seen whether blocking deficits are present from the outset. The results were discussed in terms of hormonal affects on cognitive functions as well as differences in approach and strategy used on experimental tasks between the sexes. Consideration was given to the clinical implications of the findings.

A post hoc analysis of previous samples for sex effects revealed tentative support for these findings. However, of the four tasks described, the sex effects were limited to the Oades Task procedure. This could suggest that this finding is task specific and an artefact of particular parameters of this visuo-spatial procedure rather than underlying selective attention. It is not possible to draw definite conclusions from these analyses but this would indicate the need for further evaluation of sex effects in Kamin blocking.

7.3 Implications for Theoretical and Clinical Applications

As discussed in Chapter One and at various points throughout, blocking has gained important applied roles in clinical and associative human learning research. In the following sections, the role of blocking paradigm in three key areas is discussed in light of the present findings.

7.3.1 Validity of Kamin blocking as an animal model of schizophrenia deficits

The studies described in this thesis did not directly investigate the theoretical validity of Kamin blocking as a model of schizophrenia deficits in line with the Willner (1984) hierarchy. Nevertheless, by looking at the practical parameters of the blocking measures themselves, we are able to gain a better understanding of the definition and manifestation of blocking in humans and its relationship to the animal blocking model. In light of these findings, we are able to consider how reliably the current blocking measures can be said to reflect underlying cognitive functions which may be deficient in schizophrenia. In this way the position of Kamin blocking as an experimental model for schizophrenia can be assessed and the validity of this role discussed.

A key finding of this thesis is the lack of relationship between two different experimental procedures for measuring blocking in humans. Although both formats have variously shown a decrease in people with schizophrenia, there is some suggestion that these are not deficiencies in the same process. This questions the utility of blocking measures or at least highlights the need for a standard measure to be employed in future research. It indicates that observation of group differences on a task between schizophrenic patients and healthy controls is not enough to confirm that the task necessarily follows the functions being measured in the original animal paradigms (and thereby the pharmacological models). This sentiment was reflected by Frith (1992a) who points out that models such as Kamin blocking and Latent Inhibition as employed in schizophrenia research are not delimited by specific cognitive functions as is assumed by the way they are utilised, but may be the behavioural outcomes of various underlying processes. As discussed in the present studies, blocking may be demonstrated within a number of cognitive processes and so when blocking is utilised in clinical research the specific cognitive function under test may need to be further specified. Additionally, this would indicate that the assessment of *attentional* processes in schizophrenia may be restricted to particular blocking tasks. However, blocking may still remain a highly useful paradigm in clinical studies as it may enable us to measure deficits in these other underlying processes.

It is unclear whether the contingency judgement procedures are accurate human analogues of the blocking observed in animals. For example, amphetamine administration has been found to decrease blocking in animals but this has not been easily replicated in humans – this could be due to the incompatibility of the human and animal tasks used in these studies. Nevertheless, the finding of backward blocking in the Oades Task demonstrates that there is some degree of equivalence. It has been proposed that contingency judgement and behavioural measures reflect different forms of blocking phenomenon – that one is attentional blocking and the other probability judgement or deductive reasoning strategy. This has implications for the theoretical validity of blocking in that when we talk about face or even construct validity of blocking in humans we must qualify this as specifically the attentional blocking analogue. In a recent review of Latent Inhibition, Lubow argues that construct validity of these models depends on their relationship to underlying attentional processes (Lubow, in press). The present work then would question the validity of at least some current Kamin blocking measures as experimental models for schizophrenia. Indeed, Lubow describes the Latent Inhibition model of schizophrenia deficits as deficits in the automatic processing of stimuli (hence the need for a masking task in human Latent Inhibition procedures) which suggests the learned inattention paradigm would pertain more to the behavioural and physiological response Kamin blocking measures and not the blocking observed from contingency judgement tasks. However, research finding a deficit in contingency judgment blocking in schizophrenia may also be of interest but as an independent phenomenon. It may be found through future research that reasoning processes are similarly affected by the disorder and thus blocking in this form may also be utilised as a model of dysfunction with face or other validity but this is as yet unknown. Furthermore, in terms of pharmacological support which has thus far utilised Pavlovian conditioning set-ups in animals, this may be related more to the attentional blocking processes and cannot be used as support for blocking seen in human contingency learning. Although Miller & Matute (1996) argued that the demonstration of backward blocking in animal set-up was supportive that the animal paradigms are analogous to contingency judgement in humans, the present findings do not suggest this conclusion.

7.3.2 The use of Kamin blocking as a pre-morbid indicator of psychosis

How does the present research shed light on the potential use of Kamin blocking in early intervention treatment of schizophrenia? The findings indicate that Kamin blocking as measured by the Oades Task is apparent in children as young as six years and should be present in normal development by age eight. Therefore, it does imply that this task could be used as a pre-morbid indicator of psychosis. However, further research would be necessary to demonstrate the specificity of blocking in high-risk children and the ability of Kamin blocking to differentiate future patients at this age.

In addition, the role of participant strategy and stimulus interpretation when completing the tasks has been discussed in several contexts throughout the thesis. Our findings have shown blocking effects can be observed in young children using a behavioural response task: if a more complex or judgment based task were to be utilised an additional understanding of the development of deductive reasoning processes may be required to accurately interpret the scores obtained (i.e. to make a reliable assumption that the scores are reflective of the necessary blocking strategies). Even with regards to the behavioural task used in Experiment 5 research would be needed to ensure that the blocking scores achieved by children do reflect the same mechanisms (and therefore the same dysfunctional systems) seen in adult samples. That is, the task is used to measure deficits in attentional processes thought to be indicative of schizophrenia in adults but decreases in blocking scores in children may not necessarily reflect this specific dysfunction. Again, longitudinal research investigating blocking scores in high-risk children would be important to overcome this issue.

These studies also suggest the role which sex may play in the development and observation of blocking in humans. If blocking is generally higher in females, the scores obtained as part of a high-risk assessment would need to be compared against age and sex norms to observe any true deviance. Moreover, it was postulated that the higher blocking in females may relate to an underlying protective factor which could account for the later age of onset in this group. Although highly speculative, if cognitive functions which become deficient in schizophrenia are increased in females prior to psychosis onset, it would suggest that future pre-morbid assessments using blocking (and potentially other measures of attention) may be less sensitive indicators of psychosis risk in this group.

The above summary suggests that if Kamin blocking is to be taken into the realm of early intervention research it would be at least necessary to employ a standardised measure for which population norms are well understood. However, it should be noted that even with these parameters the role of Kamin blocking in this area is limited. The issue of early intervention in schizophrenia was discussed in the Introduction (section 1.9) where it was noted that such a strategy had many ethical and practical pitfalls – not least of which being the potential for false positives. It was suggested that cognitive measures could be employed to further identify vulnerable individuals from an at-risk sample. It was as part of such a test battery that Kamin blocking could be implicated. That is, Kamin blocking would form part of a series of tests which would indicate the presence of cognitive anomalies found in schizophrenia. Thus the potential of Kamin blocking is as a partial 'marker' for psychosis-proneness rather than an independent 'diagnostic tool' for schizophrenia among the general population. Moreover, several criteria would need to be surpassed before this application is realised. For example, greater understanding of the attentional nature of the task is required and stronger evidence for the links between the task and schizotypal measures must be shown. Only at this point could investigation turn to high-risk individuals where the ability of Kamin blocking to dissociate pre-psychotics from healthy individuals could be evaluated. Inasmuch as the Kamin blocking deficit is reliably observed in schizophrenia and (as a model of) selective attention is theoretically linked to the underlying dysfunctions, there is support for further research focussing on this direction.

7.3.3 Associative learning models of Kamin blocking

Again, it was not the goal of the studies in this thesis to directly add or extend learning theory itself: extensive investigation of stimulus selection and Kamin blocking has already been done and continues to be studied by other researchers (e.g. De Houwer & Beckers, 2002a-c; Lovibond, 2003; Waldmann, 2000). However, the present findings have indirectly highlighted an important issue for this field: that different blocking tasks may not be cognitively related and therefore they may not be accounted for by the same learning models. That is, investigations using blocking to test theories should perhaps not be looking for a single model which fits all research evidence. Blocking effects drawn from different task formats may involve different underlying processes.

Traditionally the models have been divided into two groups – associative and probabilistic models. However, as illustrated by the present findings as well as much current research (for reviews see De Houwer et al., in press; Lopez, Cobos, Cano, Shanks, 2004 among others), this dichotomy may be uninformative and restrictive. The focus is now shifting towards developing newer accounts of learning processes specific to humans. These models have begun to look at the links between learning and attention and take into account context and experimental effects likely to influence human task performance.

Therefore, we should not take blocking as a learning process against which learning models should be tested rather we should see blocking as a phenomenon that occurs within (or a property of) a range of cognitive functions including associative learning, probability reasoning, attention and social cognition. In this way blocking is perhaps less useful or important in providing a definitive end to the debate on associative learning models. Indeed, it suggests that blocking effects can be differentially explained within a range of learning contexts and processes and therefore the recent attempts to develop a holistic model of blocking effects are futile. Alternatively it is illustrative of the complexity of human learning processes as being required and utilised across the great variety of situations which occur in daily life.

7.4 Future Directions

The series of studies described in this thesis have presented a number of potential directions for future research, which are described in the following section.

Although the comparison studies demonstrated a discordance between the blocking measures, it did not produce any further information about the neuropsychological measures which may underpin the tasks. Previous research has suggested blocking in the Oades Task is linked to cognitive functions such as Stroop interference, Gestalt perception and to a lesser degree verbal fluency and immediate visual memory (Oades et al., 2000). However, that study was primarily an investigation of differences between clinical and healthy populations and was not itself a specific scrutiny of cognitive functions involved in blocking effects. In the present study, the multiple regression analyses were somewhat confounded by small sample sizes relative to the number of predictors. However, in light of the differences indicated across these studies, a more stringent assessment of different neuropsychological functions (including those specifically employed in the earlier report) involved in normal blocking functions is necessary for a more definitive description of blocking mechanisms.

This finding further suggests that the performance of schizophrenic patients on contingency judgement tasks should be further investigated. Although Jones et al., (1997) report decreased blocking in patients using their contingency judgement task (Jones B here), the present failure to produce blocking effects with this task suggests it may not be a robust measure of blocking. The present studies indicate the Chapman Task to be a better and more consistent measure but this has itself not been assessed in clinical sample. However, contingency judgment tasks such as those used here may be too complex for clinical populations as has been noted by several authors (Serra, 1995; Jones et al., 1997). Moreover, the importance of the participant's interpretation of the instructions and implementation of the correct strategy is seen to be pivotal for blocking effects in these tasks and could be confounding factors in comparisons across clinical and healthy groups.

Potentially different forms of blocking could be used to investigate parallel deficits in the disease: attention processes, associative learning processes and potentially logical reasoning processes. Therefore, it could expand the utility range of blocking models in schizophrenia research. Importantly, these deficiencies in reasoning have been suggested to relate specifically to the aetiology of delusional symptoms (Goel & Bartolo, 2004). This illustrates the potential for blocking phenomena under different cognitive functional paradigms could be used to investigate the parameters of individual symptoms.

The finding of backward blocking in the Oades Task was surprising although it does reflect conclusions by Miller & Matute (1996) that tasks low in biological relevance are needed for backward blocking effects. However, as this is the first demonstration of backward blocking in human behavioural tasks, replication of this in a wider population would be necessary to consolidate this finding in the face of previous failures.

The sex differences found in Experiment 5 suggest that there may be a hormonal influence on Kamin blocking which could be indicative of the hormonal protective factor for schizophrenia in women. This is of particular relevance given the hypothesised role of oestrogen in the development and manifestation of schizophrenia (Seeman, 1997; Hoff, Kremen, Wieneke, Lauriello, Blankfeld, Faistman, Csernansky, Nordahl, 2001). It may be of interest to look at differences in Kamin blocking in women with varying levels of hormones: either at different stages of the menstrual cycle or in menopausal women who are and are not maintaining hormone levels through Hormonal Replacement Therapy. The sex effect requires further investigation: tentative assessment of sex effects in the other Tasks used here suggests that it may be an artefact of the spatial aspect to this particular computer program. Although in the Oades Task there was no significant difference in learning scores, if females generally approach the spatial and joystick element of the task with more caution and feel they are less able to perform it accurately this could change the way they approach the task regardless of underlying blocking abilities and regardless of actual performance on the task. It is therefore necessary to assess more comprehensively whether the sex difference is seen in other blocking procedures that do not involve spatial or "computer game" elements.

Finally, the present studies along with numerous accounts in the literature indicate the dependence of blocking effects on task and context parameters. It could be argued that in order to fully understand the manifestation of blocking in humans it is necessary to observe blocking phenomena in natural settings. Researchers have already started to do this by developing tasks based on social contexts, but even these remain laboratory-based tasks. It would be of great interest to try to observe the presence of blocking functions in natural settings and real-life decision making/attention contexts.

7.5 Conclusions

The aim of the thesis was to examine variables which contribute to the variability in the literature and to assess the relationship of different human measures of blocking. Five experiments were performed as part of the present thesis. There were three main findings: that blocking measures from different task formats are not related; that backward blocking can be observed in both contingency judgement and behavioural blocking measures; and finally that blocking function as measured by the Oades Task develops in childhood and is increased in females. These findings have been discussed in terms of their implications for future schizophrenia research in particular the potential use of blocking as a pre-morbid indicator in early intervention strategies, and in terms of the bearing they may have for models of learning processes in humans and how blocking may be accounted for by the current proposed models.

The findings have suggested many issues, which would need to be addressed in future research. The initial difficulties in demonstrating blocking effects in two of the tasks (Experiments 1 & 2) itself illustrates the fragility of the effects perhaps symbolising the discrepancies seen in the wider literature. However, it suggests that the effects seen here also require replication and therefore the conclusions drawn must be tentative at this stage.

The failure to find any relationships between the neuropsychological and schizotypal measures with the blocking tasks was contrary to previous reports and perhaps suggests that a more stringent and comprehensive test battery could be developed to investigate this issue. However, the primary goal of the present studies was to investigate the relationship between the two blocking measures and the questions left unanswered about cognitive and personality variables can be examined in future research.

In conclusion, the present studies caution against assuming that findings from different studies using different task formats are equivalent. They highlight the need to specify the task and population parameters involved when collating findings of "blocking deficits" in clinical populations. This is of particular importance when such findings are used as evidence to develop and support theoretical models of underlying cognitive pathology.

APPENDICES

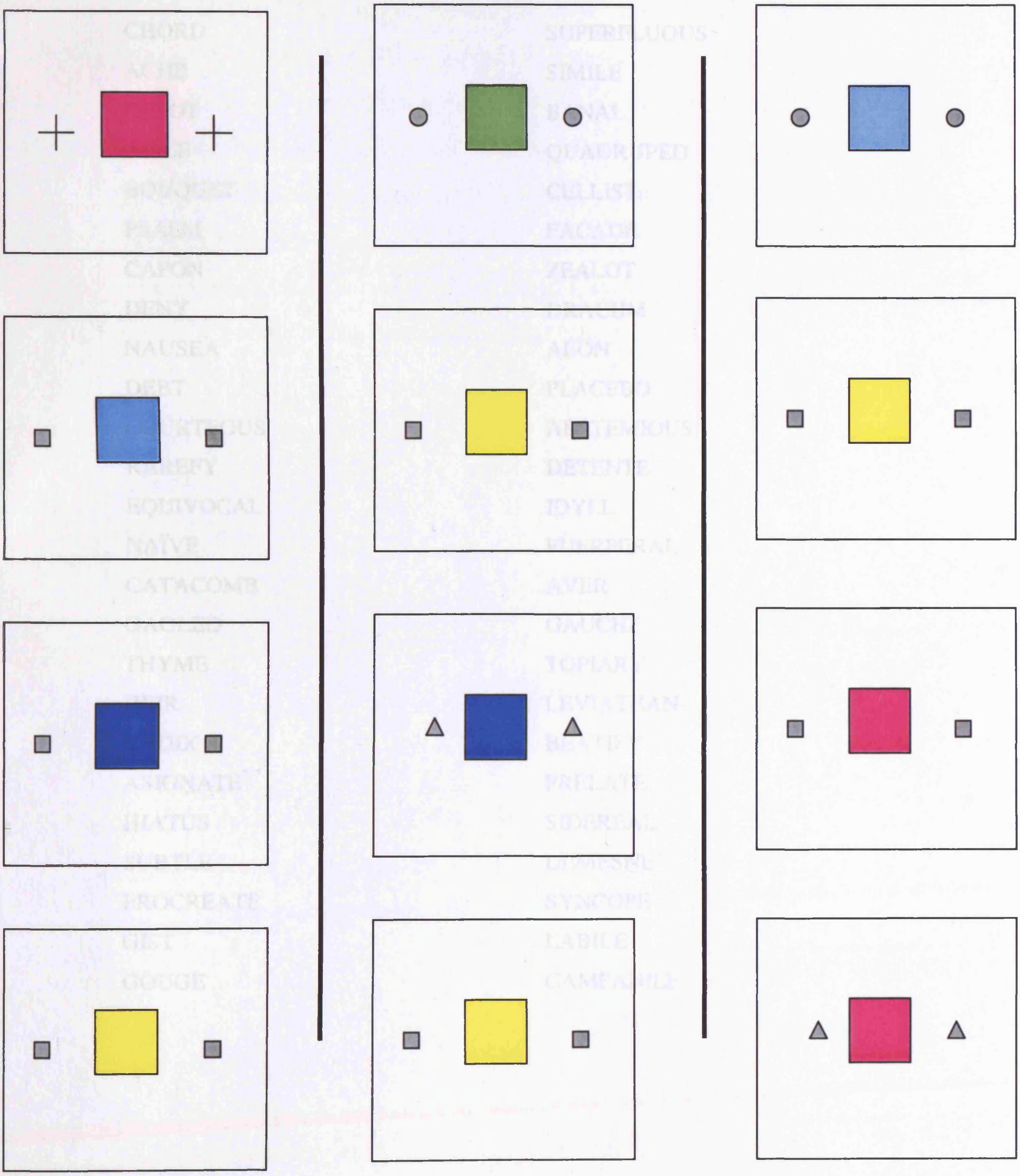
Instructions and Protocols

Statistical Appendices

Appendix One

Jones (1990) Flankers Task

Stage 1 **Stage 2** **Stage 3**



Appendix Two a

National Adult Reading Test
Word List
(Nelson, 1992)

CHORD
ACHE
DEPOT
AISLE
BOUQUET
PSALM
CAPON
DENY
NAUSEA
DEBT
COURTEOUS
RAREFY
EQUIVOCAL
NAÏVE
CATACOMB
GAOLED
THYME
HEIR
RADIX
ASIGNATE
HIATUS
SUBTLE
PROCREATE
GIST
GOUGE

SUPERFLUOUS
SIMILE
BANAL
QUADRUPED
CELLIST
FACADE
ZEALOT
DRACHM
AEON
PLACEBO
ABSTEMIOUS
DETENTE
IDYLL
PUERPERAL
AVER
GAUCHE
TOPIARY
LEVIATHAN
BEATIFY
PRELATE
SIDEREAL
DEMESNE
SYNCOPE
LABILE
CAMPANILE

Appendix Two b

NART INSTRUCTIONS

You will now be taking a short reading test based on the "National Adult Reading Test". You should have a list of 50 words in front of you. All you need to do is start at the top of the list (left hand column) and read through the list pronouncing each word as clearly and correctly as you can. Don't worry if you do not recognise the word, just try to guess how it may be pronounced. The list is designed so that many people will not recognise all the words in it.

Please speak into the recorder and try to leave a break between each word. If you have any questions please ask the experimenter.

Appendix Three a

Annett Handedness Questionnaire

Name Age Sex

Were you one of twins, triplets at birth or were you single born?

Please indicate which hand you habitually use for each of the following activities by writing R (right), L (left), or E (Either)

Which hand do you use:

1. To write a letter legibly?
2. To throw a ball to hit a target?
3. To hold a racket at tennis, squash or badminton?
4. To hold a match whilst striking it?
5. To cut with scissors?
6. To guide a thread through the eye of a needle (or guide needle on to thread)?
7. At the top of a broom while sweeping?
8. At the top of a shovel when moving sand?
9. To deal playing cards?
10. To hammer a nail into wood?
11. To hold a toothbrush while cleaning your teeth?
12. To unscrew the lid of a jar?

If you use the right hand for all of these actions, are there any one-handed actions for which you use your left hand? Please record them here.

....

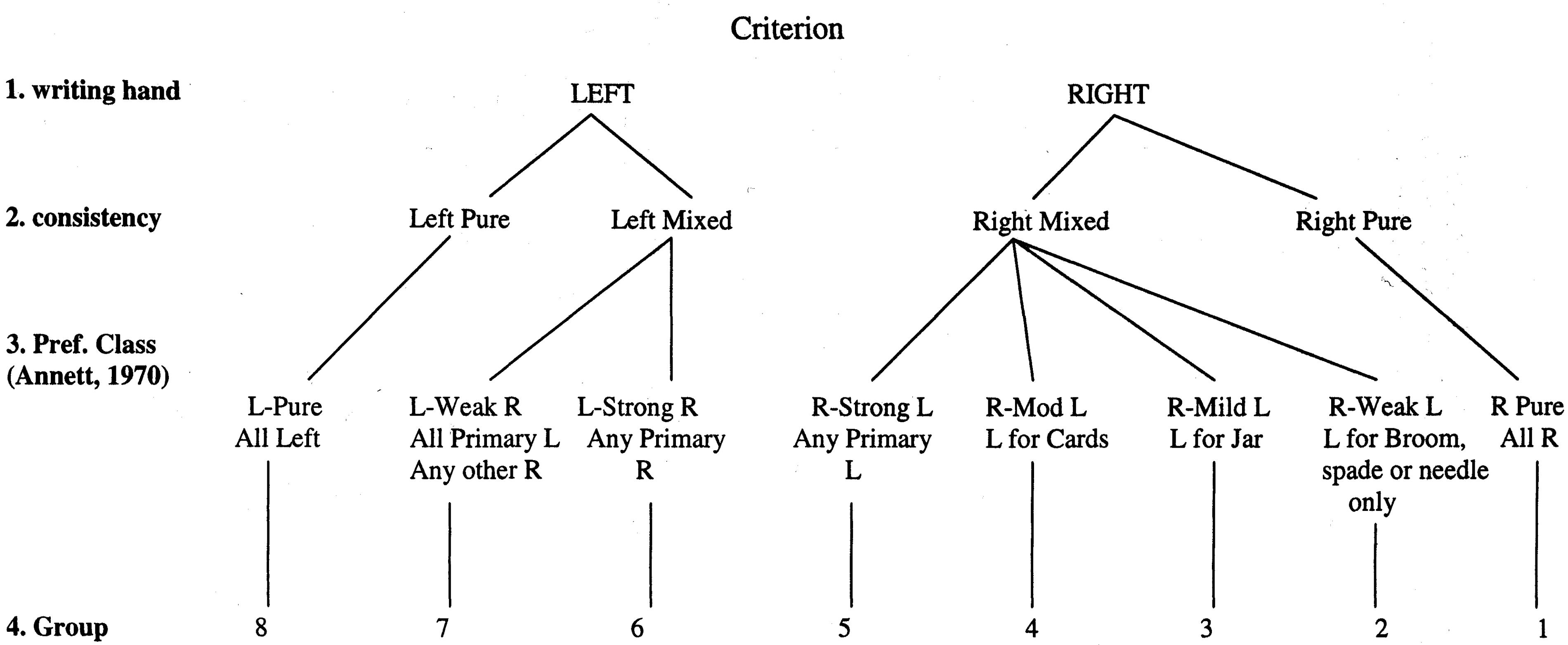
If you use your left hand for all of these actions, are there any one-handed actions for which you use your right hand? Please record them here.

....

Appendix Three b

Annett Handedness Questionnaire

Category Flow-chart



Key: **Primary actions** = writing, throwing, racket, match, hammer, toothbrush
Nonprimary actions = scissors, needle, broom, spade, dealing cards, unscrewing jar

Appendix Four

PRE-TEST QUESTIONNAIRE

(remember you do not have to answer any questions you feel uncomfortable with and all personal details are kept anonymous)

Participant Code:

Gender:

Date of Birth:

Educational Level reached:

Course / Occupation:

Any Visual Problems (glasses/problems with colours/ dyslexia)?

Any history of psychological illness in the family?

The following refer to your use of computer technology in everyday life:

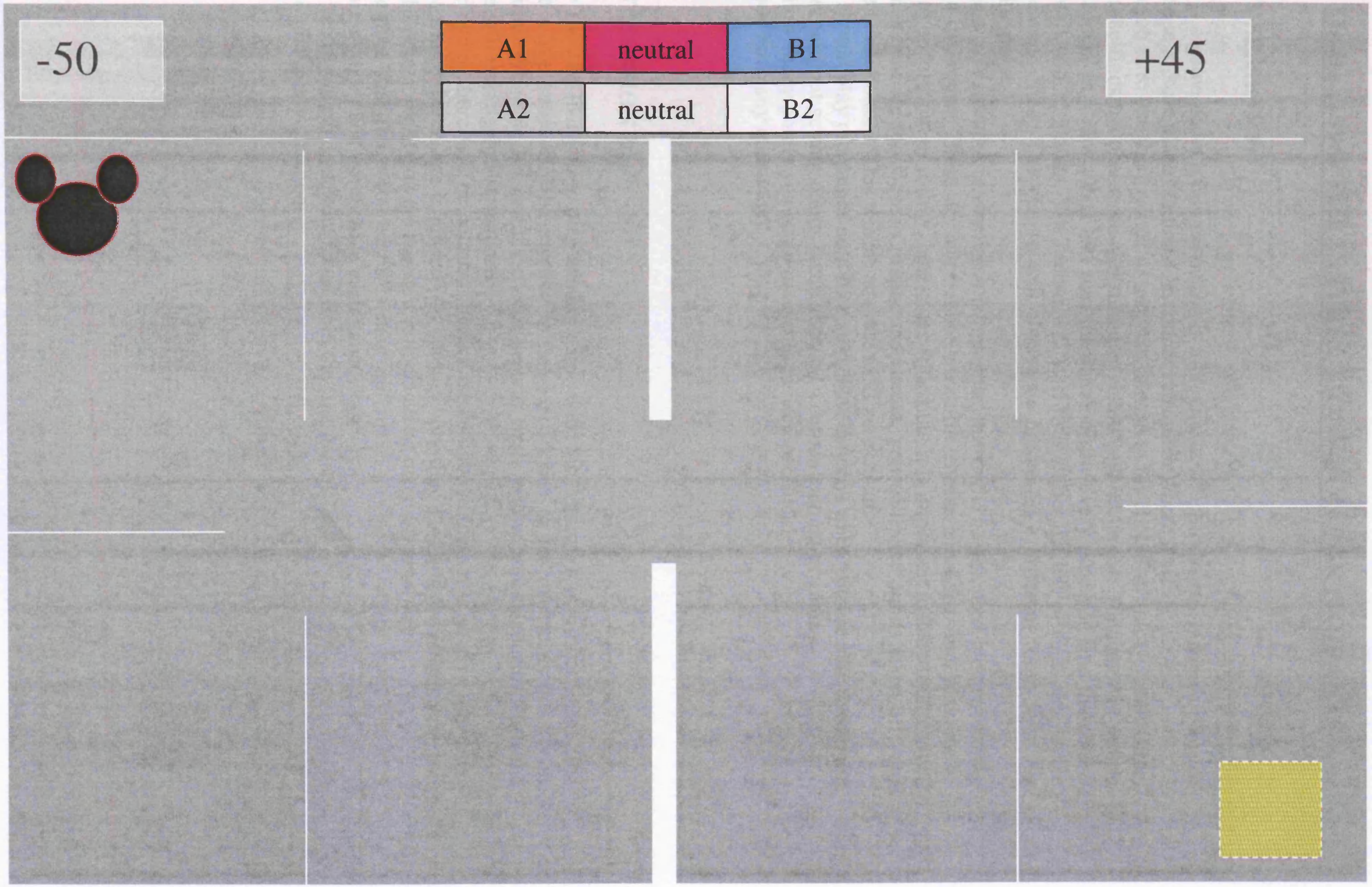
1. Do you have a Computer at home?
2. Do you use a computer at your place of work?
3. Do you ever play games using computers or games consoles?
4. Have you ever used a joystick in a computer program?

Now proceed to the first task.

....

Appendix Five a

Oades (1996) Task



Appendix Five b

Oades (1996) Task INSTRUCTIONS FOR PARTICIPANTS

TEST SESSION 1:

This is a game about a hungry mouse in a big house. Mr. Mouse has hidden a piece of cheese in a "safe place" but now he cannot remember where it is!
Your job is to use the joystick to take Mr. Mouse to his cheese as quickly as possible. When he finds his cheese he will shimmer yellow and disappear. Then another mouse will appear in a new place and start the game again. Every time you find the cheese you will win 15 points. The mouse will start from either the left or right side of the house each time. The cheese will always be hidden in a different room from his starting point.
To help you find the cheese, as it is invisible, there will be coloured blocks flashing above the house. These are clues about where the cheese is hidden. You may not be able to understand or follow these clues at first but it is important to keep trying to use them. If you are too slow in finding the cheese, you will have points taken off your score at the bottom. This will be at a rate of -2 per second.
You should play the games until they stop. This happens when you are able to find the cheese without getting points taken away on a certain amount of games.
See how many points you can win on this game. Good luck!
Do you have any questions?

TEST SESSION 2:

Now I would like you to play another game with Mr. Mouse. It is similar to the first game - you must use the joystick to get Mr. Mouse to his cheese as quickly as possible. When he has got his cheese he will flash yellow and disappear. Then the game will start again automatically.
Once again, there will be coloured blocks flashed above the house to give you clues about where the cheese is hidden. As before every time you find the cheese you will win 15 points, but if you are too slow points will be taken off your score.
Remember that the coloured clues may not make any sense at the start but it is important to try and use them in each game.
Now see if you can beat your score from the first game!
Do you have any questions?

Appendix Six a

Jones (1997) Contingency Task – Learning stage 1

Learning phase

2 x

Film no.:24

Film Stars: Dirk Black

Success rating: 86

→ This film was a box office smash!

2 x

Film no.: 25

Film Stars: Charles Strong

Success rating: 45

→ This film was NOT a box office smash!

2 x

Film no.: 26

Film stars: no famous stars

Success rating: 25

→ This film was NOT A box office smash!

Test phase 1

Please rate the likelihood That each of the following Stars will have a box Office smash.

Charles Strong: 0
Edward Smith: 56
Albert Frame: 23
Dirk Black: 100
Roger Green: 45
Mike Smart: 77

Jones (1997) Contingency Task Learning stage 2

Appendix Six b

	Learning stage 2		Outcome
9x	Film no.:10 Film Stars: Dirk Black and Albert Frame Success rating: 45	→	This film was a box office smash!
9x	Film no.: 11 Film Stars: Charles Strong And Edward Smith Success rating: 75	→	This film was a box office smash!!
9x	Film no.: 12 Film stars: Roger Green and Mike Smart Success rating: 25	→	This film was a box office smash!
9x	Film no.: 13 Film stars: No famous stars Success rating: 25	→	This film was NOT a box office smash!

Test phase 2

Please rate the likelihood That each of the following Stars will have a box Office smash.

Charles Strong: 99
Edward Smith: 56
Albert Frame: 23
Dirk Black: 100
Roger Green: 45
Mike Smart: 77

Appendix Six c

JONES B TASK INSTRUCTIONS

(Initial instructions provided by experimenter)

- In this task you will be asked to give success ratings for fictitious films and film stars.
- All instructions are given on the screen as you proceed through the task.
- Remember you must rate all the items even if you have not been given any information about them.
- There is no time limit on this task. If you are unsure of the instructions please ask for clarification.
- Please try to concentrate on the screen throughout the task.

(On screen Instructions shown to participant at start of program)

"In this task your job is to rate the likelihood that each of a series of films will succeed at the box office. You will be given a list of stars for each film. Some films will have no famous stars.

Base your ratings on information gathered during the task.

After your rating of each film, you will be informed of its success or failure at the box office. This information may help you in future ratings. For each film read the name(s) of the star (s) out loud.

Good Luck!!"

<u>Appendix Seven a</u>

Logical Memory Scales

Story A

Anna Thompson of South Boston, employed as a cook in a school cafeteria, reported at the City Hall Station that she had been held up on State Street the night before and robbed of fifty-six dollars. She had four small children, the rent was due, and they had not eaten for two days. The police, touched by the woman's story, took up a collection for her.

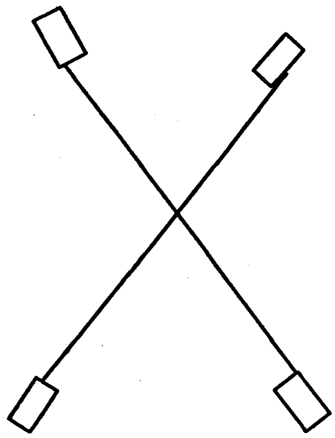
Story B

Robert Miller was driving his ten-ton truck down a highway, at night in the Mississippi Delta, carrying eggs to Nashville, when his axle broke. His truck skidded off the road, into a ditch. He was thrown against the dashboard and was badly shaken. There was no traffic and he doubted that help would come. Just then his two-way radio buzzed. He quickly answered, "This is Grasshopper".

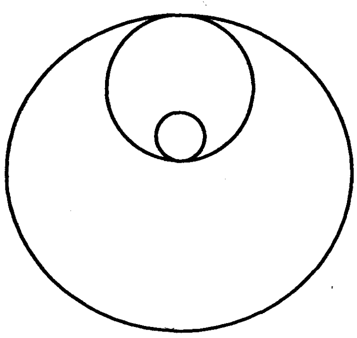
Appendix Seven b

Visual Memory Scales

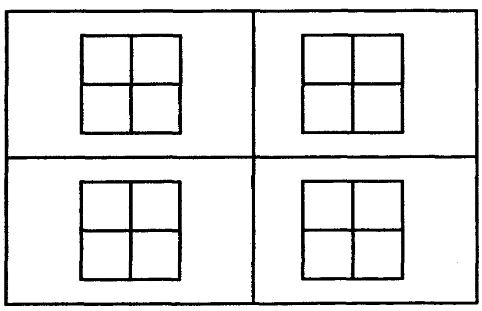
Drawing 1:



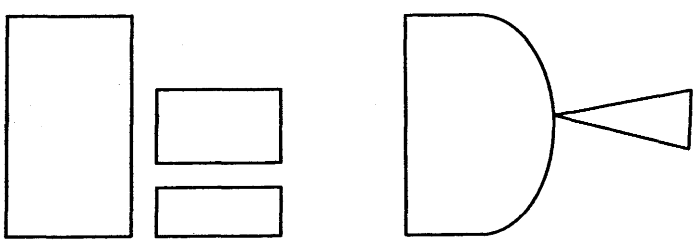
Drawing 2:



Drawing 3:



Drawing 4:



<u>Appendix Eight a</u>

OADES QUESTIONNAIRE

Participant Code:

The following questions aim to assess the strategies you used on the game and your general feelings about the task.

Please circle the appropriate number on the scale for each question.

1. How useful were the colours in finding the cheese in each game?

In the first game?

Not very		Sometimes useful		Very useful
1	2	3	4	5

In the second game?

Not very		Sometimes useful		Very useful
1	2	3	4	5

2. How often did you use the colours to locate the cheese?

Never		Sometimes		Always
1	2	3	4	5

3. How hard was it to make the mouse go where you wanted using the joystick?

Very easy		Some difficulties		Very hard
1	2	3	4	5

4. Overall, how difficult did you find the task?

Very easy		Medium difficulty		Quite hard
1	2	3	4	5

5. Were there any colours that stick out in your mind or for which you always knew the corresponding location?

Now please proceed to the next task.

....

Blocking Score:

Appendix Eight b

JONES B QUESTIONNAIRE

Participant Code:

The following questions aim at assessing the strategies you used on the previous task.

In the task you had 2 types of ratings to make in different stages:

a) Sometimes you were given the names of stars in the film and you had to rate the FILM. In this stage you were immediately told whether the film had in fact been a success or not. This stage also alternated between giving you a single star or a pair of stars in the films.

b) In other stages you were shown the names of 6 film stars and were asked to rate the PEOPLE. You were not told any further information at this stage.

The questions refer to these two types of ratings separately:

1. How did you decide on the ratings for each of the 6 PEOPLE when they appeared on the screen together ?

2. How did you decide on the ratings for the FILMS in the stage where you were given the names of TWO stars in the film?

3. How useful were the stages of type a (in which you were told the films' actual success after you gave a rating) for subsequently deciding on ratings of individual people (type b)?

Not Useful		Sometimes Helpful		Very Useful
1	2	3	4	5

3. Overall, how difficult did you find the task?

Very Easy		Medium Difficulty		Quite Hard
1	2	3	4	5

Now proceed to the next task.

Appendix Nine a

Chapman (1990) Contingency Task – Learning stage Screen

Day: 10

% Correct: 75%

COMPANY NAME	STOCK VALUE
1. HOMER	**UP**
2. MARGE	**SAME**
3. BART	**SAME**
4. KRUSTY	**SAME**
5. LISA	**UP**

INCORRECT!

The market did NOT rise today

Hit Any Key

WILL THE STOCK MARKET GO UP IN VALUE TODAY (Y or N)? **Y**

HOW CONFIDENT ARE YOU OF THIS? Answer 1 (not confident) to 5 (very confident) : **4**

Appendix Nine b

Chapman (1990) Contingency Task – Rating Screen

Now Please rate the predictive value of each stock: that is, if the individual stock rises ho

market also rose?

Ratings go from -100 to +100

Remember stocks could be positive predictors (definitely signify a market rise), negative

signify a market rise), or mixed/neutral predictors.

Remember that the stock market is sensitive and is changed by single com

PLEASE RATE THE COMPANIES IN ORDER AND DO NOT GIVE THE SAME RA

COMPANY NAME	RATING
1. HOMER	-50
2. MARGE	75
3. BART	100
4. KRUSTY	
5. LISA	

Appendix Nine c

Chapman (1990) Contingency Task INSTRUCTIONS

In this game you are a Wall Street Stock Broker trying to predict the daily rise and fall o

You will be following the stock prices from 5 companies over several months. Each day you are given info company's stock prices. Some stock prices go up and others remain the same. From this information, you a market as a whole will rise on each day.

The stock market is very sensitive and is changed by the activity of single com

Every few weeks you will be asked to rate the predictive value of each stock. I.e. how well the company st For this you should use ALL the information gathered so far.

Stocks can have 3 kinds of predictive value:

POSITIVE: when the company stock price rises, the stock market is MORE lik

NEGATIVE: when the company stock price rises, the stock market is LESS lik

NEUTRAL: the company stock rise gives no definite or novel information about the

Please Continue through each day until you reach the end.

Press any key to continue.

Appendix Ten

Chapman-back Task
Reminder Sheet

Version 1:

Stage 1 paired companies
Marge + Krusty
Bart + Lisa

Version 2:

Stage 1 paired companies
Homer + Marge
Krusty + Bart

Version 3:

Stage 1 paired companies
Lisa + Homer
Marge + Krusty

Version 4:

Stage 1 paired companies
Marge + Homer
Bart + Lisa

Version 5:

Stage 1 paired companies
Homer + Lisa
Krusty + Bart

Appendix Eleven

Sample Letter to Schools for Experiment 5 Recruitment

Dear Mr. P. Jones

We are writing to you from the School of Psychology at the University of Leicester. We are part of a research team studying the developmental aspects of learning and attention from childhood into adulthood. Findings from ours and other research groups suggest that deficits in the unfolding of specific types of attention in childhood might be predictive of schizophrenia and other mental illnesses in later adulthood. Thus, by studying how learning and attention evolve in children we may be able to define predictors for these disabilities before they become manifest in adulthood.

In order to carry out this project we will need to study groups of children of different age ranges. The test session will involve the children playing a simple computer game and taking a short reading test (based on the British Ability Scales). This should take no more than 35 minutes. We would need children from two age groups (6-8 years and 8-13 years) with 25-30 children in each group.

We would greatly appreciate if some of your students could take part in this research. We realise that 40 minutes is a significant amount of time from the school day but we feel that the potential benefit for yours and other students from a study such as this is far reaching.

In return, as researchers and lecturers at the school of Psychology, if you think it appropriate, we would be happy to deliver a lesson/lecture to some of your students on the brain and how it works.

If you are kind enough to participate in this study then we can provide more practical details about the study.
If you have any questions whatsoever please do not hesitate to ring or write to us.

Thanking you in advance

Yours Sincerely,

A. Crookes (E-mail: aec7@le.ac.uk)
Dr. P. Moran (E-mail: pmm8@le.ac.uk

<u>Appendix Twelve</u>

British Ability Scales II
Word Reading List

The	up	he	you	box
At	said	out	jump	fish
One	cup	wood	bird	clock
Ring	water	window	men	light
Oil	ship	running	dig	money
Paper	gate	knock	heel	skin
Coat	carpet	brick	thin	building
Tail	travel	babies	writing	climb
Collect	early	piece	piano	whistle
Invite	guest	electric	enormous	shoulder
Wreck	favour	supplies	encounter	universal
Ceiling	generation	environment	cough	character
Avenue	experience	radiant	statue	audience
Curiosity	obscure	diameter	chaos	boisterous
Tentative	trauma	jeopardy	silhouette	desultory
Reminiscent	divulge	diplomacy	rheumatism	tyrannical
Catastrophe	regurgitate	meticulous	initiate	tertiary
Criterion	archaic	monosyllabic	mnemonic	facetious

Appendix Thirteen

Spearman's Correlation Analysis Report: Task Learning scores, Experiment 2

	Oades Learning	Jones A learning	UNEX	COGDIS	INTAN	IMPNON	LIE	EXT	STA	Stroop	Immediate Logical Memory	Delayed Logical Memory	Verbal Fluency
Oades learning	------												
Jones A learning	0.29	------											
Unusual Experiences	-0.02	-0.28*	------										
Cognitive Disorganisation	-0.21	-0.30*	0.51**	------									
Introverted Anhedonia	-0.05	-0.08	0.09	0.40**	------								
Impulsive Nonconformity	0.17	-0.16	0.42**	0.33*	0.03	------							
Lie	-0.01	0.14	0.03	-0.09	0.12	-0.43**	------						
Extraversion	0.15	-0.06	0.12	-0.37**	-0.61**	0.22	-0.12	------					
STA	-0.13	-0.26	0.87**	0.71**	0.25	0.46**	-0.01	-0.14	------				
Stroop	0.26	0.09	0.06	0.26	-0.03	0.14	-0.05	-0.25	0.20	------			
Immediate Logical Memory	0.13	0.09	-0.15	-0.12	0.20	-0.13	0.02	-0.34*	-0.08	0.16	------		
Delayed Logical Memory	0.13	0.10	-0.13	-0.09	0.16	-0.07	-0.03	-0.27*	-0.05	0.25	0.83**	------	
Verbal Fluency	0.41**	0.30*	-0.07	-0.20	-0.29*	0.16	-0.15	0.18	-0.17	0.21	-0.16	-0.07	------

* denotes Significance at $p<0.05$ level

** denotes Significance at $p<0.01$

Appendix Fourteen Multiple regression analysis – full report Experiment 2

a)Oades Task blocking

Overall significance of model: F(7,53)=2.37; p<0.05

Block	Predictor Variable	Beta Unstand.	Beta Stand.	t-value	R (for block)	R squared	R squared change
1	Stroop	-0.00252	-0.207	-1.358	0.404	0.163	0.163
	Logical memory (immediate)	0.133	0.401	1.779			
	Logical memory (delayed)	-0.00916	-0.319	-1.413			
	Verbal fluency	-0.00268	-0.184	-1.249			
2	UNEX	-0.114	-0.469	-1.847	0.515	0.265	0.102
	COGDIS	-0.00877	-0.328	-1.67			
	STA	0.170	0.750	2.485*			

* denotes significant value at p<0.05

b) Jones B Task blocking

Overall significance of model: F(7,53)=3.50; p<0.001

Block	Predictor Variable	Beta Unstand.	Beta Stand.	t-value	R (for block)	R squared	R squared change
1	Stroop	-0.595	-0.556	-3.874*	0.478	0.229	0.229
	Logical memory (immediate)	-0.113	-0.046	-0.215			
	Logical memory (delayed)	0.150	0.059	0.280			
	Verbal fluency	0.454	0.357	2.577*			
2	UNEX	-0.808	-0.380	-1.588	0.581	0.347	0.119
	COGDIS	0.648	0.276	1.486			
	STA	-0.123	0.062	-0.219			

* denotes significant value at p<0.05

Appendix Fifteen

Results of Partial correlations, controlling for Task Order

No correlations significant at $p<0.05$ level

	Oades blocking scores
Jones blocking scores	r = 0.10, p=0.45
UNEX	r= 0.02, p=0.88
COGDIS	r=0.009, p=1.0
INTAN	r=0.04, p=0.80
STA	r=0.16, p=0.26
STROOP	r=-0.15, p=0.27
Logical memory (immediate)	r=0.20, p=0.14
Logical memory (delayed)	r=0.08, p=0.56
Verbal fluency	r=-0.26, p=0.06

Appendix Sixteen

Multiple regression analysis – full report
Experiment 3

a) Oades Task blocking

Overall model significance: F(5,40) = 1.014; p>0.10

Block	Predictor Variable	Beta Unstand.	Beta Stand.	t-value	R (for block)	R squared	R squared change
1	Stroop	-0.00606	-0.224	-1.398	0.356	0.127	0.072
	Verbal fluency	-0.00165	0.074	0.457			
2	UNEX	0.00671	0.202	0.552	0.234	0.055	0.055
	COGDIS	0.104	0.240	1.146			
	STA	-0.157	-0.515	-1.248			

* denotes significant value at p<0.05

b) Chapman Task blocking

Overall model significance: F(5,40) = 1.124; p>0.10

Block	Predictor Variable	Beta Unstand.	Beta Stand.	t-value	R (for block)	R squared	R squared change
1	Stroop	1.591	0.226	1.426	0.366	0.134	0.134
	Verbal fluency	-1.759	-0.303	-1.891			
2	UNEX	-0.165	-0.019	-0.053	0.372	0.138	0.004
	COGDIS	0.326	0.029	0.140			
	STA	0.487	0.062	0.150			

* denotes significant value at p<0.05

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