Processes and mechanisms of stimulus over-selectivity.

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Processes and Mechanisms of Stimulus Over-Selectivity

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Summary (Abstract)

Stimulus over-selectivity refers to the phenomenon whereby behaviour becomes controlled by one element of the environment at the expense of other equally salient aspects of the environment. It is a common problem for individuals with autism, learning disabilities, acquired neurological brain damage, the elderly and typically developing individuals under-going a cognitively demanding task. The current thesis presents 15 experiments that investigate the mechanisms of over-selectivity and explore potential remediation techniques. All experiments employed a simultaneous discrimination procedure using non-clinical participants under-going a cognitively taxing task. Experiments 1-3 demonstrated the robustness of over-selectivity across a range of test conditions. Experiments 5 and 6 extended this by exploring the potential role of conditioning effects and found no evidence of inhibition accruing to the under-selected stimulus. Experiment 4 showed that following extinction of the previously over-selected stimulus, the under-selected stimulus could emerge to control responding despite receiving no further direct training, thus supporting the use of extinction techniques to reduce over-selectivity. Experiment 7 indicated that partial reinforcement (PR) did not reduce over-selectivity and actually increased over-selectivity when participants underwent less training (Experiment 8). Experiments 9 and 10 showed that changing schedule of reinforcement from continuous reinforcement (CRF) to PR or from PR to CRF also failed to reduce over-selectivity. Experiment 11 found a reduction in over-selectivity following a downward shift in reinforcer value, whilst Experiment 12 ensured that neither generalisation decrement nor PR influenced this effect. Experiments 13 and 14 suggested that the decrease in over-selectivity was due to a change in the unconditioned stimulus as opposed to changing the nature of the stimuli. Finally, Experiment 15 showed no reduction in over-selectivity when the reinforcer was qualitatively manipulated. These results are discussed in terms of theoretical perspectives of over-selectivity, and implications for the remediation of the effect.

Declaration and Statements

DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

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Research Publications and Conference Presentations

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- **Reynolds, G.,** & Reed, P. (2011). Effects of schedule of reinforcement on over-selectivity. *Research in Developmental Disabilities,* **32,** 2489-2501.

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- **Reynolds, G**; Reed, P. (2010). The effects of inhibitory processes and schedule of reinforcement on stimulus over-selectivity. *Poster presented at the British Psychological Society Developmental Conference*, London Goldsmiths, U.K., September 2010.

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Chapter 1

Stimulus over-selectivity literature review

1. 1. Stimulus over-selectivity

The phenomenon of 'stimulus over-selectivity' (also known as 'restricted stimulus control') can be defined as behaviour becoming controlled by one element of the environment at the expense of other equally salient aspects of the environment; that is, only a select portion of available stimuli controls behaviour (e.g., Dube & McIlvane, 1999; Lovaas, Koegel & Schreibman, 1979; Lovaas & Schreibman, 1971; see Dube, 2009 for a review). In order for learning to occur, an individual must have the ability to associate stimuli that are presented simultaneously (Lovaas & Schreibman, 1971). Therefore, responses restricted to particular cues can be detrimental to learning as it may restrict learning of the range, breadth or number of stimuli, or features of a stimulus, and therefore result in an inability to acquire particular behaviours (Lovaas et al., 1979; Reynolds, Newsom & Lovaas, 1974; Schneider & Salzberg, 1982; Varni, Lovaas, Koegel & Everett, 1979). To clarify, the stimuli which become over-selected and thus control behaviour, are not necessarily relevant cues, but rather are often irrelevant or insignificant features of a complex array of stimuli (Lovaas, Schreibman, Koegel & Rehm, 1971).

An example of over-selectivity can be seen when individuals are taught how to discriminate between a knife and a fork. For learning to be sufficient, a number of elements are considered including shape, colour and texture. If only one of these elements (e.g., colour and not the shape) is learnt (i.e., over-selected), this can restrict learning and result in an inability to distinguish between a knife and fork (Reed, 2010). Thus, if an individual only attends to particular parts of an object at the expense of other features, this can result in a failure to learn how to use the object. Other examples include identifying people on the basis of a single feature and identifying words on the basis of the initial letter (Dickson, Wang, Lombard & Dube, 2006).

Not only is over-selectivity detrimental to current learning, it can also mean that important information is missed as a result of the over-selected stimulus dominating responding, which is likely to lead to further deficits as the child gets older (Barthold & Egel, 2001). For example, requirements for successful communication may be deficient in the child's repertoire as a result of early over-selectivity, resulting in detrimental effects in later learning (Rosenblatt, Bloom & Koegel, 1995).

Over-selectivity is a common problem for individuals with Autistic Spectrum Conditions (ASC), particularly children, as shown by a wealth of research (e.g., Allen & Fuqua, 1985; Anderson & Rincover, 1982; Chiang & Carter, 2008; Dube & McIlvane, 1997, 1999; Falcomata, Roane & Pabico, 2007; Frankel, Simmons, Fichter & Freeman, 1984; Hedbring & Newsom, 1985; Huguenin, 1997; Koegel & Wilhelm, 1973; Kolko, Anderson, & Campbell, 1980; Lovaas & Schreibman, 1971; Schreibman, Kohlenberg & Britten 1986; Schreibman & Lovaas, 1973; Wilhelm & Lovaas, 1976) but also adults (e.g., Matthews, Shute & Rees, 2001) as well as individuals with general learning disabilities (Bailey, 1981; Dickson, Wang et al., 2006; Dube & McIlvane, 1999, Gersten, 1983; Litrownik, McInnis, Wetzel-Pritchard & Filipelli, 1978; Lovaas et al., 1971; Schneider & Salzberg, 1982; Stromer, McIlvane, Dube & Mackay, 1993; Wilhelm & Lovaas, 1976), acquired neurological damage (Wayland & Taplin, 1982, 1985) and the elderly (McHugh & Reed, 2007).

1. 2. Over-selectivity and autism spectrum conditions

Autism Spectrum Conditions (ASC) can be defined as pervasive developmental disorders including a range of diagnoses; Autistic Disorder, Retts Disorder, Childhood Disintegrative Disorder, Asperger's Disorder, and Pervasive Developmental Disorder Not Otherwise Specified (including Atypical Autism) (American Psychiatric Association [DSM-IV-TR], 2000). Although unique, these disorders are generally associated with impairments in communication, deficits in reciprocal social skills, limited spontaneous imaginative play and restricted, repetitive and stereotyped patterns of behaviours, interests and activities (DSM-IV-TR, 2000). Furthermore, individuals with ASC often display challenging behaviours and externalising behaviours with self-injury and harmful self-stimulating behaviours being common. Autistic Disorder itself is the most prevalent of the conditions (although data for the prevalence of Asperger's Disorder are lacking), with rates ranging from 2 to 20 cases per 10,000 individuals in epidemiological studies, and the manifestation of autism generally beginning prior to three years of age (DSM-IV-TR, 2000).

One defining feature of ASCs is the inability of the individual to respond to environmental stimuli (Rimland, 1964), to the extent that they are often (usually wrongly) suspected of having hearing or vision impairments. Over-selectivity may contribute, as an underlying factor, to many of the language, communication, speech, social, emotional and behavioural deficits exhibited by individuals with ASC (Dube, 2009; Koegel & Schreibman, 1977; Lovaas et al., 1979).

1. 2. 1. Deficits in language acquisition and communication

Over-selectivity may contribute to the language deficits shown in children with ASC and their difficulties in understanding speech (Birnie-Selwyn & Guerin, 1997; Koegel, Schreibman, Britten & Laitinen, 1979; Lovaas, Berberich, Perloff & Schaeffer, 1966; Lovaas et al., 1979; Lovaas et al., 1971). Ploog (2010) gives the example of a teacher saying 'Dog' whilst pointing to a picture of a dog and the printed word 'DOG'. In order for the child to understand the meaning and appropriate use of the term 'dog', the child must attend to the spoken word, the printed word and the picture. If the child over-selects one of these three components, the concept of the animal is not likely to be learnt or understood.

A communicative exchange itself requires attendance to, and discrimination of, a number of complex cues that may be presented successively or simultaneously, such as, the actual words that are spoken, intonation and facial expression, amongst many others (Barthold & Egel, 2001; Dunlap, Koegel & Burke, 1981). If only one of these elements are responded to, then communication exchange deficiencies are likely to occur.

Reynolds et al. (1974) argue that part of the reason children with ASC are unable to acquire speech is as a result of only attending to few, of the many, variables that are presented and therefore failing to acquire important information from the non-attended variables which may be necessary for understanding. Over-selectivity during auditory perception may therefore adversely affect speech development. Understanding of speech requires responses to numerous acoustic components including intonation or pitch, stress or volume, rhythm, duration, voice and phonetic features of words to understand content (Crystal, 1969). In order to accurately perceive phonemes or syllables, it is not sufficient to respond to only one element (e.g., Liberman, Cooper, Shankweiler & Studdert-Kennedy, 1967). Consequently, over-selective responding to particular stimulus dimensions of speech in children with ASC can hinder learning to produce and understand auditory words (Schreibman et al., 1986).

Although not labelling their findings 'over-selectivity', Frith (1969) found that children with ASC tended to respond more to the physical qualities of auditory stimuli (stressed words) than by the content. Dysprosody (defective use of intonation, stress and rhythm) is a common characteristic of verbal children with ASC (Baltaxe, 1984) whereby the content of the language may be accurate, but the intonation is faulty. On the other hand, echolalic children often show exaggerated and varied intonation, however, the content of their speech is often contextually and semantically flawed (Schreibman et al., 1986). Such examples may be demonstrative of an over-selectivity effect.

Schreibman et al. (1986) compared echolalic and nonverbal children with ASC to typically developing children on their responsiveness to two elements of an auditory stimulus compound; content and intonation. Following discrimination training, the elements were presented individually, and results showed that the typically developing children showed no over-selectivity of particular components, however, the non-verbal autistic children over-selected the phonological element and the echolalic children over-selected the intonation element. Such over-selectivity explains the characteristic that echolalic children over-select intonation at the expense of content and vice versa for verbal children with ASC. It is important to note that the typically developing children in their study did show some over-selectivity in responding to phonological content rather than intonation. Despite this, the work shows that combating over-selectivity in auditory stimuli (not just intonation over content, but future work should also look at other speech components such as stress, rhythm, duration), may work towards remediation of speech expression, reception and understanding in children with ASC (Schreibman et al., 1986).

Contradicting these results, Ploog, Banerjee and Brooks (2009) found that children with ASC did not show a preference between content and intonation. Such a discrepancy may be explained by methodological differences in that Schreibman and colleagues (1986) utilised a successive discrimination paradigm whereby only one stimulus was presented and participants either responded or did not respond, whereas Ploog and colleagues (2009) utilised a modified simultaneous discrimination paradigm, allowing participants to choose between two alternatives. Differences may have arisen in that the former methodology requires the child to withhold a response.

Lovaas et al. (1966) found that when teaching children with ASC to learn language via imitation methods, participants responded just to a visual stimulus of the teachers face; they could only respond accurately to words when they were presented with the teacher's face, whereas when presented with the sounds alone (i.e., when the teacher covered her face or when the child was looking away) they had trouble responding. Lovaas et al. (1971) also showed that attempting to teach mute children with ASC to speak was largely unsuccessful as a result of the children only attending to (i.e., over-selecting) visual, and not auditory, cues.

Additionally, over-selectivity has caused problems when teaching children to spell; Birnie-Selwyn and Guerin (1997) found consonant-cluster (CC) errors were common as a result of selective stimulus control by one of the consonants. Furthermore, when children were given finer-grained discrimination training using single letters, fewer spelling errors were made. Dube, McDonald, McIlvane and Mackay (1991) argued that interventions designed to reduce stimulus over-selectivity may be useful in reducing such spelling errors.

Finally, Chiang and Carter (2008) suggested that spontaneous communication may also be linked to over-selectivity due to the individual attending to only the most salient stimuli as opposed to more subtle cues at higher levels of spontaneity, or due to the fact that communicative behaviours at a higher level of spontaneity often require the individual to attend to multiple cues, as opposed to being controlled by a single stimulus (Halle & Holt, 1991). Taken together, the literature clearly demonstrates the detrimental effects of over-selectivity on language and communication behaviours.

1. 2. 2. Deficits in social skills

In naturalistic environments involving social situations, over-selectivity can severely disrupt children with ASC's ability to behave appropriately, in that as the number of cues in the environment that require a response increases, the child's responses to these cues decreases (e.g., Burke & Cerniglia, 1990; Pierce, Glad & Schreibman, 1997). Social stimuli are often inherently complex and dynamic (Greenaway & Plaisted, 2005), and as a result over-selectivity can have important implications for social skills in children with ASC.

Ploog (2010) provides the example of a child with ASC playing with a toy alongside another child, but only attending to the toy as opposed to the child's verbalisations, that may be inviting, such as 'come and play with my truck' or threatening, such as 'leave me alone, this is my truck'. Even if the child with ASC attends to part of the verbalisations, such as 'my truck', as opposed to the relevant part of the verbalisations, such as 'come and play' or 'leave me alone', they will not learn the appropriate behaviours in such social situations.

Social interactions also require attendance to a range of cues such as body posture and facial expressions (Lovaas, et al., 1971; Schreibman & Lovaas, 1973). The recognition of another individual itself requires responding to numerous cues; considering people change over time and environments, in order to recognise someone, it is necessary to respond to more than one feature of that individual. If responses to an individual are restricted to a potentially inconsistent and unstable personal feature (such as hairstyle), future recognition of that person is likely to become difficult (Schreibman, 1975; Schreibman & Lovaas, 1973).

Schreibman and Lovaas (1973) explored the effects of over-selectivity on deviant social behaviour in autistic children. They trained autistic and non-clinical children to discriminate between a clothed male and a clothed female doll that closely resembled human figures. Following acquisition of the discrimination, the heads of the dolls were systematically interchanged and minor features were modified, for instance, clothing was reversed or removed. They showed that non-clinical children primarily discriminated between a male and a female doll by using the figures' heads, but could also discriminate based on specific features of the dolls, such as their clothing. On the other hand, children with ASC discriminated between the two dolls by using just one minor and idiosyncratic aspect of the figure, for example, responding only to the shoes. If this cue was subsequently removed, the children with ASC were no longer able to discriminate between the two dolls. Collectively, previous research indicates impairments in social skills as a result of stimulus over-selectivity.

1. 2. 3. Deficits in emotional behaviour

Deficiencies in emotional behaviour shown in children with ASC, such as inappropriate emotional reactions or self-stimulatory behaviour may also be accounted for by over-selectivity (Lovaas et al., 1979). Such emotional reactions are arguably acquired through the process of classical conditioning; such conditioning requires attention to two or more contiguous stimuli (the conditioned stimulus, CS, and the unconditioned stimulus, US). As a result, individuals who show over-selectivity may fail to respond to one stimulus and thus fail to be conditioned (Lovaas et al., 1979; Maltzman & Raskin, 1965). In terms of identifying emotions, Ploog (2010) provides an example of a child hearing his mother say 'No!' and over-selecting hearing the word 'no' whilst failing to respond to the mother's frown or other cues, and subsequently failing to associate frowning with negative consequences, whilst also failing to learn the meaning of 'No!' or the meaning of frowning.

1. 2. 4. Deficits in behavioural skills

Impaired observational learning in children with ASC may also be accounted for by over-selectivity (Lovaas et al., 1979; Varni et al., 1979). Observational learning generally requires a response to multiple cues; the behaviour of the individual being modelled and the consequence of this behaviour (Lovaas et al., 1979). Varni et al. (1979) investigated the number of features of an observational situation that children with ASC acquired after observing an adult following verbal instruction to engage in specific behaviours. They showed that the children acquired limited features of the observational situation and concluded that over-selectivity causes considerable problems for children attempting to learn via observation, in particular when taught using prompts; a traditional teaching method. Such methods can cause problems for a child with ASC as they require the use of multiple cues which can subsequently result in more potential for over-selectivity to occur (see section 1.7. Experimental studies)

Children with ASC also often fail to transfer treatment gains, or to generalise what they learn in a therapeutic setting to a naturalistic environment, possibly as a result of over-selectivity. Rincover and Koegel (1975) showed that four out of ten autistic children failed to transfer behaviour changes from a treatment room to a novel extra-therapy environment as a result of over-selective responding to an incidental stimulus (for example, a teacher's hand movement touching her chin as opposed to her verbal instruction to touch your chin). When the over-selected stimulus was identified and used in the extra-therapy setting, all four children responded correctly. Closer analysis of the results revealed that these four children had over-selected irrelevant stimuli during training and as such had not learned the appropriate response based on the relevant stimuli, for example, behaviour being controlled by the movement of the teacher's hand rather than the verbal cue. Falcomata et al. (2007) inadvertently supported this research when attempting to treat pica in an individual with autism (a potentially life-threatening self injurious behaviour commonly displayed by children with ASC whereby inedible objects are ingested or inserted into the oral cavity: Roane, Kelly & Fisher, 2003). They found that their participant responded to the therapist's behaviour rather than the intended stimulus prompt. Additionally, once stimulus control was established, the treatment gains were not generalised over time and conditions.

Cook, Anderson and Rincover (1982) hypothesised that over-selectivity may also account for the reduced ability in children with ASC to develop appropriate play as it may result in the child attending to only a small part of a toy and thus they may fail to see the function and purpose of this toy. Likewise, over-selectivity may result in the child only attending to particular toys (or particular parts of toys), and therefore becoming upset if this is withdrawn or moved. Similarly, Rimland (1964) suggests that a child with ASC's poor reaction to change may also be accounted for by over-selectivity, as if one aspect of an environment is changed or removed, this may have been the only aspect the child was responding to. Once again, the research supports the suggestion that a range of behavioural skills may be disrupted as a result of over-selectivity.

1. 2. 5. Conclusion: over-Selectivity and ASC

Overall, over-selectivity plays an important role in many of the behavioural, language, social and emotional deficits, and general characteristics, found in individuals with ASC, and may be viewed as having a negative impact on overall quality of life. The phenomenon can impair the ability to monitor internal and external cues simultaneously and can subsequently result in a variety of problems. As a result, it is vital that the phenomenon succumbs to comprehensive investigation (Schreibman, Koegel & Craig, 1977).

1. 3. Over-selectivity and general learning disabilities

Early work proposed that over-selectivity was associated differentially with a diagnosis of autism as opposed to children with a low mental age or IQ (Frankel et al., 1984; Wilhelm and Lovaas, 1976). That is, over-selective responding is specific to ASC. However, further research has indicated that this is not the case. Over-selectivity is not unique to ASC and ASC alone is not a predictor of over-selectivity; all individuals with ASC do not necessarily exhibit over-selective responding. Even some of the early studies in the 1970s did not report over-selectivity in all children with ASC in their sample (e.g., Koegel & Wilhelm, 1973). The diagnosis of ASC as a predictor of over-selectivity is confounded by factors such as co-morbidity with intellectual disabilities, functioning level and mental age (Ploog, 2010). Conversely, the characteristic is also exhibited in individuals with general learning disabilities (Allen & Fuqua, 1985; Bailey, 1981; Dube & McIlvane, 1999; Dube et al., 2010; Gersten, 1983; Huguenin, 2000, 2004; Huguenin & Touchette, 1980; Lovaas et at al., 1971; Schneider & Salzberg, 1982; Stromer et al., 1993; Wilhelm & Lovaas, 1976) although some contradictory research (e.g., Tarver, Hallahan, Kauffman & Ball, 1976) actually indicated that children with general learning disabilities were more likely to be under-selective and respond to too many cues, as opposed to being over-selective.

Individuals with general learning disabilities often show many similar characteristics to those with ASC, however, it is questionable whether they would perform similarly to children with high functioning ASC or typically developing children. Bailey (1981) trained and tested younger and older children with high-functioning ASC, children with learning disabilities and typically developing children using a three-element stimulus card in order to see whether all three elements would equally control behaviour. Results showed that children with learning disabilities performed most similar to the younger children with high-functioning ASC as opposed to the healthy children, however, over-selectivity was much less severe. That is, for the children with ASC, behaviour was controlled by one element from the three-element compound whereas for the children with learning disabilities, behaviour tended to be controlled by two of the elements from the compound. Typically developing children indicated no evidence of over-selectivity in that they equally selected all components (Bailey, 1981). Kovattana and Kraemer (1974) showed that children with general learning disabilities and non-verbal children with ASC were more likely to show evidence of over-selectivity compared to typically developing children and verbal children with ASC. However, other research has not found differences between verbal and non-verbal autistic children (e.g., Schover & Newsom, 1976).

Dickson, Wang et al. (2006) explored over-selectivity by using a within-subjects design and a range of different stimuli; a two-element alphanumerical compound, a compound stimuli with dimensions of form and colour, and pictures of adult faces. They found the most over-selectivity using the two-element alphanumerical compound and supported findings that despite over-selectivity being most prevalent in children with ASCs, it is also evident, albeit to a lesser extent, in children with general learning disabilities. Similarly, Stromer et al. (1993) explored over-selectivity in teenagers and adults with learning disabilities, using a delayed matching-to-sample (MTS) task and indicated that when participants were required to discriminate between two features of a stimuli, performance accuracy on the task declined, indicative of over-selectivity.

Other research has actually shown higher levels of over-selectivity in individuals with general learning disabilities than children with ASC (e.g., Matthews, Shute & Rees, 2001). Litrownik et al. (1978) also found significantly higher levels of over-selectivity in children with Down's syndrome compared to autistic and typically developing children. In fact, Wilhelm and Lovaas (1976) concluded that the level of over-selectivity is positively related to the degree of disability.

Taken together, generally the findings reveal that individuals with general learning disabilities show over-selectivity at an intermediate level; non-clinical children show less over-selectivity whereas children with ASC show the most severe over-selectivity (Bailey, 1981; Dickson, Wang et al. 2006; Frankel, et al. 1984; Lovaas et al., 1971).

Of course, it is always important to remember that work using children with ASC may not always be directly comparable to children with general learning disabilities (Lovaas et al., 1979). Koegel and Lovaas (1978) point out that different subject populations used across research are unlikely to be equivalent. That is, the subjects in Litrownik et al.'s (1978) research had moderately low IQ scores (a mean of 46) compared to many autistic children participant's who's IQ is severely lower. Furthermore, over-selectivity may be more evident in individuals with general learning disabilities who also experience memory deficits as a result of increased task demand (see section 1.7. Experimental studies) (Reed & Gibson, 2005).

Over-selectivity has been argued to be a function of developmental level or mental age (e.g., Eimas, 1969; Gersten, 1983; Hale & Morgan, 1973; Hale & Taweel, 1974; Koegel & Wilhelm, 1973; Kolko et al., 1980; Reynolds et al., 1974; Rincover & Ducharme, 1987; Schover & Newsom, 1976; Schreibman et al., 1986). Within the developmental literature, research reveals that typically developing children are able to attend to three or more stimuli, and select the most relevant stimulus depending on their requirements, by the age of six years old (Eimas, 1969). Additionally, Ross (1976) suggested that the extent of over-selectivity decreases with age. Schover and Newsom (1976) supported this work by showing that younger children had higher levels of over-selectivity.

Wilhelm and Lovaas (1976) found that children with lower IQs showed greater levels of over-selectivity than those with higher IQs. Similarly, Dickson, Deutsch, Wang and Dube (2006) tested 70 individuals attending residential special-education schools. Patients who failed MTS pre-tests were excluded from the remainder of the intervention. 35 out of the remaining 49 individuals showed significant stimulus over-selectivity and mental age was significantly associated with levels of stimulus over-selectivity. Likewise, Schover and Newsom (1976) indicated that when children with autism were matched according to mental age with their non-clinical counterparts, both showed similar over-selectivity scores. Finally, Bailey (1981) showed that in their sample of children with learning disabilities, mental age was a conclusive factor in determining the level of over-selectivity. Although results for the children with ASC were less conclusive (Bailey, 1981).

Varni et al.'s (1979) findings that children with ASC show deficits in observational learning similar to that of young children, have been argued to support the suggestion that over-selectivity is associated with developmental delays. Additionally, they showed that chronological age was only associated with over-selectivity for non-clinical children, but not children with ASC. On the other hand, independently of developmental level, Gersten (1983) showed that as chronological age increased, the level of over-selectivity decreased for children with ASC, general learning difficulties and typically developing children.

However, Ploog and colleagues (e.g., Ploog et al., 2009; Ploog & Kim, 2007) argue that the finding of the degree of over-selectivity being related to mental age has not been consistently found. Although, it is of note that Ploog et al. (2009) arguably have found atypical attention as opposed to stimulus over-selectivity per se, and Ploog and Kim (2007) did not perfectly match participants based on mental age. Despite this, Frankel et al. (1984) demonstrated that children with ASC showed more over-selectivity than learning disabled children who's IQs were lower than the children with ASC. Butler and Rabinowitz (1981) investigated a potential explanation of the inconsistent results regarding whether children with lower mental ages show higher degrees of over-selectivity and indicated that this may be a result of solving discriminations on a configurational basis, as opposed to a dimensional basis.

Much research matching participants using the construct of 'mental age' needs to be treated tentatively as matching of participants has been severely criticised (e.g., Campbell & Stanley, 1966; Kerlinger, 1973). This is predominantly due to the fact that choosing whether to use 'mental age', 'cognitive ability' or 'language ability' is arbitrary. Furthermore, it is questionable whether a six year old child with an IQ of 33 can be reliably matched with a typically developing 24 month old child considering both will have experienced different learning situations and reinforcement patterns as well as having diverse social histories (Baumeister, 1967; Gersten, 1983). Additionally, Baumeister (1967) supposes that 'mental age' itself is a meaningless construct but rather is simply an average of performance amongst a range of sub-tests; two children matched on mental age, may in fact perform very differently across different tests. As a result, conclusions based on such research should be made with caution.

Taken together, over-selectivity may be related to low mental age as opposed to severe psychopathology, and as cognitive functioning improves, the level of over-selectivity decreases (e.g., Schover & Newsom, 1976). As such, it is arguable that over-selectivity may be a maturational characteristic sensitive to intellectual and learning dysfunctions (Kolko et al., 1980; Varni et al., 1979).

1. 4. Over-selectivity and acquired neurological damage

Research has also indicated over-selectivity in individuals with brain injury. Wayland and Taplin (1982) compared fluent and non-fluent aphasic participants (a disorder caused by damage to parts of the brain controlling language) with non-aphasic brain-injured controls on a pattern recognition task requiring organisation of categorical semantic information. They showed that a number of participants organised category membership based on variations in just one feature, that is, they over-selected a particular feature (usually the mouth) from the overall stimulus (faces). Wayland and Taplin (1985) extended this work using a pattern recognition memory test and supported the suggestion that brain-injured participants had difficulties with the task as a result of feature over-selectivity in a complex multi-dimensional stimulus.

Cohen, Geifer and Sweet (1980) supported this by showing that aphasic participants performed similarly to controls when forming judgments based on global comparisons as opposed to analytical comparisons. It was thought that the reason for this was that the former comparisons can be made based on one salient feature whereas the latter comparisons require knowledge of numerous features. Other research has also provided evidence for this over-selective tendency in aphasic participants (Cohen & Woll, 1981).

Furthermore, Caramazza and his colleagues (e.g., Caramazza, Berndt & Brownell, 1982; Whitehouse, Caramazza & Zurif, 1978) indicated that aphasic participants (patients of a single left-hemisphere cerebrovascular accident) identified particular objects based on one perceptual feature, failing to consider the combination of perceptual and functional features, impairing their ability to name and recognise objects. Although they generally argue that this impairment is a result of difficulties in conceptual organisation of the concepts underlying word meaning, as opposed to retrieval difficulties. Taken together, research support exists for the finding of an over-selectivity effect in individuals with acquired neurological damage.

1. 5. Over-selectivity and age

McHugh and Reed (2007) explored age trends in over-selectivity by giving three different age groups (18-22 years, 47-55 years and 70-80 years) a simple discrimination task and testing for the emergence of over-selectivity. This effect was found across all participants when given a distracter task, demonstrating over-selectivity across age groups. In their second experiment, they verbally punished the previously over-selected stimulus and found that in the two younger age groups, the under-selected stimulus emerged to gain control over behaviour, however this was not the case for the eldest age-group of participants. McHugh, Simpson and Reed (2010) replicated the finding of significant over-selectivity in an older sample when investigating appropriate means of remediating the effect in this population (see Section 1. 10). Moreover, research has found high levels of over-selectivity in nursery and preschool children (e.g., Bickel, Stella & Etzel, 1984; Eimas, 1969). Taking these research findings into consideration, over-selectivity seems most prominent in the extreme age groups.

1. 6. General conclusion

Overall, over-selectivity can be found across a range of disorders and individuals, including ASC, general learning disabilities, brain injured patients and the elderly. It has also been advocated as a characteristic of individuals with schizophrenia; distinguishing between acute and chronic schizophrenia is often carried out by exploring the breadth of cues the individual utilises. That is, patients with acute schizophrenia tend to respond to too many cues and are unable to differentiate what cues are relevant or important and which cues require less attention. On the other hand, patients with chronic schizophrenia often exhibit over-selectivity similar to that of children with autism and general learning disabilities (Broen, 1973). As a result, the investigation of the processes and mechanisms of over-selectivity are vital in an attempt to find potential remediation of this effect.

1. 7. Experimental studies

Most methodology used to explore over-selectivity involves a simultaneous discrimination task whereby participants are trained (through trial-and-error) to select a complex stimulus involving at least two elements over an alternative two-element compound. These elements may be from the same modality (e.g., visual; Wilhelm & Lovaas, 1976; auditory: Reynolds et al., 1974; Schreibman et al., 1986; or tactile: Lovaas et al., 1971; Ploog & Kim, 2007) or from different modalities (e.g., auditory and visual; Lovaas & Schreibman, 1971). Once discriminative control has been established, the elements are presented individually with an exploration of which element is responded to most in order to assess their independent control of responding (e.g., Reed & Gibson, 2005). Separate components tend to be selected equally in typically developing populations, whereas individuals with ASC and general learning disabilities tend to over-select one element at the expense of other elements and thus such over-selected elements control behaviour (e.g., Allen & Fuqua, 1985; Dube & McIlvane, 1997, 1999; Huguenin, 1997; Koegel & Wilhelm, 1973; Kolko et al., 1980; Lovaas & Schreibman, 1971; Schreibman et al., 1986; Schreibman & Lovaas, 1973; Wilhelm & Lovaas, 1976).

Lovaas and colleagues first began comprehensively exploring the concept of over-selectivity in 1971. In this landmark study, three groups of children (autistic, developmentally delayed, and typically developing children) were presented with a multi-dimensional compound cue comprising a visual stimulus (a red floodlight), an auditory stimulus (a white noise) and a tactile stimulus (a pressure cuff around the participant's leg) for 5 seconds. Children were taught to press a lever when the compound stimulus was presented, and to withhold lever presses in the absence of the compound. Once the discrimination had been learnt, children were presented with the individual elements in order to assess their control in responding. Typically developing children responded to all three cues in an equal manner, whereas children with autism responded to one cue more than the alternative cues and children with general learning disabilities responded at a level in between these two extremes. Additionally, they were able to train a previously non-functional cue separately as opposed to in association with other cues, to come to control behaviour.

Lovaas and Schreibman (1971) replicated this study and found evidence for stimulus over-selectivity even when only two modalities were used (visual and auditory components only) with no preference for a particular modality. They therefore concluded that over-selectivity is not only a result of 'flooding' from three stimuli sensory modalities. Although it is important to note that over-selectivity was most severe when three modalities were used, suggesting that over-selectivity is most noticeable with larger quantities of, or more complex, stimuli (Burke & Cerniglia, 1990).

Koegel and Wilhelm (1973) extended this work further by exploring over-selectivity in children with ASC, when stimuli were presented in the same modality (visual), using a discrete-trial simultaneous discrimination procedure. Participants were presented with two cards, each card consisting of a stimulus compound of two visual stimuli (half the participants were presented with pictures of common objects and half the participants were presented with geometric shapes) and were rewarded for pointing to one of the compound cards. Following this training, participants were presented with the individual elements of the compound in order to assess which elements had become functional in controlling behaviour. It was found that the majority of children with ASC (12 out of 15) demonstrated over-selectivity in that one element of the compound stimulus consistently controlled their responding, compared to non-clinical control participants who showed no evidence of over-selectivity in that both components of the compound were selected on 100% of trials.

Reynolds et al. (1974) trained and tested typically developing children and children with ASC on a discrimination learning task using two stimulus compounds in the auditory modality. One compound consisted of a continuous high tone presented simultaneously with periodic relay clicks and the second compound consisted of a continuous low tone presented simultaneously with periodic bursts of the sound of a motor. Once learning was to criterion, presentations of the individual elements of the compounds showed that the majority of children with ASC over-selected particular elements compared to the typically developing children who responded similarly to each element of the compound stimulus. They concluded that over-selectivity in the auditory modality can partially account for the speech comprehension deficits shown in children with ASC.

It is important to note that tests used in early work exploring the extent of control over particular elements of the reinforced compound (e.g., Koegel et al., 1979; Schover & Newsom, 1976; Schreibman et al., 1977) have been criticised for requiring participants to choose between incorrect alternatives (an element of the non-reinforced stimulus; an incorrect stimulus and a novel element). Such methods may not accurately test the extent of control maintained by the reinforced stimulus (Allen & Fuqua, 1985).

Research has explored a variety of stimulus dimensions whereby over-selectivity has been demonstrated, including form or colour (e.g., Burke & Cerniglia, 1990; Dickson, Wang et al. 2006; Litrownik et al., 1978; Smeets, 1994), multiple discrete elements (e.g., Allen & Fuqua, 1985; Broomfield, McHugh & Reed, 2008a, 2008b; Dube & McIlvane, 1997, 1999; Wilhelm & Lovaas, 1976), and social stimuli (e.g., Schreibman & Lovaas, 1973). Using abstract objects, Kovattana and Kraemer (1974) found evidence for the breadth of over-selectivity by using different dimensions of cues (e.g., form, size and colour, such as a large blue circle verses a small red triangle) within the same modality. Over-selectivity is likely to be shaped by the quantity of stimuli presented, the ability of the participant to process information (Lovaas et al., 1979), as well as the difficulty of the task (e.g., McHugh & Reed, 2007; Reed, 2006; Reed & Gibson, 2005).

More recently, stimulus over-selectivity has been observed in intellectually typical adults during tasks with high cognitive demands or a concurrent and distracting activity (e.g., Broomfield et al., 2008a, 2008b; 2010; Dube, Balsamo, Fowler, Dickson, Lombard & Tomanari, 2006; Reed, 2006; Reed & Gibson, 2005). Such studies show that when given a high concurrent task load, participants show the over-selectivity effect by subsequently selecting one element of the reinforced compound more than the other. The concurrent load is important in this context because it reduces the processing capacity of non-clinical participants allowing their subsequent task performance to resemble the performance shown when using individuals with developmental delays. Such research allows an investigation of the phenomenon in a more accessible population. Therefore, the use of participants without ASC or general learning disabilities enables theoretical investigations to be developed more fully and the strengths or weaknesses of various interventions to be tested before being applied to individuals with intellectual disabilities (Reed, 2006).

Further research support for over-selectivity has come from MTS tasks (e.g., Dickson, Deutsch et al., 2006; Dickson, Wang et al., 2006; Dube & McIlvane, 1997, 1999; Reed, 2006; Schneider & Salzberg, 1982; Stromer et al., 1993). Such tasks are in a multiple-choice format whereby participants are presented with a sample stimulus (auditory or visual) and two or more comparison stimuli (usually visual) (Dube, 2009). For example, participants may be presented with a two-element sample stimulus (AB), followed by a comparison array of AB, CD and EF. On the next trial, the sample stimulus may be CD with a comparison array of AB, CD and EF. When testing for over-selectivity, only one element is shown in the comparison display, for example, if AB is the sample stimulus, if participants perform accurately when given a comparison array including A, C and E but perform at chance accuracy when the comparison array includes B, D and F, such results indicate over-selective responding towards element A (Dube, 2009). Over-selectivity impedes performance on MTS tasks as a result of failing to reject the incorrect comparisons (Dube, 2009; Reed, 2010; Reed & Gibson, 2005). MTS techniques are often used as a teaching method in special education classrooms (Dube & McIlvane, 1999) but in order to perform accurately, participants are required to respond to the correct comparisons, and reject the incorrect comparisons. MTS tasks are useful for exploring over-selectivity as choice items are manipulated in a way that allows for components of stimulus control to be identified, as well as making it possible to explore the effect of delayed response paradigms on over-selectivity (Schneider & Salzberg, 1982; Stromer et al., 1993).

The discrete-trial approach implemented in much previous work, and in the experiments in the current thesis, arguably provides a foundation for the development of an instructional program (Dube, 2009). Research has suggested that the use of discrete-trials and naturalistic training are represented on a continuum as opposed to being distinct categories. The discrete-trial approach is often implemented initially in therapeutic settings followed by naturalistic training in typical routines (Thompson, 2007). Kasari, Freeman and Paparella (2006) began their interventions with discrete-trials training focusing on specific skills used for joint attention or symbolic play in children with ASC, followed by a semi-structured play setting whereby this trained skill was integrated in a naturalistic environment.

Recently, research has attempted to develop animal models of over-selectivity, for instance, Gibson and Reed (2005) propose the concept of 'over-shadowing' as a model for the phenomenon. According to Mackintosh (1975), 'over-shadowing' occurs when a stimulus which is presented alone strongly controls behaviour, however, when accompanied by another stimulus, this control may be reduced or eliminated as a result of the presence of the second stimulus. Thus, this phenomenon refers to the finding that following the conditioning of two stimuli in a compound, each comes to control responding less than if the elements were conditioned separately (Pavlov, 1927) and has often been found in the animal conditioning literature (see Trabasso & Bower, 1968).

1. 8. Measuring over-selectivity

Over-selectivity is measured based on the number of responses participants give to all reinforced stimuli at test. To date, there is no single agreed-upon method of measuring over-selectivity, or defining the degree of stimulus selection that composes 'stimulus over-selectivity' (Ploog, 2010). As Dube and McIlvane (1997) point out, calculating separate accuracy scores for each stimulus element is not sufficient to determine over-selective responding as separating positive and negative stimulus functions results in a loss of conditionality. That is, if a participant selects stimulus A on every trial, their accuracy for stimulus A would be 100%. However, it cannot be concluded that stimulus A therefore controls responding, as it may actually indicate non-conditional control by the comparison stimulus (Sidman, 1980).

In order to analyse over-selectivity in the current thesis, the most and least chosen stimuli from the previously reinforced compound were calculated for each compound presented. The percentage number of trials in which these stimuli were selected was calculated, and the mean most and least selected stimulus was then averaged across the compounds. The resultant difference between the most selected stimulus and the least selected stimulus indicates the level of over-selectivity. That is, the greater the discrepancy between the most and least selected, the higher the degree of over-selectivity.

After organising the data into the percentage of times that the most and least selected stimuli were chosen during test, a two-way repeated-measures analysis of variance (ANOVA) is performed, with condition and stimulus type (most v least) as factors. Of course, such an analysis will produce a numeric difference between the most- and least-selected stimuli, and this analysis will not show that there is over-selectivity *per se*; however, it does show whether there is a difference in the relative difference between the most- and least-selected stimuli in various conditions. Moreover, it should be noted that, in conditions whereby over-selectivity is not expected (i.e., in healthy populations with no concurrent task load), no significant differences are found between the most- and least-selected stimuli (e.g., Reed, Broomfield, McHugh, McCausland & Leader, 2009; Reed & Gibson, 2005).

Given the above considerations, further analysis of the data was undertaken, based on binomial theory, to determine whether the deviation in the times that the most-selected and least-selected stimuli were chosen was statistically greater than would be expected by random chance around an average probability of selection of the two stimuli. This analysis was undertaken to indicate whether the difference from the level of choice that would be expected if both stimuli had the same probability of being chosen was statistically significant – i.e. whether there was absolute over-selectivity, as opposed to relative differences in stimulus selection.

In the absence of any *a priori* method of determining the probability of choosing a stimulus, the mean probability of choosing A and B was first calculated. Given this probability, the binomial equation was used to obtain the probability of choosing all possible combinations of A and B over C or D on 10 trials. The probability of choosing a reinforced compound stimulus was set at the mean probability of choosing A and B stimuli in a particular condition. Then, the probability of obtaining 10 A, and zero to 10 B; the probability of obtaining 9 A, and zero to 10 B; etc., were calculated, and put in a 10 x 10 contingency table. The contents of this table were then multiplied by a 10 x 10 table that contained the absolute A minus B difference score for each combination. The resulting 10 x 10 table contained the expected frequency of obtaining each possible A minus B difference resulting from all possible combinations of A and B frequencies. The sum of the values in this table (multiplied by 10) provided an estimate of the most minus least selected difference, in percentage terms, expected by random variation of selection of A and B stimuli. Paired t-tests were then used to test this sum against the obtained data, in order to investigate whether significant over-selectivity occurred.

1. 9. Theories of over-selectivity

After around forty years of research in the area of stimulus over-selectivity, the exact mechanisms underlying such responding are still in question. Numerous theoretical explanations for over-selectivity have been advocated to account for over-selectivity. Specifically to ASC, the Weak Central Coherence Theory suggests that individuals with ASC process incoming sensory information in a local, detailed, featural and specific manner as opposed to processing global and contextual information as is the case with typically developing individuals (Happé & Frith, 2006). That is, they have problems with integrating detailed information into a coherent whole and thus perform poorly in tasks requiring an understanding of global meaning (e.g., Frith & Happé, 1994; Happé & Frith, 2006). The theory itself has been surrounded with much controversy with research finding contradictory results (Chiang & Carter, 2008). In particular, support for the theory is rarely found using perceptual or verbal-semantic tasks (van Lang, Bouma, Sytema, Kraijer & Minderaa, 2006). Additionally, there has been disagreement regarding whether the term 'weak central coherence' refers to an inability to process global information or a preference for processing local information (Chiang & Carter, 2008; Happé & Frith, 2006; van Lang et al., 2006). Overall, it is arguable that the nature of a weak central coherence in autism is still somewhat tentative, and does not lend itself to application to remediation that logically follows from the theory (Happé & Frith, 2006; Ploog, 2010).

An alternative theoretical explanation of over-selectivity specifically in individuals with ASC was suggested by Lovaas et al. (1979) who argue that individuals with ASC are 'super-efficient' in processing stimuli. Participants in research by Koegel and Schreibman (1977) were first trained to respond to individual presentations of an auditory stimulus and a visual stimulus. They were then tested with a visual cue, auditory cue or a visual and auditory cue compound, whereby only the compound was reinforced. Despite only the compound being reinforced, it was found that children with ASC continued to respond to only one of the components of the compound, whereas children in the control group responded to the compound more than the single cues. Such results imply that individuals with ASC may be aware that responding to single components of a complex stimulus is sufficient to learn the discrimination. That is, they expend minimum effort for optimal results. However, it is important to note that the children did eventually begin responding to both cues, and as such, it seems more likely that they were attempting to learn the initial discrimination but something was preventing them from doing so. Additionally, the children continued to respond to one of the elements of the compound even when reinforced. Such findings discredit the 'super-efficiency' hypothesis. Overall, this account is generally not well supported with research suggesting that children with ASC have difficulty discriminating between components of complex stimuli (Lovaas et al., 1979).

Research has also suggested that over-selectivity may be the result of sensory overload in that sensory information is only partially processed (Ploog, 2010). Ploog (2010) provides anecdotal evidence for this hypothesis stating that some children with ASC appear unresponsive to some sensory stimuli from a particular sense modality whilst reacting excessively to other sensory stimuli from the same modality, implying they only responded partially to the overall sensory information.

Despite such evidence, the sensory overload hypothesis is largely unsupported as research shows that over-selectivity is evident even in situations when sensory overload does not seem likely, such as when the compound stimulus only constitutes two elements (e.g., Lovaas & Schreibman, 1971) particularly when they are from the same modality (e.g., Koegel & Wilhelm, 1973; Schreibman et al., 1986). Additionally, recent research has indicated that children with ASC are capable of discriminating (in terms of perceiving and processing) particular stimuli, such as the processing of prosodic or pitch contours in linguistic stimuli, with some research even finding superior perceptual processing abilities in children with ASC compared to non-clinical controls (e.g., Järvinen-Pasley, Wallace, Ramus, Happé & Heaton, 2008; Ploog et al., 2009; Remington, Swettenham, Campbell & Coleman, 2009). Such research actually implies that children with ASC in fact show less over-selectivity.

Moving away from theoretical accounts targeted only at individuals with ASC, an additional explanation of over-selectivity that has been suggested is that it results from the demand level of a task. According to Myerson and Green (1995), participants under-taking choice studies with high task demand, reduce this demand by limiting the number of choice-responses they make and thus focus on one element of the compound. Similarly, Reed and Gibson (2005) added a memory load to the task, and argued that only limited stimuli can control behaviour as a result of pressure on the processing abilities of participants. It follows that individuals with an increased memory load in the task are likely to show higher levels of over-selectivity, as are individuals with general learning disabilities or ASC who also have deficits in memory (e.g., Bennetto, Pennington & Rogers, 1996; Boucher, 1981; Boucher & Warrington, 1976).

Overall, it is likely that there are multiple processes and mechanisms underlying stimulus over-selectivity (e.g., Reed, 2006), however, all theories are unified in the belief that over-selectivity is a within-individual deficit. The current thesis focuses predominantly on the attention deficit perspective, due to the popularity of the theory, the generalisability across different populations as opposed to specifically to ASC, and the fact that many of the interventions developed to combat over-selectivity are based on this approach.

1. 9. 1. *Attention deficit perspective*

Over-selectivity has been regarded as a pre-processing, attention deficit in that the individual fails to attend to all elements of the stimulus during initial training. If only certain elements are attended to, only these elements can subsequently acquire control over behaviour (e.g., Dube, Lombard, Farren, Flusser, Balsamo & Fowler, 1999; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971).

Dube et al. (1999) used eye-movement analysis and delayed MTS tasks to show that children showing over-selectivity failed to attend to all elements within a complex stimulus and thus these elements did not subsequently control behaviour in test trials. Anderson, Colombo and Shaddy (2006) found similar findings in that individuals with ASC had a significantly decreased level of visual scanning compared to non-clinical controls.

It is important to note, however, that the correlation between eye-movements and attention is imperfect (Remington, 1980), studies have revealed attention-shifts independent of eye movements (e.g., Shaw, 1978; Wurtz & Mohler, 1976) and much research is inconsistent (e.g., Kemner & van Engeland, 2006; Sigman, Mundy, Sherman & Ungerer, 1986; van der Geest, Kemner, Camfferman, Verbaten & van Engeland, 2002; Volkmar & Mayes, 1990). Van der Geest et al. (2002) explored the amount of time spent looking at pictures and found no differences between children with ASC and typically developing children. Similarly, Sigman et al. (1986) explored the social interactions of autistic children, general learning disabilities and typically developing children with their caregivers and found that autistic children did show less sharing of attention but they directed a similar frequency of looking, vocalising and proximity behaviours as the other participants.

Also contradicting an attentional deficit perspective, Butler and Rabinowitz (1981) argued that their finding of over-selective children responding to discriminations configurally as opposed to on a dimensional basis suggests that over-selectivity is more likely to be a problem-solving difference as opposed to a result of an attention deficit. Consequently, research has often suggested that over-selectivity is the result of a bias, as opposed to a deficit, in that individuals showing over-selectivity fail to prioritise relevant stimuli or lack guided focus (Ploog, 2010).

Broadbent (1958) hypothesised a 'filter' theory of selective attention, suggesting that when messages reaching the senses are processed, a selective filter blocks messages that are unimportant or irrelevant, and thus only the important and relevant information is attended to and subsequently controls behaviour. Using a forced-choice reaction time task, Burack (1994) suggested that children with autism have an 'inefficient attentional lens' which renders problems in filtering relevant and irrelevant information from the environment. Moreover, as a result of devoting more resources to this processing, additional problems occur in other areas of attending.

Such an attentional deficit may be a result of impaired shifting of voluntary attention. Treisman (1969) argued that non-clinical individuals sample the elements of a compound cue by rapidly switching attention to different features of the compound, whereas children with autism fail to do this but rather focus on one feature which blocks the other features. Thus, inadequate switching may result in stimulus blocking or stimulus blocking may result in inadequate switching (Lovaas et al., 1971). Courchesne et al. (1994), and more recently, Goldstein, Johnson and Minshew (2001) also hypothesised that individuals with ASC have trouble with shifting from one stimulus to another, between modalities or to filter or disengage attention.

Research by Plaisted, O'Riordan and Baron-Cohen (1998) questions the theory that individuals with ASC are impaired in their shifting of spatial attention by showing that children with ASC showed superior performance in searching for a conjunctive target in comparison to non-clinical counterparts; serial searching requires attention shifts between successive locations in the visual presentation. Similarly, Pascualvaca, Fantie, Papageorgiou and Mirsky (1998) found that participants with ASC performed at an equal level to healthy control participants when the computer task was a continuous performance test which required successive comparisons. However, findings from their Wisonsin Card Sorting Test indicated difficulties in disengaging attention. Moreover, if there is an ability to switch attention from one cue to another, over-training should not increase learning and therefore would not have an effect on over-selectivity, however this has not always been the case (Schover & Newsom, 1976).

Attentional theory does not explain Reed and Gibson's (2005) findings in that an increase in memory load is unlikely to have an effect on attention. It is important to note that some attentional-like phenomena have been found to be influenced by task demands, for example, Lubow and Gerwirtz (1995) explored latent inhibition and showed that when individuals who score high in schizotypy were given a moderately high masking task, their controlled processing was inhibited. Although, Tsakanikos, Sverdrup-Thygenson and Reed (2003) critiqued whether the masking task is necessary for such an effect. However, such hypotheses, in general, fail to explain the work by Reed and Gibson (2005).

In Dube et al.'s (1999) eye-movement analysis discussed above, they also suggested that over-selectivity may not be a result of an attentional deficit per se, but rather extremely short observing duration, or observing failures (thus faulty observational behaviour) may contribute to over-selectivity. As such, over-selectivity may be due to 'inadequate contact with the stimuli' (Dube et al., 2010, pg. 298). Their research showed that the control participants observed each sample stimulus, whereas individuals showing over-selectivity failed to observe one of the sample stimuli and as a result, responded only to the stimulus they had observed.

Supportive work comes from Dube et al. (2010) who related stimulus over-selectivity to observing response deficiencies. They used eye-tracking apparatus to show that 6 out of 10 individuals with intellectual disabilities showed over-selectivity during a delayed MTS task. They revealed that the over-selective participants failed to observe the sample stimuli and showed brief observing durations. This observing failure was removed and observing durations were increased in the majority of participants using interventions targeted at modifying the stimuli or imposing contingencies on observing behaviour (alone or in combination) such as differential reinforcement for longer observing durations, extra-stimulus and within-stimulus prompts, an increase in reinforcement for high accuracy scores and a contingency that extended the sample observation period. However, they did find that increasing observing did not always translate into improved over-selectivity, termed 'instances of observing without attending', and only when they imposed contingencies on observing behaviour was over-selectivity reduced. They concluded that in order to remediate over-selectivity, procedures that increase observing behaviour and duration may be necessary but not sufficient. Despite this, their research does imply that over-selectivity is not necessarily a central attention deficit and can be corrected via the appropriate training.

Taken together, the attentional deficit perspective of stimulus over-selectivity has been widely accepted and researched, despite many contradictory results. The current thesis focuses on examining this theoretical perspective, however, alternative views have attributed over-selectivity to performance, rather than acquisition, deficits.

1. 9. 2. Performance deficit and the comparator hypothesis

More recently, an alternative view to the attentional deficit approach has been proposed, suggesting that all stimuli are attended to and initial learning is intact, however, only particular elements of these stimuli control behaviour. That is, following learning, individuals fail to recognise which stimuli best predict future events and thus which stimuli should be responded to in order to control behaviour. Therefore, individuals with ASC possess post-processing, retrieval difficulties rather than possessing an attentional deficit which hinders the acquisition of information (see Broomfield et al., 2008a, 2010; Leader, Loughnane, McMoreland & Reed, 2009; Reed et al., 2009).

Support for the idea that over-selectivity is a result of performance (as opposed to attention) deficits comes from studies in the animal conditioning literature (generally using aversive conditioned suppression procedures in rats) that have provided evidence that under-selected stimuli (the over-shadowed CS) may emerge to control behaviour when the previously over-selected (the over-shadowing CS) or more salient stimulus (and hence the more controlling stimulus) has been extinguished (e.g., Kaufman & Bolles, 1981; Matzel, Schachtman & Miller, 1985; Miller, Barnet & Grahame, 1992). Similar results are found in blocking (e.g., Blaisdell, Gunther & Miller, 1999), backward blocking (e.g., Pineño, Urushihara & Miller, 2005) and latent inhibition (Grahame, Barnet, Gunther & Miller, 1994).

In the animal conditioning literature, Reynolds (1961) taught pigeons to discriminate between a triangle on a red background (positive) and a circle on a blue background (negative). At test, the pigeons responded most highly to one of the components at the expense of the other components, i.e., the colour red or the triangle, indicating over-selectivity. Wilkie and Masson (1976) extended this work by reinforcing pigeons with grain for key pecking in the presence of a particular compound stimulus composed of one colour element and one shape element (e.g., a white triangle on a red background) whilst not reinforcing an alternative colour-form compound (e.g., a white circle on a green background). Once pigeons were exclusively pecking at this reinforced compound, the colour (red and green) and shape (triangle and circle) elements were presented separately with no reinforcement. They showed over-selectivity in that pigeons only pecked at the colour element as opposed to the shape element. They then reinforced pigeons for only pecking this under-selected or over-shadowed stimulus (the shape) and showed that pigeons who had previously been exposed to the shape element acquired subsequent pecking in the presence of this element more rapidly than those pigeons that had not been exposed to the shape element. Thus, the shape element had been learned during initial training but was not salient enough to control behaviour when combined with the colour element, but revaluation training resulted in an emergence effect of the previously under-selected stimulus.

Kaufman and Bolles (1981) showed that when rats were trained in a conditioned fear paradigm, rats showed a significant level of fear to a light stimulus and less fear to a noise stimulus when both were presented simultaneously prior to an electric shock. They then extinguished responses to the light stimulus and found that rats showed higher levels of fear to the noise stimulus despite no further training. Such research suggests that the rats had paid attention to, and learnt about, the noise stimulus, it just had not controlled behaviour.

Kasprow, Cacherio, Balaz and Miller (1982) conditioned water-deprived rats resulting in a flash light being over-shadowed by a tone. However, when rats were exposed to the flash light (over-shadowed stimulus) during a retention interval (i.e., a 'reminder' event), they subsequently showed an increase in lick suppression. Therefore, the under-selected stimulus was able to emerge to control behaviour. Similarly, Balaz, Gutsin, Cacheiro and Miller (1982) also used conditioned lick suppression in rats showing that an over-shadowed light cue (blocked by a tone cue) could subsequently emerge at test, following exposure to the over-shadowed light cue. Such finding of an emergence of the under-selected (or over-shadowed) cue to subsequently control behaviour, point to the conclusion that the initial overshadowing is more likely due to a failure to retrieve associations as opposed to a failure to form these associations in the first place.

Causal-learning research has shown further evidence for retrospective revaluation; the finding that despite a cue not being present during a training episode, it still has the ability to undergo a change in its response eliciting potential (see Dickinson & Burke, 1996; Van Hamme & Wasserman, 1994). Dickinson, Shanks and Evendon (1984) showed that when training occurred with both elements of a compound, judgements concerning the causal effectiveness of one element in the compound was reduced or blocked as a result of such training (see also Miller & Matute, 1996; Vadillo, Castro, Matute & Wasserman, 2008; Wasserman & Berglan, 1998). Shanks (1985) reversed the two phases of the blocking paradigm by pairing a compound stimulus (AB) with an outcome, followed by the pairing of just one element (A) with the outcome. He showed that the element that is not specifically trained with the outcome (compound B) then loses associative strength obtained in the initial training with the compound (AB) despite this compound (B) not being present in the second training phase, thus providing evidence for the occurrence of backward blocking. Such research is challenging to Wagner's (1981) standard operating procedure (SOP) model of learning which argues that absent cues have no influence over responding or learning, however, Shanks' (1985) research suggests that retrospective revaluation of information is required. As a result, the SOP model was modified by Dickinson and Burke (1996) to become the MSOP model which used the idea of 'un-overshadowing' to explain the emergence of under-selected cues (see Aitken & Dickinson, 2005). Other research from human conditioning suggests that mechanisms, such as retrospective revaluation and un-overshadowing, may be involved in over-selectivity (see Dickinson & Burke, 1996).

The comparator hypothesis (Matzel et al., 1985; Miller & Matzel, 1988; Miller & Schachtman, 1985) was originally advocated to account for features of contingency learning in animals but has recently been adapted to account for over-selectivity (Reed et al., 2009). According to this theory, a memory or representation of learning is activated following the presentation of a previously learned-about target stimulus, as well as triggering a comparator mechanism which indirectly activates other stimuli that were learned about in the existence of the target stimulus (such as contextual cues or an alternative CS that is presented with the target CS as a compound). This is followed (at the time of performance) by a comparison of the strengths of both the directly and indirectly learned-about representations; the comparator mechanism is more likely to select the stimuli with stronger predictive value to control behaviour (Miller & Schachtman, 1985; Reed, 2010). Therefore, at the time of testing, the associated strengths of the CS are compared with the associative strength of the other cues that were present during training, and this determines conditioned responding (Schachtman, Brown, Gordon, Catterson & Miller, 1987). That is, an over-shadowed CS fails to displace acquired associations with an US because the associative strength of its comparator stimulus is even stronger; subsequently, if the over-shadowed stimulus is extinguished, the comparator's strength is lowered, allowing the previously under-shadowed stimulus to emerge and control behaviour (see Matzel et al., 1985).

Two aspects of the comparator theory may explain why over-selectivity is more pronounced in individuals with general learning disabilities or ASC. Firstly, it may be the case that the comparator utilises the relative, rather than absolute, strengths of the stimuli. As such, when learning is not as strong or sub-asymptotic, the relative differences between the stimuli will be greater (Reed, 2010). Secondly, and perhaps specifically to ASC, Reed et al. (2009) argued that over-selectivity results from having an over-sensitive comparator rather than a failure to learn the elements of a compound stimulus. According to this idea, an over-sensitive comparator is sensitive to relative, as opposed to absolute, differences in stimuli that are all potentially important in predicting behaviour, and therefore only particular stimuli come to control behaviour. They showed that behaviour was controlled by one out of two possible elements and argued that a less-sensitive comparator would not have detected such differences (Reed et al., 2009).

According to Leader et al. (2009), the salience of the stimuli may influence an over-sensitive comparator in individuals with autism, in that individuals with ASC may fail to inhibit responses to salient stimuli. The comparator theory would suggest that difficulties in inhibited responses to salient stimuli may be a result of over-sensitivity to differences in the salience of stimuli and thus a higher readiness to detect subtle differences in salience (which would not generally create differential responding) leads to control over performance by one stimulus and inhibition by the less salient stimulus. This can of course result in control by just one stimulus. The comparator hypothesis would therefore predict that if the comparator mechanism in individuals without ASC is less sensitive compared to individuals with ASC, then such subtle-differences in the salience of stimuli would show very little effect. In support of this prediction, Leader et al. (2009) found that stimuli with a distinct salience triggered over-selectivity in individuals with ASC, whereas control participants were not affected by the salience of the stimuli. That is, from a comparator perspective, the sensitive comparator mechanism noticed the difference in salience of the stimuli, whereas the typically functioning comparator in the control participants did not notice such a difference. Subsequently, the sensitive comparator attributed more importance to one stimulus than the other stimulus and as a result, the former stimulus controlled behaviour at test. Leader et al.'s (2009) results may be explained by the comparator's over-sensitivity to aspects of the visual environment (Kemner & van Engeland, 2006) or to novelty (O'Riordan, Plaisted, Driver & Baron-Cohen, 2001) in that the less salient cue may be viewed as novel (Reed, 2010).

Broomfield et al. (2010) found evidence for the previously under-selected cue coming to control behaviour when the control by the previously over-selected cue is reduced, supporting work with non-humans (Kaufman & Bolles, 1981; Matzel et al., 1985) and humans (McHugh & Reed, 2007; Reed & Gibson, 2005) by employing both a technique to punish the previously over-selected stimulus as well as reinforcing a novel stimulus. The comparator theory may adequately explain the emergence effects resulting from post-training extinction as such extinction lowers the strength of the over-selected cues comparator which allows the under-selected stimulus to generate greater strength and thus control behaviour.

Such a prediction of the comparator theory of over-selectivity, that the post-learning manipulations of the over-selected stimulus can enhance control by the previously under-selected stimulus, is unique to this theory and is not inherent in other theories of over-selectivity (Reed et al., 2009). From an attention deficit perspective, it is questionable how an under-selected stimulus can emerge to control behaviour if it has previously not been attended to. Although it is of note that Schmajuk, Lam and Gray (1996) developed a neural network model of classical conditioning which involves an attention process that controls retrieval as well as storage. According to this model, over-shadowing is a result of a decrease in attention to the target CS as well as a decrease in the target CS–US associations due to the competition with the accompanying CS. Moreover, emergence from over-shadowing can be accounted for by an increase in attention to the target CS after the over-shadowing CS has been extinguished (Schmajuk & Larrauri, 2006).

Taking into account the research findings and theoretical viewpoints discussed, the comparator hypothesis, contrasting with the attention deficit perspective, is arguably a viable perspective of over-selectivity.

1. 10. Reducing over-selectivity

Thus far, the detrimental consequences of over-selectivity have been clearly documented in a variety of clinical and non-clinical groups. As a result, it is imperative that successful remediation procedures for this characteristic are well-research and developed. Moreover, if remediation can be achieved, and in particular if it can be implemented early in life, it can prevent the development of secondary characteristics of over-selectivity, especially for those with ASC and general learning difficulties.

Likewise, it has been argued that teaching children to respond to multiple stimuli in the environment can serve to influence cortical development (Walsh & Greenough, 1976). Certain types of environmental stimulation may facilitate changes in the anatomy and physiology of the brain (Bennett, Rosenzweig & Diamond, 1969). Thus, according to Burke and Cerniglia (1990), reducing over-selectivity and increasing responding to multiple stimuli in the environment, thus establishing sensory enrichment, may affect cortical functioning. In this introductory section, a range of techniques (e.g., multiple-cue responding, response marking, mindfulness, prompting and prompt fading) used to remediate over-selectivity will be briefly discussed, despite not being tested in the current thesis, due to their prominence in the literature.

One approach to remediation of over-selectivity is to teach children to respond to multiple cues in the context of over-selectivity occurring (e.g., Koegel et al., 1979; Schover & Newsom, 1976; Schreibman et al., 1977). However, many techniques involve teaching participants to attend to multiple cues, rather than attempting to teach learning even when over-selective responding occurs. This is primarily because not all learning situations involve the requirement of responding to only one cue. Additionally, if children can be taught to respond to multiple cues, they then lend themselves to environments and educational settings using traditional teaching methods, improving the likelihood and success of school-based programs (Koegel & Schreibman, 1977). As Ross (1976, pg. 54) states; 'if one could discover techniques to teach these children the skill of attending to all relevant aspects of a stimulus in a learning situation, one would contribute significantly to their education'.

Response marking has also been developed as an intervention for over-selectivity, which focuses on drawing the attention of the individual to every response, regardless of whether the response is correct or incorrect (Lieberman, McIntosh & Thomas, 1979). Baumeister, Berry and Forehand (1969) suggested that over-selectivity may be reduced by providing specific information which directs attention to the different cues. As opposed to a 'cue value' technique whereby a neutral cue is associated with reinforcement and as such the cue only follows responses that are to be reinforced, response marking procedures present the same cue regardless of whether the response is correct or not (Grindle & Remington, 2002).

Alternatively, McHugh et al. (2010) advocated the use of mindfulness (i.e., focused attention) as an intervention for over-selectivity in the elderly. Intervention techniques utilising extinction procedures (See Section 1. 10. 2. Extinction) failed to have an effect on the oldest age group in McHugh and Reed's (2007) research exploring age trends. McHugh et al. (2010) therefore used mindfulness training in an attempt to combat over-selectivity as a result of such training being suitable for the elderly (e.g., Smith, 2004) as well as having an effect on attention to stimuli (e.g., Bishop et al., 2004). They supported their hypothesis that a mindfulness intervention attenuated over-selectivity in an elderly population compared to participants receiving an unfocused attention intervention. Research in the area of mindfulness reducing over-selectivity, at present, remains limited and further research is required to explore the long-term benefits of mindfulness training in reducing over-selectivity.

Prompting techniques have also been commonly used to teach discriminations to children with developmental disabilities, whereby the individual is physically or verbally guided to the correct alternative (e.g., Repp, Karsh, & Lenz, 1990). Prompting usually requires an extra stimulus being added to a learning setting, for instance, a pointing finger. The idea of the prompt is to increase the saliency of the discriminative stimulus. As the individual's learning gradually progresses, this prompt and guidance is slowly removed so that the individual learns to behave in the taught way without the prompt (prompt-fading) (Lovaas et al., 1979). Other fading or 'attentional shaping' methods present the relevant cue in an exaggerated form then gradually introduce irrelevant cues (Ploog, 2010).

Much research has attempted to utilise fading in order to remediate over-selectivity (e.g., Ploog & Williams, 1995; Schreibman, 1975) with some successful use of prompts and prompt-fading being reported with autistic children (e.g., Lovaas et al., 1966; Lovaas, Freitas, Nelson & Whalen, 1967; Metz, 1965; Risley & Wolf, 1967; Schreibman & Charlop, 1981; Schreibman, Charlop, & Koegel, 1982). Dube et al. (1991) found that using a prompt-fading technique in their MTS procedure improved spelling of their two learning disabled participants. Matson, Sevin, Box, Francis and Sevin (1993) found that extra-stimulus prompts were effective when used within a component treatment package when multiple stimulus dimension discriminations are taught.

Extra-stimulus prompts are useful to the extent that they can be used across a range of learning environments (Schreibman et al., 1982). However, one problem consistent with over-selectivity that may occur in such learning environments is known as prompt dependency. That is, in prompting procedures, the prompt and training stimulus are both presented contiguously (or near-contiguously), and as a result, for children with over-selectivity, if they only respond to the prompt stimulus and fail to respond to the discriminative training stimulus, then transfer from the prompt to the target is not likely to occur (Dube, 2009; Lovaas et al., 1979; Nelson, Gergenti & Hollander, 1980; Ploog, 2010). Over-selectivity targeted at the prompt may prevent learning the intended purpose of the training stimulus (Dube, 2009) and can actually disrupt learning (e.g., Rincover, 1978). Specifically, Ploog and Williams (1995) attributed the deficit of over-selective responding in extra-stimulus prompting to stimulus blocking (Kamin, 1969). That is, if the prompts have acquired stimulus control (as is intended for them to be effective), then the acquisition of stimulus control to the discriminative stimuli may be blocked by the prompts.

As a result of inconsistent findings regarding the success of extra-stimulus prompts. Barthold and Egel (2001) argued that rather than the prompt itself being responsible for the over-selective responding, it is more likely that it is the way the prompt is used that contributes to the over-selectivity. Within-stimulus prompting techniques have been developed which allow learning regardless of over-selective responding (e.g., Rincover, 1978; Schreibman, 1975). That is, a within-stimulus prompt modifies a feature within the training stimulus (such as adjusting the colour) and thus does not add multiple features (such as a finger pointing) which require multiple responses to multiple stimuli (Schreibman, 1975). Some early research has found promising results (e.g., Schreibman, 1975), but others (e.g., Rincover, 1978) have indicated that although within-stimulus (internal) fading techniques appear to be a more efficient training technique than using extra-stimulus (external) cues, they still appear to have limited effectiveness. Additionally, such interventions can be tedious and time-consuming (Schreibman et al., 1982) and are not appropriate for learning environments whereby learning is not based on a single cue.

The current thesis focuses on alternative techniques to those mentioned above, particularly the effects of schedules of reinforcement (especially partial reinforcement, PR) and training procedures, as well as briefly exploring extinction techniques. Furthermore, although the current thesis does not explicitly test observing response procedures, it was thought important to discuss such techniques briefly below, due to their relevance for the attention deficit perspective of over-selectivity (which is under examination in the current thesis).

1. 10. 1. Observing responses

As a result of the influence of the attention deficit perspective of over-selectivity, several studies have attempted to use observing response procedures to target the effect (e.g., Broomfield et al., 2008b; Constantine & Sidman, 1975; Dube & McIlvane, 1999). Observing responses refer to a response that results in exposure to a discriminative stimulus, bringing sensory receptors into contact with the stimuli

(Wyckoff, 1952) thus, all aspects of the discrimination contingency are required to be identified before making a response. Differential observing response procedures (DORs) present participants with different stimuli which require different responses, as opposed to general observing response procedures which require the same response for all stimuli.

The observing response procedure may overcome attentional deficits by ensuring that all aspects of the stimulus are initially attended to (see Dube et al., 1999) or it may increase the amount of exposure to the stimuli as well as increasing the amount learnt about the stimuli, thus increasing the associative strength of such stimuli relative to other simultaneously presented cues (Broomfield et al., 2008b; Dinsmoor, 1985; Mueller & Dinsmoor, 1986) which could support either an attentional or performance view.

Over-selectivity has been shown to have a negative impact on MTS tasks particularly with children with learning difficulties, however much research has found an improvement in scores on a MTS task when DOR procedures are used (e.g., Broomfield et al., 2008b; Constantine & Sidman, 1975; Dube & McIlvane, 1997; 1999; Dube et al., 1991; Geren, Stromer & Mackay, 1997; Gutowski, Geren, Stromer & Mackay, 1995; Walpole, Roscoe & Dube, 2007). Dube and McIlvane (1999) took into consideration that not all participants would be able to verbally name a stimuli, and therefore modified the DOR by requiring participants to respond to simultaneous identity-matching stimuli (e.g., if AB were the sample stimulus, the comparison array consisted of AB, AC and DB) which meant that observation of both stimuli was necessary and both stimuli had to be discriminated. They found an improvement in accuracy scores when using these DOR procedures.

The drawback of most findings exploring observing responses is that the positive results found with observing response procedures are not maintained; they were eradicated and returned to baseline following removal of the intervention and therefore the clinical usefulness of such procedures is questionable (Broomfield et al., 2008b; Dube & McIlvane, 1999).

1. 10. 2. Extinction

As a result of the poor success of observing-response procedures, the viability of the comparator hypothesis rather than an attentional deficit theory, and the empirical findings (see section 1. 7. Experimental studies), an alternative intervention using extinction procedures has been advocated whereby over-selected aspects of the environment that gain control of behaviour are extinguished (e.g., Reed et al., 2009). From a clinical perspective, extinction has been used as an intervention to reduce a range of disruptive and high-rate problem behaviours, for example, self-injurious behaviour (Iwata, Pace, Cowdery & Miltenberger, 1994) and aggression in children with ASC (Koegel, Egel & Williams, 1980). According to Reed (2010), over-selectivity can be seen in a similar manner and may, therefore, also be addressed through the use of extinction.

Much support for the finding that under-selected stimuli can re-emerge to control behaviour as a function of extinction, has been prominently shown in the animal conditioning literature (e.g., Reed & Reilly, 1990; Reilly, Schachtman & Reed, 1996; Wilkie & Masson, 1976) (See section 1. 9. 2 in support of a comparator perspective of over-selectivity). Matzel et al. (1985) and Miller et al. (1992) found enhanced responding to the previously over-shadowed stimulus using aversive conditioned suppression procedures in rats. However, there has been relatively little research investigating such extinction procedures in human participants, despite the importance of developing successful interventions.

Reed and Gibson (2005) observed stimulus over-selectivity in typically developing human participants during a cognitively demanding task; a concurrent memory task. Participants were given a simultaneous discrimination task and were required to learn, through trial-and-error, to select one two-element compound over an alternative two-element compound. Participants with a high concurrent task load were more likely to select one element from the reinforced compound at the expense of the other element, that is, they showed over-selective responding. Following the establishment of this over-selective response, the over-selected stimulus was extinguished through pairing it with novel stimuli. Extinguishing the over-selected elements resulted in the emergence of the under-selected elements.

Similarly, Broomfield et al. (2008a) investigated the emergence of under-selected cues following extinction of over-selected cues in an automated MTS paradigm and also found support for the usefulness of extinction procedures. Furthermore, they showed that the reduction in over-selectivity remained post-intervention, giving the extinction procedures an advantage over the observing-response interventions which have shown limited success in benefits combating over-selectivity remaining post-intervention (e.g., Broomfield et al., 2008b; Dube & McIlvane, 1999).

Reed et al. (2009) extended and supported this work in an ASC population using Reed and Gibson's (2005) discrimination task. Leader et al. (2009) also used this task and supported the use of extinction procedures in allowing the re-emergence of a previously under-selected stimulus. It is important to acknowledge that in these latter two studies (Leader et al., 2009; Reed et al., 2009) the effects were only found in individuals with ASC who showed high functioning compared to individuals with ASC who showed low functioning, which may limit the effectiveness of extinction as an intervention.

Broomfield et al. (2010) carried out a number of studies and established several important factors associated with an extinction procedure as a clinical intervention. Extinction was only successful when the levels of over-selectivity shown initially were high and therefore for extinction procedures to be beneficial, the over-selectivity effect must be substantial in the first place. This may be because a large difference allows for a greater degree of control by the under-selected stimulus. Furthermore, if no over-selectivity effect is found, an under-selected cue cannot 'emerge' to control behaviour that is, there is a ceiling effect (Reed, 2010).

An additional potential problem in generating an over-selectivity effect, is that some participants may perceive the stimuli as a compound rather than perceiving it as two elements (within-compound associations). This may have resulted in no effect following extinguishing one element as perceiving the stimuli as a configured stimulus may mean that extinction of one element would have generalised to extinction of the other element as well (e.g., Rescorla & Cunningham, 1978; Speers, Gillan & Rescorla, 1980). This would mean that very low scores for the under-selected stimulus (e.g., less than 50%) would increase to 50% as inhibitory control is extinguished, making it appear to be an increase in choice for the previously under-selected stimulus, when it is, in fact random and a complete lack of control. When large over-selectivity was found pre-intervention, it is more likely that the compound was perceived as two separate elements and therefore increasing the likelihood that the under-selected stimuli could emerge following extinction of the over-selected stimuli (Broomfield et al, 2010; Reed, 2010). In support of this, Plaisted et al. (1998) suggest that individuals with ASC display poor configural learning; as a result, they perform better in visual search tasks than non-clinical counterparts (O'Riordan et al. 2001) and it may also explain why they are susceptible to over-selectivity effects (Broomfield et al., 2010).

These effects shown in extinction procedures support the comparator hypothesis assumption that reducing the predictive value of the previously over-selected stimulus can result in an emergence of the previously under-selected stimulus to subsequently control behaviour (Reed, 2010). Kaufman and Bolles (1981) advocate an alternative, but somewhat similar, approach to dealing with over-selectivity and emergence. They argue that when animals experience conditioning episodes, they learn about contiguity and causality, however, it is the knowledge of causality that influences performance of conditioned responding. Therefore, animals assign causality to the stronger cue which results in a failure of the over-shadowed stimulus to control behaviour. Diminishing this causal relation by extinction can result in the causal value of the previously under-selected cue increasing, allowing it to emerge to control behaviour.

Other research findings raise alternative possibilities regarding the mechanisms underlying the extinction procedure. Studies have shown that on its initial application, extinction may increase variability in behaviour. For example, Carr and Kologinsky (1983) and Duker and van Lent (1991) withdrew reinforcement for high rate gesture requests in individuals with developmental disabilities and successfully increased the quantity of spontaneous gesture requests. Likewise, Lalli, Zanolli and Wohn (1994) showed that untrained topographies could occur as a result of extinguishing the previously reinforced topographies of toy play. These findings imply that extinction may increase variability in behaviour by instigating greater sampling of previously under-selected stimuli.

Therefore, it may be the case that extinction findings are not only explained in terms of a comparator hypothesis, but rather are due to increased sampling. However, it is important to note that if responses to the novel cue are reinforced, the extinction procedure does not necessarily involve an overall reduction in reinforcement rate. Therefore, participants could potentially regain rates of reinforcement and thus it is debateable whether increased changes in responding would occur under these circumstances (Reed, 2010).

In contrast to previous retrospective revaluation findings, Holland (1999) carried out a number of experiments with modifications of design, stimuli and quantity of conditioning and extinction in rats. He showed that responses to blocked or over-shadowed cues were either unaffected or reduced by extinction. This supports the attribution of over-selectivity to acquisition deficits rather than retrieval problems and detracts away from the comparator hypothesis. Additionally, Speers et al. (1980) and Rescorla and Cunningham (1978) extinguished flavour aversion conditioning to one element and showed that such extinction reduced the conditioned responding to the un-extinguished element, rather than enhancing it. Furthermore, Holland (1984) used appetitive conditioning to show no effect of extinction. It may be the case that reduction of responding to the un-extinguished element (rather than enhancement of responding) could be a result of within-compound associations affecting responding (Rescorla & Cunningham, 1978; Speers et al., 1980).

It is still fundamentally important to establish clinical studies investigating such interventions and generalisation must be made with caution. The reduction of behavioural control by an over-selected stimulus and enhancement of behavioural control by an under-selected stimulus may not always be useful (Reed et al., 2009). For example, if such extinction procedures are used as a means of reducing over-selectivity to particular dimensions of speech (such as volume and pitch), they may be detrimental to the point that it simply substitutes one over-selected stimulus for another. That is, if the volume of speech is being over-selected and therefore becomes extinguished in order to enhance selectivity to the pitch of speech, important information regarding the volume may be lost at the expense of enhancing attention to pitch. A procedure involving training successive conditional discriminations has been advocated to reduce over-selectivity (e.g., Koegel & Schreibman, 1977; Schreibman et al., 1982) and can counteract the identified problem by impacting learning whereby the over-selectivity has been reduced, and allowing learning of compounds which had failed to be learnt previously.

Taken together, despite contradictory findings (e.g., Holland, 1999), research has shown that previously under-selected cues can emerge to control behaviour following extinction of the over-selected stimulus, using non-human participants (e.g., Gunther, Cole & Miller, 1998; Kaufman & Bolles, 1981; Matzel et al., 1985; Miller et al., 1992; Reed & Reilly, 1990; Reilly et al., 1996; Wilkie & Masson, 1976) and work from the human retrospective revaluation literature (e.g., Dickinson & Burke, 1996; Shanks, 1985). Work on non-human participants is limited as a result of procedural and species differences and therefore supportive work using human participants is fundamental; such support comes from human participants without intellectual disabilities (e.g., Broomfield et al., 2008a, 2008b, 2010; Reed & Gibson, 2005) and individuals with ASC (e.g., Leader et al., 2009; Reed et al., 2009).

1. 10. 3. Schedules of reinforcement

Research has begun exploring the effects of different schedules of reinforcement on over-selectivity, in particular investigating the potential differential effects of PR and continuous reinforcement (CRF). In particular, PR has been shown to increase breadth of learning (Sutherland, 1966). It is therefore arguable that over-selectivity may be reduced by introducing PR contingencies that require broader control (e.g., Huguenin, 1997; Schreibman et al., 1982).

In the associative learning literature, research has found promising results showing that using a surprising reduction in reinforcer magnitude can attenuate the blocking effect (e.g., Dickinson, Hall & Mackintosh, 1976; Holland & Kenmuir, 2005). Similar supportive work by Feldman (1971) investigated the effects of changing from CRF in initial training to PR in compound training in an appetitive instrumental discrimination learning experiment using rats lever pressing for food pellets, and supported the idea of unblocking being attributed to a surprising change in reinforcement.

In line with this work, research has introduced the idea of combining over-training with varying schedules of reinforcement in an attempt to reduce stimulus over-selectivity. Schreibman et al. (1977) trained children on a discrimination task involving a two-element, visual complex stimulus. During testing, children were presented with single cue elements interspersed with the two-element complex stimulus. They showed that over-selectivity decreased with continued exposure during testing, despite a lack of reinforcement. Such research appears to indicate that during testing, implementing different schedules of reinforcement, by presenting some test trials without reinforcement, may result in a reduction in over-selectivity. Importantly, this research showed that simple exposure over-training did not reduce over-selectivity, but rather prolonged testing with a PR schedule reduced over-selectivity.

According to Trabasso and Bower (1968) errors in discrimination learning result in the individual responding to more subsequent cues as a result of broadening attention on subsequent trials. With this in mind (Schreibman et al., 1977; Trabasso & Bower, 1968), it follows that if a reduction in over-selectivity is shown by presenting non-reinforced (correct) trials, then over-selectivity should also be reduced if the reinforcement schedule is changed from CRF to PR during testing. That is, changing from CRF to PR may result in the individual perceiving the lack of reinforcement as an indication of error, resulting in increasing their breadth of attention on subsequent trials and thus increasing responding to alternative cues. Koegel et al. (1979) systematically investigated the effect of changing reinforcement schedule by using a multiple cue discrimination task in order to show that CRF used in the initial training phase, followed by PR in an over-training phase, resulted in a decrease in over-selectivity, compared to a CRF overtraining phase. They concluded that as participants were not receiving reinforcement for all correct responses, they were required to attend to more of the compound stimuli in order to obtain reinforcement. Other research has supported this finding (e.g., Koegel & Rincover, 1977; Schover & Newsom, 1976).

Over-selectivity is a problem in stimulus generalisation, however some successful research has reported effective use of PR to combat this. In particular, Koegel and Rincover (1977) found that PR training procedures resulted in improved responding in extra therapy environments. This research indicates that PR should reduce over-selectivity and therefore improve learning related to generalisation

(Koegel et al., 1979). Albeit, such research needs to be treated cautiously and generalisability is questionable due to the single-subject designs.

In contrast, Remington and Clarke (1993) failed to find re-mediation of over-selectivity using PR in a study teaching matching-to-sample skills to children with intellectual disabilities in the context of augmentative and alternative communication training. Additionally, Dube and McIlvane (1997) showed that over-selectivity was not reduced using intermittent reinforcement schedules in extensive two-sample delayed MTS training. Williams (1989) also failed to show facilitation in performance on discrimination learning using PR in a rat model. Dube et al. (2010) used differential reinforcement for observing as an intervention to increasing observing behaviour and duration and resultantly reducing over-selectivity, but found no change from baseline. The difference in outcome between studies may be due to some studies comparing CRF and PR as two separate conditions, and other studies involving a switch from CRF to PR; such a noticeable shift may heighten attention (Ploog 2010).

The prediction that PR results in less over-selectivity would follow from some views of conditioning (e.g., Pearce & Hall, 1980), and would tend to support an attention-deficit account of over-selectivity (see also Dinsmoor, 1985; Trabasso & Bower, 1968; for similar attentional explanations in the context of over-selectivity). It is important to note that associability theories (e.g., Mackintosh, 1975, 1983; Pearce & Hall, 1980) never considered over-selectivity specifically, however, such attention theories of conditioning could potentially be extended as previous views of attention in the over-selectivity literature do not allow the types of predictions made by these learning based theories to be drawn. Pearce-Hall (1980) propose that conditioning of a CS is dependent on the associability of (informally, the attention paid to) the CS. The orienting response has been used as an index of stimulus associability (Swan & Pearce, 1988), and indicates that the associability of a CS remains high (the orienting response is emitted at a high rate) when the consequences of a CS are unpredictable, but it declines when the CS has come to accurately predict the consequences (Pearce & Bouton, 2001; Pearce & Hall, 1980; Wilson, Boumphrey, & Pearce, 1992). Thus, extending these assumptions to the over-selectivity paradigm, PR should increase attention to the stimulus, as the consequences are unpredictable, and, therefore, it should result in relatively lower levels of over-selectivity; in contrast, CRF would accurately predict consequences, resulting in relatively higher levels of over-selectivity.

This prediction stands in contrast to that drawn from the comparator model outlined by Reed (2010), which suggests that the relative difference in strength between two stimuli will be greater when those stimuli have weaker associative strengths compared to when they have relatively higher associative strengths (see also Leader et al., 2009). Thus, for a given number of trials, associative strength should be weaker after PR than after CRF, and, consequently, over-selectivity should be greater after PR than CRF. Therefore, according to this view, over-selectivity should be relatively greater with PR than with CRF.

1. 11. The current thesis

The current thesis aims to explore the processes and mechanisms of stimulus over-selectivity in an attempt to contribute to the development of remediation procedures for the effect, using a non-clinical population. Before this can be achieved, a sound theoretical understanding of the concept is required. As such, the thesis also attempts to investigate the theories of over-selectivity, particularly exploring whether it is better explained as an attention failure, or as a performance deficit. If a comprehensive and detailed account of over-selectivity can be given, then future research will be more comprehensive in understanding the conditions responsible for this characteristic and the potential of effective remediation can be examined.

Much early previous research utilises a successive discrimination procedure (e.g., Lovaas et al., 1971). Alternatively, simultaneous discrimination procedures arguably hold higher ecological validity in that the majority of sensory information a child is exposed to in everyday life occurs simultaneously rather than successively. Furthermore, successive discriminations require withholding a particular response, a difficulty for children with ASC, whereas simultaneous procedures offer a response alternative. Resultantly, the current thesis utilises simultaneous discrimination procedures, with the use of visual stimuli as previous work (e.g., Lovaas et al., 1971) found no differences between sensory modalities.

The thesis begins by exploring the strength and generality of stimulus over-selectivity. Previous work has indicated that over-selectivity may be a function of task parameters (Anderson & Rincover, 1982) and as such, it was thought vital to explore the conditions under which over-selectivity may occur. It then explores the potential role of inhibition accruing to the under-selected stimulus during training and thus generating over-selectivity. A finding of the under-selected stimulus functioning as an inhibitor would challenge the revaluation findings; one of the major criticisms targeted at attention-deficit theories of over-selectivity, by explaining the effect in terms of generalised removal of inhibition. Following on from this, the effects of schedule of reinforcement and training regimes are investigated in order to begin examining techniques for reducing over-selectivity. Finally the effects of a surprising shift in reinforcer value are explored as a further investigation of the attention deficit perspective, and importantly, as a potentially novel remediation technique of over-selectivity.

Chapter 2

The strength and generality of stimulus over-selectivity

in simultaneous discrimination procedures

2. 1. Introduction

Chapter 1 provides a detailed account of the over-selectivity phenomenon and the range of detrimental effects that can result from such a characteristic, including social skill deficits, language, communication and speech impairments, deficiencies in emotional behaviour, impaired observational learning and an inability to transfer treatment gains. Given the finding that over-selectivity is not only found in individuals with ASC (e.g., Lovaas & Schreibman, 1971) but also in learning disabilities (e.g., Dube et al., 1999), the elderly (e.g., McHugh & Reed, 2007), individuals with acquired brain injury (e.g., Wayland & Taplin, 1985) and in situations involving cognitive strain in a healthy population (e.g., McHugh & Reed, 2007; Reed & Gibson, 2005), understanding the nature of over-selectivity has implications for understanding the nature of deficits seen across a variety of situations and populations. Therefore, given the apparent ubiquity, the first chapter aimed to investigate the over-selectivity effect under a range of test conditions, in order to explore the relative strength and generality of the effect, as currently few actual test conditions have been studied. Such research is important in order to begin to understand the potential theoretical frameworks for this effect.

As Chapter 1 indicates, previous work, regardless of the population, often has focused on simple discrimination task methodologies (although not exclusively; see Dube & McIlvane, 1999), whereby participants are trained to respond to a compound stimulus comprising of two elements for which they get positive feedback, while responses to the other compound stimulus receives negative feedback (e.g., AB+ CD-). Participants are then presented with the elements of the complex stimulus (one element from the previously reinforced compound and one from the non-reinforced compound; e.g., A v C; A v D; B v C; B v D) in extinction, and the degree of selection to each element is recorded. It is found that non-autistic populations experiencing no cognitive strain (such as a concurrent cognitive load task (e.g., Gibson & Reed, 2005), show equal responding to both elements of the compound stimulus; whereas participants with ASC (e.g., Koegel & Schreibman, 1977) or general learning disabilities (e.g., Bailey, 1981), for example, over-select one of the stimulus elements over the other. Likewise, healthy adults also display over-selective responding when presented with cognitively demanding tasks during the trials (e.g., Broomfield et al., 2008a, 2008b; Reed, 2006; Reed & Gibson, 2005).

In this procedure, the initial training involves the use of positive feedback for one compound, and negative feedback to the other compound. Thus, the test during which over-selectivity is displayed involves a choice between a previously reinforced element and a previously punished element; presumably involving both approach to the previously reinforced element and avoidance of the previously punished stimulus. Over-selectivity not only involves approach of the previously reinforced stimulus, but also avoidance responses relating to the previously punished stimulus, and both may be implicated in its generation. The use of such restricted numbers of training and test methods generates the possibility that the level of over-selectivity (or even, the existence of over-selectivity) may be determined not only by learning about reinforced cues but also the way those reinforced cues are tested. Until such basic issues are resolved, it is unclear how theoretical accounts of the phenomena should be developed.

2. 2. Experiment 1

As noted above, the typical procedure for investigating over-selectivity requires participants to choose between elements from previously reinforced and previously punished compound stimuli. Such discrimination performance reflects both a tendency to approach an element at test (the previously reinforced element), as well as a tendency to avoid an element (the previously punished stimulus). It is not clear whether, in this simultaneous discrimination procedure, over-selectivity between elements of the previously reinforced compound would emerge when an avoidance response was not implicated.

The first experiment explores whether the over-selectivity effect occurs when the avoidance response is removed. This was attempted by training stimuli to be used as comparison for the elements from the previously reinforced compound at test that were associatively neutral, and would not be avoided (as previously punished elements would be). To this end, the experiment aimed to replicate the basic over-selectivity effect when previously reinforced and previously neutral elements were used at test, and explore its occurrence using an alternative test condition compared to the standard procedure. If the training procedure did produce neutral stimuli, as opposed to punished elements, then the neutral stimuli would be predicted to be chosen more often than the punished elements. If this impacts on over-selectivity, then its generality needs to be considered.

2. 3. Method

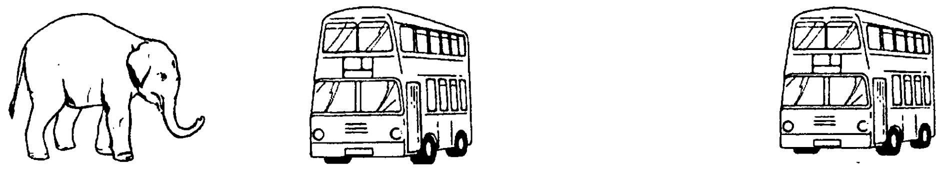
Participants

Sixteen healthy volunteer participants were recruited from the general public, and included seven males and nine females, with an age range of 18 to 29 years (mean = 19.56 years, SD = 1.86). Opportunity sampling was used to select participants, and they were not paid for their participation. Based on McHugh and Reed's (2007) research on age trends, participants under the age of 18, and over the age of 55, were excluded.

Apparatus and Materials

Participants completed a standardised measure; the Autism Spectrum Quotient (AQ: Baron-Cohen et al., 2001) to assess pre-existing high functioning autism. Those scoring over 32 were excluded from the analysis as such scores indicate meeting the criteria for high functioning Asperger's Syndrome.

Stimuli were presented on white laminated cards (measuring 21cm by 7cm) with all pictures being taken from the British Picture Vocabulary Scale. The compound stimulus contained two stimuli, whilst other cards presented the individual element stimuli and contained one of the pictures from the compound stimulus. Figure 1 shows an example of a compound stimulus and one of its individual stimuli (not to scale).



Compound Stimuli

Associated Stimuli

Figure 1 An example of one of the compound cards and one of its associated stimuli presented to participants.

Procedure

A table-top method was utilised, with the participant completing the task whilst sitting opposite the experimenter in a quiet room, with no distractions. As a result of Reed and Gibson's (2005) finding of a concurrent cognitive load being required to generate over-selectivity in healthy participants, the participants were required to vocally count backwards in sevens from a random five-digit number throughout the experiment. Participants were prompted to continue counting if they showed hesitation. A within-subjects design was used with all participants experiencing a training phase involving two simple discrimination tasks, with trials from each being randomly interspersed, followed by two test phases. The order in which the test phases were presented was counterbalanced across the participants. Table 1 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase 1	AB vs. CD Selection of AB yields positive ‘yes’ response Selection of CD yields negative ‘no’ response	Trials in Training Phase 1 and Training Phase 2 are presented interspersed randomly until ten consecutive correct responses in Training Phase 1 and until ten trials of Training Phase 2 regardless of whether a correct response is given
Training Phase 2	E vs. F Selection of E yields positive ‘yes’ response on 50% of trials and negative ‘no’ response on 50% of trials Selection of F yields positive ‘yes’ response on 50% of trials and negative ‘no’ response on 50% of trials	
Test Phase 1 (Standard)	A vs. C A vs. D B vs. C B vs. D	Five trials of each combination presented randomly
Test Phase 2 (Neutral)	A vs. E A vs. F B vs. E B vs. F	Five trials of each combination presented randomly

Training Phase: The training phase consisted of two simple discrimination tasks, presented concurrently, with trials from discrimination task one (AB vs. CD) being intermixed randomly with trials from discrimination task two (E vs. F).

Discrimination task one aimed to generate potential over-selectivity; the experimenter presented two cards on the centre of the table facing the participant. One card contained one compound stimulus (AB), and the second card contained an alternative compound stimulus (CD). Participants were instructed to point to a card, and were informed that they would be given corrective verbal feedback in the form of 'yes' or 'no'. Selection of the AB compound stimulus yielded a positive 'yes' response and selection of the CD compound stimulus yielded a negative 'no' response. Thus, AB was reinforced in the presence of the punished CD. The experimenter recorded all choices made.

The effects of intrinsic salience of the elements was avoided by using different elements of the stimuli (i.e., 'A', 'B', 'C' and 'D') for each participant. The position of the cards was determined by systematic randomisation, with the correct card being presented on the left 50% of the time, and on the right 50% of the time, thus, eliminating the possibility that selection was based on position. Following the participant choosing a card, and the recording of the response, the next cards were immediately presented.

Discrimination task two was employed to produce associatively neutral stimuli for the test phase and consisted of the presentation of one card displaying one stimulus (E), and a second card with another stimulus element (F). Selection of E was reinforced with a positive 'yes' response on a random 50% of trials, whilst F yielded a negative 'no' response on those trials; and the selection of F was reinforced with a positive 'yes' response on a random 50% of trials, whilst E yielded a negative 'no' response on those trials. The physical nature of the stimuli E and F were different for each participant. This procedure resulted in the cards being exposed to the participants, whilst producing neutral associative strength. This phase continued until the participant produced ten consecutive correct responses in the first discrimination task (above), and were presented with the E and F comparison ten times.

Test Phase (Standard): Participants were required to choose between two simultaneously presented cards; one card depicted an element from the reinforced stimulus, whilst the other card depicted a picture from the punished stimulus ('A' vs. 'C'; 'A' vs. 'D'; 'B' vs. 'C'; 'B' vs. 'D'). Each combination involved 5 trials, and, thus, 20 trials in total. No verbal feedback was provided during this phase.

Test Phase (Neutral): This test phase was similar to the standard test phase, in that participants were required to choose between two simultaneously presented cards; but one card contained one of the previously reinforced-compound stimuli ('A' or 'B'), and the other card contained one of the neutral stimuli ('E' or 'F').

Therefore, four combinations were used ('A' vs. 'E'; 'A' vs. 'F'; 'B' vs. 'E'; 'B' vs. 'F'), with 5 trials for each combination, and, thus, 20 trials in total. No verbal feedback was provided.

Following completion of all trials, each participant was given the AQ to assess their levels of pre-existing high functioning autism.

2. 4. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Participants on average took 13.5 (± 4.05) trials during training to reach the criterion of selecting the 'positive' AB card 10 consecutive times.

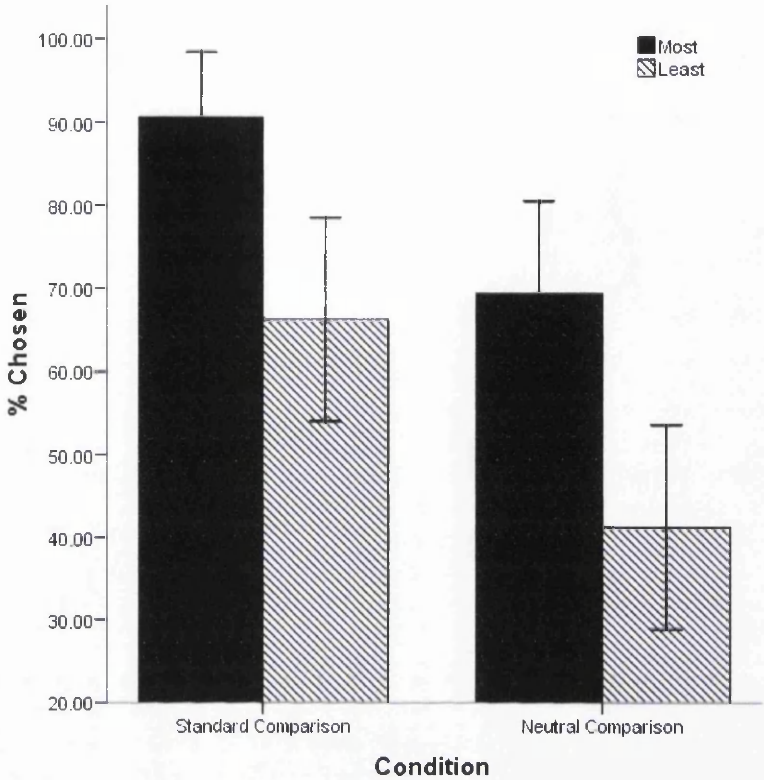


Figure 2 Group mean levels of over-selectivity in both conditions: the standard comparison (participants choosing between a previously reinforced stimulus and previously punished stimulus at test) and the neutral comparison (participants choosing between a previously reinforced stimulus and a neutral stimulus at test) (error bars = SEM).

Figure 2 shows the mean percentage of times that each stimulus (i.e., the most selected and the least selected from the initially reinforced compound, AB) was chosen in the test phase. The standard comparison condition involved testing the elements from the previously reinforced compound (i.e., A and B) against the elements from the previously punished compound (i.e., C and D). The neutral comparison condition involved testing the elements from the previously reinforced compound (i.e., A and B) against neutral cues (i.e., E and F). Inspection of Figure 2 indicates that levels of choice accuracy at test were higher in the standard condition than in the neutral condition. There was a large difference between the percentage of times that the most and least chosen stimuli were chosen, but the difference between the most and least selected stimuli was similar in the standard comparison and the neutral comparison conditions. A two-way, repeated measures ANOVA (stimulus type – most versus least, and condition – standard versus neutral) was conducted on these data, and a rejection criterion of $p < 0.05$ was used for this and all subsequent analyses. This analysis indicated statistically significant main effects of stimulus type (most selected / least selected), $F(1,15) = 48.29$, and a statistically significant main effect of condition (standard / neutral), $F(1,15) = 14.43$. There was no significant interaction between the two factors, $F < 1$.

In order to determine whether there was a statistically significant difference in the level of choice for the stimuli compared to deviation from the level of choice expected by chance, the random model based on the binomial equation provided the necessary difference between the over-selected and under-selected stimuli in 10 choices (see Section 1.8. Measuring over-selectivity). The expected differences were 14% for the standard condition and 17% in the neutral condition. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated a significant difference in the standard condition, $t(15) = 2.43$, and in the neutral condition, $t(15) = 1.81$, thus, indicating significant over-selectivity in both conditions.

Taken together, the findings support the prediction that associatively neutral stimuli would be chosen more than punished cues, as the over-selected stimulus was chosen less when a comparison was neutral, rather than punished. This is not surprising, as participants have no reason to avoid a neutral stimulus. However, the findings still indicated over-selectivity occurred in both the condition involving punished cues and in the condition involving neutral cues, suggesting that over-selectivity is not a function of an unspecified interaction with avoidance.

2. 5. Experiment 2

Experiment 2 aimed to replicate the over-selectivity effect using an alternative (non-punished) test condition. The prior study reported here attempted to produce an associatively neutral stimulus. Experiment 2 extended this work by exploring the impact of employing a novel stimulus as the test comparator. If it were to be the case that the under-selected stimulus is responded away from as a result of being perceived as novel, comparison of the under-selected stimulus with a genuinely novel stimulus, as opposed to a neutral stimulus, during test should reduce the effect of active avoidance of the under-selected stimulus, but will not reduce this effect if this mechanism is not responsible.

2. 6. Method

Participants

Sixteen healthy volunteer participants were recruited from the general public, and included eleven males and five females, with an age range of 18 to 21 years (mean = 19.50 years, SD = 0.82). As with Experiment 1, opportunity sampling was used to select participants, they were not paid for their participation, and participants under the age of 18 and over the age of 55 were excluded.

Apparatus and Materials

The apparatus and materials were the same as those used in Experiment 1.

Procedure

The procedure was identical to Experiment 1, with participants counting backwards in sevens from a random five digit number, and the only difference being that in the non-standard test phase (labelled the 'novel phase' in this experiment), the participants were required to choose between two simultaneously presented cards, with one card containing one of the reinforced-compound stimuli ('A' or 'B') and the other card containing a completely novel stimulus ('G' or 'H'), which had not been previously seen by participants (rather than being presented with the neutral stimulus). Therefore, four combinations were used ('A' vs. 'G'; 'A' vs. 'H'; 'B' vs. 'G'; 'B' vs. 'H'), with 5 trials for each combination, and, thus, 20 trials in total. The 20 novel phase test trials were presented immediately following the presentation of the 20 standard phase test trials as in Experiment 1. Following completion of all trials, each participant was given the AQ to assess their levels of pre-existing high functioning autism. Table 2 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase 1	AB vs. CD Selection of AB yields positive 'yes' response Selection of CD yields negative 'no' response	Trials in Training Phase 1 and Training Phase 2 are presented interspersed randomly until ten consecutive correct responses in Training Phase 1 and until ten trials of Training Phase 2 regardless of whether a correct response is given
Training Phase 2	E vs. F Selection of E yields positive 'yes' response on 50% of trials and negative 'no' response on 50% of trials Selection of F yields positive 'yes' response on 50% of trials and negative 'no' response on 50% of trials	
Test Phase 1 (Standard)	A vs. C A vs. D B vs. C B vs. D	Five trials of each combination presented randomly
Test Phase 2 (Novel)	A vs. G A vs. H B vs. G B vs. H	Five trials of each combination presented randomly

2. 7. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Participants on average took 12.44 (± 3.92) trials during training to reach the criterion of selecting the 'positive' AB card 10 consecutive times.

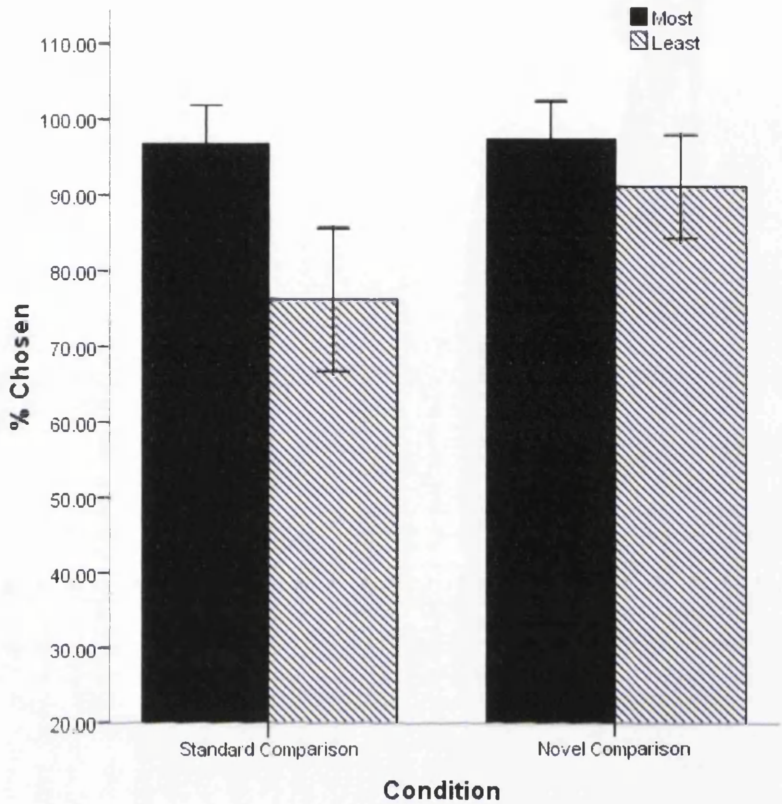


Figure 3 Group mean levels of over-selectivity in both conditions: the standard comparison (participants choosing between a previously reinforced stimulus and previously punished stimulus at test) and the novel comparison (participants choosing between a previously reinforced stimulus and a novel stimulus at test) (error bars = SEM).

Figure 3 displays the mean percentage of times each stimulus (the most selected and the least selected from the initially reinforced compound, AB) was chosen in the test phases, the standard comparison condition when the previously reinforced elements (i.e., A and B) were presented with the previously punished elements (i.e., C and D), and the novel comparison condition when the previously reinforced elements (i.e., A and B) were tested against novel elements (i.e., G and H). Inspection of Figure 3 shows that the overall level of accuracy was higher in the novel condition compared to the standard condition, that one stimulus was chosen more often than the other in both conditions, but that there were greater levels of over-selectivity in the standard condition compared to the novel condition.

A two-way, repeated measures ANOVA (stimulus type – most versus least and condition – standard versus novel) was conducted on these data, and indicated a statistically significant main effect of stimulus type, $F(1,15) = 28.22$, but only a marginal main effect of condition (standard / novel), $F(1,15) = 3.81$, $p < 0.07$. Additionally, there was a statistically significant interaction between the two factors, $F(1,15) = 8.27$. Simple effect analyses conducted on the stimulus type (most versus least) for the standard comparison revealed a statistically significant difference between the most and least chosen stimulus, $F(1,15) = 34.07$, but no statistically significant simple effect of stimulus (most versus least) for the comparison with the novel stimulus, $F(1,15) = 3.13$.

Simple effects conduced on the group (standard versus novel) for the most-selected stimulus revealed no statistically significant difference between the standard and novel comparisons, $F < 1$, but a statistically significant difference between the standard and novel comparisons for the least selected stimulus, $F(1, 15) = 18.02$.

In order to determine whether there was a statistically significant difference in the level of choice for the stimuli compared to deviation from the level of choice expected by chance, the random model based on the binomial equation provided the necessary difference for significance between the over-selected and under-selected stimuli, in 10 choices, which was 11% in the standard condition, and 7% in the novel condition. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated a significant difference in the standard condition, $t(15) = 2.09$, but not for the novel condition, $t < 1$.

The results showed that the reinforced elements were numerically more likely to be chosen in both test conditions, but that only in the standard test condition was the over-selectivity effect statistically significant. The results also revealed that novel cues were chosen less than punished cues (the chosen stimuli being chosen more often in the novel condition than in the punished condition). This result was unexpected and therefore deserves some comment. The literature generally reveals a preference for novelty (e.g., Cantor, 1968; Cantor & Cantor, 1964a; Cantor &

Cantor, 1965; Gottfried, Rose & Bridger, 1977; Schreibman & Charlop, 1981; Steele & Pederson, 1977; Wilson, 1974; Witte & Cantor, 1967) and longer visual orienting has been found towards a novel stimulus rather than a familiar stimulus (e.g., Cantor & Cantor, 1964b; Daehler & Bukatko, 1977; Fantz, 1964; Hutt, 1975; Saayman, Ames & Moffett, 1964; Steele & Pederson, 1977).

One possibility for the current findings is that novelty, itself, may be aversive, and that such novel cues are avoided. This is often found in some condition preparations (e.g., Blanchard, Kelley, & Blanchard, 1974; Carroll, Dinc, Levy & Smith, 1975; Mandler, 1970; Mitchell, 1976; see Corey, 1978), and can occur in humans, especially in those with learning disabilities (e.g., Zeaman & House, 1962).

2. 8. Experiment 3

Experiment 3, again, aimed to replicate the over-selectivity effect using a third alternative test condition. Re-examining the results of Experiment 1, in the light of Experiment 2, might suggest that the cues used in the former experiment were not really neutral, as a result of their conditioning history. It is, therefore, necessary to create elements with no associative strength and no conditioning history. If conditioning using a stimulus with no associative strength, but which is also not novel, occurs, it is questionable whether the same effect as seen in Experiment 1 will arise, or whether the same effect as shown by the comparison with a novel stimulus will arise.

Additionally, it may be the case that reinforcing CD with 'no' feedback is not particularly punishing, as there are actually few trials on which CD is chosen: In Experiment 1, participants on average chose the AB compound 11.56 (± 2.56) times, and chose the CD compound 1.94 (± 1.69) times; in experiment 2, participants on average chose the AB compound 11.25 (± 1.88) times, and chose the CD compound 1.19 (± 2.54) times. It is paradoxical that novelty would be worse than punishment. Therefore, it is important to explore the effects of providing no verbal feedback for CD. It is assumed that participants would have no reason to avoid C and D and therefore these elements would be more likely to be selected.

2. 9. Method

Participants

Sixteen healthy volunteer participants were recruited from the general public, and included thirteen males and three females, with an age range of 19 to 34 years (mean = 25 years, SD = 4.18). As with Experiments 1 and 2, opportunity sampling was used to select participants, they were not paid for their participation, and participants under the age of 18 and over the age of 55 were excluded.

Apparatus and Materials

The apparatus and materials used were the same as those used in Experiments 1 and 2.

Procedure

As with the previous two experiments, a table-top method was used with participants vocally counting backwards in sevens from a random five-digit number. The study involved two conditions; Condition 1 was the standard discrimination procedure, Condition 2 involved a training procedure in which only positive feedback was given to AB, but no negative feedback was given to CD. The order of presentation of the conditions was counterbalanced across the participants. Table 3 represents the procedure in this experiment

Phase	Procedure	Criterion to continue
Training Condition 1	AB vs. CD Selection of AB yields positive 'yes' response Selection of CD yields negative 'no' response	Task continues until participant gives ten consecutive correct responses
Test Phase Condition 1 (Standard)	A vs. C A vs. D B vs. C B vs. D	Five trials of each combination presented randomly
Training Condition 2	AB vs. CD (Using different AB and CD stimuli cards to those used in Condition 1) Selection of AB yields positive 'yes' response Selection of CD yields no response	Task continues until participant gives ten consecutive correct responses
Test Phase Condition 2	A vs. C A vs. D B vs. C B vs. D	Five trials of each combination presented randomly

Training Condition 1: The first training phase consisted of a simple discrimination task as used in Experiments 1 and 2. Participants were presented with one card containing one compound stimulus (AB), whilst the second card contained an alternative compound stimulus (CD). Selection of AB yielded a positive 'yes' response, whereas selection of CD yielded a negative 'no' response. This phase continued until the participant produced ten consecutive correct responses.

Test Phase Condition 1: This phase was identical to the standard testing phase used in Experiments 1 and 2.

Training Condition 2: The second training phase consisted of the same simple discrimination task as used in experiments 1 and 2, but using different cards. Additionally, although selection of AB still yielded a positive 'yes' response, selection of CD yielded no response from the experimenter. This phase continued until the participant produced ten consecutive correct responses.

Test Phase Condition 2: This phase was identical to the above testing phase. Following completion of all trials, each participant was given the AQ to assess their levels of pre-existing high functioning autism.

2. 10. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

In the standard discrimination task, participants on average took 13.06 (± 3.36) trials during training to reach the criterion of selecting the correct card 10 consecutive times. On the second discrimination task, without negative feedback, participants on average took 21.50 (± 10.48) trials during training to reach the criterion of selecting the correct card 10 consecutive times. A t-test revealed a statistically significant difference between the number of trials taken to reach criterion for each discrimination task, $t(30) = 3.07$. Therefore, it took participants significantly longer to learn the discrimination when participants were only reinforced for selecting AB and received no verbal feedback for selected CD.

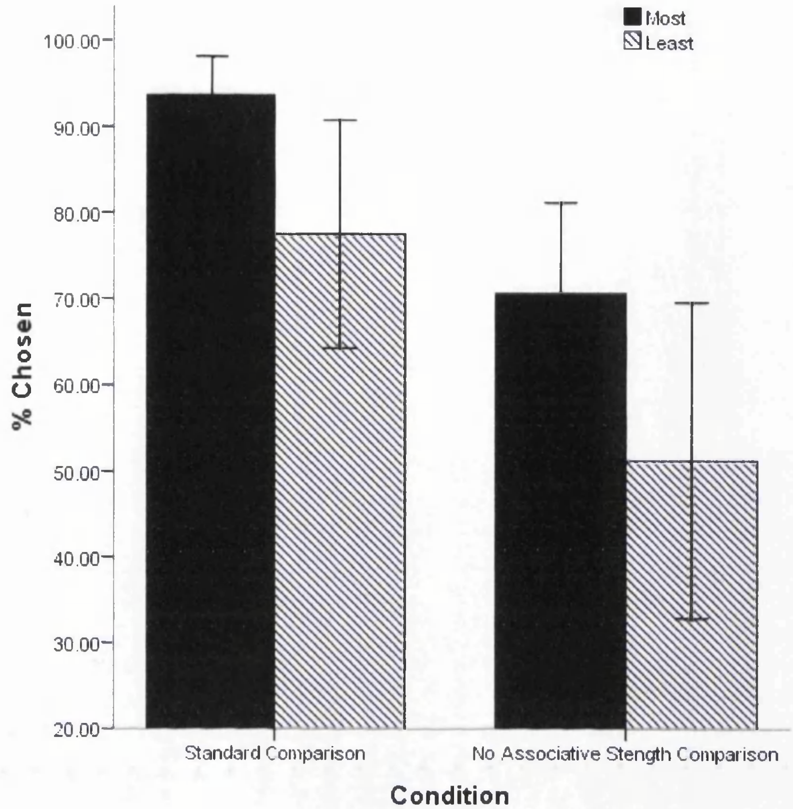


Figure 4 Group mean levels of over-selectivity in both conditions: the standard comparison (participants receiving verbal feedback in the form of 'yes' for selecting AB and verbal feedback in the form of 'no' for selecting CD) and the neutral with no associative strength comparison (participants receiving verbal feedback in the form of 'yes' for selecting AB and no verbal feedback for selecting CD) (error bars = SEM).

Figure 4 shows the mean percentage of times each stimulus (the most selected and the least selected from the initially reinforced compound, AB) was chosen in the test phases: the standard condition tested the previously reinforced elements against the previously punished elements; and the second condition tested the previously reinforced elements against cues that had received no reinforcement or punishment. Figure 4 reveals over-selectivity in both conditions, in that one stimulus (A or B) was chosen more often than the other, providing further evidence for this effect. Additionally, the findings closely resemble those of Experiment 1, indicating that the over-selected stimulus was chosen less when presented with an associatively neutral cue with no conditioning history, compared to when presented with a punished cue. A two-way, repeated measures ANOVA (stimulus type – most verses least; and condition – standard verses neutral with no associative strength) was conducted and indicated statistically significant main effects of stimulus type (most selected / least selected), $F(1,15) = 13.02$, and condition (standard / neutral with no associative strength), $F(1,15) = 24.90$. However, there was no significant interaction between the two factors, $F < 1$.

In order to determine whether there was a statistically significant difference in the level of choice for the stimuli compared to deviation from the level of choice expected by chance, the random model based on the binomial equation provided the necessary difference for significance between the over-selected and under-selected stimuli, in 10 choices, which was 10% in the standard condition, and 17% in the neutral with no associative strength condition. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated marginally significant differences in the standard condition, $t(15) = 1.50, p < 0.08$, and in the neutral with no associative strength condition, $t(15) = 1.45, p < 0.08$, indicating a similar tendency to over-selectivity in both conditions.

The findings therefore, indicate that the neutral stimuli with no associative strength were chosen more than punished cues, in that the over-selected stimulus was chosen less when the comparison stimulus was neutral with no associative strength, rather than punished. Additionally, over-selectivity still occurred in both the condition involving punished cues and in the condition involving neutral cues with no associative strength. As was predicted, results showed that when no verbal feedback for CD was provided (and therefore the stimuli are not punished), participants have no reason to avoid these elements and as such, these elements are more likely to be selected at test.

2. 11. General discussion

The present chapter aimed to investigate the relative strength and generality of the over-selectivity effect under a range of test conditions. Such research is important in order to begin to understand the potential theoretical framework of this effect. Previous work, regardless of the population, has typically focused on the standard method identified. This generates the possibility that the level of over-selectivity may be determined not only by learning about reinforced cues, but also by the way those reinforced cues are tested. All three experiments successfully replicated previous work showing that stimulus over-selectivity can be found in non-clinical adult participants, through the use of a concurrent cognitive load (e.g., Broomfield et al., 2008a; Reed, 2006; Reed & Gibson, 2005) whilst screening for high functioning autism, using the AQ.

Additionally, the over-selectivity effect was replicated under some alternative test conditions, when the comparison stimulus was neutral (Experiment 1), and associatively neutral with no conditioning history (Experiment 3), indicating that over-selectivity occurs regardless of training and test procedures. Coupled with the studies that have employed MTS procedures (e.g., Broomfield et al., 2008a), this suggests that over-selectivity is a highly robust phenomenon.

Although there was no impact on the demonstration of over-selectivity, the current studies did show that the training and testing procedures did have an impact on the level of control exerted by the stimuli. Experiment 1 explored whether presenting the reinforced stimuli with an associatively neutral stimulus reduced the levels of responding normally seen to the previously reinforced elements when compared to previously punished elements. Experiment 2 indicated an impact on the level of responding in that participants actively avoided the novel stimulus. This supports previous research indicating the avoidance of novelty, especially in relation to those suffering cognitive strain (e.g., Zeaman & House, 1962). Experiment 3 extended these findings, and explored the effects of presenting the reinforced stimuli with neutral stimuli with no associative strength and no conditioning history. It would be assumed that participants would have no reason to avoid C and D, and, therefore, these elements would be more likely to be selected. This was found to be the case, with findings replicating those of Experiment 1.

From a clinical perspective, using a non-clinical population, the present research demonstrates the generality of the over-selectivity effect, which is often displayed in individuals with ASC (e.g., Koegel & Schreibman, 1977) and individuals with general learning disabilities (e.g., Bailey, 1981). As indicated in Chapter 1, responses restricted to particular cues can be detrimental to learning as it may restrict learning of the range or number of features of a stimulus, and, therefore, result in an inability to acquire particular behaviours (Schneider & Salzberg, 1982). Over-selectivity may account for many of the behavioural deficits found in individuals with ASC, as well as individuals with general learning disabilities, thus it is vital that the phenomenon succumbs to comprehensive investigation (Schreibman et al., 1977).

Additional support for the strength and generality of the over-selectivity effect in individuals without intellectual disabilities was fundamental as it allows for a model of the phenomenon to be established, and, therefore, an exploration of potential strengths and weaknesses of possible interventions can be developed (Reed, 2006). It is important to note that the underlying cause of the over-selectivity shown in a non-clinical population compared to an ASC population may vary and therefore generalisations must be made with caution (Reed & Gibson, 2005) (See Section 6. 6. Generalisation of results, in Chapter 6).

In summary, the present research demonstrated the over-selectivity effect in all three experiments indicating the fact that it can be generated in a range of test conditions. Additionally, in terms of level of responding, behavioural control in the standard test procedure appears indicative of both responding towards reinforced stimuli as well as avoiding test stimuli. The current support indicating the strength and generality of the over-selectivity deficit provides ubiquity to the phenomenon, making it important to investigate further.

Chapter 3

Lack of evidence for inhibitory processes in stimulus over-selectivity

3. 1. Introduction

Chapter 2 confirmed the existence and strength of the over-selectivity effect under a range of test conditions, including the standard condition when the comparison stimulus was punished (Experiments 1, 2 and 3), as well as when the comparison stimulus was neutral (Experiment 1), and associatively neutral with no conditioning history (Experiment 3). Such research provided ubiquity to the over-selectivity effect, and was essential before potential theoretical frameworks of the phenomenon can be developed. As opposed to exploring the influence of test conditions, conditioning effects may play a role in over-selectivity in that there may be an enhanced inhibitory mechanism resulting from a concurrent load, which produces greater inhibition to the under-selected stimulus.

As outlined in Chapter 1 (Section 1. 9. Theories of over-selectivity), a number of theories have been advanced to accommodate over-selectivity findings, but a commonly-held view is based on an attention-deficit perspective (e.g., Dube et al., 1999; Lovaas et al., 1971). Such a view argues that over-selectivity occurs as a result of failing to attend to all of the elements of the stimulus during initial training, and, as a result, only the elements attended to subsequently control behaviour (e.g., Dube et al., 1999; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971).

However, research has indicated that when control of behaviour exerted by a previously over-selected stimulus is reduced through a revaluation procedure, the under-selected stimulus may subsequently emerge to control behaviour, despite having undergone no direct conditioning itself (Broomfield et al., 2008a; Leader, et al., 2009; McHugh & Reed, 2007; Reed et al., 2009). Such a finding is not easily explained by an attention-deficit account of over-selectivity, as such a view would not allow any learning to have accrued to the under-selected stimulus in training; hence, it could not control behaviour as a result of manipulations to the strength of the over-selected stimulus.

Despite some contradictory findings (e.g., Holland, 1984, 1999; Speers et al., 1980) support for the view that stimuli initially showing little evidence of behavioural control can come to control behaviour as a result of revaluation of other stimuli also has been shown in the conditioning literature (e.g., Gunther et al., 1998; Kaufman & Bolles, 1981; Matzel et al., 1985; Miller et al., 1992; Reed & Reilly, 1990; Reilly et al., 1996; Wilkie & Masson, 1976). To this extent, attention-based theories of over-selectivity are weakened, as they would not predict that revaluation of one cue would have an influence on the other cue, especially if that second cue has not been attended too in initial training.

The current research, therefore, concerns the potential role of inhibition in generating over-selective responding, and its importance when considering the type of learning that accrues to the under-selected stimuli during training. It should be noted that employment of the concept of inhibition could potentially explain the successfulness of revaluation procedures directed at the over-selected stimulus in remediating responding to the under-selected stimulus (e.g., Reed et al., 2009), and, if this explanation were supported, it would remove the critique of the attention-based theories. This possibility is based on the notion that the under-selected stimulus from the reinforced compound may gain inhibitory properties during initial training. If this is so, then reducing the strength of the over-selected stimulus from this reinforced compound may also result in a devaluing of the inhibitory properties of the under-selected stimulus through generalisation. Therefore, an increase in responding to the under-selected stimulus from initial training to test may actually reflect a loss of inhibitory control, rather than a gain in the ability to control behaviour *per se*. Some previous work has indicated that the under-selected stimulus is chosen less than 50% of the time at first test, potentially implying that it is controlling behaviour in an inhibitory way (see Reed et al., 2010). Of course, it is not the case that only under-50% selection reflects inhibitory control; the choice of a stimulus in the current procedures is a product of both the associative strength of that target stimulus, and the associative strength of the comparison stimulus. If the comparison stimulus (which is drawn from the non-reinforced compound) has greater inhibitory strength than the target, then the target will be selected, even if it itself has inhibitory properties, given an above 50% selection.

However, there is nothing necessarily apparent in the simultaneous discrimination procedure (AB+ CD-) that might be expected to lead to conditioned inhibition accruing to the under-selected element from the reinforced compound (either A or B). Conditioned inhibition typically requires a feature negative procedure, whereby the inhibitory stimulus predicts the absence of an otherwise predicted reinforcer (e.g., A+ AB-, where B becomes a conditioned inhibitor). Moreover, in the case of the present AB+ CD- procedure, it may be expected to be limited to the elements of the non-reinforced compound. However, conditioned inhibition procedures are not the only method through which a stimulus can gain inhibitory strength. A potential candidate mechanism for generating inhibition in these circumstances, that may deserve exploration, is the retrieval induced forgetting (RIF) effect (see Anderson, Bjork, & Bjork, 1994, 2000). If a set of stimuli belong to the same class, and attention is focused on a subset of those stimuli, then the unattended subset is less well remembered, most probably due to the development of inhibition of those items (see, for example, Anderson, 2003; Anderson et al., 1994; Anderson & Spellman, 1995; Ciranni & Shimamura, 1999; Shaw, Bjork & Handal, 1995). That is, the act of remembering itself results in forgetting of other stimuli. In this case, the elements A and B may well form an equivalence set due to their common outcome (see Dickins & Dickins, 2001). Given the potential importance of the effects to attention-based views of over-selectivity, the suggestion that the least attended stimuli gains inhibitory strength by virtue of being associated with a more attended to stimulus deserves exploration.

The current research aims to examine this possibility further, and to explicitly test for the presence of inhibition through the use of summation and retardation tests (Rescorla, 1969). If the under-selected stimulus was found to function as an inhibitor, then it would undermine a main strand of the criticism about attention-deficit theories of over-selectivity, that is, the revaluation findings (Reed, 2010).

3. 2. Experiment 4

Experiment 4 aimed to replicate the over-selectivity effect using the standard procedure employed by the experiments in Chapter 2, as well as recent work in this area (e.g., Reed & Gibson, 2005). Furthermore, Experiment 4 aimed to explore whether control over behaviour by a previously over-selected stimulus may be reduced (and control exerted by an under-selected stimulus be increased) through revaluation of this stimulus, by reinforcing novel cues in the presence of this stimulus (Leader et al., 2009; McHugh & Reed, 2007; Reed et al., 2009). If it is found to be the case that extinction of the over-selected stimulus allows an emergence of the under-selected stimulus to gain control over behaviour, this provides considerable problems for a strict attention-deficit perspective of over-selectivity. That is, such accounts assume that the under-selected stimulus was not attended to in initial training (e.g., Dube et al., 1999; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971) and thus this stimulus would not be able to subsequently control behaviour following extinction of the over-selected stimulus.

To this end, participants were randomly assigned to one of two groups. Both groups received initial simultaneous discrimination training with two, two-compound stimuli (along with a concurrent load task) to replicate the basic over-selectivity effect. The Revaluation Group then received extinction of responses to the over-selected stimulus to reduce control by this stimulus, whereby novel stimuli were reinforced with positive feedback in the presence of the identified over-selected stimulus. The Control Group did not receive such revaluation training. Both groups were then re-tested to explore whether there was over-selectivity in the groups, and to determine whether a reduction in the strength of the previously over-selected stimuli would impact the level of behavioural control exerted by the previously under-selected stimulus.

3. 3. Method

Participants

Sixteen healthy volunteer participants (seven males and nine females), were recruited from the general public, with an age range of 19 to 31 years (mean = 21.38 years, SD = 3.81). Participants were selected based on opportunity sampling, and those under the age of 18, and over the age of 55, were excluded as a result of McHugh and Reed's (2007) research on age trends in over-selectivity.

Apparatus and Materials

As with the experiments in Chapter 2, participants completed the AQ (Baron-Cohen et al., 2001) to assess pre-existing high functioning autism. Those scoring over 32 were excluded from the analysis as such scores indicate meeting the criteria for high functioning Asperger's Syndrome.

All stimuli presented to participants were identical to those utilised in the experiments in Chapter 2.

Procedure

As with the previous experiments, a table-top design was used (with the experimenter sitting opposite the participant) and all participants were required to vocally count backwards in sevens from a random five-digit number. The experiment consisted of four tasks, all conducted immediately after one another, in a quiet room. Table 4 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase	AB vs. CD Selection of AB yields positive 'yes' response Selection of CD yields negative 'no' response	Ten consecutive correct responses of selecting AB
Test Phase (Standard)	A vs. C A vs. D B vs. C B vs. D	Five trials of each combination presented randomly
Revaluation Training Phase	Over-Selected vs. Novel 1 Over-Selected vs. Novel 2 Over-Selected vs. Novel 3 Over-Selected vs. Novel 4 Where selection of over-selected yields negative 'no' response and selection of novel yields positive 'yes' response	Ten consecutive correct responses of selecting novel stimulus
Test Phase (Re-Testing)	A vs. C A vs. D B vs. C B vs. D	Five trials of each combination presented randomly

Training Phase: All participants in both the Revaluation and the Control group completed the same training phase utilised in the previous experiments; a simple discrimination task, whereby compound stimuli AB was reinforced with verbal feedback in the form of 'yes', in the presence of the non-reinforced compound stimuli CD which received verbal feedback in the form of 'no'. Different elements of the stimuli (i.e., A, B, C and D) were used for each participant and randomisation determined the position of the cards in order to ensure that selection was not based on position. The phase lasted until the participant produced 10 consecutive correct responses, as it was said that they had acquired the training discrimination by this time (see Leader et al., 2009; Reed & Gibson, 2005).

Testing Phase: All participants in both groups then underwent the Standard Testing Phase whereby they were presented with two cards simultaneously, each comprising of one picture from the compound stimulus (A, B, C or D). The pictures were paired so that participants chose between a stimulus from the reinforced compound, and a stimulus from the non-reinforced compound (A v C; A v D; B v C; B v D), with 5 trials for each combination, and, thus, 20 trials in total. No verbal feedback was provided.

Participants were then required to complete the AQ to assess their levels of pre-existing high functioning autism, whilst the experimenter determined which stimulus element from the previously reinforced compound (i.e. 'A' or 'B') had been selected the most by calculating the percentage of times during the test each element had been chosen.

Revaluation Training Phase: Only participants in the Revaluation group received Revaluation Training; those in the control group did not receive this phase. For those in the Revaluation group, the identified over-selected stimulus was presented simultaneously with one of four previously unseen (and, therefore, novel) stimuli. The four novel stimuli were presented randomly over the trials. Participants were given positive verbal feedback in the form of 'yes' when they selected the novel stimulus and were punished (told 'no') when they selected the over-selected stimulus. The final phase commenced once the novel stimulus had been selected 10 consecutive times.

Re-Testing Phase: The re-testing phase was identical to the test phase, with 20 trials in total, and all participants from both groups receiving testing.

3. 4. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of group, participants on average took 13.06 (± 2.24) trials to reach criterion for choosing the reinforced compound stimulus (AB). Participants in the Revaluation group on average took 12.75 (± 2.60) trials to reach criterion for choosing AB, and participants in the Control group on average took 13.38 (± 1.92) trials to reach criterion for AB. A rejection criterion of $p < 0.05$ was used for this and all subsequent analyses. A t-test confirmed there were no statistically significant differences between the two groups, $t < 1$.

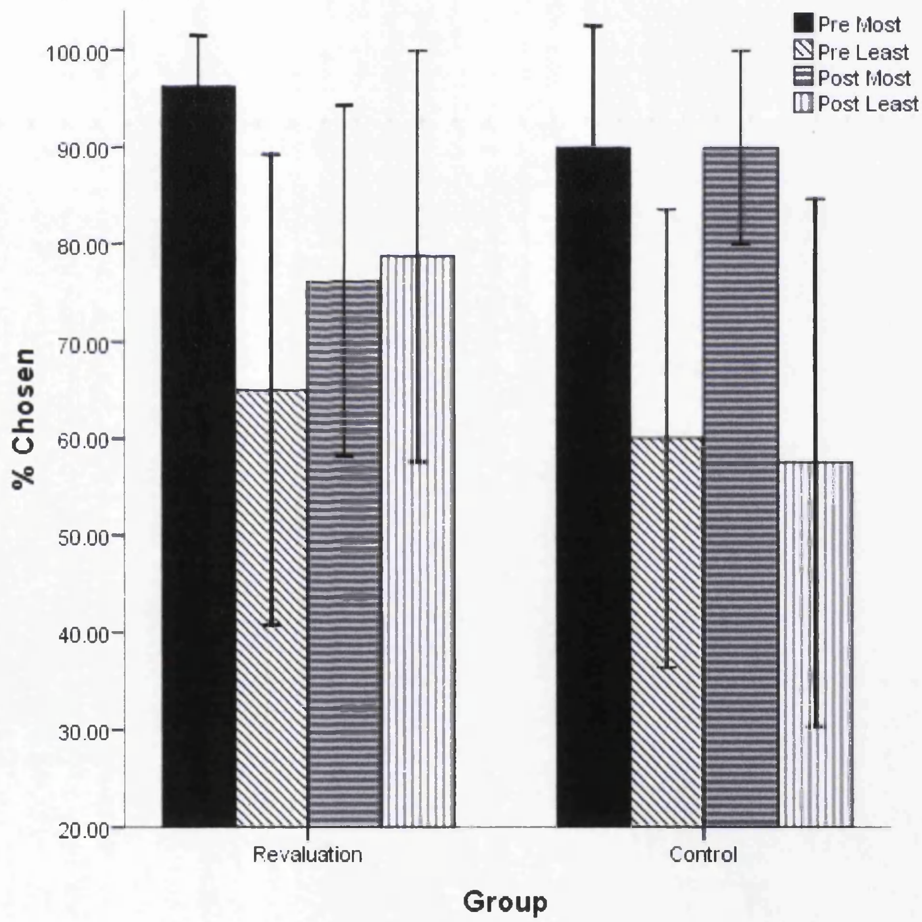


Figure 5 Group mean levels of pre-extinction and post-extinction over-selectivity in both groups: the Revaluation group (participants who received the Revaluation Training Phase) and the Control group (participants who did not receive the Revaluation Training Phase) (error bars = SEM).

The mean percentage of times each stimulus (i.e., the most selected and the least selected from the initially reinforced compound, AB) was chosen in the initial test phase (pre-extinction), and the re-testing phase following revaluation training (post-extinction), is shown in Figure 5. This indicates evidence of selection of one stimulus than the other (i.e., stimulus over-selectivity) in both groups (the Revaluation group who received extinction of responses to the over-selected stimulus, whereby novel stimuli were reinforced with positive feedback in the presence of the identified over-selected stimulus and the Control Group who did not received revaluation training) following initial training. In order to determine whether there was a statistically significant difference in the level of choice for the stimuli following initial training, compared to deviation from the level of choice expected by chance, the random model based on the binomial equation provided the necessary difference for significance between the over-selected and under-selected stimuli for the combined group means, in 10 choices, giving a value of 14%. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance. A rejection criterion of $p < 0.05$ was used for this and all subsequent analyses. This analysis revealed a statistically significant difference, $t(15) = 2.27$, thus indicating over-selectivity.

Inspection of the data post-revaluation shows a reduction in over-selectivity in the revaluation group following revaluation training, but very little change in over-selectivity in the control group following revaluation training. A three-way mixed model ANOVA (stimulus – most versus least, and phase – pre- versus post-revaluation as within-subjects factors, and group – revaluation and control as a between-subjects factor) was conducted on these data. This analysis indicated a significant main effect of stimulus type, $F(1,14) = 11.82$, indicating over-selectivity, but no significant main effect of phase, $F < 1$. However, there was a statistically significant interaction between stimulus and phase, $F(1,14) = 6.72$, and a significant interaction between the three factors, $F(1,14) = 9.04$.

As a result of the statistically significant three-way interaction, two separate two-factor ANOVAs (stimulus type x phase) were conducted on the revaluation group and the control group, as recommended by Howell (1997). The ANOVA conducted on the control group revealed a statistically significant main effect of stimulus, $F(1,7) = 8.30$, but no statistically significant main effect of phase, nor a statistically significant interaction between the two factors, $Fs < 1$. The ANOVA conducted on the revaluation group revealed no statistically significant main effect of stimulus, $F(1,7) = 3.54$ or phase, $F < 1$, but a statistically significant interaction between the two factors, $F(1,7) = 10.31$. Simple effect analyses conducted, for the revaluation group, on the stimulus type (most versus least) pre-revaluation revealed a statistically significant difference between the most and least chosen stimulus pre-revaluation, $F(1,7) = 17.68$, but no statistically significant simple effect of stimulus post-revaluation, $F < 1$. Simple effect analyses conducted, for the revaluation group, on the phases (pre-revaluation and post-revaluation) for the most selected stimulus revealed a statistically significant difference pre- and post-revaluation, $F(1,7) = 7.24$, and a statistically significant simple effect of phase for the least selected stimulus, $F(1,7) = 3.42$.

Taken together, these data replicate the over-selectivity effect seen in numerous previous demonstrations (e.g., Broomfield et al., 2008a; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Lovaas & Schreibman, 1971; Lovaas et al., 1979) and in Chapter 2, and suggest that revaluation of the previously over-selected stimulus does allow emergence of control by the previous under-selected stimulus, despite that latter stimulus not being directly conditioned. Such results provide a problem for the attention deficit perspective (e.g., Dube et al., 1999; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971) which cannot explain how the under-selected stimulus gains control over behaviour when it has not been attended to in initial training.

3. 5. Experiment 5

Experiment 5 sought to explore the type of learning that accrues to the under-selected stimuli, by using a summation test to investigate whether under-selectivity can be attributed to inhibition. A summation test involves the presentation of a CS- in conjunction with a CS+. The CS+ alone elicits a conditioned response (CR) and the effect of the CS- can be detected by its ability to reduce the likelihood of this CR (Mackintosh, 1983; Pearce, 1987). That is, the CS+ produces a non-zero baseline rate of responding against which the CS- can be measured (Mackintosh, 1983). Summation tests used with human participants generally involve the participant rating a target cue in compound with a transfer excitor which has been independently trained. Inhibition is supposed if the target cue reduces the ratings that would be attributed to either the excitor alone, or to the excitor presented in compound with a novel stimulus (Amundson, Wheeler & Miller, 2005; Calton, Mitchell & Schachtman, 1996; Urcelay, Perelmuter & Miller, 2008). The logic of a summation test is that if a positive value is combined with a negative value, the sum will be lower than the positive value alone. In testing for inhibition in the current research, the summation test involves exploring whether the under-selected stimulus delays the response that would usually be produced by an alternative stimulus (Rescorla, 1969).

The participants were randomly assigned to one of three groups. The experimental group, being tested with a summation test, received a discrimination task consisting of a novel compound of two elements, presented with a compound consisting of the under-selected (potentially 'inhibitory') stimulus, and a previously reinforced (excitatory) stimulus. This group will be referred to as Group Exc-Inh. One control group received a similar discrimination training task, but consisting of the novel compound, presented with a compound consisting of the excitatory stimulus and a novel stimulus. This group will be referred to as Group Exc-Nov. The other control group received two novel compounds, each with two novel elements. This group will be referred to as Group Nov-Nov.

It was predicted that, compared to those participants in Group Exc-Nov, and Group Nov-Nov, participants in Group Exc-Inh group would take longer to learn the discrimination when the task involved choosing the compound comprising the 'under-selected' and excitatory elements, which would be indicative of inhibition. This would redeem the attention deficit perspective of over-selectivity as it would allow a potential explanation of the findings in Experiment 4; that the under-selected stimulus gains control over behaviour following revaluation of the over-selected stimulus, in terms of generalised removal of inhibition.

3. 6. Method

Participants and Apparatus

Seventeen healthy participants (seven males and ten females) were recruited from the general public, with an age range of 19 to 29 years (mean = 21.06 years, SD = 2.70). As with Experiment 4, participants were volunteers, selected based on opportunity sampling, and those under the age of 18 and over the age of 55 were excluded.

The apparatus and materials were the same as those used in the previous experiments.

Procedure

The setting was the same as Experiments 1-4, and each participant vocally counted backwards in sevens throughout the experiment. Table 5 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase 1	AB vs. CD Selection of AB yields positive 'yes' response Selection of CD yields negative 'no' response	Trials in Training Phase 1 and Training Phase 2 are presented interspersed randomly until ten consecutive correct responses in both phases
Training Phase 2	Z vs. M Selection of Z yields positive 'yes' response Selection of M yields negative 'no' response	
Test Phase (Standard)	A vs. C A vs. D B vs. C B vs. D	Five trials of each combination presented randomly
Summation Phase	*Group Exc-Inh:* ZB vs. XY Where B is the under-selected stimulus, and X and Y are novel Selection of ZB yields positive 'yes' response Selection of XY yields negative 'no' response *Group Exc-Nov:* ZW vs. XY Where W, X and Y are novel	Ten consecutive correct responses of selecting the reinforced stimulus

Selection of ZW yields
positive 'yes' response

Selection of XY yields
negative 'no' response

Group Nov-Nov:

VW vs. XY

Where V, W, X and Y are
novel

Selection of VW yields
positive 'yes' response

Selection of XY yields
negative 'no' response

Training Phase: The training phase consisted of two simple discrimination tasks, which were presented concurrently with one another; trials from each task being randomly intermixed with each other.

Discrimination task one was identical to that described in the previous experiments, with participants being given positive verbal feedback in the form of 'yes' for selecting AB and punished in the verbal form of 'no' for selecting CD.

The other discrimination task involved the participant being shown two cards: one displaying an individual stimulus (Z), and another displaying an alternative individual stimulus (M). Selection of Z by the participant resulted in positive verbal feedback from the experimenter in the form of 'yes' whereas selected of M was punished in the verbal form of 'no'. Therefore, stimulus Z was reinforced with verbal feedback in the presence of the non-reinforced stimulus M. This phase commenced until participants gave 10 consecutive correct responses for both discrimination tasks.

Testing Phase: The testing phase (the standard over-selectivity test) was identical to that used in Experiments 1-4.

Following completion of the task, participants were required to complete the AQ to assess their levels of pre-existing high functioning autism. During this time, the experimenter calculated which stimulus element from the previously reinforced compound (i.e., A or B) had been selected the most by calculating the percentage of time during the test each element had been chosen.

Summation Phase: After identifying the under-selected stimulus from the reinforced compound (A or B), participants in Group Exc-Inh were presented with a compound stimulus consisting of stimulus Z (the excitatory stimulus), and the under-selected stimulus from the AB compound, and a compound stimulus consisting of two novel stimuli (XY). The former compound stimulus was reinforced until it was chosen 10 consecutive times. Group Exc-Nov were presented with a compound stimulus consisting of Z (excitatory conditioner), and a novel stimulus, and a compound stimulus consisting of two novel stimuli (XY). The former compound stimulus being reinforced until it was chosen 10 consecutive times. Group Nov-Nov were presented with two compound stimuli, both consisting of novel stimuli (XY and VW), with one being reinforced, until it was chosen 10 consecutive times. The number of trials taken to choose the required stimulus was recorded.

3. 7. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of condition, participants took 17.41 (± 5.88) trials, on average, during initial training to reach the criterion for choosing the reinforced compound stimulus (AB), and 15.35 (± 5.81) trials to reach the criterion for choosing the excitatory stimulus (Z). Participants in group Exc-Inh, on average, took 15.60 (± 6.54) trials during training to reach the criterion for choosing AB, participants in group Exc-Nov on average, took 16.00 (± 2.58) trials to reach the criterion for choosing AB, and participants in group Nov-Nov on average, took 21.20 (± 7.76) trials to reach the criterion for choosing AB. A one-way independent measures ANOVA confirmed there were no statistically significant differences between the groups, $F(2, 16) = 1.58$.

Participants in group Exc-Inh, on average, took 15.40 (± 6.47) trials during training to reach the criterion for choosing Z, participants in group Exc-Nov on average, took 13.14 (± 2.67) trials to reach the criterion for choosing Z, and participants in group Nov-Nov on average, took 19.00 (± 7.58) trials to reach the criterion for choosing Z. A one-way independent-measure ANOVA confirmed that there were no statistically significant differences between the groups, $F(2, 16) = 1.59$.

Independent of group, the mean level of choice for the most selected stimulus was 86.47 (± 19.63), and the mean level of choice for the least selected stimulus was 63.53 (± 27.37). A t-test revealed a statistically significant difference between the over- and under-selected stimuli, $t(16) = 5.74$. In order to determine if there was a statistically significant difference in the level of choice for the stimuli relative compared to any deviation from this level of choice that might be expected by chance, the random model generated provides the total absolute difference expected between the over-selected and under-selected stimuli in 10 choices, giving a value of 15%. A paired t-test (one-tailed) was performed to compare the obtained differences and the expected differences based on chance, which indicated a significant difference, $t(16) = 1.99$, thus indicating significant over-selectivity.

These results replicate the relative over-selectivity effect found in the present Experiments 1-4, and also in much prior research (e.g., Broomfield et al., 2008a; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Lovaas et al., 1979; Reed et al., 2009; Reed & Gibson, 2005).

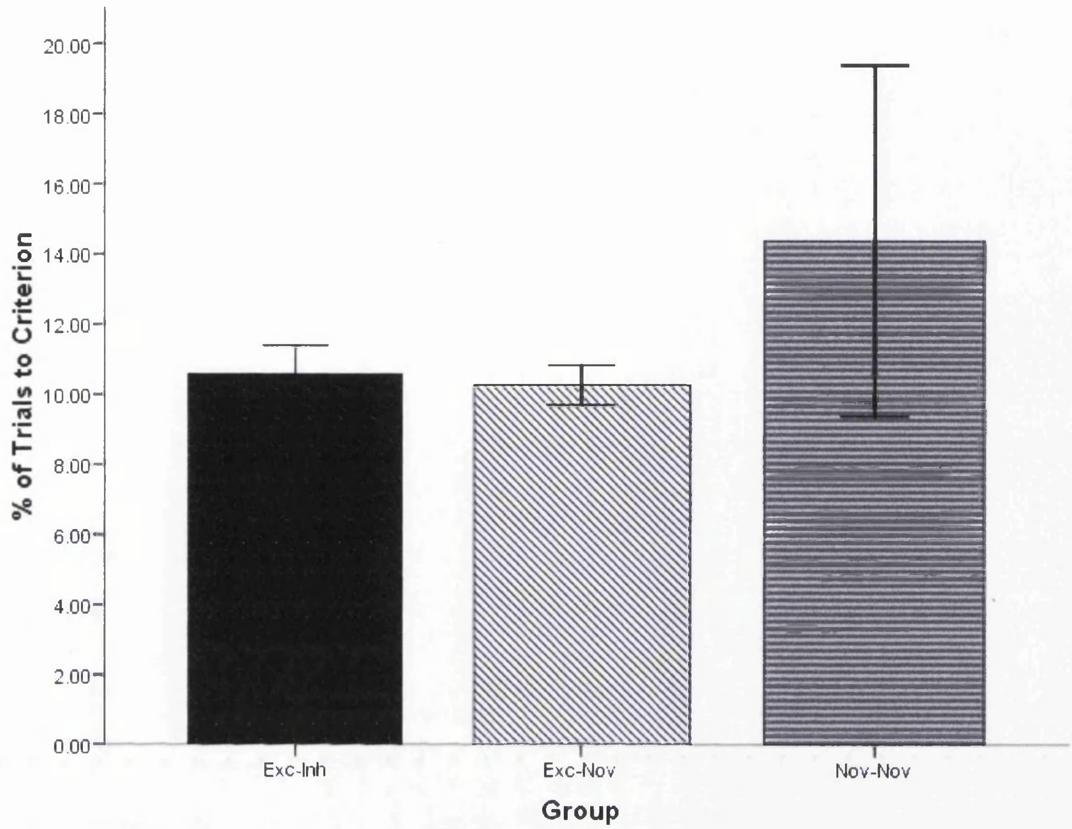


Figure 6 Mean number of trials taken to reach criterion in the summation phase for the three groups; Group Exc-Inh (participants who received a discrimination task consisting of a novel compound of two elements presented with a compound consisting of the under-selected (inhibitory) stimulus and the previously reinforced (excitatory) stimulus) Group Exc-Nov (participants who received the task consisting of the novel compound presented with a compound consisting of the excitatory stimulus with a novel stimulus) and Group Nov-Nov (participants who received two novel compounds each with two novel elements) (error bars = SEM).

Figure 6 displays the mean percentage of trials taken to reach criterion in the summation phase for the three groups (Exc-Inh, Exc-Nov, Nov-Nov). Inspection of Figure 6 indicates very few differences between the two experimental groups (Exc-Inh and Exc-Nov). A one-way independent-measure ANOVA revealed no statistically significant differences between the groups, $F(2,16) = 2.99$.

These results indicate that there was no summation effect, suggesting that the under-selected stimulus does not acquire inhibitory properties. This might have been predictable on the basis that the under-selected stimulus was selected on average on over 50% of the occasions that it was presented at test. However, as noted in the Introduction (Section 3.1), this is only an imperfect indication of inhibition, as the selection depends not only on the valence of the target stimulus, but also on the effect of the comparison stimulus on choice. If the comparison stimulus from the previously non-reinforced compound was itself aversive in some way, then choice for the target may well be above 50%, even though it was inhibitory. Thus, the summation test provides independent corroboration of the non-inhibitory status of the under-selected stimulus. That there was no evidence for inhibition undermines the explanation of the revaluation effect based on the generalised extinction of inhibition, and, thus, this effect remains problematic for an attention-deficit view of the over-selectivity effect.

3. 8. Experiment 6

Experiment 6 extended the investigation started in Experiment 5 by testing whether the under-selected stimulus was an inhibitor by the use of a retardation test (Rescorla, 1969). It has been argued (e.g., Hearst, 1972; Rescorla, 1969) that a single test of inhibition is not sufficient to test for inhibitory status and the summation test alone allows for an attentional theoretical account with participants paying increased attention to the excitor stimulus at the expense of the target stimulus. The logic behind a retardation test is that if inhibitory conditioning produces behaviour opposed to that of excitatory conditioning, turning a CS- for a given reinforcer into a CS+ for that reinforcer should be somewhat complex (Mackintosh, 1983). That is, prior inhibitory conditioning 'retards' subsequent excitatory conditioning to that CS (Mackintosh, 1983). The retardation test thus involves pairing the conditioned inhibitor with the US for which it has previously signalled the absence; this excitatory conditioning should be disrupted if inhibitory conditioning occurred (Pearce, 1987).

The independent establishment of an excitatory conditioner, as used in Experiment 5, is therefore not required for the retardation test, but, rather, the under-selected cue (which is putatively inhibitory) is paired with a novel stimulus in compound. The compound containing the under-selected element with a novel cue would be avoided, in comparison with a novel compound, if the under-selected cue had gained inhibitory status. Like Experiment 5, if inhibition does accrue to the under-selected stimulus, this would provide support for the attention deficit theory as it allows the revaluation findings to be explained by the generalised removal of inhibition.

To test this possibility, participants were randomly assigned to one of two groups (retardation and control). During the test phase, participants in the retardation group received a discrimination task consisting of the under-selected (potentially inhibitory) stimulus paired with a novel cue, presented with a compound consisting of two novel cues and were reinforced for selecting the compound consisting of the under-selected stimulus, whereas participants in the control group were presented with two compounds, each compound comprising two novel stimuli with one of the compounds being randomly selected as the 'correct' card and, thus, reinforced.

3. 9. Method

Participants and Apparatus

Eighteen healthy participants (ten males and eight females) with an age range of 18 to 45 years (mean = 26.28 years, SD = 6.45), recruited from the general public, took part in this experiment. As with the previous experiments, participants were selected based on opportunity sampling, were not paid, and were between the age of 18 and 55 years.

The apparatus and materials were the same as those used in the previous experiments.

Procedure

The setting was the same as previous experiments, and each participant vocally counted backwards in sevens from a random five-digit number throughout the whole experiment. Table 6 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase	AB vs. CD Selection of AB yields positive 'yes' response Selection of CD yields negative 'no' response	Ten consecutive correct responses of selecting AB
Test Phase (Standard)	A vs. C A vs. D B vs. C B vs. D	Five trials of each combination presented randomly
Retardation Phase	*Control Group:* VW vs. XY Where V, W, X and Y are Novel Selection of VW yields positive 'yes' response Selection of XY yields negative 'no' response *Retardation Group:* BW vs. XY Where B is the under-selected stimulus and W, X and Y are Novel Selection of BW yields positive 'yes' response Selection of XY yields negative 'no' response	Ten consecutive correct responses of selecting the reinforced compound

Training Phase: The training phase was identical to the AB vs. CD training phase used in Experiment 4. That is, participants were given positive verbal feedback in the form of 'yes' for selecting AB and punished in the verbal form of 'no' for selecting CD.

Testing Phase: The testing phase (the standard over-selectivity test) was identical to that used in Experiments 1-5.

Participants were then asked to complete the AQ, to assess their levels of pre-existing high functioning autism, whilst the experimenter determined the under-selected stimulus by calculating the percentage of time during the test each element had been chosen.

Retardation Phase: Participants in the control group were presented with two compounds, each compound comprising two novel stimuli. One of the compounds was randomly selected as the 'correct' card, and the participants were given corrective feedback as in Training Phase 1. The phase ended once the participant identified the correct card 10 consecutive times.

Participants in the retardation group were presented with a compound consisting of the under-selected cue identified from the testing phase, paired with a novel cue, and a compound consisting of two novel cues. Participants were given corrective feedback as in Training Phase 1. That is, they were reinforced with a positive 'yes' response for selecting the compound consisting of the under-selected stimulus (and a novel element) and punished with a negative 'no' response for selecting the novel compound. The phase ended once the participant had identified the correct card (the compound consisting of the under-selected cue) 10 consecutive times.

3. 10. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of condition, participants took 13.72 (± 3.69) trials, on average, during initial training to reach the criterion for choosing the reinforced compound stimulus (AB). Participants in the retardation group, on average, took 15.60 (± 6.54) trials during training to reach the criterion, and participants in the control group on average, took 16.00 (± 2.58) trials to reach the criterion. A t-test revealed no statistically significant difference between participants in the retardation or control groups, $t(16) = 1.06$.

Independent of group, the mean level of choice for the over-selected stimulus was 81.67 (± 15.43), and the mean level of choice for the under-selected stimulus was 67.78 (± 25.57). A t-test revealed a statistically significant difference between the over- and under-selected stimuli, $t(16) = 4.57$. The random model gave an expected most versus least difference value of 15%, which was narrowly greater than the actual difference (14%). A paired t-test (one-tailed) was performed to compare the obtained differences and the expected differences, which indicated no statistically significant difference, $t < 1$. Overall, these results provide partial evidence in replicating the over-selectivity effect demonstrated in the literature (e.g., Broomfield et al., 2008a; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Lovaas et al., 1979; Reed et al., 2009; Reed & Gibson, 2005) and in the previous experiments.

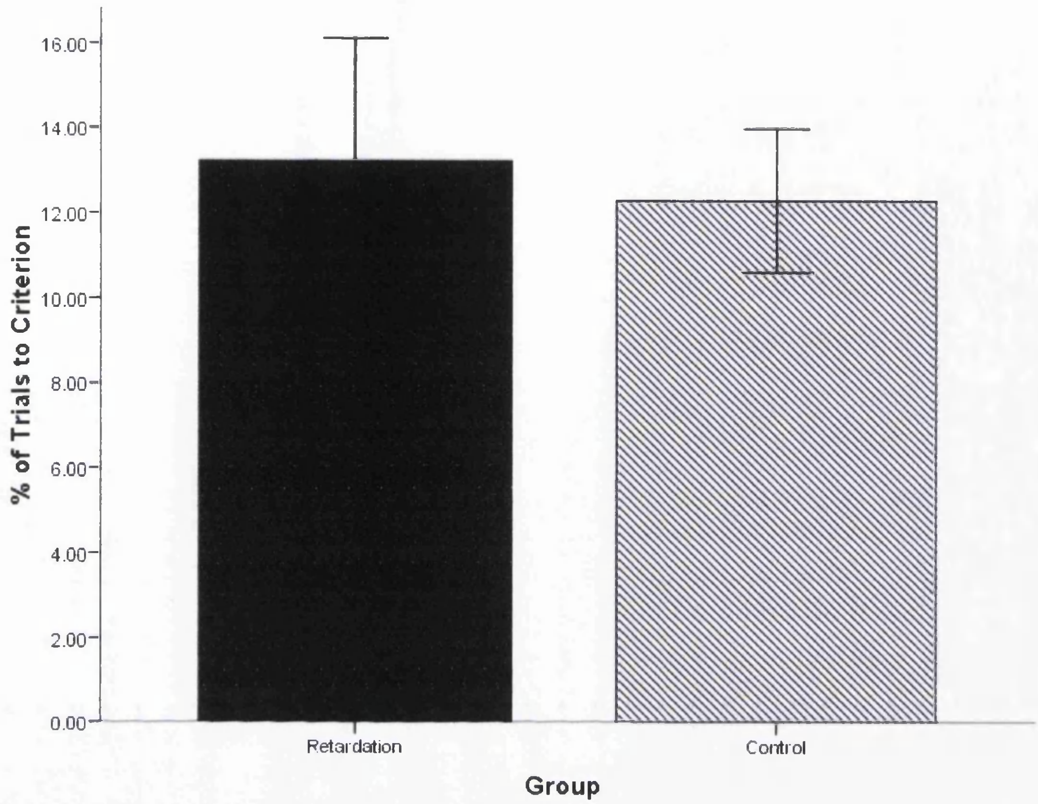


Figure 7 Mean number of trials taken to reach criterion in the retardation phase for the two groups; the Retardation Group (participants who were presented with a compound consisting of the under-selected cue paired with a novel cue, and a compound consisting of two novel cues) and the Control Group (participants who were presented with two compounds of two novel stimuli) (error bars = SEM).

The mean percentage of trials taken to reach criterion in the retardation phase for the retardation and control groups is displayed in Figure 7. These data indicate very few differences between the two groups (Retardation and Control). This impression was confirmed by a one-way ANOVA which showed no statistically significant differences between groups, $F < 1$. Thus, a retardation effect did not occur, therefore, suggesting that the under-selected stimulus did not acquire inhibitory properties. This corroborates what was apparent from the initial training data from this study, where the stimulus was not picked less than 50% of the time on average, and from the results of the summation test in Experiment 5. As with the summation test in Experiment 5, the current retardation tests provided no suggestion of an inhibitory status for the under-selected stimulus. That there was no evidence for inhibition in this study, further undermines the explanation of the revaluation effect based on the generalised extinction of inhibition, providing a problem for attentional-deficit perspectives of over-selectivity.

3. 11. General discussion

The present chapter replicated the experiments thus far, as well as previous studies, in generating an over-selectivity effect, and presented further evidence that stimulus over-selectivity can be generated in non-clinical adult participants, by giving participants a concurrent cognitive load (e.g., Broomfield et al., 2008a; Reed, 2006; Reed & Gibson, 2005).

Furthermore, Experiment 4 replicated research findings showing that revaluation of the over-selected stimulus can result in the under-selected stimulus emerging to control behaviour. Such an effect has not only been found in individuals with ASC (e.g., Leader et al., 2009; Reed et al., 2009), but also in non-human participants (e.g., Kaufman & Bolles, 1981; Matzel et al., 1985; Miller et al., 1992; Reed & Reilly, 1990; Reilly et al., 1996; Wilkie & Masson, 1976), individuals without intellectual disabilities when given concurrent cognitive loads (e.g., Broomfield et al., 2008a, 2008b, Reed & Gibson, 2005), as well as work from the human retrospective revaluation literature (e.g., Dickinson & Burke, 1996). It is of note that it is unclear whether the current findings would conclusively generalise to individuals with ASC; however, the results of Experiment 4 do support the use of revaluation procedures seen as a potential intervention which may be used to remediate over-selectivity (see Reed et al., 2009, for a fuller discussion, and section 1. 10. 2 Extinction). Additionally, following on from Chapter 2, the three experiments screened for high functioning autism, using the AQ, unlike some earlier research (e.g., Reed & Gibson, 2005); thus, results are not confounded by participants with high functioning autism.

The present research also explored the type of learning that accrues to the under-selected stimulus, in order to investigate whether inhibition plays a role in producing under-selectivity. To this end, the present series of studies used Rescorla's (1969) strategies for assessing inhibitory properties of the under-selected stimulus; a summation test (Experiment 5), and a retardation test (Experiment 6). In the summation test, if the under-selected cue had gained inhibitory status, then participants would have weaker responding in the experimental group, compared to the control groups. Similarly, in the retardation test, if the under-selected cue had gained inhibitory status, then the participants would have avoided selecting the compound that contained the under-selected element with a novel cue, in comparison with a novel compound.

The current research revealed that neither the summation test, nor the retardation test, was 'passed', indicating that the under-selected stimulus did not gain inhibitory status. It should be noted that any putative inhibition for the under-selected stimulus would have to accrue from RIF type training, rather than conditioned inhibition training. Of course, the strategies used for assessing inhibitory properties following RIF training are not strictly identical to the test procedures used in the current research (typically designed to test for conditioned inhibition), however, the recognition paradigms used following RIF training are not dissimilar to those used in this research. As a result, future work may employ techniques directed at testing for inhibition following RIF. However, given the current results, it remains likely that such methods will still fail to find evidence for the existence of inhibitory properties assigned to the under-selected stimulus. Additionally, the current research did not indicate that the under-selected stimulus was chosen less than 50% of the time at first test, and as a result, failing to find any further evidence for inhibition.

One feature of the present procedures requires some comment, in these experiments, RIF was addressed with traditional methods that are appropriate for conditioned inhibition. However, there have been no other documentations that these methods are appropriate for investigating RIF. Thus, the putative RIF processes were only speculatively linked to inhibitory processes involving the S+ components, which, typically, would not be expected to acquire inhibitory properties. Nevertheless, it was thought important to rule out any such process as they may impact on the traditional conditioning processes involved in the over-selectivity paradigm, and further work will be necessary to explore the relationship between RIF and conditioned inhibition further.

Partially related to the above point, the issue of inhibition playing a role in the revaluation effect, seen in Experiment 4, also needs some comment, and further research. The revaluation of S+ components through extinction occurs in a novel context (i.e. the S+ component is being contrasted with novel stimuli), and, under these circumstances, Bouton (2004) has suggested that inhibition may accrue to the extinguished S+ component. It is unclear exactly what influence the revaluation procedure has on inhibition, although it is not apparently present in the under-selected stimuli.

It is also important to acknowledge that there is the potential for a generalisation decrement between training and test, as a result of training taking place under a CRF schedule and testing taking place under extinction. It has been suggested that a shift in such contingencies can potentially disrupt performance, and therefore the training and testing situation should be as indiscriminable as possible in order to avoid a generalisation decrement (Guttman & Kalish, 1956). However, it is of note that all of the groups did receive the same CRF training and extinction testing treatment.

From a theoretical perspective, the findings from the present research (particularly the finding of revaluation found in Experiment 4) are difficult to explain by a strict attention-deficit account of over-selectivity that would assume the under-selected stimulus was not attended to in initial training (e.g., Dube et al., 1999; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971). If this were the case, the under-selected stimulus would be unable to subsequently control behaviour following revaluation of the over-selected stimulus if it was not initially attended to. That the potential explanation of the effect in terms of generalised removal of inhibition was not supported further undermines this position.

Alternatively, the findings of an emergence of the previously under-selected stimulus in Experiment 4, as well as the finding that over-selectivity can be generated in healthy participants given a concurrent task load, provides further evidence that over-selectivity may be explained as a retrieval or performance deficit. The comparator theory may be extended to accommodate these findings. Such a theory may suggest that the over-selected stimuli's strength (i.e., the comparator stimuli) is reduced due to extinction which results in emergence of the previously under-selected stimuli to control behaviour (Reed, 2006). Additionally, the revaluation and emergence findings can be explained using Dickinson and Burke's (1996) idea of un-overshadowing in their MSOP model. Like a comparator perspective, such a theory suggests that the over-shadowed stimulus (the 'under-selected' stimulus) is attended to and learnt about but fails to control behaviour as a result of the presence of a more salient stimulus or a stimulus with greater associative strength.

In summary, the present chapter finds no evidence of RIF related inhibition having a role in producing under-selectivity. Future work is required to evaluate the role of inhibition in an ASC or general learning disabilities population in order to assess the generality of the current findings. Moreover, the research finds no evidence in favour of an attention-deficit account of over-selectivity, thus, extends literature explaining the phenomenon of over-selectivity as due to post-processing retrieval failures as opposed to acquisition deficits. Additionally, further support for the use of revaluation and extinction procedures, in order to reverse over-selectivity deficits by adjusting behaviour control, was found.

Chapter 4

Effects of training schedule of reinforcements on stimulus over-selectivity

4. 1. Introduction

Previous experiments in Chapters 2 and 3 have provided support for the generation of over-selectivity in a healthy population through the use of a concurrent cognitive load, with Chapter 2 further demonstrating over-selectivity in alternative test conditions, and thus providing ubiquity to the phenomenon. Furthermore, Chapter 3 indicated no evidence of RIF related inhibition having a role in producing under-selectivity, as well as finding no evidence in favour of an attention-deficit account of over-selectivity.

Chapter 4 extends the previous chapters, focusing on exploring a potential method to remediate the over-selectivity effect, as well as, further examining the attention deficit theoretical account of over-selectivity. Therefore, four experiments explore the effects of different simultaneous discrimination training regimes on over-selectivity, with the aim of examining potential techniques that may serve to reduce this effect. In particular, there has been some suggestion, and debate, regarding whether the use of PR schedules may reduce levels of over-selectivity, especially when there has been a change from a CRF to PR schedule of reinforcement during training.

Such an investigation of the impact of PR on over-selectivity seems warranted based on, at least, two bases derived from predictions about the impact of PR on attentional responses. Firstly, some views of conditioning, in particular that of Pearce and Hall (1980), would be likely to predict that over-selectivity would be attenuated as a result of a PR schedule during training. Thus, such views would support the attention-deficit perspective of the effect. As has been detailed earlier (see Section 1. 10. 3. Schedules of reinforcement), the Pearce-Hall (1980) perspective (as well as other similar associability theories, such as Mackintosh, 1975; 1983) never addressed over-selectivity itself, however, they may be extended in order to aid a theoretical understanding of the effect. That is, using the orienting response as a measure of associability, the theory proposes that when the consequences of a CS are unpredictable, the associability of the CS remains high but declines when the consequences become predictable (Pearce & Bouton, 2001; Pearce & Hall, 1980; Wilson et al., 1992). Thus as PR leads to unpredictability of the consequences of the stimulus, lower levels of over-selectivity should occur as attention is increased (See Section 1. 10. 3). However, as CRF leads to accurate predictability of the consequences, lower levels of observing response would occur and subsequently higher levels of over-selectivity would be expected.

Secondly, also related to the predictions derived from associability theories, it has been shown that a surprising reduction in reinforcer magnitude can reduce the blocking effect in classical conditioning (e.g., Dickinson et al., 1976; Holland & Kenmuir, 2005). Feldman (1971) extended this work, indicating a reduction in the blocking effect, by implementing a surprising shift in the schedule of reinforcement. They employed a discrimination learning experiment with rats and found unblocking occurred when rats initially received CRF during training followed by a shift from CRF to PR in later training. This work could be extended to over-selectivity, and it could be suggested that a reduction in over-selectivity may result when the reinforcement schedule is changed from CRF to PR, representing a decrease in the level of reinforcement obtained. In fact, such reductions in reinforcement levels have been predicted to increase attention in discrimination learning (Trabasso & Bower, 1968), which is thought to be one of the mechanisms underlying over-selectivity (Dube, 2009). That is, according to Trabasso and Bower (1968), changing from CRF to PR may result in the individual perceiving the lack of reinforcement as an indication of error, resulting in increasing their breadth of attention on subsequent trials and thus increasing responding to alternative cues.

Section 1. 10. 3 (Schedules of reinforcement) outlines research supporting the finding of a reduction in over-selectivity following a switch in reinforcement from CRF to PR. That is, Schreibman and colleagues (1977) showed a reduction in over-selectivity on a two-element compound discrimination task, when training was continued under a PR schedule. Likewise, Koegel et al. (1979) employed a multiple-cue discrimination task and also found a switch in reinforcement from CRF to PR reduced over-selectivity compared to continuing with CRF in the extended training phase. Other research has failed to find supportive results (e.g., Dube et al., 2010; Dube & McIlvane, 1997; Remington & Clarke, 1993; Williams, 1989; See Section 1. 10. 3. Schedules of reinforcement). The impact of a change from a CRF schedule to a PR schedule on levels of over-selectivity requires further examination, both in itself, and in relation to attention-based theories of over-selectivity.

It is of note that the research by Koegel et al. (1979) and Schover and Newsom (1976) provided extensive overtraining, with the former utilising 100 overtraining trials and the later utilising 50 overtraining trials. It may be the case that over-training *per se* reduces over-selectivity. In accordance with this, Huguenin (2000, 2004) has shown that extensive training reduces over-selectivity. Research using animals has also indicated a reduction in over-selective responding as a result of learning more about redundant cues during overtraining (e.g., Sutherland & Holgate, 1966; Sutherland & MacKintosh, 1971). However, such results are not typically reported in humans (Trabasso & Bower, 1968).

Given the above considerations, the current chapter aims to investigate the effects of PR, and different training regimes, on the extent to which over-selectivity is observed. This research will both extend and clarify existing findings in the literature, and potentially identify novel remediation strategies for over-selective responding, which would be of benefit to individuals with developmental and intellectual disabilities, as well as the findings being of importance to attention-based theories of over-selectivity.

4. 2. Experiment 7

The simple aim of Experiment 7 was to explore the effects of PR and CRF on over-selectivity in themselves, rather than exploring the shift from CRF to PR. Based on associability theories (e.g., Pearce & Hall, 1980) it might be predicted that PR training would produce less over-selectivity than CRF training. Moreover, previous work has generated inconsistent findings with such shifts, with some research suggesting that the use of PR can reduce over-selectivity (Koegel et al., 1979; Schreibman et al., 1977), whereas other research has failed to find this effect (Dube et al., 2010; Dube & McIlvane, 1997; Remington & Clarke, 1993). However, it is completely unclear whether this is due to the complexity of those 'shift' studies, or whether PR itself may attenuate over-selectivity (see Trabasso & Bower, 1968). To this end, the current experiment aimed to explore such effects using a simultaneous discrimination procedure of the type commonly employed in recent work on over-selectivity (e.g., Reed & Gibson, 2005). Participants were randomly assigned to one of two groups. Participants in group CRF received CRF throughout the training phase, that is, they were reinforced on 100% of trials. Participants in group PR received PR throughout the training phase, that is, they were reinforced on 50% of trials.

4. 3. Method

Participants and Apparatus

Sixty four healthy volunteer participants (23 males and 41 females) with an age range of 18 to 42 years (mean = 21.72 years, SD = 4.24) were recruited from the general public. As with experiments in Chapters 2 and 3, the participants were not paid for their participation and those under the age of 18 years, and over the age of 55 years, were excluded.

Apparatus and materials were the same as those used in the previous two chapters.

Procedure

As with previous experiments a table-top method was used in a quiet room, with no distractions, and participants were required to vocally count backwards in sevens from a random five-digit number. Table 7 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase 1	*Group CRF:* AB vs. CD Selection of AB yields positive 'yes' response on 100% of trials Selection of CD yields negative 'no' response on 100% of trials *Group PR:* AB vs. CD Selection of AB yields positive 'yes' response on 50% of trials Selection of CD yields negative 'no' response on 50% of trials	Trials in Training Phase 1 and Training Phase 2 are presented interspersed randomly until ten consecutive correct responses in both phases
Training Phase 2	Z vs. M Selection of Z yields positive 'yes' response Selection of M yields negative 'no' response	
Test Phase (Standard)	A vs. C A vs. D B vs. C B vs. D	Five trials of each combination presented randomly

Training Phase: The training phase consisted of the same two discrimination tasks utilised in Experiment 5, presented concurrently with one another; trials from each task being randomly intermixed throughout the training phase. In the first discrimination task, the experimenter presented the participant with two cards, depicting the compound stimuli (AB and CD) and individuals were instructed to point to a card. Participants receiving CRF were told that they would be given corrective verbal feedback in the form of 'yes', or 'no'; whereas, participants receiving PR were told that they would be given corrective verbal feedback, but not for all trials, and, if they did not receive verbal feedback, this did not necessarily mean that they were incorrect. On each trial, the participant was presented with: one compound stimulus (AB), that yielded a positive 'yes' response if selected (on every occasion for participants in the CRF group, and on a random 50% of trials for participants in the PR group); and an alternative compound stimulus (CD), that yielded a negative 'no' response if selected (always for participants in the CRF group, and on a random 50% of trials for participants in the PR group). Thus, compound stimuli AB was reinforced with verbal feedback on every occasion for participants in the CRF group, and occasionally for participants in the PR group, in the presence of the non-reinforced compound stimuli CD.

In the second discrimination task, the participant was shown two cards: one displayed an individual stimulus (Z), that yielded a positive 'yes' response if selected by the participant; and another which displayed an individual stimulus (M), that yielded a negative 'no' response if selected. The purpose of this second discrimination task was to act as a distracter, yielding the overall training phase more complex, as Reed and Gibson (2005) indicated higher over-selectivity with the use of two discrimination tasks relative to just one.

This phase lasted until the participant produced ten consecutive correct responses for each discrimination task.

Testing Phase: The testing phase was identical to the previous experiments, whereby pictures were paired so that participants chose between a picture from the reinforced stimulus, and a picture from the non-reinforced stimulus (A v C; A v D; B v C; B v D), with 5 trials for each combination, and, thus, 20 trials in total. Participants were not provided with verbal feedback. Following this phase, each participant was given the AQ (Baron-Cohen et al., 2001) to assess their levels of pre-existing high functioning autism.

4. 4. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of whether participants received CRF or PR, participants on average took 15.95 (± 5.58) trials during training to reach the criterion for choosing the reinforced compound stimulus (AB), and 15.58 (± 6.04) trials to reach the criterion for choosing the reinforced single stimulus (Z). Participants who received CRF took a mean 15.84 (± 5.09) trials during training to reach the criterion for choosing AB, and participants who received PR took a mean 16.06 (± 6.10) trials during training to reach the criterion for choosing AB. Participants receiving CRF took a mean 15.15 (± 5.26) trials during training to reach the criterion for choosing Z, and participants who received PR on average took 16.00 (± 6.79) trials during training to reach the criterion for choosing Z. A rejection criterion of $p < 0.05$ was used for all subsequent analyses. T-tests revealed no statistically significant difference between participants receiving CRF or PR in the number of trials to criterion for choosing AB, $t < 1$, and no statistically significant difference in the number of trials to criterion for choosing Z, $t < 1$.

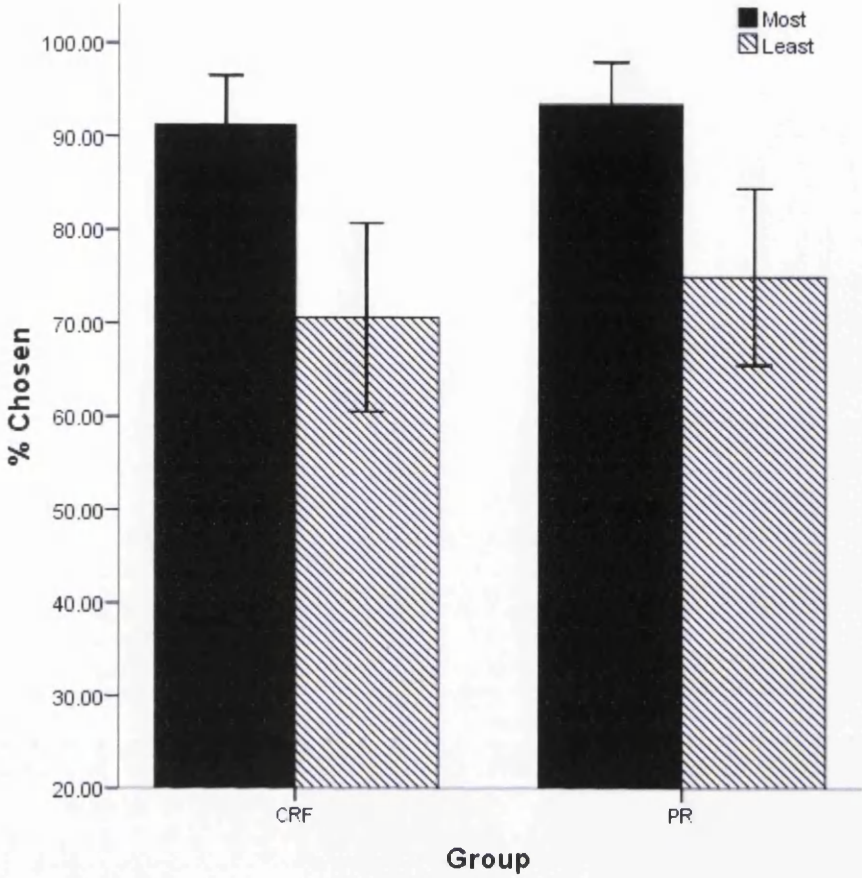


Figure 8 Group mean levels of over-selectivity in both groups: Group CRF (participants receiving reinforcement on every trial during the training phase) and Group PR (participants receiving reinforcement on a random 50% of trials during the training phase) (error bars = SEM)

The mean number of times that each stimulus (i.e., the most selected and the least selected from the initially reinforced compound, AB) was chosen in the test phase was recorded for the CRF and PR groups, and these data are displayed in Figure 8. This indicates evidence of selection of one stimulus more than the other (i.e., stimulus over-selectivity) in both groups with very few differences between them. A two-way, mixed-model ANOVA (stimulus type – most verses least, and group – CRF and PR) was conducted on these data. This analysis revealed a statistically significant main effect of stimulus type, $F(1,62) = 50.78$, but no statistically significant main effect of group, $F < 1$. The interaction between the two factors was also not statistically significant, $F < 1$.

In order to determine if there was a statistically significant difference in the level of choice for the stimuli compared to the deviation from this level of choice that might be expected by chance, the random model provided the total absolute difference expected between the over-selected and under-selected stimuli in 10 choices, giving a value of 13% for the CRF group, and 12% for the PR group. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated a statistically significant difference for the CRF group $t(31) = 2.03$, and a marginally significant difference for the PR group $t(31) = 1.61$, $p = 0.06$

These data provide support for the existence of the over-selectivity effect in non-clinical participants, which has also been observed in numerous previous demonstrations (e.g., Broomfield et al., 2008a; Reed & Gibson, 2005) and the experiments of the current thesis thus far. Additionally, the current evidence suggests that there was no strong differential effect of CRF or PR on over-selectivity when the groups are trained to criterion. This supported the previous results reported by Dube and McIlvane (1997), and Remington and Clarke (1993), which showed little effect of PR training on levels of over-selectivity, but did so in a direct investigation of the impact of PR, rather than examining its impact in a 'shift-paradigm'. Furthermore, the results fail to support an attention deficit perspective of over-selectivity (Dube et al., 1999; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971) which would expect reduced levels of over-selectivity following PR as a result of the unpredictability of reinforcement.

4. 5. Experiment 8

Experiment 8 further explored the effects of differential reinforcement (CRF versus PR) on the over-selectivity effect in healthy adults. As this effect has been the subject of some inconsistency in the literature (e.g., Dube & McIlvane, 1997; Remington & Clarke, 1993; see Dube, 2009), it was thought prudent to further examine the effect found in Experiment 7. Additionally, the experiment explored the effects of the level of training on over-selectivity. If an associability account is extended to over-selectivity, then, according to Pearce-Hall (1980), associability is maintained to a stimulus when the outcome is unpredictable. Therefore, the Pearce-Hall model would predict that associability is highest when training first commences, but reduces after extended training. Thus, if training is not continued to criterion, the higher rates of associability should result in low levels of over-selectivity, as attention will be high to the stimuli; and this over-selectivity effect would be even lower after PR training than after CRF training. Of course, it may be the case that over-training *per se* reduces over-selectivity. In line with this, Huguenin (2000; 2004) indicated attenuation of over-selectivity following extensive training procedures. Furthermore, in the non-human literature, research has provided evidence that blocking can be reduced following over-training due to learning more about redundant cues (e.g., Sutherland & Holgate, 1966; Sutherland & MacKintosh, 1971). Given this, the current experiment explored whether longer training procedures would reduce levels of over-selectivity, and whether this would interact with the training schedule (CRF or PR).

Participants were randomly assigned to one of four groups: participants receiving CRF training who were trained to criterion (CT); participants receiving PR training who were trained to criterion (PT); participants receiving CRF training but who were not trained to criterion (CNT) and participants receiving PR training but who were also not trained to criterion (PNT).

4. 6. Method

Participants and Apparatus

Forty eight healthy volunteer participants (18 males and 30 females) with an age range of 19 to 37 years (mean = 21.27 years, SD = 3.40) years from the general public took part. Participants were not paid for their participation, and participants under the age of 18, and over the age of 55, were excluded.

The apparatus and materials were the same as those used in Experiments 1-7.

Procedure

The setting was the same as Experiments 1-7, using a table-top procedure, during which time all participants vocally counted backwards in sevens from a random five-digit number. Table 8 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase	AB vs. CD	Ten consecutive correct responses for participants in groups CT and PT.
	Groups CT and CNT:	
	Selection of AB yields positive 'yes' response on 100% of trials	Ten training trials, regardless of whether the participant chose the correct stimulus for participants in CNT and PNT.
	Selection of CD yields negative 'no' response on 100% of trials	
	Groups PT and PNT:	
	Selection of AB yields positive 'yes' response on 50% of trials	
	Selection of CD yields negative 'no' response on 50% of trials	
Test Phase (Standard)	A vs. C	Five trials of each combination presented randomly
	A vs. D	
	B vs. C	
	B vs. D	

Training Phase: The training phase consisted of one of the simple discrimination tasks, as used in Experiment 7; On each trial, the participant was presented with: one compound stimulus (AB), that yielded a positive 'yes' response if selected (on every occasion for participants in Groups CT and CNT, and on a random 50% of trials for participants in Groups PT, and PNT); and an alternative compound stimulus (CD), that yielded a negative 'no' response if selected (always for participants in Groups CT, and CNT, and on a random 50% of trials for participants in Groups PT, and PNT). Thus, compound stimuli AB was reinforced with verbal feedback on every occasion for participants in Groups CT, and CNT, and occasionally for participants in Groups PT, and PNT, in the presence of the non-reinforced compound stimuli CD.

For participants in Groups CT, and PT, the next phase commenced following the participant producing 10 consecutive correct responses, as it was said that they had acquired the training discrimination by this time (see Leader et al., 2009; Reed & Gibson, 2005). For participants in Groups CNT, and PNT, the next phase commenced following 10 training trials, regardless of whether the participant chose the correct stimulus.

Testing Phase: This phase was identical to the testing phase used in Experiment 7. Following this phase, each participant was then given the AQ to assess their levels of pre-existing high functioning autism.

4. 7. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of whether participants received CRF or PR, participants trained to criterion on average took 19.04 (± 7.07) trials to reach criterion for choosing the reinforced compound stimulus (AB). All participants in the two groups who were not trained to criterion (CNT and PNT) received 10 trials of training. Participants trained to criterion who received CRF (CT) took a mean 13.17 (± 2.52) trials to reach criterion for choosing the reinforced compound stimulus (AB), and participants trained to criterion who received PR (PT) took a mean 24.92 (± 4.79) trials. A t-test indicated a statistically significant difference between the two groups, $t(22) = 7.52$.

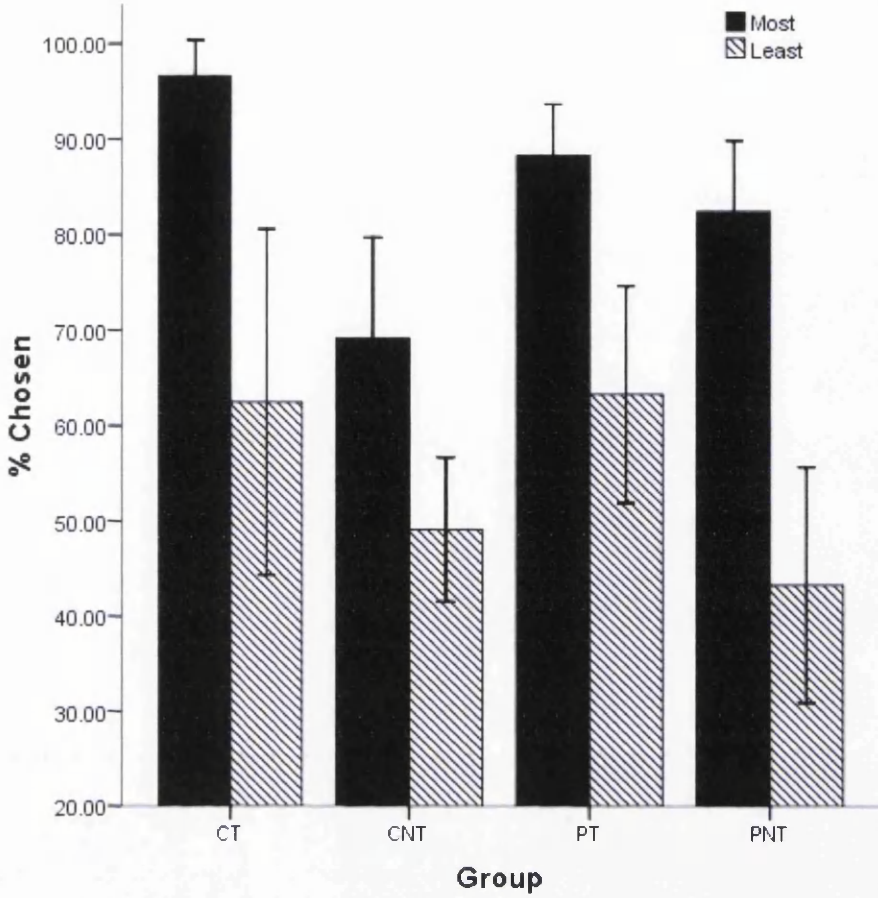


Figure 9 Group mean levels of over-selectivity in all four groups: Group CT (participants receiving CRF and training to criterion in the training phase), Group CNT (participants receiving CRF but were not trained to criterion in the training phase), Group PT (participants receiving PR and training to criterion in the training phase) and Group PNT (participants receiving PR but were not trained to criterion in the training phase) (error bars = SEM).

The mean percentage of times each stimulus (i.e., the most selected and the least selected from the initially reinforced compound, AB) was chosen in the test phase for each group is shown in Figure 9. This indicates that for the groups receiving less training (PNT and CNT), those receiving PR (PNT) showed greater evidence of selection of one stimulus than the other (i.e., stimulus over-selectivity) compared to those receiving CRF (CNT). On the other hand, there are few differences between the groups who were trained to criterion (PT and CT). A three-way, mixed-model analysis of variance (ANOVA) with stimulus type (most versus least) as a within-subjects factor, and reinforcement group (CRF versus PR), and training to criterion (trained to criterion or not trained to criterion), as the between-subject factors, revealed a statistically significant main effect of stimulus type, $F(1,44) = 75.50$, indicating over-selectivity, and a statistically significant main effect of training to criterion, $F(1,44) = 17.50$, indicating differences between those trained to criterion and those not trained to criterion. The main effect of reinforcement group was not statistically significant, $F < 1$, indicating no main effect of CRF versus PR. There were no statistically significant two-way interactions, all $ps > 0.45$, but the interaction of the three factors was statistically significant, $F(1,44) = 4.33$.

As a result of the statistically significant three-way interaction, two separate two-factor mixed-model ANOVAs (stimulus type x reinforcement group) were conducted on the 'trained to criterion', and 'not trained to criterion' groups, as recommended by Howell (1997). The ANOVA on the groups that were trained to criterion revealed a statistically significant main effect of stimulus, $F(1,22) = 28.54$, but no statistically significant main effect of group, nor interaction between the two factors, both Fs < 1. The ANOVA conducted on the groups that were not trained to criterion revealed a statistically significant main effect of stimulus, $F(1,22) = 55.73$, no statistically significant main effect of group, $F < 1$, but a statistically significant interaction between the two factors, $F(1,22) = 5.85$. Simple effect analyses revealed a statistically significant difference between the most and least chosen stimuli for the CRF group, $F(1,22) = 31.63$, and for the PR group $F(1,22) = 44.40$.

In order to determine if there was a statistically significant difference in the level of choice for the stimuli relative compared to any deviation from this level of choice that might be expected by chance, the random model provided the total absolute difference expected between the over-selected and under-selected stimuli in 10 choices, giving a value of 13% for CT, 17% for CNT, 14% for PT and 17% for PNT. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated a significant difference in the CT group, $t(11) = 2.31$, and in the PNT group, $t(11) = 3.72$, and a marginally significant difference in the PT group, $t(11) = 1.71$, $p < 0.06$, however, there was no significant difference for the CNT group, $t < 1$.

Thus, the current study showed the emergence of an over-selectivity effect, replicating previous demonstrations of this phenomenon in a healthy population (e.g., Broomfield et al., 2008a; Reed & Gibson, 2005) and the experiments in the current thesis thus far. However, this effect was more pronounced for the PR group receiving less training, than for the CRF group receiving less training, whereas there was no difference in the extent of over-selectivity between the CRF and PR groups when both were trained to criterion. This effect would not be predicted by the attention-deficit view of over-selectivity, which would assume that that when training is only partially reinforced, and is not continued to criterion, the outcome is less predictable, thus attention to the stimuli would be higher, resulting in lower over-selectivity.

4. 8. Experiment 9

It may be that PR failed to have an effect on over-selectivity in Experiments 7 and 8 because it was introduced from the start of training, whereas previous work has found a reductive effect of PR on over-selectivity when it is introduced following CRF training (e.g., Koegel et al., 1979; Schover & Newsom, 1976; but see Dube & McIlvane, 1997; Remington & Clarke, 1993). Thus, it may be that PR failed to have an effect on over-selectivity in Experiments 7 and 8 because it was introduced independently of any other reinforcement schedule (i.e. from the start of training). Experiment 9 explored whether such a shift from CRF to PR would impact over-selectivity using the current training procedures.

To this end, participants were initially trained on a simultaneous discrimination task (AB v CD) in which they received CRF. Once participants reached criterion, they received one of four additional training procedures. Group CC received additional training identical to the initial training (CRF for 10 trials to criterion). Group CP received additional PR training (for 10 trials to criterion). Group CP20 received PR in the over-training phase, but with 20 trials to criterion (in order for reinforcement level to be the same as CRF trained to 10 trials to criterion). Group Control received no over-training. If the results were to confirm the effect of a shift to PR on reducing over-selectivity (e.g., Koegel et al., 1979; Schover & Newsom, 1976) and support an attentional account of over-selectivity, then groups receiving CRF followed by PR in the over-training phase would display attenuation of over-selectivity relative to the non-shifted groups.

4. 9. Method

Participants

Thirty-two healthy participants (seven males and 25 females) with an age range of 18 to 29 years (mean = 20.56 years, SD = 2.45) took part in the experiment, were not paid for their participation and those under the age of 18, and over the age of 55, were excluded.

Apparatus and Materials

All of the previous experiments used nameable stimuli as previous work in the literature has also used such stimuli. However, Experiments 9 and 10 of this chapter, and the remaining experiments of this thesis, used abstract stimuli with the goal of reducing the role of pre-experimentally established history with specific pictures as a potential artefact. Participants were, therefore, presented with abstract pictorial stimuli taken from various fonts from Microsoft Word 2000 (Wingdings, Wingdings 2 and Symbol). As with previous experiments, these stimuli were either presented as a compound stimulus for training or an individual stimulus for test. Figure 10 shows an example of the compound stimulus and one of its associated individual stimuli (not to scale).

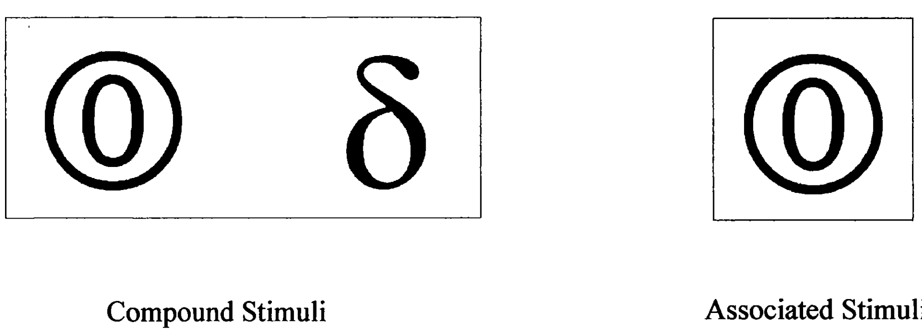


Figure 10. An example of one of the abstract compound cards and one of its associated stimuli.

‘Table top’ procedures are often used in behavioural research as they allow the benefit of interactive research, however, critics of the approach argue that the experimenter’s behaviour can unintentionally influence the participant’s behaviour and ultimately control task performance (see Dymond, Rehfeldt, & Schenk, 2005). Automated procedures remove this risk and as such, the remaining experiment used this method. The experiments were therefore automated on a Hewlett Packard Laptop written in VB.Net on Visual Studio 2010. The compound stimulus measured 14cm by 6cm on the computer screen (size of screen: 35.5cm), and the individual element cards measured 6cm by 6cm. These were presented in the centre of the screen (top to bottom), and displayed to the left or right of the screen. All stimuli were presented as a black abstract symbol on a white background, and the screen background was also white.

Again, following completion of all trials, each participant was given the AQ to assess their levels of pre-existing high functioning autism.

Procedure

The same basic paradigm as the previous experiments was implemented, with the exception that the procedures were automated as opposed to table-top. As with previous experiments, participants were required to vocally count backwards in sevens from a random five-digit number. Participants sat in front of the computer in a quiet room, free from distractions. Table 9 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase 1	AB vs. CD Selection of AB yields 'Correct' feedback Selection of CD yields 'Incorrect' feedback	Trials in Training Phase 1 and Training Phase 2 are presented interspersed randomly until ten consecutive correct responses, in both phases, are given
Training Phase 2	EF vs. GH Selection of EF yields 'Correct' feedback Selection of GH yields 'Incorrect' feedback	
Over-Training Phase 1	AB vs. CD *Group CC:* Selection of AB yields 'Correct' feedback on 100% of trials Selection of CD yields 'Incorrect' feedback on 100% of trials *Groups CP and CP20:* Selection of AB yields 'Correct' feedback on 50% of trials Selection of CD yields 'Incorrect' feedback on 50% of trials	Trials in Over-Training Phase 1 and Over-Training Phase 2 are presented interspersed randomly until ten consecutive correct responses, in both phases, are given for participants in Groups CC and CP, and until twenty consecutive correct responses are given for participants in Group CP20.
Over-Training Phase 2	EF vs. GH *Group CC:* Selection of EF yields 'Correct' feedback on 100%	

	of trials	
	Selection of GH yields 'Incorrect' feedback on 100% of trials	
	Groups CP and CP20:	
	Selection of EF yields 'Correct' feedback on 50% of trials	
	Selection of GH yields 'Incorrect' feedback on 50% of trials	
Test Phase 1 (Standard)	A vs. C	Five trials of each combination presented randomly
	A vs. D	
	B vs. C	
	B vs. D	
	E vs. G	
	E vs. H	
	F vs. G	
	F vs. H	

Training Phase: The training phase commenced with instructions appearing on the screen, explaining the training procedure:

> "*Please select one of the two cards presented. Sometimes the computer will tell you when you are correct or incorrect, and sometimes it won't. If the computer does not give you a response, it does not necessarily mean you are incorrect. You are free to withdraw from the experiment at any time. You should now begin counting backwards in sevens, and press 'Next' to begin.*"

The procedure commenced with two simple discrimination tasks, which were presented concurrently with one another; trials from each task being randomly intermixed throughout the training phase. In the first discrimination task, two compound stimuli (AB and CD) were presented next to one another on the centre of the screen. If participants clicked the reinforced compound (AB), the word 'Correct' appeared, in green, on the screen for 2s, whereas if they clicked the punished compound (CD), the word 'Incorrect' appeared, in red, on the screen for 2s. Once a card was selected, the next presentation was shown immediately. All choices were recorded in Microsoft Excel.

The second discrimination task was identical to the first discrimination task, with the exception that different stimuli (i.e., E, F, G, and H) were used, with the purpose of this task being to make the training more complex (Reed & Gibson, 2005).

As with the previous experiments, different elements of the stimuli (i.e., A, B, C, D, E, F, G and H) were used for each participant, and systematic randomisation determined the position of the stimuli. This phase lasted until the participant selected ten consecutive correct responses for each discrimination task.

Over-Training Phase: The over-training phase commenced immediately following ten consecutive correct responses. That is, no new instructions were given, therefore, participants were not aware that a separate phase had commenced. Participants in group CC received the training phase again, until they produced 10 more consecutive correct responses. Participants in group CP received the training phase again, until they reached 10 consecutive correct responses, with the exception that only 50% of responses were reinforced with 'correct' or 'incorrect'. Participants in group CP20 also received reinforcement on only 50% of responses, but had to give 20 consecutive correct responses in order to commence onto the final phase. This group was tested in order for reinforcement level to be the same as CRF trained to 10 trials to criterion. The control group did not receive the over-training phase and therefore commenced directly onto the test phase immediately following initial training.

Testing Phase: Once participants completed the training and over-training phases, they were given the following instructions:

"Please select one of the two pictures presented. The computer will not tell you whether you are correct or incorrect. You should now continue counting, and press 'Next' to begin."

They were then presented simultaneously with two cards, each comprising of one picture from the compound stimulus (A, B, C, or D, and E, F, G, or H). The pictures were paired so that participants chose between a picture from the reinforced stimulus, and a picture from the non-reinforced stimulus (A v C; A v D; B v C; B v D; E v G; E v H; F v G; F v H), with 5 trials for each combination, and, thus, 40 trials in total. Participants were not provided with feedback.

As with the previous experiments, following this phase, each participant completed the AQ to assess their levels of pre-existing high functioning autism.

4. 10. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of condition, participants took 20.13 (± 10.81) trials, on average, during initial training to reach the criterion for choosing the reinforced compound stimulus (AB or EF). Participants in group CC, on average, took 20.31 (±7.84) trials during training to reach the criterion for choosing AB or EF, participants in group CP on average, took 18.56 (±8.72) trials to reach the criterion, participants in group CP20 on average, took 20.19 (±10.09) trials to reach the criterion and participants in the Control group on average, took 21.44 (±16.52) trials to reach the criterion. A one-way independent measures ANOVA confirmed there were no statistically significant differences between the groups, $F < 1$.

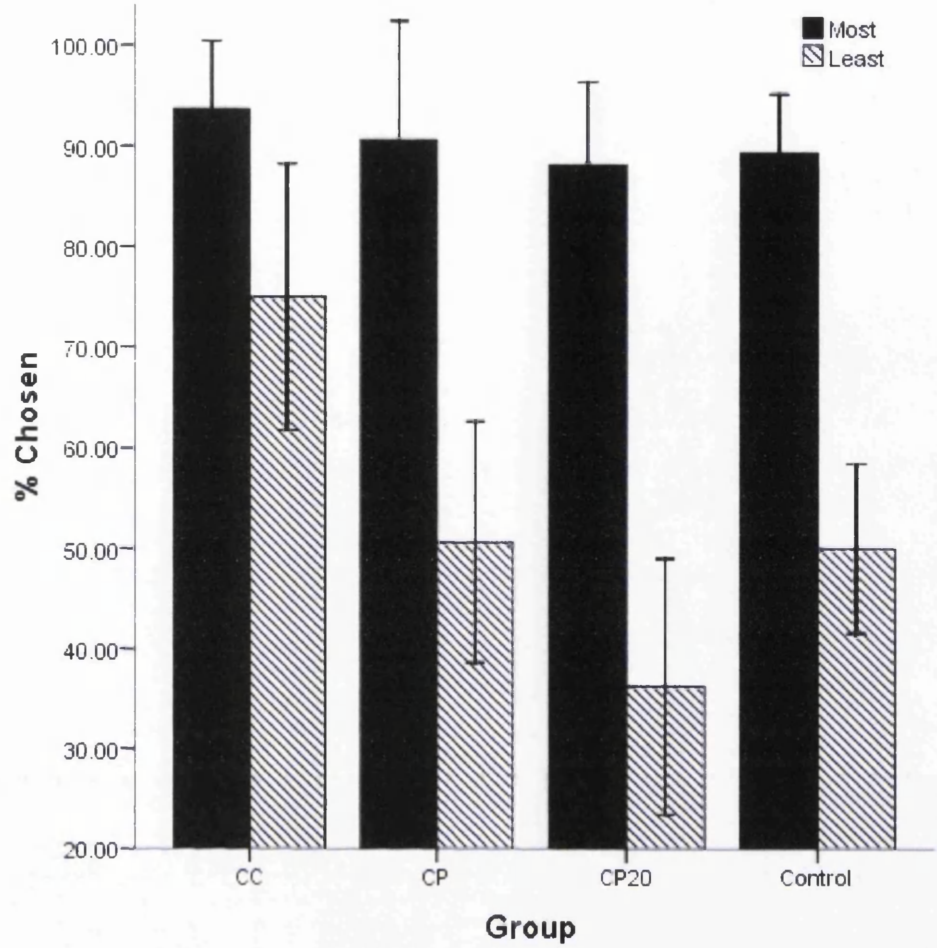


Figure 11 Group mean levels of over-selectivity in all four groups: Group CC (participants receiving CRF in both the initial and over-training phase), Group CP (participants receiving CRF in the initial phase and PR in the over-training phase), Group CP20 (participants receiving CRF in the initial phase and PR at 20 trials to criterion in the over-training phase) and the Control Group (participants receiving CRF in the initial phase and no over-training) (error bars = SEM)

The mean number of times each stimulus (i.e., the most selected and the least selected from the initially reinforced compound, AB) was chosen in the test phase was recorded for each group, and these data are displayed in Figure 11. This indicates greater evidence of selection of one stimulus than the other (i.e., stimulus over-selectivity) in the groups receiving a change in reinforcement from CRF to PR (CP and CP20), as well as the Control group, compared to the CC group who received consistent CRF throughout. The CP20 group, receiving more training following a change in reinforcement schedule from CRF to PR, showed the highest level of over-selectivity. A two-factor, mixed model ANOVA (stimulus type – most verses least, and group – CC, CP, CP20, Control) was conducted on these data. This analysis revealed a statistically significant main effect of stimulus type, $F(1,28) = 162.45$, a significant main effect of group, $F(1,28) = 4.84$, and a significant interaction between the two factors $F(1,28) = 5.47$. Simple effect analyses revealed statistically significant differences between the most and least chosen stimuli in all four groups: CC, $F(1,28) = 60.91$, CP, $F(1,28) = 15.40$, CP20, $F(1,28) = 25.91$ and the Control group, $F(1,28) = 14.93$.

In order to determine if there was a statistically significant difference in the level of choice for the stimuli relative compared to any deviation from this level of choice that might be expected by chance, the random model generated provides the total absolute difference expected between the over-selected and under-selected stimuli in 10 choices. This gives a value of 12% for the CC group, 15% for the CP group, 17% for the CP20 group and 16% for the Control group. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated a significant difference for the CP group, $t(7) = 5.00$, the CP20 group, $t(7) = 4.51$, and the control group, $t(7) = 4.10$, but was not significant for CC group, $t(7) = 1.45$.

As with Experiments 1-8, the current experiment also replicated the over-selectivity effect found in the literature (e.g., Broomfield et al., 2008a; Reed & Gibson, 2005). The experiment supported previous research (e.g., Huguenin, 2000, 2004), showing that extended training can reduce over-selectivity. In particular, continuing with CRF reduced this effect.

Such results detract from an attention-deficit hypothesis of over-selectivity which would argue that CRF would predict consequences and result in higher levels of over-selectivity. On the other hand, the experiment supported research showing that a change in reinforcement contingency from CRF to PR did not attenuate over-selectivity (e.g., Dube & McIlvane, 1997; Remington & Clarke, 1993). This would not be predicted by an attentional theory of over-selectivity (e.g., Dube & McIlvane, 1999), as such an account would assume that a change from CRF to PR would increase attention to the stimulus as the consequences are unpredictable, and, thus, this change should reduce levels of over-selectivity. However, the present experiment actually showed that more training (20 trials to criterion) following a change in reinforcement schedule (CRF to PR) resulted in the highest level of over-selectivity when comparing the four groups.

4. 11. Experiment 10

There are two potential reasons why continued training with CRF results in a decrease in over-selectivity, whereas a shift to PR did not have this impact. Firstly, it may be that shifting between schedules *per se* results in a disruption of learning, and may promote over-selectivity; it has been suggested that similar generalisation decrement is the reason underlying the sometimes observed reduction of blocking effects by a surprising shift in reinforcer value (see Dickinson et al., 1976). Secondly, it may be that extended training with CRF, specifically, reduces over-selectivity. In order to clarify these issues, it was decided to investigate whether it is the use of CRF that attenuates over-selectivity, or whether it is continued training with a consistent schedule of reinforcement that reduces over-selectivity.

To this end, all participants in Experiment 10 received PR in the initial training phase, followed by a different over-training regime, depending on which group they were assigned to. Participants in group PP received over-training identical to the first training phase (PR for 10 trials to criterion), group PC received CRF in the over-training (for 10 trials to criterion), group PP20 received PR in the over-training phase, but with 20 trials to criterion and the Control group received no over-training.

4. 12. Method

Participants and Apparatus

Thirty-two healthy participants (eight males and 24 females) with an age range of 19 to 33 years (mean = 21.38 years, SD = 3.03) took part in the experiment, were not paid for their participation and those under the age of 18 years and over the age of 55 years were excluded from participating.

The apparatus and materials were identical to those used in Experiment 9.

Procedure

The procedure followed the same paradigm as that used in previous experiments. Again, participants were required to vocally count backwards in sevens from a random five-digit number. Table 10 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase 1	AB vs. CD Selection of AB yields 'Correct' feedback on 50% of trials Selection of CD yields 'Incorrect' feedback on 50% of trials	Trials in Training Phase 1 and Training Phase 2 are presented interspersed randomly until ten consecutive correct responses, in both phases, are given
Training Phase 2	EF vs. GH Selection of EF yields 'Correct' feedback on 50% of trials Selection of GH yields 'Incorrect' feedback on 50% of trials	
Over-Training Phase 1	AB vs. CD *Group PC:* Selection of AB yields 'Correct' feedback on 100% of trials Selection of CD yields 'Incorrect' feedback on 100% of trials *Groups PP and PP20:* Selection of AB yields 'Correct'	Trials in Over-Training Phase 1 and Over-Training Phase 2 are presented interspersed randomly until ten consecutive correct responses, in both phases, are given for participants in Groups PC and PP, and until twenty consecutive correct responses are given for participants in Group PP20.

	feedback on 50% of trials	
	Selection of CD yields 'Incorrect' feedback on 50% of trials	
	EF vs. GH	
Over-Training Phase 2	*Group PC*	
	Selection of EF yields 'Correct' feedback on 100% of trials	
	Selection of GH yields 'Incorrect' feedback on 100% of trials	
	Groups PP and PP20:	
	Selection of EF yields 'Correct' feedback on 50% of trials	
	Selection of GH yields 'Incorrect' feedback on 50% of trials	
Test Phase 1 (Standard)	A vs. C	Five trials of each combination presented randomly
	A vs. D	
	B vs. C	
	B vs. D	
	E vs. G	
	E vs. H	
	F vs. G	
	F vs. H	

Training Phase: The training phase consisted of the same two simple discrimination tasks as those used in Experiment 9 with the exception that all participants received PR. That is, they were reinforced with positive feedback in the form of the word 'Correct' for selecting AB and EF on 50% of trials, and were punished with negative feedback in the form of the word 'Incorrect' for selecting CD and GH on 50% of trials.

Over-Training Phase: The over-training phase was the same as that in Experiment 9. Participants in group PP received the training phase again (50% reinforcement) until they produced 10 more consecutive correct responses. Participants in group PC received the training phase again until they reached 10 consecutive correct responses, with 100% of trials being reinforced. Participants in group PP20 also received reinforcement on only 50% of responses, but had to give 20 consecutive correct responses in order to commence onto the final phase. The control group did not receive the over-training phase.

Testing Phase: The testing phase was the same as that in Experiment 9. Following completion of all trials, each participant was given the AQ to assess their levels of pre-existing high functioning autism.

4. 13. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of condition, participants took 17.91 (± 2.69) trials, on average, during initial training to reach the criterion for choosing the reinforced compound stimulus (AB or EF). Participants in group PC, on average, took 17.50 (± 3.06) trials during training to reach the criterion for choosing AB or EF, participants in group PP on average, took 18.69 (± 2.39) trials to reach the criterion, participants in group PP20 on average, took 17.50 (± 2.58) trials to reach the criterion and participants in the Control group on average, took 17.94 (± 3.04) trials to reach the criterion. A one-way independent measures ANOVA confirmed there were no statistically significant differences between the groups, $F < 1$.

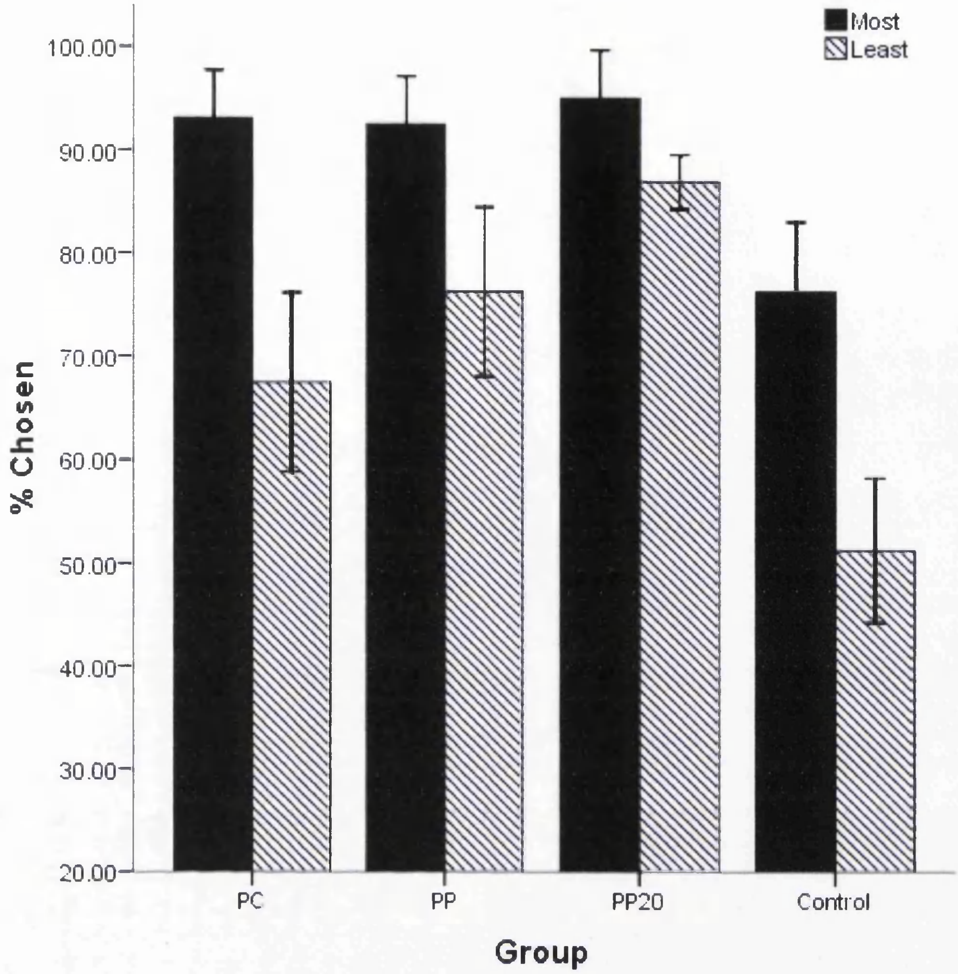


Figure 12. Group mean levels of over-selectivity for participants in all four groups: Group PC (participants receiving PR in the initial phase and CRF in the over-training phase), Group PP (participants receiving PR in both the initial and over-training phase), Group PP20 (participants receiving PR in the initial phase and PR at 20 trials to criterion in the over-training phase) and the Control group (participants receiving PR in the initial phase and no over-training) (error bars = SEM).

The mean number of times each stimulus (i.e., the most selected and the least selected from the initially reinforced compound, AB) was chosen in the test phase was recorded for each group, and these data are displayed in Figure 12. This indicates greater evidence of selection of one stimulus than the other (i.e., stimulus over-selectivity) in the Control group and the group receiving a change in reinforcement schedule from PR to CRF (Group PC). The group receiving consistent PR with extended training (PP20) showed the lowest levels of over-selectivity. A two-factor, mixed model ANOVA (stimulus type – most verses least, and group – PC, PP, PP20 and Control) was conducted on these data, and revealed a statistically significant main effect of stimulus type, $F(1,28) = 110.28$, a significant main effect of group, $F(1,28) = 20.90$, and a significant interaction between the two factors $F(1, 28) = 5.37$. Simple effect analyses revealed statistically significant differences between the most and least chosen stimuli in groups PC, $F(1,28) = 17.17$, PP, $F(1,28) = 6.90$ and the Control group, $F(1,28) = 16.34$, but no significant difference between the most and least chosen stimuli in group PP20, $F(1,28) = 1.73$.

In order to determine if there was a statistically significant difference in the level of choice for the stimuli relative compared to any deviation from this level of choice that might be expected by chance, the random model generated provides the total absolute difference expected between the over-selected and under-selected stimuli in 10 choices. This gives a value of 13% for the PC group, 12% for the PP group, 9% for the PP20 group and 16% for the Control group. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated a significant difference for the PC group, $t(7) = 2.51$, the PP group, $t(7) = 1.88$, and the Control group, $t(7) =2.31$, but no significant difference for the PP20 group, $t < 1$.

Experiment 10, again, replicated the over-selectivity effect found in the previous experiments and the over-selectivity literature (e.g., Broomfield et al., 2008a; Reed & Gibson, 2005) and also supported the findings from Experiment 9, in that a change in reinforcement schedule, regardless of whether it is a change from CRF to PR, or from PR to CRF, does not reduce over-selectivity. This extends previous research (e.g., Koegel & Rincover, 1977; Koegel et al., 1979; Schover & Newsom, 1976; Schreibman et al. 1977) exploring the effects of a change in reinforcement schedule by looking at switching from PR to CRF, however, replicates the finding that this does not reduce over-selectivity (e.g., Dube & McIlvane, 1997; Remington & Clarke, 1993). Thus, the impact of a change from a CRF schedule to a PR schedule on levels of over-selectivity, requires further examination, both in itself, and in relation to attention-based theories of over-selectivity. Additionally, the experiment replicated the finding that continuing training (20 trials to criterion) with the same reinforcement schedule (in this case, PR) does reduce over-selectivity, supporting Huguenin's (2000, 2004) finding of an impact of extended training on over-selectivity, and those of Experiment 9. Again, neither finding would be predicted by an attentional deficit account of over-selectivity (e.g., Dube & McIlvane, 1999). The finding that overtraining *per se* reduces over-selectivity has implications for the development of remediation techniques which focus on extended training (see Section 6. 4. 2 of Chapter 6).

4. 14. General discussion

The present chapter aimed to extend and clarify previous research findings regarding the attenuation of over-selectivity by investigating the effect of different training and reinforcement schedules. In particular, the experiments explored the effects of CRF and PR schedules (Experiments 7 and 8), training to criterion as opposed to not training to criterion (Experiment 8), and changing from CRF to PR and vice versa in training and 'over-training' phases (Experiment 9 and 10).

The current research successfully replicated Experiments 1 to 6, and previous work showing that stimulus over-selectivity can be found in non-clinical adult participants, through the use of a concurrent cognitive load (e.g., Broomfield et al., 2008a; Reed, 2006; Reed & Gibson, 2005). The current study also screened for high functioning autism, using the AQ, unlike some earlier research (e.g., Reed & Gibson, 2005); thus, these current results are not potentially confounded by participants who have high functioning autism.

As previous work has reported contradictory findings regarding whether PR can reduce over-selectivity (see Dube, 2009, for a review), it was thought important to verify whether or not this was the case, as this has some bearing on the validity of an attention-deficit view of the effect. Experiment 7 indicated that PR did not result in a reduction of over-selectivity when compared to CRF. This supports the findings from Dube and McIlvane (1997), and Remington and Clarke (1993), who also failed to find an influence of variable reinforcement schedules. In fact, Experiment 8 actually indicated that PR tended to increase over-selectivity when the participants had undergone less training. Experiment 9 showed that even when participants were originally trained with CRF, followed by training with PR in an over-training phase, the PR schedule still did not reduce over-selectivity. In fact, both Experiments 9 and 10 showed that continuing training with the same schedule of reinforcement was most effective in reducing over-selectivity, rather than changing reinforcement from CRF to PR or from PR to CRF. The finding that overtraining *per se* reduces over-selectivity has implications for the development of remediation techniques which focus on extended training, although the current work should be replicated on those with developmental or learning disabilities to allow further evidence for these effects and implications for treatment to be substantiated.

These findings also have some theoretical implications regarding understanding over-selectivity as they stand in contrast to the predictions derived from an attention-deficit account of over-selectivity (e.g., Dube, 2009; see also Dinsmoor, 1985; Trabasso & Bower, 1968), which suggest that PR should increase attention and, therefore, decrease over-selectivity, especially early on in training. There may be a number of reasons for this effect which have implications for various theoretical accounts of over-selectivity.

Firstly, from the Pearce-Hall perspective of conditioning, PR should increase attention, and, thus, decrease levels of over-selectivity. As discussed in section 1. 10. 3 (Schedules of reinforcement), this associability theory never specifically considered stimulus over-selectivity however it is not unreasonable to assume that such conditioning theories may be extended to account for this effect, allowing an examination of the potential predictions made by such attention-deficit accounts. As was discussed in Section 1. 10. 3, Pearce and Hall (1980) argued that the associability of a CS determines the conditioning of that stimulus. When the consequences of a CS are unpredictable, the associability of that CS remains high, but this associability is reduced when the CS is able to predict the consequences (Pearce & Bouton, 2001; Pearce & Hall, 1980; Wilson et al., 1992). In extending these assumptions to cover over-selectivity, PR should increase attention to the stimulus (as its associability is high) because the consequences of selecting that stimulus are unpredictable. Consequently, this would result in relatively lower levels of over-selectivity. Alternatively, CRF would allow an accurate prediction of the consequences of responding, resulting in lower associability, and subsequently higher levels of over-selectivity.

However, these effects were not found in the current experiments. From the same perspective, changing from CRF to PR or from PR to CRF should also increase attention, and as such, should reduce over-selectivity. Again, such an effect was not found in the current experiments.

Secondly, as Pearce-Hall (1980) advocates that associability is maintained to a stimulus when the outcome is unpredictable, such a model would predict that associability is highest when training first commences, but reduces after extended training. Therefore, if training is not continued to criterion, the higher rates of associability should result in low levels of over-selectivity, as attention will be high to the stimuli; and this over-selectivity effect would be even lower after PR training than after CRF training. Such results were not found in the current experiments.

In contrast to the attention-deficit explanation, the results of the present chapter arguably support a comparator model of over-selectivity, which suggests that the relative difference in strength between two stimuli will be greater when those stimuli have weaker associative strengths compared to when they have relatively higher associative strengths. Thus, for a given number of trials, associative strength should be weaker after PR training, especially early in that training, and, consequently, over-selectivity should be greater after PR, when compared to CRF, when associative strengths are high (see also Gibson & Reed, 2005; Huguenin, 2000, 2004, for similar results). Additionally, the Comparator theory can account for the finding in Experiment 8 that when training is not continued to criterion, more over-selectivity occurred, particularly when trained with PR, as the relative difference between the associative strengths of elements is larger.

In summary, the present chapter supports research showing that PR per se does not influence over-selectivity; however, continued training with a consistent schedule of reinforcement can reduce over-selectivity. Additionally, changing schedule of reinforcement from CRF to PR or from PR to CRF does not attenuate over-selectivity. The finding that overtraining *per se* reduces over-selectivity has implications for the development of remediation techniques which focus on extended training. Similarly to Chapter 3, the findings of the current Chapter are in opposition to over-selectivity being regarded as an attention-deficit, but rather provides support for the Comparator hypothesis and the perspective of over-selectivity as a performance deficit. The research thus extends the growing body of literature which explains over-selectivity deficits as due to retrieval, as opposed to attention, failures.

Chapter 5

Effect of a surprising downward shift in reinforcer value on stimulus over-selectivity

5. 1. Introduction

As indicated in the previous chapters, over-selectivity is important to study given its ubiquity across circumstances, and as it has been suggested as responsible for a range of deficits in a variety of behaviours seen in those with learning and developmental disorders (Reed, 2010; Schreibman et al., 1977).

Chapter 4 explored the effects of schedules of reinforcement on the remediation of over-selectivity. Previous research exploring the effects of CRF and PR were inconsistent with some reporting a reduction in over-selectivity using PR (e.g., Koegel & Rincover, 1977; Koegel et al., 1979; Schover & Newsom, 1976; Schreibman et al., 1977) whilst others fail to find a reduction in over-selectivity using PR (e.g., Dube & McIlvane, 1997; Remington & Clarke, 1993). From an attentional perspective, CRF allows an accurate prediction of the consequences of responding (as reinforcement occurs on 100% of trials), therefore, lower observing responses and higher levels of over-selectivity would be assumed. On the other hand, under a PR schedule, the consequences of selecting the stimulus are unpredictable (as reinforcement only occurs on 50% of trials), therefore, attention to the stimulus should be increased resulting in lower levels of over-selectivity. Chapter 4 concluded that PR *per se* did not reduce over-selectivity; however, continued training with a consistent schedule of reinforcement did so, thus results failed to support the theoretical perspective of over-selectivity being regarded as an attention-deficit.

In a similar vein based on the view that attention may be involved in stimulus over-selectivity, research has explored the potential of remediation of over-selectivity through the use of observing response procedures (e.g., Broomfield et al., 2008b; Dinsmoor, 1985; Dube & McIlvane, 1999; Mueller & Dinsmoor, 1986; Stromer et al., 1993; See Section 1. 10. 1. Observing responses). Observing responses refer to a response that results in exposure to a discriminative stimuli, bringing sensory receptors into contact with the stimuli (Wyckoff, 1952) thus, all aspects of the discrimination contingency are required to be identified before making a response. The observing response procedure may overcome attentional deficits by ensuring that all aspects of the stimulus are initially attended to (see Dube et al., 1999).

In addition to these possible manipulations, the associative learning literature provides further examples whereby cue interference effects are reduced in magnitude by attention-based manipulations. One example is the impact of a surprising downshift in reinforcer value on reducing the blocking effect (Dickinson et al., 1976). Blocking refers to the process whereby prior conditioning of one element (A) prevents subsequent conditioning of another element (X) when presented in a compound consisting of both elements (AX; Kamin, 1969). However, if a 'surprising' reinforcer is introduced at the beginning of the compound training, this results in substantial learning about the added element (see for example, Dickinson et al., 1976; Holland, 1984; Holland & Kenmuir, 2005; Mackintosh, Bygrave & Picton, 1977; Mackintosh & Turner, 1971). It is thought that such manipulations restore the associability, and, hence, attention of the stimuli. Mackintosh (1975) and Pearce and Hall (1980) argue that surprise maintains the associability of stimuli; the surprising event maintains attention to a stimulus that would otherwise be ignored, allowing the initial reinforcement to have its normal effect.

Dickinson et al. (1976) explored the effects of the omission of an otherwise expected reinforcer. Two groups of rats were given a light stimulus followed by two shocks. In the second training phase, the rats received a light and clicker compound, with one group receiving the same two shocks (representing the conventional blocking design), and a second group of rats received just one shock (the surprising omission of the second shock). The second group of rats displayed attenuation of blocking, supporting the prediction that a surprising event has high importance in the process of unblocking. Similarly, Holland and Gallagher (1993) investigated the phenomenon of downward shifts in reinforcer value, by providing rats with a visual CS paired with a sequence of a single food pellet reward followed by 2 more food pellets 5 seconds later. Following training with this pairing, an auditory CS was added to the visual cue, and this compound was paired with the single pellet reward; thus, omitting the second reinforcer (2 food pellets) therefore resulting in a downward shift in reinforcer value. Findings revealed that the rats acquired excitatory learning about the added auditory stimulus. More recently, Holland and Kenmuir (2005) replicated and extended the findings of Holland and Gallagher (1993), exploring the influence of downward shifts in reinforcer value in appetitive unblocking procedures, by excluding the second of a two-reinforcer sequence in rats.

They showed that omitting the second reinforcer in normal rats resulted in improved processing of the initial reinforcer.

The key issue in the current chapter is to explore whether a surprising downward shift in reinforcer value can result in an attenuation of over-selectivity. If over-selectivity is, at least in part, produced by attention-deficits, then such manipulations may be expected to have an impact. This would extend the findings regarding downward shifts in reinforcer value to another cue interference paradigm; that is, it attempts to replicate work by Dickinson et al. (1976) using an over-selectivity paradigm. Not only would this allow further investigation of processes that could reduce over-selective responding, and, thus, be of potential therapeutic benefit, but it would also represent one of the few demonstrations of this effect in human subjects.

5. 2. Experiment 11

Experiment 11 aimed to extend previous research (e.g., Dickinson et al., 1976), and to provide evidence for the attenuation of cue interference following a surprising downward shift in reinforcer value. As such, the study investigated the effect of a similar surprising downward shift in reinforcer value on the phenomenon of over-selectivity. If a downwards shift in reinforcer value (an attentional manipulation) is found to reduce over-selectivity, this would provide support for an attention deficit perspective of the phenomenon (e.g., Dube & McIlvane, 1999). To this end, participants were randomly assigned to one of four groups. Participants in Group 3-Control, and Group 3-Down, both received 3 points for a correct response in initial discrimination training, whereas Group 10-Control, and Group 10-Down, both received 10 points for a correct response in initial training. In the next phase, the control groups continued to receive the same number of points that they were presented with in the initial training, whereas participants in Groups 3-Down and 10-Down received only 1 point for a correct response. If the downward shift manipulation was effective, supporting an attention deficit perspective of over-selectivity, it would be expected that participants in the experimental groups (3-

Down and 10-Down) would show lower levels of over-selectivity at test compared to the control groups.

5. 3. Method

Participants and Apparatus

Thirty-two healthy participants (8 males and 24 females), with an age range of 19 to 28 years (mean = 21.22 years, SD = 2.03), took part in the experiment, and were not paid for their participation. Participants under the age of 18 years, and over the age of 55 years, were not recruited.

Like Experiments 9 and 10, the experiment was an automated procedure on a Hewlett Packard Laptop, using abstract stimuli, and the AQ (Baron-Cohen, 2001) was used to assess pre-existing high functioning autism.

Procedure

As with previous experiments, participants were required to vocally count backwards in sevens from a random five-digit number throughout the study. Participants sat in front of the computer in a quiet room, free from distractions. Table 11 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase 1		
Task 1	AB vs. CD *Groups 10-Control and 10-Down:* Selection of AB yields 10 points on 100% of trials Selection of CD yields 0 points on 100% of trials *Groups 3-Control and 3-Down:* Selection of AB yields 3 points on 100% of trials Selection of CD yields 0 points on 100% of trials	Trials in both discrimination tasks are presented interspersed randomly until ten consecutive correct responses in both phases
Task 2	EF vs. GH *Groups 10-Control and 10-Down:* Selection of EF yields 10 points on 100% of trials Selection of GH yields 0 points on 100% of trials *Groups 3-Control and 3-Down:* Selection of EF yields 3 points on 100% of trials Selection of GH yields 0 points on 100% of trials	
Training Phase 2	*Groups 10-Control and 3-Control* received Training Phase 1 again.	Trials in both discrimination tasks

	Groups 10-Down and 3-Down:	are presented interspersed randomly until ten consecutive correct responses in both phases
Task 1	AB vs. CD	
	Selection of AB yields 1 point on 100% of trials	
	Selection of CD yields 0 points on 100% of trials	
Task 2	EF vs. GH	
	Selection of EF yields 1 point on 100% of trials	
	Selection of GH yields 0 points on 100% of trials	
Test Phase	A vs. C	Five trials of each combination presented randomly
	A vs. D	
	B vs. C	
	B vs. D	
	E vs. G	
	E vs. H	
	F vs. G	
	F vs. H	

Training Phase 1: The training phase commenced with instructions appearing on the screen, explaining the training procedure:

> "*Please select one of the two cards presented. You will be given points for selecting particular cards. Your aim is to get as many points as possible. You should begin counting backwards now and press Next.*"

The procedure commenced with two simple discrimination tasks, which were presented concurrently with one another; trials from each task being randomly intermixed throughout the training phase. In the first discrimination task, two compound stimuli (AB and CD) were presented next to one another on the centre of the screen. If participants clicked the reinforced compound (AB), for participants in groups 3-Control and 3-Down, the number '3' appeared, in green, on the screen for 2s, whereas if they clicked the punished compound (CD), the number '0' appeared, in red, on the screen for 2s. For participants in groups 10-Control and 10-Down, if participants clicked the reinforced compound (AB), the number '10' appeared, in green, on the screen for 2s, whereas if they clicked the punished compound (CD), the number '0' appeared, in red, on the screen for 2s. Once a card was selected, the next presentation was shown immediately. All choices were recorded in Microsoft Excel.

The second discrimination task was identical to the first discrimination task, with the exception that different stimuli (i.e., E, F, G, and H) were used, with the purpose of this task being to make the training more complex, and increase the chance of observing an over-selectivity effect in healthy participants (see Reed & Gibson, 2005).

Different elements of the stimuli (i.e., A, B, C, D, E, F, G and H) were used for each participant, and systematic randomisation determined the position of the stimuli. This phase lasted until the participant selected ten consecutive correct responses for each discrimination task.

Training Phase 2: The second phase commenced immediately following ten consecutive correct responses. That is, no new instructions were given, therefore, participants were not aware that a separate phase had commenced.

Participants in group 3-Control and 10-Control received the training phase again until they produced 10 more consecutive correct responses with the 3-Control group continuing to receive 3 points for a correct response and the 10-Control group continuing to receive 10 points for a correct response. Participants in group 3-Down and 10-Down received the training phase again until they reached 10 consecutive correct responses, with the exception that both groups only received 1 point for a correct response. All groups continued to receive 0 points for an incorrect response.

Testing Phase: Once participants completed the first and second phases, they were given the following instructions:

> "*Please select one of the two pictures presented. The computer will not tell you whether you are correct or incorrect. You should now continue counting, and press 'Next' to begin.*"

They were then presented simultaneously with two cards, each comprising of one picture from the compound stimulus (A, B, C, or D, and E, F, G, or H). The pictures were paired so that participants chose between a picture from the reinforced stimulus, and a picture from the non-reinforced stimulus (A v C; A v D; B v C; B v D; E v G; E v H; F v G; F v H), with 5 trials for each combination, and, thus, 40 trials in total. Participants were not provided with feedback.

Following this phase, each participant was asked to complete the AQ to assess their levels of pre-existing high functioning autism.

5. 4. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of condition, participants took a mean 21.98 (± 10.37) trials during initial training to reach the criterion for choosing the reinforced compound stimulus (AB or EF), and 12.45 (± 2.54) trials during Phase 2 to reach the criterion for choosing the reinforced compound stimulus. Group 3-Down took mean of 18.31 (± 6.54) trials during initial training to reach the criterion, and 13.69 (± 1.44) trials during Phase 2 to reach criterion; participants in Group 10-Down took 27.31 (± 13.59) trials to reach the criterion in initial training, and 14.25 (± 3.44) trials during Phase 2 to reach the criterion; Group 3-Control took 23.50 (± 11.25) trials to reach the criterion in initial training, and 10.75 (± 1.36) trials during Phase 2 to reach the criterion; and Group 10-Control, on average, took 18.81 (± 7.77) trials to reach the criterion in initial training and 11.13 (± 1.41) trials during Phase 2 to reach the criterion. A rejection criterion of $p < 0.05$ was used for all subsequent analyses. A one-way independent-measures ANOVA confirmed there were no statistically significant differences in the number of trials to criterion in initial training between the groups, F (3,28) = 1.40, but there was a statistically significant difference between the groups in the number of trials to criterion in Phase 2, F (3,28) = 5.66.

Post hoc comparisons using the Tukey Honestly Significant Difference test (Tukeys HSD) at the .05 level of significance, indicated that the mean trials to criterion in Phase 2 for the 3-Down group was significantly different than the 3-Control group. The mean trials to criterion in Phase 2 for the 10-Down group was also significantly different than the 3-Control group as well as the 10-Control group. All other comparisons were not significant. Taken together, the results indicate that participants receiving a downward shift in reinforcer value in the second phase took longer to learn the discrimination than participants in the control conditions.

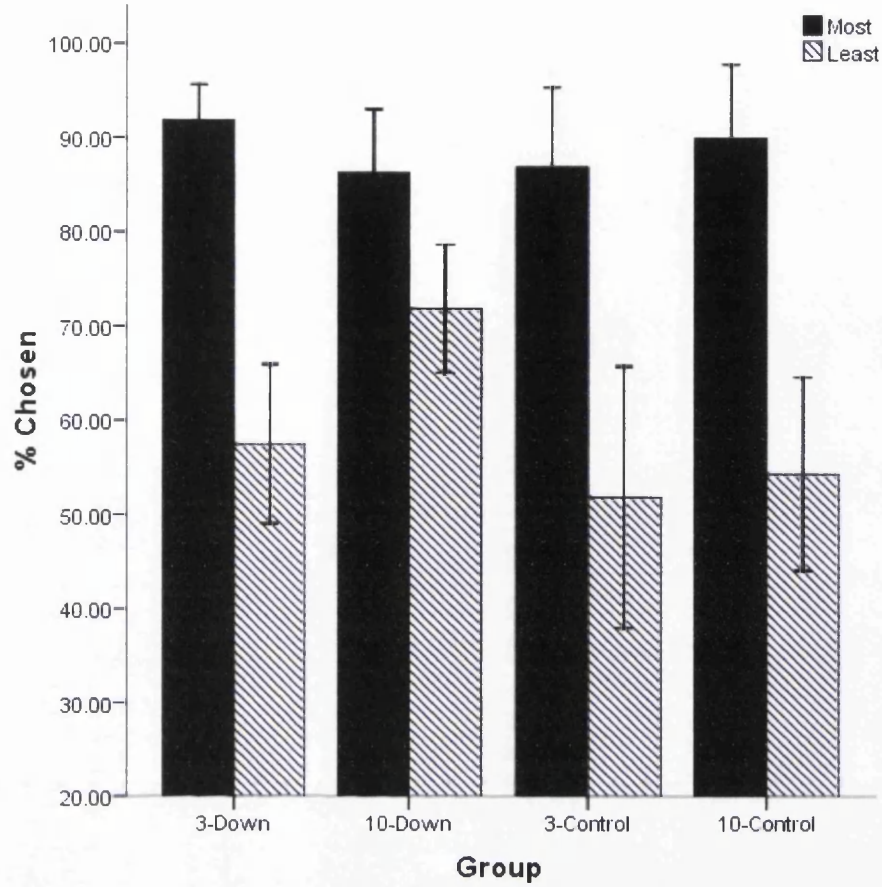


Figure 13. Group mean levels of over-selectivity in all four groups: 3-Down (participants receiving 3 points in initial training for selecting the correct compound stimulus and 1 point in Phase 2 for selecting the correct compound stimulus) 10-Down (participants receiving 10 points in initial training for selecting the correct compound stimulus and 1 point in Phase 2 for selecting the correct compound stimulus), 3-Control (participants receiving 3 points in initial training for selecting the correct compound stimulus and continued to receive 3 points in Phase 2 for selecting the correct compound stimulus) and 10-Control (participants receiving 10 points in initial training for selecting the correct compound stimulus and continued to receive 10 points in Phase 2 for selecting the correct compound stimulus) (error bars = SEM).

The mean number of times each stimulus (i.e., the most selected and the least selected from the initially reinforced compounds, AB and EF) was chosen in the test phase for each group (3-Down, 10-Down, 3-Control and 10-Control) are displayed in Figure 13. Groups 3-Down, 3-Control and 10-Control showed greater evidence of selection of one stimulus than the other (i.e., stimulus over-selectivity) compared to the 10-Down group. A two-factor, mixed model ANOVA (stimulus type – most verses least, and group – 3-Down, 10-Down, 3-Control, 10-Control) was conducted on these data, and revealed a statistically significant main effect of stimulus type,

$F(1,28) = 99.56$, a significant interaction between the two factors, $F(1, 28) = 2.98$, but no significant main effect of group, $F(1,28) = 1.69$. Simple effect analyses conducted on the stimulus type (most versus least) for the 3-Down group revealed a statistically significant difference between the most and least chosen stimulus, $F(1,28) =11.01$, and there was also a statistically significant simple effect of stimulus for the 3-Control group, $F(1,28) = 11.41$, and the 10-Control group, $F(1,28) = 11.82$, but no statistically significant simple effect of stimulus for the 10-Down group, $F(1,28) = 1.92$. For the most selected stimulus, simple effect analyses revealed no statistically significant difference between the groups, $F(1, 28) = 1.18$. For the least selected stimulus, simple effect analyses revealed a statistically significant difference between the four groups, $F(1, 28) = 13.42$. Tukeys HSD tests revealed significantly significant differences between groups 10-Down and 3-Control, and groups 10-Down and 10-Control. All other comparisons were not significant.

In order to determine if there was a statistically significant difference in the level of choice for the stimuli relative compared to any deviation from this level of choice that might be expected by chance, the random model generated provides the total absolute difference expected between the over-selected and under-selected stimuli in 10 choices. This gives a value of 15% for the 3-Down group, 14% for the 10-Down group, 16% for the 3-Control group and 15% for the 10-Control group. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated a significant difference for the 3-Down group, $t(7) = 4.15$, the 3-Control group, $t(7) = 2.40$, and the 10-Control, $t(7) = 2.83$, but no significant difference for the 10-Down group, $t < 1$.

Taken together, the results reveal that over-selectivity was attenuated in the group receiving the largest reduction in point value (10-Down). Therefore, the experiment replicates the effect of a downward shift in reinforcer value on blocking procedures (e.g., Dickinson et al., 1976; Holland, 1984; Holland & Kenmuir, 2005; Mackintosh et al., 1977; Mackintosh & Turner, 1971) and extends this effect to the current cue interference procedure. The results also support an attention deficit perspective as the downward shift deems the reinforcement unpredictable and therefore reduces over-selectivity. Of note is that significant attenuation of over-selectivity did not occur in the group receiving a lower reduction in point value (3-Down), potentially due to insufficient reduction in points value.

5. 5. Experiment 12

An alternative explanation for the finding of a surprising shift in reinforcer value attenuating blocking was provided by Neely and Wagner (1974), who advocated the idea of a generalisation decrement. Changes in post-trial stimuli introduce a discrepancy between initial and subsequent learning environments, which may, in itself, cause changes in performance. A further study reported by Dickinson et al. (1976) explored whether generalisation decrement may be a justified explanation of the effects of downward shifts in reinforcer values, by maintaining aspects of the initial conditioning procedure in the downward shift phase. They first conditioned rats to a light signalling a double shock, with either 4 seconds, or 8 seconds, between shocks. In the second stage, all the rats were conditioned to a compound consisting of a light and a clicker, which signalled a double shock with 8 seconds between these shocks. For the surprise and control group, the shock that was signalled by the light alone was the same in the second phase as it was in the first phase, with the compound signalling the same shock as the light for the control group, and a longer interval between shocks for the surprise group. They also introduced a surprise generalisation decrement group, and a control generalisation decrement that received a light signalling different interval shocks in the two phases. The former group received the presentation of a light signalling a longer interval between shocks in the two phases, and the latter group received the same inter-shock intervals associated with compound trials across the two phases. It was hypothesised that if a shift in the inter-shock interval on compound trials attenuated blocking, this would support the importance of the element of surprise, whereas according to the concept of generalisation decrement, shifting inter-shock intervals for the conditioning of the light alone would attenuate blocking. The results demonstrated that generalisation decrement did not influence the downward shift effect; that is, the finding that the surprise condition showed more suppression to the clicker than the control group indicates that generalisation decrement could not entirely account for the unblocking effect (see also Holland, 1984; Mackintosh et al., 1977).

The current Experiment 12 aimed to replicate and extend Experiment 11, as well as exploring the potential influence of generalisation decrement. To this end, participants were randomly assigned to one of four groups. Participants in a Control group received 10 points for a correct response in the first training phase, and continued to receive 10 points for a correct response in Phase 2. Participants in group Down received 10 points for a correct response in the first training phase, but this reinforcement was reduced to 1 point for a correct response in Phase 2, resulting in a surprise downward shift in reinforcer value. Participants in the GD group (Generalisation Decrement) received 10 points for a correct response in the first training phase, followed by Phase 2 whereby they received 10 points for a correct response on 50% of trials and 1 point for a correct response on 50% of trials, as such, the reinforcement trace is maintained along with the element of surprise. It was predicted that if the reduction in over-selectivity shown in the Down group in Experiment 11 was a result of a generalisation decrement, then maintaining the conditions of the initial training in the GD group would lead to less generalisation decrement between phases, and over-selectivity would not be reduced. However, as would be argued by an attention deficit perspective of over-selectivity, if the downward shift is successful in reducing over-selectivity and is not simply a result of a generalisation decrement, then over-selectivity would still be reduced in the GD group. Participants in the PR-Control group received 10 points for a correct response on 50% of trials and 1 point for a correct response on 50% of trials in both Phases, in order to control for any effect found in the GD group being a result of a PR schedule.

5. 6. Method

Participants and Apparatus

Forty healthy participants (10 males and 30 females) with an age range of 19 to 26 years (mean = 20.93 years, SD = 1.78) took part in the experiment. Participants were recruited based on opportunity sampling. Individuals under the age of 18 years, and over the age of 55 years, were not recruited.

The apparatus and materials were the same as those employed in Experiment 11.

Procedure

As with all previous experiments, participants were required to vocally count backwards in sevens from a random five-digit number and sat in front of the computer in a quiet room. Table 12 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase 1		
Task 1	AB vs. CD	Trials in both discrimination tasks are presented interspersed randomly until ten consecutive correct responses in both phases
	Groups Control, Down and GD:	
	Selection of AB yields 10 points on 100% of trials	
	Selection of CD yields negative 0 points on 100% of trials	
	Group PR-Control	
	Selection of AB yields 10 points on 50% of trials and 1 point on other 50%	
	Selection of CD yields negative 0 points on 100% of trials	
Task 2	EF vs. GH	
	Groups Control, Down and GD:	
	Selection of EF yields 10 points on 100% of trials	
	Selection of GH yields negative 0 points on 100% of trials	
	Group PR-Control:	
	Selection of EF yields 10 points on 50% of trials and 1 point on other 50%	

	Selection of GH yields negative 0 points on 100% of trials	
Training Phase 2	The *Control Group* received Training Phase 1 again.	Trials in both discrimination tasks are presented interspersed randomly until ten consecutive correct responses in both phases
Task 1	AB vs. CD	
	Group Down:	
	Selection of AB yields 1 point on 100% of trials	
	Selection of CD yields negative 0 points on 100% of trials	
	Group GD and PR-Control:	
	Selection of AB yields 10 points on 50% of trials and 1 point on other 50%	
	Selection of CD yields negative 0 points on 100% of trials	
Task 2	EF vs. GH	
	Group Down:	
	Selection of EF yields 1 point on 100% of trials	
	Selection of GH yields negative 0 points on 100% of trials	
	Group GD and PR-Control:	
	Selection of EF yields 10 points on 50% of trials and 1 point on the 50%	

	Selection of GH yields negative 0 points on 100% of trials	
Test Phase	A vs. C A vs. D B vs. C B vs. D E vs. G E vs. H F vs. G F vs. H	Five trials of each combination presented randomly

Training Phase: The training phase commenced with the same instructions appearing on the screen as those in Experiment 11. The phase consisted of the same two simple discrimination tasks as those used in Experiment 11, with trials from each task presented concurrently. All participants except those in the PR-Control group received the same treatment in this phase: If they clicked the correct, reinforced compound (AB or EF), the number '10' appeared, in green, on the screen for 2s, whereas if they clicked the incorrect compound (CD or GH), the number '0' appeared, in red, on the screen for 2s. Participants in the PR-Control group received 10 points for selecting the correct, reinforced compound (AB or EF) on 50% of trials and for the other 50% of trials they received 1 point for a correct response. They always received 0 points for selecting the incorrect compound (CD or GH) response.

Once a card was selected, the next presentation was shown immediately. All choices were recorded in Microsoft Excel. This phase lasted until the participant selected ten consecutive correct responses for each discrimination task.

Training Phase 2: As with Experiment 11, the second phase commenced immediately following ten consecutive correct responses, with no new instructions.

Participants in the Control group received the training phase again until they produced 10 more consecutive correct responses, that is they were given 10 points for a correct response (selecting AB or EF), and 0 points for an incorrect response (selecting CD or GH). Participants in group Down received the training phase again, however, they only received 1 point for a correct response, and continued receiving 0 points for an incorrect response, until they reached 10 consecutive correct responses. Participants in group GD and the PR-Control group received the training phase again, but on 50% of trials they continued to receive 10 points for a correct response and for 50% of trials they received 1 point for a correct response, and they always received 0 points for an incorrect response.

Testing Phase: The testing phase was then identical to that used in Experiment 11 and participant's completed the AQ, to assess their levels of pre-existing high functioning autism.

5. 7. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of condition, participants took a mean 22.61 (± 5.42) trials during initial training to reach the criterion for choosing the reinforced compound stimulus (AB or EF), and 12.88 (± 3.15) trials during Phase 2 to reach the criterion for choosing the reinforced compound stimulus. Participants in group Down, on average, took 24.25 (± 5.93) trials during initial training to reach the criterion, and 12.90 (± 1.49) trials during Phase 2 to reach criterion. Participants in the Control group, on average, took 23.45 (± 5.71) trials to reach the criterion in initial training and 10.75 (± 1.25) trials during Phase 2 to reach the criterion. Participants in group GD, on average, took 20.55 (± 4.90) trials to reach the criterion in initial training and 13.55 (± 2.16) trials during Phase 2 to reach the criterion. Participants in the PR-Control group, on average, took 22.20 (± 5.19) trials to reach the criterion in initial training and 14.30 (± 5.17) trials during Phase 2 to reach the criterion. A one-way independent measures ANOVA confirmed there were no statistically significant differences in the number of trials to criterion in initial training between the groups, $F < 1$ or in the number of trials to criterion in Phase 2, $F(3, 36) = 2.65$.

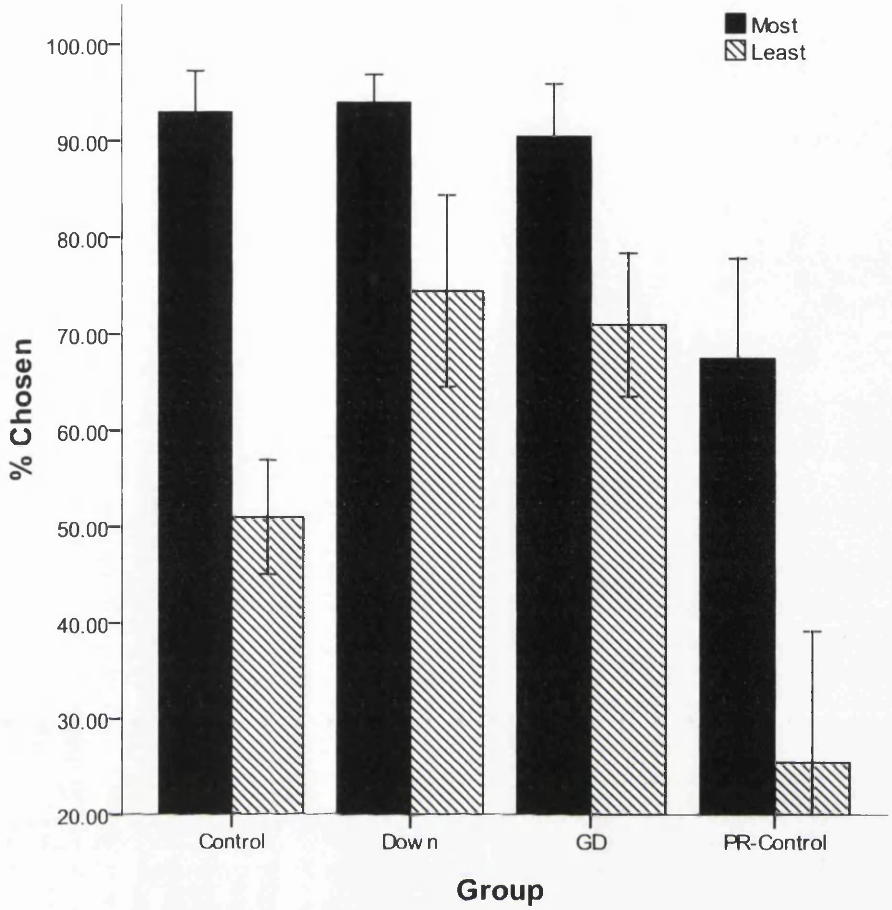


Figure 14. Group mean levels of over-selectivity in all four groups: the Control group (participants receiving 10 points for selecting the correct compound stimulus in initial training followed by receiving 10 points for selecting the correct compound stimulus in the second phase), group Down (participants receiving 10 points in initial training for selecting the correct compound stimulus followed by receiving 1 point in the second phase for selecting the correct compound stimulus) group GD (participants receiving 10 points for selecting the correct compound stimulus in initial training followed by receiving 1 point for selecting the correct compound stimulus on 50% of trials in the second phase and 10 points in the other 50% of trials) and group PR-Control (participants receiving 1 point for selecting the correct compound stimulus on 50% of trials in both phases and 10 points in the other 50% of trials) (error bars = SEM).

Figure 14 shows the mean number of times each stimulus (i.e., the most selected and the least selected from the initially reinforced compounds, AB and EF) was chosen in the test phase for each group (Control, Down, GD, PR-Control). The Control and PR-Control groups showed greater evidence of selection of one stimulus than the other (i.e., stimulus over-selectivity) compared to the Down and GD groups.

Few differences were found between the Down and GD groups. A two-factor, mixed model ANOVA (stimulus type – most verses least, and group – Control, Down, GD, PR-Control) was conducted on these data, and revealed a statistically significant main effect of stimulus type, $F(1, 36) = 196.91$, a significant main effect of group, $F(1, 36) = 24.04$ and a significant interaction between the two factors, $F(1, 36) = 8.79$. Simple effect analyses conducted on the stimulus type (most versus least) revealed a statistically significant difference between the most and least chosen stimulus, for the Control group $F(1,36) = 91.84$, the Down group $F(1,36) = 19.79$, the GD group, $F(1,36) = 19.79$ and group PR-Control $F(1,36) = 91.84$. For the most selected stimulus, simple effect analyses revealed a statistically significant difference between the groups, $F(1, 36) = 49.48$. Tukeys HSD tests revealed significantly significant differences between groups PR-Control and Control, PR-Control and GD, and PR-Control and Down. All other comparisons were not significant. Simple effects analyses also revealed a statistically significant difference for the least selected stimulus, $F(1, 36) = 158.42$. Tukeys HSD tests revealed significantly significant differences between all group comparisons except the Down-GD comparison.

In order to determine if there was a statistically significant difference in the level of choice for the stimuli relative compared to any deviation from this level of choice that might be expected by chance, the random model generated provides the total absolute difference expected between the over-selected and under-selected stimuli in 10 choices. This gives a value of 15% for the Control group, 12% for group Down, 14% for group GD and 17% for the PR-Control group. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated a significant difference for the Control group, $t(9) = 10.82$ and the PR-Control group, $t(9) = 4.47$, but no significant difference for the GD group, $t(9) = 1.56$ or the Down group, $t(9) = 1.45$.

Taken together, the results replicate Experiment 11, and research on blocking procedures (e.g., Dickinson et al., 1976; Holland, 1984; Holland & Kenmuir, 2005; Mackintosh et al., 1977; Mackintosh & Turner, 1971) indicating that participants receiving a downward shift in points (Group Down) showed reduced levels of over-selectivity. Additionally, the current experiment explored the potential influence of generalisation decrement in order to replicate work on blocking procedures (e.g., Dickinson et al., 1976; Holland, 1984; Mackintosh et al., 1977). If the reduction in over-selectivity shown in the Down group was a result of a complete removal of previous contingencies (i.e. generalisation), then maintaining the baseline in the GD group would allow a reduction in this disruption and over-selectivity would not be reduced. However, this was not found to be the case but rather maintaining the baseline in the same context of the downward shift (an attentional manipulation) still resulted in the attenuation of over-selectivity, providing partial support for an attention deficit perspective of over-selectivity (e.g., Dube et al., 1999; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971). A PR-control group verified that these results were not due to a PR schedule as over-selectivity was not reduced in this group. This is consistent with the findings from Chapter 4 and previous work (e.g., Dube & McIlvane, 1997; Remington & Clarke, 1993) which find no evidence of an attenuating effect of PR on over-selectivity, but is not consistent with an attention deficit perspective of over-selectivity.

5. 8. Experiment 13

Experiments 11 and 12 provide evidence to suggest that a downward shift in reinforcer value does reduce over-selectivity, arguably supporting an attention deficit perspective. Furthermore, Experiment 12 explored the influence of a generalisation decrement by maintaining the original points value in Phase 2 along with the downward shift, and still found a reduction in over-selectivity. However, it is arguable that the GD group only received half as much disruption as the Down group and as such, the group does not fully explore the effect of disruption. Experiment 13 therefore aimed to further examine the generalisation disruption, through other means, by manipulating the nature of the stimulus.

To this end, participants were randomly assigned to one of two groups. Participants in group Down received 10 points for a correct response in the first phase, followed by 1 point for a correct response in the second phase and 0 points for an incorrect response in both phases. Participants in group Change received 10 points for a correct response and 0 points for a correct response throughout both phases, however, they experienced a change in stimulus colour across phases. From an attentional perspective, changing the nature of the stimulus should result in a change in associability, thus also reducing over-selectivity in group Change.

5. 9. Method

Participants and Apparatus

Twenty healthy participants (8 males and 12 females) with an age range of 19 to 28 years (mean = 22.50 years, SD = 3.28) took part in the experiment. As with previous experiments, participants were recruited based on opportunity sampling and were all between the ages of 18 and 55.

The apparatus and materials were the same as those employed in Experiments 11 and 12.

Procedure

The setting was the same as previous experiments and participants were required to vocally count backwards in sevens from a random five-digit number. Table 13 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase 1		Trials in both discrimination tasks are presented interspersed randomly until ten consecutive correct responses in both phases
Task 1	AB vs. CD Selection of AB yields 10 points on 100% of trials Selection of CD yields 0 points on 100% of trials	
Task 2	EF vs. GH Selection of EF yields 10 points on 100% of trials Selection of GH yields 0 points on 100% of trials	
Training Phase 2		
Task 1	AB vs. CD *Group Down:* Selection of AB yields 1 point on 100% of trials Selection of CD yields 0 points on 100% of trials Stimulus colour remains the same *Group Change:* Selection of AB yields 10 point on 100% of trials Selection of CD yields 0 points on	Trials in both discrimination tasks are presented interspersed randomly until ten consecutive correct responses in both phases

	100% of trials	
	Stimulus colour changed from red to black or from black to red	
Task 2	EF vs. GH	
	Group Down:	
	Selection of EF yields 1 point on 100% of trials	
	Selection of GH yields 0 points on 100% of trials	
	Stimulus colour remains the same	
	Group Change:	
	Selection of EF yields 10 point on 100% of trials	
	Selection of GH yields 0 points on 100% of trials	
	Stimulus colour changed from red to black or from black to red	
Test Phase	A vs. C	Five trials of each combination presented randomly
	A vs. D	
	B vs. C	
	B vs. D	
	E vs. G	
	E vs. H	
	F vs. G	
	F vs. H	

Training Phase: The training phase commenced with the same instructions appearing on the screen as those in the previous experiments and consisted of the same two simple discrimination tasks. Participants in both groups received the same treatment: If they clicked the correct, reinforced compound (AB or EF), the number '10' appeared, in green, on the screen for 2s, whereas if they clicked the incorrect compound (CD or GH), the number '0' appeared, in red, on the screen for 2s. For some participants in group Change, the stimuli were red, and for the remaining participants the stimuli were black. As with the previous experiments, this phase lasted until the participant selected ten consecutive correct responses for each discrimination task.

Phase 2: The second phase commenced immediately following ten consecutive correct responses, with no new instructions. Participants in group Change underwent the training phase again, receiving the same amount of points as in the first phase. The only modification was that the colour of abstract stimuli presented in the task were changed. For participants received red stimuli in Phase 1, the stimuli changed to black in Phase 2, and for participants who received black stimuli in Phase 1, the stimuli changed to red in Phase 2. Participants in group Down received the training phase again (with the same black stimuli), however, they only received 1 point for a correct response, and continued receiving 0 points for an incorrect response. The task continued until all participants reached 10 consecutive correct responses for both discriminations.

Testing Phase: The testing phase was then identical to that used in the previous experiments and participant's completed the AQ to assess their levels of pre-existing high functioning autism.

5. 10. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of condition, participants took a mean 24.48 (± 8.32) trials during initial training to reach the criterion for choosing the reinforced compound stimulus (AB or EF), and 12.45 (± 2.52) trials during Phase 2 to reach the criterion for choosing the reinforced compound stimulus. Participants in group Down, on average, took 24.20 (± 7.86) trials during initial training to reach the criterion, and 11.25 (± 1.74) trials during Phase 2 to reach criterion. Participants in the Change group, on average, took 24.75 (± 9.18) trials to reach the criterion in initial training and 13.65 (± 2.69) trials during Phase 2 to reach the criterion. T-tests confirmed there were no statistically significant differences in the number of trials to criterion in initial training between the groups, $t < 1$, or in the number of trials to criterion in Phase 2, $t(18) = 2.37$.

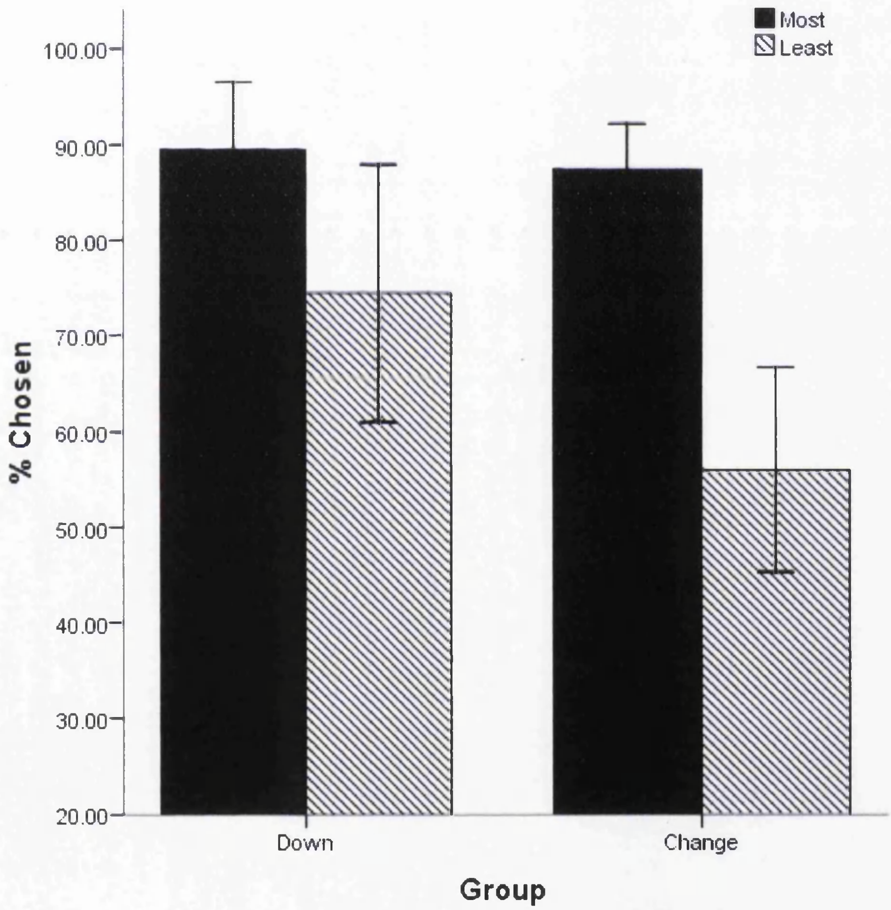


Figure 15. Group mean levels of over-selectivity in both groups: the Down group (participants receiving 10 points for a correct response in the first phase, followed by 1 point for a correct response in the second phase) and group Change (participants receiving 10 points for a correct response throughout both responses, however, in the second phase, the colour of the abstract stimuli in the task was changed from black to red or from red to black) (error bars = SEM).

Figure 15 shows the mean number of times each stimulus (i.e., the most selected and the least selected from the initially reinforced compounds, AB and EF) was chosen in the test phase for each group (Down, Change). The Change group showed greater evidence of selection of one stimulus than the other (i.e., stimulus over-selectivity) compared to the Down group. A two-factor, mixed model ANOVA (stimulus type – most verses least, and group –Down, Change) was conducted on these data, and revealed a statistically significant main effect of stimulus type, $F(1, 18) = 46.86$, but no significant main effect of group, $F(1, 18) = 3.04$. However, there was a significant interaction between the two factors, $F(1, 18) = 5.90$. Simple effect analyses conducted on the stimulus type (most versus least) revealed a significant simple effect for both the Down group $F(1, 18) = 9.75$ and the Change group $F(1, 18) = 43.01$.

For the most selected stimulus, simple effect analyses revealed no statistically significant difference between the Down group and Change group, $F < 1$. For the least selected stimulus, simple effect analyses revealed a statistically significant difference between the Down group and Change group, $F(1,18) = 14.84$.

In order to determine if there was a statistically significant difference in the level of choice for the stimuli relative compared to any deviation from this level of choice that might be expected by chance, the random model generated provides the total absolute difference expected between the over-selected and under-selected stimuli in 10 choices. This gives a value of 13% for the Down group and 15 % for the Change group. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated no significant difference for the Down group, $t < 1$, but a significant difference for the Change group, $t(9) = 3.9$, indicating significant over-selectivity in the Change group but not the Down group.

Taken together, the results replicate Experiments 11 and 12, demonstrating that a downward shift in reinforcer value attenuates the over-selectivity effect, providing further evidence for this manipulation. Additionally, the results indicate that modifying the nature of the stimulus during training, that is, changing the colour, does not reduce the over-selectivity effect. From an associability perspective, changing the nature of the stimulus should result in a change in associability, thus reducing over-selectivity. Therefore, the results fail to explain over-selectivity as an attentional deficit. Despite this, such results do indicate that the finding of a downward shift in reinforcer value reducing over-selectivity is not simply a result of generalised disruption.

5. 11. Experiment 14

Experiment 13 replicated the attenuating effect of a downward shift in reinforcer value on over-selectivity as well as indicating that generalisation did not play a role in reducing the effect. However by modifying the nature of the stimuli across both phases, no baseline is maintained. Therefore, Experiment 14 replicated the results of Experiment 13 by exploring whether modifying the colour of the stimuli in one discrimination task and maintaining the colour in the other discrimination task would have an effect on over-selectivity. To this end, the task was of a within-subjects nature in that participants in group Change2 received the Control Task whereby the stimulus colour remained the same, and the Change Task whereby participants received a change in the colour of the stimulus from red to black, or from black to red.

Participants were randomly assigned to one of three groups. All participants received 10 points for a correct response (e.g., selecting AB over CD and EF over GH) and 0 points for an incorrect response. Participants in Group Change2 received the same treatment as participants in Group Change in Experiment 13; that is, a change in the colour of the abstract stimuli either from black in Phase 1 to red in Phase 2, or from red in Phase 1 to black in Phase 2, for both discrimination tasks (AB vs. CD and EF vs. GH). Participants in Group Change1 received a change in the colour of the abstract stimuli (either from black in Phase 1 to red in Phase 2, or from red in Phase 1 to black in Phase 2) for only one discrimination task (AB vs. CD). The stimuli for the second discrimination task (EF vs. GH) remained the same in Phase 2 as it was in Phase 1. Participants in the Control Group did not receive a change in the colour of the stimulus, some of the participants received Phase 1 and Phase 2 whereby all stimuli were black, and some of the participants received Phase 1 and Phase 2 whereby all stimuli were red.

5. 12. Method

Participants and Apparatus

Thirty healthy participants (11 males and 19 females) with an age range of 21 to 33 years (mean = 23.17 years, SD = 2.57) took part in the experiment, and were recruited based on opportunity sampling. Participants under the age of 18 years and over the age of 55 years were not recruited.

The apparatus and materials were the same as those employed in Experiments 11 - 13.

Procedure

The setting was the same as previous experiments and participants were required to vocally count backwards in sevens from a random five-digit number. Table 14 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase 1		
Task 1	AB vs. CD Selection of AB yields 10 points Selection of CD yields 0 points	Trials in both discrimination tasks are presented interspersed randomly until ten consecutive correct responses in both phases
Task 2	EF vs. GH Selection of EF yields 10 points Selection of GH yields 0 points	
Training Phase 2	AB vs. CD Selection of AB yields 10 points Selection of CD yields 0 points	Trials in both discrimination tasks are presented interspersed randomly until ten consecutive correct responses in both phases
Task 1	EF vs. GH Selection of EF yields 10 points Selection of GH yields 0 points	
Task 2	*Group Control:* Stimulus colour remains the same *Group Change1:* Stimulus colour changes from red to black or from black to red for task 1 but remains the same for task 2	

	Group Change2: Stimulus colour changes from red to black or from black to red for both tasks 1 and 2	
Test Phase	A vs. C A vs. D B vs. C B vs. D E vs. G E vs. H F vs. G F vs. H	Five trials of each combination presented randomly

Training Phase: The training phase commenced with the same instructions as those in the previous experiments and the task was identical to that used in Experiment 13 for all participants, that is, if they clicked the correct, reinforced compound (AB or EF), the number '10' appeared, in green, on the screen for 2s, whereas if they clicked the incorrect compound (CD or GH), the number '0' appeared, in red, on the screen for 2s. For some participants, the stimuli were red, and for the remaining participants the stimuli were black.

Training Phase 2: The second phase commenced immediately following ten consecutive correct responses, with no new instructions. Participants in Group Change1 received a change in the colour of the abstract stimuli in the second task, from black to red or from red to black, for only one discrimination task (AB vs. CD). The stimuli for the second discrimination task (EF vs. GH) remained the same. Participants in Group Change2 received a change in the colour of the abstract stimuli in the second task, from black to red or red to black, for both discrimination tasks (AB vs. CD and EF vs. GH). Participants in the Control Group did not receive a change in colour in Phase 2, but rather the stimuli remained black or red throughout.

The task continued until all participants reached 10 consecutive correct responses for both discriminations.

Testing Phase: The testing phase was then identical to that used in the previous experiments and participant's completed the AQ to assess their levels of pre-existing high functioning autism.

5. 13. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of condition, participants took a mean 25.58 (±10.93) trials during initial training to reach the criterion for choosing the reinforced compound stimulus (AB or EF), and 12.57 (± 2.71) trials during Phase 2 to reach the criterion for choosing the reinforced compound stimulus. Participants in group Change1, on average, took 25.40 (± 9.00) trials during initial training to reach the criterion, and 12.55 (± 2.99) trials during Phase 2 to reach criterion. Participants in group Change2, on average, took 27.75 (± 13.66) trials to reach the criterion in initial training and 13.70 (± 2.10) trials during Phase 2 to reach the criterion. Participants in the Control group, on average, took 23.60 (±10.37) trials to reach the criterion in initial training and 11.45 (± 2.74) trials during Phase 2 to reach the criterion. A one-way independent measures ANOVA confirmed there were no statistically significant differences in the number of trials to criterion in initial training between the three groups, $F < 1$ or in the number of trials to criterion in Phase 2, $F\,(2, 27) = 1.82$.

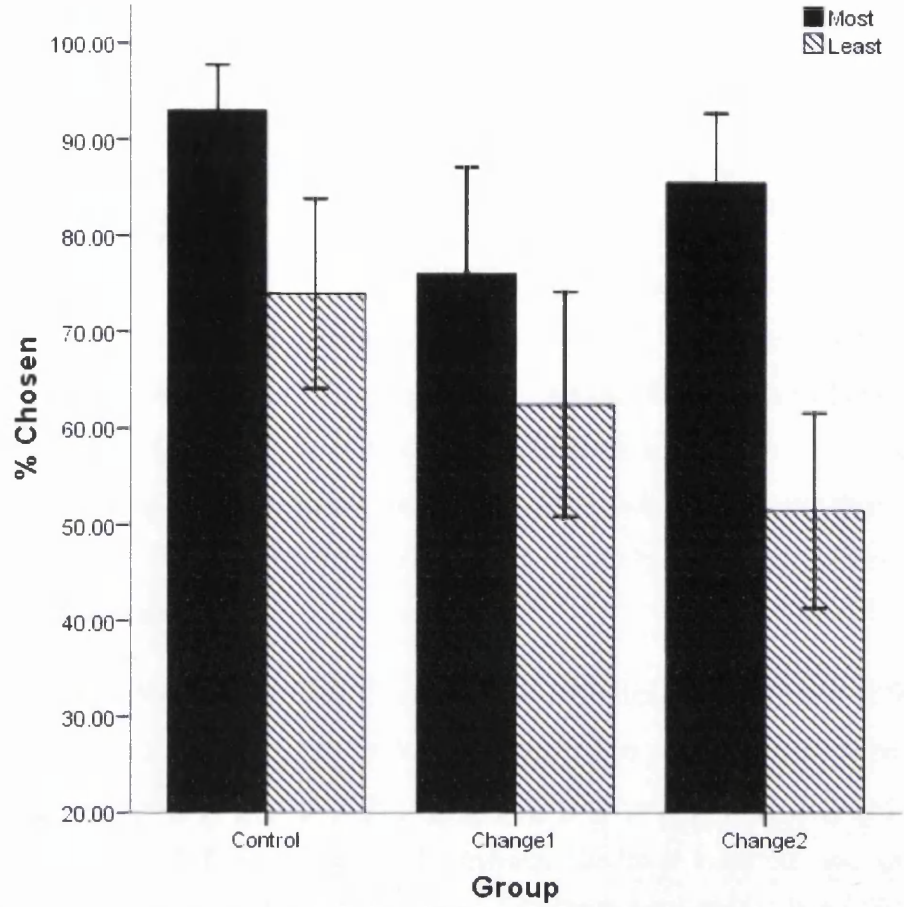


Figure 16. Group mean levels of over-selectivity in all three groups: the Control group (participants receiving no change in colour in Phase 2, but rather the stimuli remained the same), group Change1 (participants receiving a change in the colour of the abstract stimuli in the second task, from black to red, for only one discrimination task) and group Change2 (participants receiving a change in the colour of the abstract stimuli in the second task, from black to red, for both discrimination tasks) (error bars = SEM).

Figure 16 shows the mean number of times each stimulus (i.e., the mean of the most selected and the least selected from the initially reinforced compounds, AB and EF) was chosen in the test phase for each group (Change1, Change2, Control). The Control and Change2 groups showed greater evidence of selection of one stimulus than the other (i.e., stimulus over-selectivity) compared to the Change1 group. The Change2 group showed the highest level of over-selectivity. A two-factor, mixed model ANOVA (stimulus type – most verses least, and group – Change1, Change2, Control) was conducted on these data, and revealed a statistically significant main effect of stimulus type, $F(1, 27) = 95.16$, a significant main effect of group, $F(1, 27) = 3.88$ and a significant interaction between the two factors, $F(1, 27) = 7.27$. Simple effect analyses conducted on the stimulus type (most versus least) revealed a significant simple effect for the Change1 group $F(1, 27) = 11.77$, the Change2 group $F(1, 27) = 74.63$, and the Control group $F(1, 27) = 23.31$. For the most selected stimulus, simple effect analyses revealed a statistically significant difference between the groups, $F(1, 27) = 18.74$. Tukeys HSD tests revealed significantly significant differences between groups Control and Change1. All other comparisons were not significant. For the least selected stimulus, simple effect analyses revealed a statistically significant difference between the three groups, $F(1, 27) = 32.69$. Tukeys HSD tests revealed significantly significant differences between all group comparisons.

In order to determine if there was a statistically significant difference in the level of choice for the stimuli relative compared to any deviation from this level of choice that might be expected by chance, the random model generated provides the total absolute difference expected between the over-selected and under-selected stimuli in 10 choices. This gives a value of 16% for the Change1 group, 16 % for the Change2 group and 12% for the Control group. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated a significant difference for the Change2 group, $t(9) = 3.74$ and a marginally significant difference for the Control group, $t(9) = 1.69$, $p = 0.06$ but no significant difference for the Change1 group, $t(9) = 1.01$, indicating significant over-selectivity in the Control and Change2 groups but not the Change1 group.

Additional analysis of the results from group Change1 was undertaken to explore the independent levels of over-selectivity in each discrimination task. The Control Task refers to the discrimination task whereby participants did not receive a change in the colour of the stimulus. The Change Task refers to the discrimination task whereby participants received a change in the colour of the stimulus from red to black, or from black to red. In the Control Task, participants took a mean 25.90 (± 8.43) trials during initial training to reach the criterion for choosing the reinforced compound stimulus, and 11.50 (± 3.43) trials during Phase 2 to reach the criterion for choosing the reinforced compound stimulus. In the Change Task, participants took a mean 24.90 (± 9.71) trials during initial training to reach the criterion for choosing the reinforced compound stimulus, and 13.30 (± 3.43) trials during Phase 2 to reach the criterion for choosing the reinforced compound stimulus. T-tests confirmed there were no statistically significant differences in the number of trials to criterion in initial training between the tasks, $t < 1$, or in the number of trials to criterion in Phase 2, $t(18) = 1.28$.

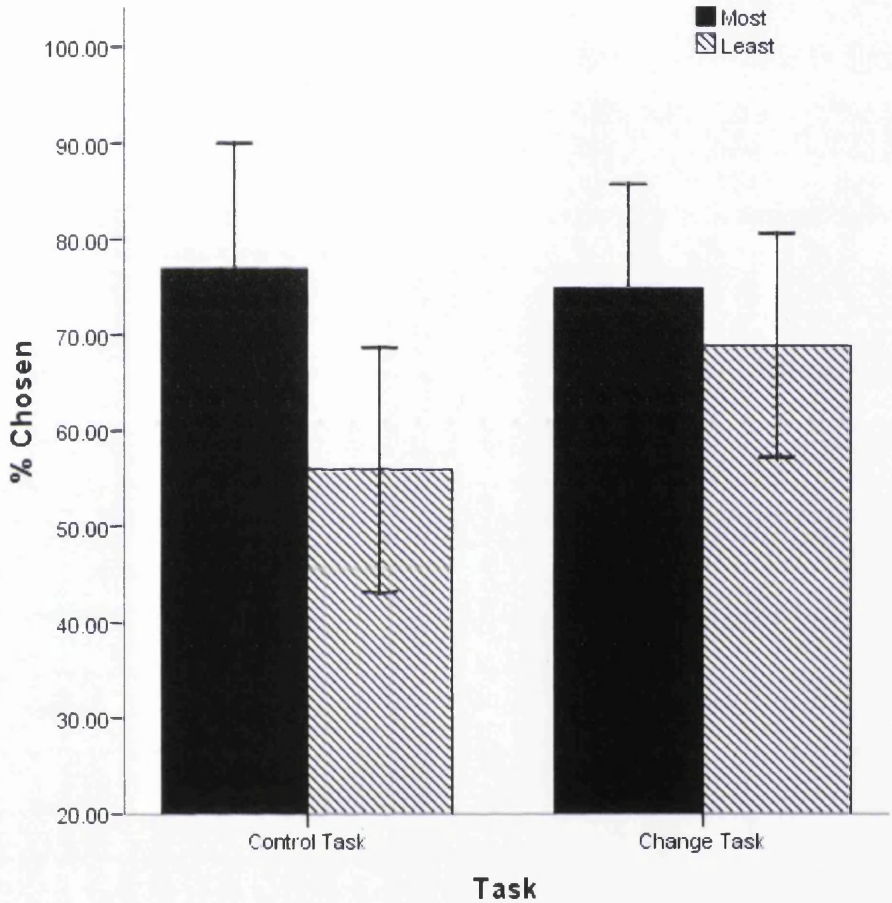


Figure 17. Group Change1 mean levels of over-selectivity in the Control Task (the discrimination task that remained the same colour throughout both phases) and the Change Task (the discrimination task that changed colour in Phase 2 from red to black, or from black to red) (error bars = SEM).

Figure 17 shows the mean number of times each stimulus was chosen (i.e., the most selected and the least selected from the initially reinforced compounds, AB and EF) in the Change Task and the Control Task. Greater evidence of selection of one stimulus than the other (i.e., stimulus over-selectivity) can be seen in the Control

Task compared to the Change Task. A two-factor, repeated measures ANOVA (stimulus type – most verses least, and task – Change, Control) was conducted on these data, and revealed a statistically significant main effect of stimulus type, $F(1, 9) = 29.69$, but no significant main effect of task, $F(1, 9) = 2.32$. Additionally, there was a significant interaction between the two factors, $F(1, 9) = 16.20$. Simple effect analyses conducted on the stimulus type (most versus least) revealed a marginally significant difference between the most and least selected stimulus for the Change Task $F(1, 9) = 5.18$, and a significant difference between the most and least selected stimulus for the Control task $F(1, 9) = 63.51$.

For the most selected stimulus, simple effect analyses revealed no significant difference between the Control Task and the Change Task, $F < 1$, but for the least selected stimulus, simple effect analyses revealed a significant difference between the Control Task and the Change Task, $F(1, 9) = 24.33$.

In order to determine if there was a statistically significant difference in the level of choice for the stimuli relative compared to any deviation from this level of choice that might be expected by chance, the random model generated provides the total absolute difference expected between the over-selected and under-selected stimuli in 10 choices. This gives a value of 16% for the Control Task and 15% for the Change Task. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated no significant difference for the Control Task, $t(9) = 1.59$, but a significant difference for the Change Task, $t(9) = 2.95$.

Taken together, the results replicate Experiment 13 in that when the nature of the stimuli in both discrimination tasks is changed, there is no reduction in the over-selectivity effect. However, when the nature of the stimuli in one discrimination task remains the same, but the colour of the stimuli in the second discrimination task is changed, that is, when the stimuli in one task changes in the context of another one that does not, there is a reduction in the over-selectivity effect. Furthermore, over-selectivity is relative to the task that changes and not the one that remains the same. Therefore, the current experiments provide evidence that downward shifts in reinforcer value do reduce over-selectivity, in the same way they have been shown to remove blocking (e.g., Dickinson et al., 1976; Holland, 1984; Mackintosh et al., 1977). Furthermore, this effect is not due to a generalisation decrement as similar attenuation of over-selectivity does not occur when the nature of the stimuli is modified. Resultantly, it appears to be the case that the reduction in over-selectivity may be a function of the reinforcer and not the stimuli.

5. 14. Experiment 15

Experiment 15 explored the possibility that the reinforcer plays a key role in the reduction of over-selectivity. Previous research (e.g., Broomfield et al., 2010; Leader et al., 2009; McHugh & Reed, 2007; Reed et al., 2009; Reed & Gibson, 2005) has provided participants with verbal feedback (rather than points feedback) after selection of the stimuli, in the form of 'yes' or 'correct' for selecting the reinforced compound (e.g., AB), and 'no' or 'incorrect' for selecting the punished compound (e.g., CD). In the current thesis, Experiments 1-11 in Chapters 2-4 all provided participants with verbal feedback, whereas Experiments 12-14 in the current Chapter provided participants with feedback using a points based system. Cross-experimentally, the experiments employing verbal feedback indicate less over-selectivity than those utilising a points based system. This may suggest that the reduction in over-selectivity is indeed an US effect as opposed to a CS effect. Therefore, Experiment 15 examined any potential differences between providing participants with verbal or numerical feedback, as well as exploring whether a transfer between reinforcer quality would attenuate over-selectivity. The apparent finding that less over-selectivity is shown with verbal feedback, implies that this form of reinforcement is more effective than the points based system. As such, transferring from verbal feedback (the more effective reinforcer) to numerical feedback (the less effective reinforcer) may be viewed as a downward shift in reinforcer value, and may be predicted to reduce levels of over-selectivity.

In order to explore whether the reduction of over-selectivity is indeed an US effect, participants were randomly assigned to one of four groups. Participants in group VV received verbal feedback in Phase 1 in the form of 'correct' and 'incorrect' and continued to receive verbal feedback in Phase 2. Participants in group VP also received verbal feedback in Phase 1, however, in Phase 2, they received 10 points for a correct response and 0 points for an incorrect response. Participants in group PP received 10 points for a correct response and 0 points for an incorrect response in both Phases 1 and 2. Participants in group PV received 10 points for a correct response and 0 points for an incorrect response in Phase 1 and feedback in the form of 'correct' and 'incorrect' in Phase 2.

5. 15. Method

Participants and Apparatus

Forty healthy participants (12 males and 28 females) with an age range of 19 to 42 years (mean = 25.75 years, SD = 4.88) took part in the experiment. Participants were selected based on opportunity sampling and participants over the age of 18 and under the age of 55 were excluded.

The apparatus and materials were the same as those employed in Experiments 11 - 14.

Procedure

The setting was the same as previous experiments and participants were required to vocally count backwards in sevens from a random five-digit number. Table 15 represents the procedure in this experiment.

Phase	Procedure	Criterion to continue
Training Phase 1		Trials in both discrimination tasks are presented interspersed randomly until ten consecutive correct responses in both phases
Task 1	AB vs. CD	
	Groups PP and PV:	
	Selection of AB yields 10 points	
	Selection of CD yields 0 points	
	Groups VV and VP:	
	Selection of AB yields positive 'Correct' feedback	
	Selection of CD yields negative 'Incorrect' feedback	
Task 2	EF vs. GH	
	Groups PP and PV:	
	Selection of EF yields 10 points	
	Selection of GH yields 0 points	
	Groups VV and VP:	
	Selection of AB yields positive 'Correct' feedback	
	Selection of CD yields negative 'Incorrect' feedback	
Training Phase 2		Trials in both discrimination tasks are presented interspersed randomly until ten consecutive correct responses in
Task 1	AB vs. CD	

		both phases
	Groups PP and VP: Selection of AB yields 10 points Selection of CD yields 0 points	
	Groups VV and PV: Selection of AB yields positive 'Correct' feedback Selection of CD yields negative 'Incorrect' feedback	
Task 2	EF vs. GH	
	Groups PP and VP: Selection of EF yields 10 points Selection of GH yields 0 points	
	Groups VV and PV: Selection of AB yields positive 'Correct' feedback Selection of CD yields negative 'Incorrect' feedback	
Test Phase	A vs. C A vs. D B vs. C B vs. D	Five trials of each combination presented randomly

E vs. G

E vs. H

F vs. G

F vs. H

Training Phase: The training phase commenced with instructions appearing on the screen, explaining the training procedure:

> "*Please select one of the two cards presented. The computer will either: tell you whether you are correct or incorrect, OR give you points for selecting particular cards. When receiving points, you should aim to gain as many points as possible. You should now begin counting backwards in sevens, and press 'Next' to begin.*"

The two discrimination tasks (AB vs. CD, and EF vs. GH) were then presented concurrently with one another, as in the previous experiments. If participants in groups PV and PP clicked the reinforced compound (AB or EF), they were given 10 points, whereas if they clicked the punished compound (CD or GH), they were given 0 points as in Experiments 11-14. However, for participants in groups VP and VV, rather than being given a certain number of points for each response, if participants clicked the reinforced compound (AB or EF), the word 'Correct' appeared, in green, on the screen for 2s, whereas if they clicked the punished compound (CD or GH), the word 'Incorrect' appeared, in red, on the screen for 2s. As with the previous experiments, this phase lasted until the participant selected ten consecutive correct responses for each discrimination task.

Phase 2: The second phase commenced immediately following ten consecutive correct responses, with no new instructions. Participants in Group VV and PV received feedback in the form of 'correct' for selecting AB or EF and 'incorrect' for selecting CD or GH. Participants in group VP and PP received the points based reinforcement; they were given 10 points for selecting compounds AB and EF, and were given 0 points for selecting compounds CD and GH. The task continued until all participants reached ten consecutive correct responses for both discriminations.

Testing Phase: The testing phase was then identical to that used in the previous experiments and participants completed the AQ to assess their levels of pre-existing high functioning autism.

5. 16. Results and discussion

No participants scored over 32 on the AQ, indicating that no participants reached the criteria for high functioning Asperger's syndrome.

Regardless of condition, participants took a mean 24.40 (± 10.48) trials during initial training to reach the criterion for choosing the reinforced compound stimulus (AB or EF), and 10.46 (± 1.00) trials during Phase 2 to reach the criterion for choosing the reinforced compound stimulus. Participants in group VV, on average, took 22.30 (± 6.80) trials during initial training to reach the criterion, and 10.10 (± 0.32) trials during Phase 2 to reach criterion. Participants in group VP, on average, took 24.30 (± 11.41) trials to reach the criterion in initial training and 10.30 (± 0.63) trials during Phase 2 to reach the criterion. Participants in group PP, on average, took 20.90 (± 4.90) trials during initial training to reach the criterion, and 10.65 (± 1.11) trials during Phase 2 to reach criterion. Participants in group PV, on average, took 30.10 (± 14.85) trials to reach the criterion in initial training and 10.80 (± 1.49) trials during Phase 2 to reach the criterion. A one-way independent measures ANOVA confirmed there were no statistically significant differences in the number of trials to criterion in initial training between the groups, $F(3, 36) = 1.56$ or in the number of trials to criterion in Phase 2, $F(3, 36) = 1.03$.

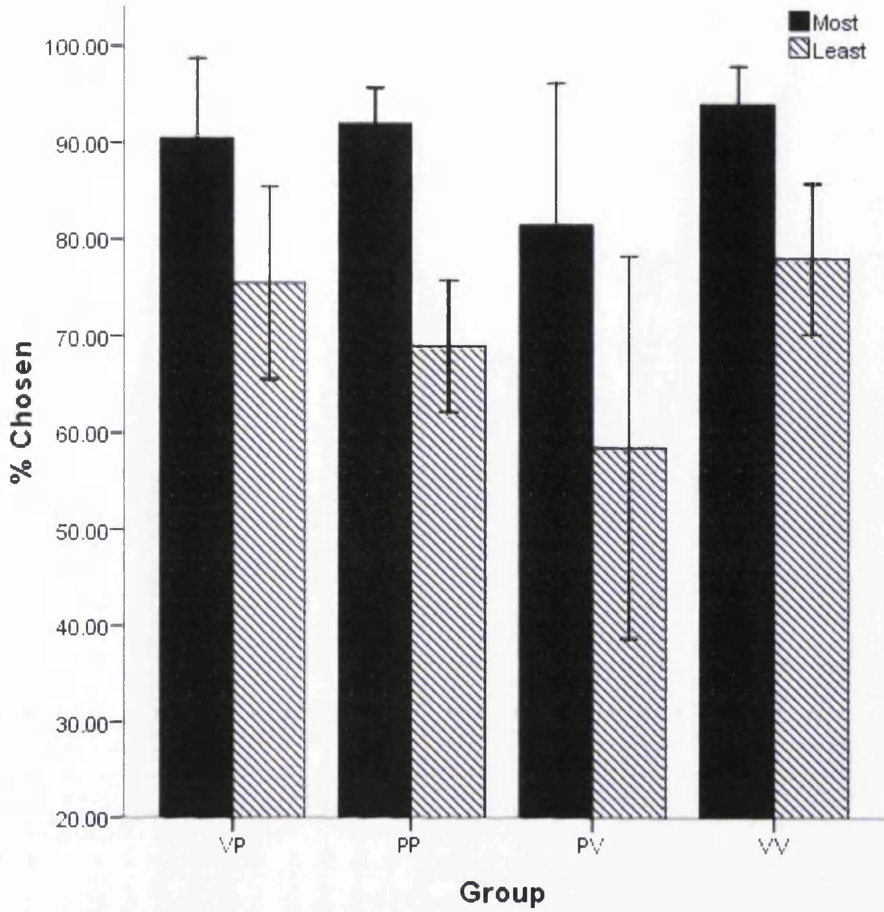


Figure 18. Group mean levels of over-selectivity in all four groups: group VP (participants receiving verbal feedback in Phase 1 and points feedback in Phase 2) group PP (participants receiving points feedback in both Phases 1 and 2) group PV (participants receiving points feedback in Phase 1 and verbal feedback in Phase 2) and group VV (participants receiving verbal feedback in both Phases 1 and 2) (error bars = SEM).

Figure 18 shows the mean number of times each stimulus was chosen in the test phase for each group (VV, VP, PP, PV), indicating few differences in the selection of one stimulus than the other (i.e., stimulus over-selectivity) across the groups. A two-factor, mixed model ANOVA (stimulus type – most verses least, and group – VV, VP, PP, PV) was conducted on these data, and revealed a statistically significant main effect of stimulus type, $F(1, 36) = 92.64$, but no significant main effect of group, $F(1, 36) = 1.98$, and no significant interaction between the two factors, $F(1, 36) = 1.18$.

In order to determine if there was a statistically significant difference in the level of choice for the stimuli relative compared to any deviation from this level of choice that might be expected by chance, the random model generated provides the total absolute difference expected between the over-selected and under-selected stimuli in 10 choices. This gives a value of 11% for the VV group, 12 % for the VP group. 13% for the PP group and 16% for the PV group. Paired t-tests (one-tailed) were performed to compare the obtained differences and the expected differences based on chance, which indicated a significant difference for the PP group, $t(9) = 2.62$, but no significant difference for the VP group, $t < 1$, the PV group, $t(9) = 1.40$ or the VV group, $t(9) = 1.47$.

Taken together, the results suggest that reinforcer quality has little effect on over-selectivity, in particular, no difference was found between remaining consistent with the verbal reinforcement or switching reinforcer quality from points to verbal feedback, or verbal to points feedback. Partial support was found for significant over-selectivity when points feedback was used throughout the tasks, and less over-selectivity in the remaining three groups. It may be the case that less over-selectivity was found with verbal feedback rather than points because using a form of social interaction is a more effective reinforcer.

5. 17. General discussion

The present chapter attempted to explore whether previous findings (e.g., Dickinson et al., 1976) indicating an attenuation of blocking as a result of a surprising downward shift in reinforcer value could be extended to work attempting to remediate stimulus over-selectivity. In particular, the experiments examined the effects of a contextual change or a surprising downward shift in reinforcer value on over-selectivity using an automated procedure as well as exploring the contribution of a generalisation decrement. The research replicated previous work (e.g., Broomfield et al., 2008a, 2008b; Reed, 2006; Reed & Gibson, 2005) and Chapters 2-4, showing that stimulus over-selectivity can be found in non-clinical adult participants when under-going a concurrent cognitive load, as well as screening for high functioning autism using the AQ, thus, ensuring the results are not confounded by participants who have high functioning autism.

Experiment 11 showed that participants who received a downward shift in point value following reaching criterion in initial training, showed a reduction in over-selectivity compared to control participants who continued receiving the same number of points. Additionally, this was seen more in participants receiving 10 points shifting down to 1, as opposed to those receiving 3 points shifting down to 1. This was potentially due to an insufficient reduction in points value. Taken together, the experiment confirmed the finding of an associative effect impacting on stimulus over-selectivity: generating a surprising shift in points reduced the level of over-selectivity.

As previous work has reported contradictory findings regarding whether generalisation decrement plays a role in the reduction of blocking following a surprising shift in reinforcer value (e.g., Dickinson et al., 1976; Mackintosh et al., 1977; Neely & Wagner, 1974), it was thought important to verify whether or not this was the case for over-selectivity. Experiment 12 indicated that generalisation decrement did not influence this effect, supporting similar findings in the blocking literature (e.g., Dickinson et al., 1976). Additionally, it may be argued that the reduction of over-selectivity in the GD group is a result of the PR schedule used, however, when PR was controlled for, no reduction in over-selectivity was found. This is consistent with the findings from Chapter 4, as well as previous work (e.g., Dube & McIlvane, 1997; Remington & Clarke, 1993) which has indicated no attenuating effects of PR in over-selectivity.

Additionally, the findings may have been attributed to the fact that participants in the GD group received less exposure to the reduced outcome than participants in the Down group. However, Experiment 8 of Chapter 4 showed that participants receiving less exposure to the outcome of training due to PR and receiving only 10 trials regardless of response (as opposed to being trained until 10 consecutive correct responses are given) showed more over-selectivity than participants receiving the same treatment but being reinforced on every trial (CRF) as well as participants receiving PR who received training to criterion. Such work implies that less exposure to the outcome may result in higher levels of over-selectivity.

Experiments 13 and 14 extended the work exploring the effect of a downward shift in reinforcer value by exploring the potential of generalisation disruption. This was implemented by manipulating the colour of the stimuli across the phases, but failed to find a reduction in over-selectivity except for when the nature of the stimuli in one task changed in the context of another one that remained the same.

Taken together, the results extend earlier findings (e.g., Dickinson et al., 1976), of an attenuation of blocking following a surprising downward shift in reinforcer value, to an over-selectivity paradigm, in human subjects. Such work has important implications for remediation of over-selectivity in that the effect can be attenuated following such manipulations.

Experiments 13 and 14 infer that a reduction in over-selectivity is related to a change in the US rather than changing the nature of the stimuli. That is, when the colour of the stimuli was manipulated (from red to black or black to red), a reduction in over-selectivity was not found. This is consistent with previous research indicating that making the stimulus more salient actually increased the levels of over-selectivity (Leader et al., 2009).

Controversially, the current experiments employed an attentional based manipulation, that is, the downward shift in reinforcer value, which produced the effect of a reduction in over-selectivity. However, when the CS is manipulated, the over-selectivity effect is not reduced. On the contrary, it seems that a shift in the US is having an effect and it is this shift that is enabling learning more about the least selected stimuli. Experiment 15 further explored whether a reduction in over-selectivity is a function of the reinforcer rather than the stimuli. Findings revealed that changing the reinforcer qualitatively had no differential effect on over-selectivity compared to a group receiving verbal feedback throughout training. Partial support was found for higher levels over-selectivity when points feedback was used throughout training, potentially indicative of a social interaction form of feedback (verbal rather than points) being a more effective reinforcer. Experiment 11 indicated that a vast reduction in points value was required to reduce over-selectivity. Furthermore, Experiment 8 of Chapter 4 has indicated that over-selectivity is reduced with extended training and as such, it would follow that a stronger or more effective reinforcer may also be expected to reduce over-selectivity but with fewer trials.

From a theoretical perspective, Kamin's (1969) viewpoint implies that the notion of 'surprise' is related to reinforcement value in that surprise is required in order for an associative process to occur but it does not directly determine reinforcement value. Therefore, from Kamin's (1969) perspective, in order to reduce over-selectivity, only an added element of some surprising event is required rather than the requirement of an increase in the magnitude of reinforcement as would be predicted by Rescorla and Wagner (1972).

At first glance, the finding that a surprising downward shift in reinforcer value did reduce over-selective responding could suggest that over-selectivity may be caused, at least partially, by an attention deficit. According to the Pearce-Hall (1980) model, when a reinforcer is not well predicted, the CS is highly associable, whereas when the reinforcer is already well predicted, the CS associability is low (Pearce & Bouton, 2001; Pearce & Hall, 1980; Wilson et al., 1992). A surprising shift in reinforcer value, therefore, increases attention to the stimulus, as the reinforcer is unpredictable, resulting in lower levels of over-selectivity. In a similar vein, Mackintosh (1975) argues that surprise maintains the associability of a CS: the surprising event does not reinforce conditioning *per se*, but rather it maintains attention to a stimulus that would otherwise be ignored, allowing the initial reinforcement to have its normal effect.

However, taken as a whole, these studies do not support an attentional view of over-selectivity for two main reasons. Firstly, changing the nature of the CS did not reduce over-selectivity, whereas from an associability perspective, manipulating the CS should result in a change in associability. Secondly, Experiment 12 supported the findings of Chapter 4, and previous research (e.g., Dube & McIlvane, 1997; Remington & Clarke, 1993), in that PR did not reduce over-selectivity.

In summary, the current chapter extends previous work based on findings from the associative learning literature that show a reduction in blocking following a surprising downward shift in reinforcer value. The present experiments apply such research to an over-selectivity paradigm and findings support the idea that over-selectivity may be reduced following a downward shift in reinforcer value.

Additionally, the experiments indicate that the findings are not the result of a generalisation decrement, and that changing the nature of the stimulus during training fails to reduce over-selectivity. The current experiments have important implications for the remediation of over-selectivity.

Chapter 6

General Discussion

6. 1. Overview of the aims

The primary aim of the current thesis was to explore the processes and mechanisms of stimulus over-selectivity, particularly exploring the attention deficit perspective, and attempt to contribute to the remediation of the effect, for both clinical and educational purposes. Over-selectivity refers to the phenomenon whereby an individual responds to only a limited subset of the total number of stimuli present in the environment, and therefore, only particular aspects of the environment come to control behaviour. It is a highly replicable phenomenon (e.g., Dube & McIlvane, 1999; Lovaas et al., 1979; Lovaas & Schreibman, 1971; see Dube, 2009 for a review) and can be problematic as failing to learn about the range, breadth or features of stimuli, can lead to deficiencies in acquiring particular behaviours. Over-selectivity has been implicated in a range of disorders (e.g., ASC and general learning disabilities) and situations (acquired neurological damage, the elderly, and typically-developing individuals undergoing a cognitively demanding task), and can account for a variety of deficits and characteristics within such populations.

In particular, over-selectivity may contribute to a range of deficits particularly shown in ASC, for example, language deficiencies and difficulties understanding speech (e.g., Birnie-Selwyn & Guerin, 1997; Koegel et al., 1979; Lovaas et al., 1966; Lovaas et al., 1979; Lovaas et al., 1971), deficits in social skills (e.g., Burke & Cerniglia, 1990; Lovaas, et al., 1971; Schreibman, 1975; Schreibman & Lovaas, 1973), deficits in emotional behaviour (e.g., Lovaas et al., 1979; Maltzman & Raskin, 1965), impaired observational learning (e.g., Lovaas et al., 1979; Varni et al., 1979), an inability to transfer treatment gains (e.g., Rincover & Koegel, 1975), deficits in developing appropriate play (e.g., Cook et al., 1982) and poor reaction to change (e.g., Rimland, 1964).

The current thesis therefore aimed to explore the phenomenon of over-selectivity, by employing a simultaneous discrimination task whereby non-clinical participants are trained to select a compound stimulus comprised of two elements over an alternative two-element compound (as utilised in previous research in clinical and non-clinical samples, e.g., Allen & Fuqua, 1985; Dube & McIlvane, 1997, 1999; Huguenin, 1997; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971; Ploog & Kim, 2007; Reed et al., 2009; Reed & Gibson, 2005; Schreibman et al., 1986; Schreibman & Lovaas, 1973; Wilhelm & Lovaas, 1976). Following the establishment of discriminative control, the elements of the compound are presented separately, and the levels of responding to the independent elements are calculated. Typically-developing individuals tend to respond to each element equally, whereas individuals prone to showing over-selectivity effects tend to select one of the elements at the expense of the other elements (therefore, indicating over-selectivity).

Specifically, the current thesis had three main aims. The first aim was to confirm the generality of the over-selectivity effect. The previous literature exploring over-selectivity using a simultaneous discrimination task has focused on initial training involving an approach and avoidance response. Therefore it was considered imperative to replicate the effect using, not only this standard test condition, but also alternative test conditions when the comparison stimulus was novel, associatively neutral and associatively neutral with no conditioning history.

A second aim of the thesis was to provide a theoretical understanding of over-selectivity. Based on the previous literature, the thesis examined whether over-selectivity may be better explained as an attentional deficit (e.g., Dube et al., 1999; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971), or a performance deficit (e.g., Broomfield et al., 2008a, 2010; Leader et al., 2009; Reed, 2010; Reed et al., 2009).

Once the robustness of the effect had been established, the third aim of the thesis was to explore potential remediation of the effect. Firstly, it aimed to explore the use of revaluation and extinction techniques as previous work has found a reduction in over-selectivity when the over-selected stimulus is extinguished, allowing the under-selected stimulus to emerge to control behaviour (e.g., Broomfield et al., 2008a, 2008b, 2010; Leader et al., 2009; Reed, 2010; Reed et al., 2009; Reed & Gibson, 2005). Secondly, the thesis investigated the effect of different training schedules of reinforcement on attenuating the over-selectivity effect, as a result of inconsistent findings in the literature (e.g., Dube & McIlvane, 1997; Koegel & Rincover, 1977; Koegel et al., 1979; Remington & Clarke, 1993; Schover & Newsom, 1976; Schreibman et al., 1977). Finally, the thesis examined the effects of surprising shifts in reinforcer value, in order to determine whether such a manipulation can attenuate over-selectivity in the same way research has shown it to attenuate blocking (e.g., Dickinson et al., 1976).

Taken together, the current thesis aimed to develop a sound theoretical understanding of stimulus over-selectivity, focusing in particular on the attention deficit account, as well as attempting to contribute to the attenuation of the effect. As a result of previous research (e.g., Broomfield et al., 2008a, 2008b; 2010; Reed, 2006; Reed & Gibson, 2005) this thesis satisfied the key aims using a non-clinical model population undergoing a concurrent cognitive load.

6. 2. Summary of the findings

It is important to acknowledge that comparison of previous research studies is problematic in that they differ in terms of their paradigms and procedures, populations used, research philosophy and their interpretation or analysis of the data (Bailey, 1981; Ploog, 2010). However, all of the current experiments did replicate previous work indicating that over-selectivity can be generated in non-clinical adults, through the use of a concurrent cognitive load (e.g., Broomfield et al., 2008a, 2008b; Reed, 2006; Reed & Gibson, 2005). Additionally, this was achieved whilst screening for high functioning autism, using the AQ, unlike some earlier research (e.g., Reed & Gibson, 2005), thus, the results are not confounded by participants with high functioning autism.

Chapter 2 explored the relative strength and generality of stimulus over-selectivity in simultaneous discrimination procedures. Such research was thought necessary before an understanding of the theoretical framework of the effect can be achieved. All three experiments replicated the effect utilising the standard training and testing procedures. Furthermore, over-selectivity was generated using two alternative test conditions; when the comparison stimulus was neutral (Experiment 1), and associatively neutral with no conditioning history (Experiment 3). Unexpectedly, results indicated that participants avoided novel cues more than punished cues, with less over-selectivity shown in the novel test condition

(Experiment 2). Despite this, the experiments indicated over-selectivity in a range of test conditions, supporting the universality of the phenomenon.

Thus, Chapter 2 indicated that over-selectivity is a highly robust phenomenon, evident across a range of test conditions. Chapter 3 extended this by exploring the role of conditioning effects, in particular, a potential inhibitory mechanism accruing to the under-selected stimulus. This allowed an exploration of the attention deficit perspective in that if inhibition was found to accrue to the under-selected stimulus, this would undermine one of the main criticisms targeted at the attention perspective, namely the revaluation findings. Notably, any putative inhibition for the under-selected stimulus would have to accrue from RIF type training, rather than conditioned inhibition training. Despite the fact that previous research is yet to utilise Rescorla's (1969) traditional techniques for assessing inhibition to investigate RIF, Experiments 5 and 6 utilised a summation and retardation test, respectively. Neither experiment indicated that the under-selected stimulus gained inhibitory status, therefore found no evidence of RIF related inhibition having a role in producing under-selectivity. Therefore, this potential explanation of the revaluation effect in terms of generalised removal of inhibition was not supported, thus undermining the attention deficit perspective of over-selectivity.

Additionally, Chapter 3 began exploring a potential means of remediating over-selectivity. As the robustness of over-selectivity was demonstrated in the initial chapters, the remainder of the experiments focused on developing learning procedures in order to reduce over-selectivity, whilst still investigating the attention deficit theory. That is, experiment 4 replicated previous research (e.g., Broomfield et al., 2008a, 2008b, Leader et al., 2009; Reed et al., 2009; Reed & Gibson, 2005) indicating that the under-selected stimulus can emerge to control behaviour following revaluation of the over-selected stimulus, despite the under-selected stimulus receiving no direct conditioning. Such results support the use of revaluation and extinction procedures in remediating over-selectivity (see section 1. 10. 2. Extinction) and reveals evidence against the attention deficit perspective.

Thus, in Chapter 3, one potential means of remediating over-selectivity, that is, revaluation procedures was explored. Chapter 4 aimed to explore an alternative means of remediating the effect by investigating the influence of training schedules of reinforcement on over-selectivity. Results indicated that PR during training did not result in an attenuation of over-selectivity when compared to CRF during training (Experiment 7) and that PR actually increased over-selectivity when the participants had undergone less training (Experiment 8). Therefore, the results support the literature indicating that PR *per se* does not attenuate over-selectivity (e.g., Dube & McIlvane, 1997; Remington & Clarke, 1993). Furthermore, additional evidence was provided that contradicts the assumptions of an attention deficit perspective of over-selectivity.

Additionally, Experiments 9 and 10 failed to support findings from previous research (e.g., Koegel & Rincover, 1977; Koegel et al., 1979; Schover & Newsom, 1976) and the attention deficit perspective, as they indicated that changing schedule of reinforcement from CRF to PR or from PR to CRF did not attenuate over-selectivity. On the other hand, continuing training with the same schedule of reinforcement was most effective in attenuating over-selectivity. The finding that overtraining *per se* attenuated over-selectivity (supporting work by Huguenin, 2000, 2004) has important implications for remediation techniques focusing on extended training.

Finally, Chapter 5 explored an alternative means of attenuating over-selectivity, based on the associative learning literature indicating a reduction in blocking following a surprising downward shift in reinforcer value (e.g., Dickinson et al., 1976). The experiments supported the attenuation of over-selectivity with the use of a downward shift in points reinforcement (Experiment 11), providing an element of initial support for the attention deficit perspective, as well as indicating that neither generalisation decrement nor PR influenced this effect (Experiment 12). Experiments 13 and 14 manipulated the colour of the stimuli across phases and suggested that a reduction in over-selectivity is related to a change in the US rather than changing the nature of the stimuli. This supported the work by Leader et al. (2009) who indicated an increase in over-selectivity when the salience of the stimulus was increased, whilst also failing to support an attention deficit perspective. Finally, qualitatively changing the reinforcer, rather than the stimuli, had no differential effect on over-selectivity (Experiment 15).

Therefore, Chapter 5 concluded the thesis with the finding that results from the blocking literature, indicating unblocking following a surprising downward shift in reinforcer value, could be extended to an over-selectivity paradigm, and that changing the nature of the stimulus during training does not attenuate over-selectivity, providing further important implications for the remediation of the effect, and additional evidence against the attention deficit perspective.

Taken together, the findings of the current thesis indicate the robustness of the phenomenon and the lack of an inhibitory mechanism accruing to the under-selected stimulus. In terms of remediation of the effect, the thesis failed to support the use of PR to attenuate the effect, but supports the use of revaluation and extinction procedures, over-training with a consistent reinforcement schedule (particularly CRF), and a surprising downward shift in reinforcer value. Altogether, theoretically the findings fail to support an attention deficit account of over-selectivity.

6. 3. Theoretical implications of the findings

As chapter 2 supported previous research exploring the over-selectivity effect (e.g., Dube & McIlvane, 1997, 1999; Koegel & Wilhelm, 1973; Lovaas et al., 1971; Lovaas & Schreibman, 1971; Reed & Gibson, 2005; Reed et al., 2009; Schreibman et al., 1986; Schreibman & Lovaas, 1973; Wilhelm & Lovaas, 1976) and therefore provided convincing evidence for the strength and generality of the phenomenon, this enables the development of a potential theoretical framework of the effect. Of course, it seems probable that over-selectivity is caused by multiple processes, however, most theories advocate the phenomenon as a within-individual deficit. In particular, as discussed below, the findings of the current thesis have implications for attention verses retrieval deficit accounts of over-selectivity. Specifically, the findings contradict the assumptions made by an attention deficit perspective, and are more in line with a retrieval-based explanation.

6. 3. 1. Attention deficit theory of over-selectivity

Arguably, one of the most popular theoretical accounts of stimulus over-selectivity maintains that the phenomenon is a result of an attentional deficit whereby the individual fails to attend to all features of a stimulus, or elements of a compound, during initial training. Only the aspects of the stimulus that are attended to, can subsequently control behaviour (e.g., Dube, et al., 1999; Dube & McIlvane, 1999; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971). Dube et al. (1999) employed eye-movement analyses to indicate that children failed to attend to all elements within a complex stimulus and therefore, at test, the elements not attended to could not subsequently control behaviour. Similarly, individuals with ASC have been shown to have a significantly reduced level of visual scanning compared to typically developing individuals (Anderson et al., 2006). Problematic for these results is the finding that the correlation between eye-movements and attention is imperfect (Remington, 1980; Shaw, 1978; Wurtz & Mohler, 1976). Despite other inconsistent findings (e.g., Kemner & van Engeland, 2006; Sigman et al., 1986; van der Geest et al., 2002; Volkmar & Mayes, 1990) the attention deficit explanation of over-selectivity is prominently accepted.

Despite this, the findings from the current thesis largely fail to support predictions that would be made according to an attention deficit account of over-selectivity. First and foremost, although task demands have been reported to influence some attention-like phenomena (e.g., Lubow & Gerwitz, 1995), the finding that an increased cognitive load produces over-selectivity suggests that the phenomenon cannot be simply an attention deficit.

In a similar vein, an attention deficit perspective fails to explain the revaluation findings from Experiment 4 (Chapter 3) and previous research (e.g., Broomfield et al., 2008a; Leader et al., 2009; McHugh & Reed, 2007; Reed et al., 2009). This evidence for an emergence of the under-selected stimulus to gain control over behaviour following revaluation of the over-selected stimulus, is difficult to explain by a strict attention-deficit account of over-selectivity that would assume the under-selected stimulus was not attended to in initial training (e.g., Dube & McIlvane, 1999; Dube et al., 1999; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971). If the under-selected stimulus was not attended to in initial training, it is difficult to explain how it can subsequently control behaviour.

Experiments 5 and 6 (Chapter 3) attempted to overcome the above-mentioned criticism of the attention deficit perspective by exploring whether inhibition could explain the revaluation results by remediating responding to the under-selected stimulus. The experiment hypothesised that the under-selected stimulus from the previously reinforced compound may gain inhibitory properties in initial training. As a result, revaluation of the over-selected stimulus may result in generalisation and consequently, devaluation of the inhibition that had accrued to the under-selected stimulus. Therefore, the emergence of the under-selected stimulus to control behaviour may actually reflect a loss of inhibitory control. The failure to find an inhibitory mechanism accruing to the under-selected stimuli, in Chapter 3, eliminates the potential explanation of the effect in terms of generalised removal of inhibition.

An additional prediction made by the attention deficit perspective of over-selectivity is that PR training should attenuate over-selectivity as a result of increasing attention (e.g., Dube, 2009; see also Dinsmoor, 1985; Trabasso & Bower, 1968). Extending the Pearce-Hall perspective of conditioning to the over-selectivity paradigm, the consequences of selecting a stimulus under a PR schedule are unpredictable, which should increase attention to the stimulus, and therefore, should result in an attenuation of over-selectivity. On the other hand, the consequences of selecting a stimulus under a CRF schedule are much more predictable and therefore, lower levels of observing response would be evident and over-selectivity should not be attenuated. The findings from Chapter 4 that PR did not succeed in remediating over-selectivity are difficult to explain by a strict attention deficit perspective of over-selectivity. Furthermore, Experiment 12 in Chapter 5 also failed to find an influence of PR.

Additionally, from an attentional perspective, switching reinforcement schedule during training (either from CRF to PR, or from PR to CRF) should increase attention, and again should attenuate over-selectivity. Experiments 9 and 10 failed to support findings from previous research (e.g., Koegel & Rincover, 1977; Koegel et al., 1979; Schover & Newsom, 1976) as shifting the schedule of reinforcement from CRF to PR or from PR to CRF did not reduce over-selectivity, but rather lower levels of over-selectivity were found when training was continued with a consistent schedule of reinforcement.

A Pearce-Hall model would predict that associability to stimuli is highest when training first commences, but after extended training, this attention would decrease. Subsequently, from an attention deficit perspective, when training was not continued to criterion in Experiment 8, the higher rates of associability should attenuate over-selectivity as a result of the high attention being paid to the stimulus. This would more so be the case following PR. The results of Experiment 8 failed to support this assumption.

Finally, at first sight, the findings from Chapter 5 appear to suggest that over-selectivity may, at least partially, be explained by an attention deficit perspective. From a Pearce-Hall (1980) perspective, a surprising shift in reinforcer value would be unpredictable and therefore would increase attention to the stimulus, resulting in lower levels of over-selectivity. Likewise, Mackintosh (1975) argues that the surprising event does not reinforce conditioning *per se*, but rather it maintains attention to a stimulus that would otherwise be ignored, allowing the initial reinforcement to have its normal effect.

However, taking a closer look, the experiments of Chapter 5 do not support an attention deficit perspective of over-selectivity, in particular because over-selectivity was not attenuated when the nature of the CS was changed across phases. If the attention deficit perspective of over-selectivity was correct, manipulating the nature of the CS should result in a change in associability.

Taken together, the results of the current thesis largely fail to support an attention deficit account of over-selectivity as a result of four main findings: 1) that a concurrent cognitive load generates over-selectivity in typical adults, 2) that revaluation of the over-selected stimulus resulted in an emergence of behavioural control by the under-selected stimulus, 3) that PR failed to remediate over-selectivity in a range of test conditions, and 4) manipulating the nature of the stimuli did not reduce over-selectivity. This, along with other findings in the literature, such as those by Plaisted et al. (1998) indicating individuals with ASC having superior performance in serial visual search tasks (that require shifting attention), strongly suggest that over-selectivity is not merely a failure of attention.

6. 3. 2. The comparator perspective of over-selectivity

In contrast to the attention deficit account of over-selectivity, the phenomenon may be better explained as a retrieval, or performance, failure. Reed et al. (2009) adapted the comparator hypothesis (Matzel et al., 1985; Miller & Matzel, 1988; Miller & Schachtman, 1985) in order to better explain over-selectivity.

The comparator hypothesis advocates that when a previously learned-about target stimulus is presented, both a memory or representation of learning and a comparator mechanism are activated, with the comparator mechanism indirectly activating other stimuli with which the target has been previously paired (such as contextual cues or an alternative stimuli that has been presented with the target stimuli as a compound). At the time of performance, the comparator mechanism is then responsible for selecting the most appropriate stimuli to control behaviour (that is, the stimuli with stronger predictive value) by comparing the strengths of the directly and indirectly learned-about representations. Subsequently, an under-selected stimulus may fail to displace acquired associations with the US as a result of the stronger associative strength of the over-selected stimulus (the comparator).

Reed (2010) argued that the comparator mechanism may not utilise the absolute strengths of the stimuli, but rather only focuses on the relative strengths of the stimuli. As a result, the relative differences will be greater when learning is not as strong. Specifically to ASC, over-selectivity may be a result of an over-sensitive comparator mechanism which detects relative differences between stimuli, that may have otherwise gone unnoticed, that may all be important in predicting behaviour. Subsequently, only certain stimuli come to control behaviour (Leader et al., 2009; Reed et al., 2009). Arguably, a less-sensitive comparator would not have detected such differences.

Taken together, the consistent finding that over-selectivity can be generated in healthy participants under-taking a concurrent cognitive task load, supports the assumption that over-selectivity may be explained as a retrieval or performance deficit. That is, if over-selectivity is the result of a comparison between weakly-learned about stimuli and well-learned about stimuli, the weakly-learned about stimuli will have larger relative differences in strength between them.

Unlike the attention deficit perspective of over-selectivity, the comparator hypothesis accommodates the revaluation findings. In explaining these revaluation results of Chapter 3, and previous research (e.g., Broomfield et al., 2008a; Leader et al., 2009; McHugh & Reed, 2007; Reed et al., 2009), the comparator hypothesis would argue that the associative strength of the over-selected stimulus (comparator stimulus) is stronger than that of the under-selected stimulus. When the over-selected stimulus (comparator stimulus) is extinguished, it's comparator strength and importance is reduced and as such, the under-selected stimulus is able to generate greater strength and subsequently control behaviour, as its relative importance attributed by the comparator mechanism is increased (see Matzel et al., 1985; Reed, 2006).

Furthermore, the findings in Chapter 3 that inhibition did not accrue to the under-selected stimuli are also supportive of a comparator account of over-selectivity. Such a theory denies the existence of conditioned inhibition, arguing that all associations are excitatory (Amundson et al., 2005; Friedman, Blaisdell, Escobar & Miller, 1998). That is, rather than competing for associative strength at the time of training, the cues compete for control of responding at the time of testing based on the relative excitatory status of each of the cues (Amundson et al., 2005). According to Friedman et al. (1998) the comparator hypothesis explains behaviour indicative of conditioned inhibition as resulting from inhibitory test procedures whereby the direct associations (CS-US association) is weak relative to the indirect associations (the target CS-comparator stimulus association and the comparator stimulus-US association).

Similarly, the schedules of reinforcement results of Chapter 4 may also be accommodated by a comparator perspective of over-selectivity. From such an approach, two stimuli with weaker associative strengths results in a greater relative difference in strength between those stimuli compared to stimuli with higher associative strengths. Consequently, associative strength should be weaker following training with a PR schedule, and thus would result in greater over-selectivity compared to training with a CRF schedule whereby associative strengths are higher.

The findings in Experiment 8 that over-selectivity was higher when training was not continued to criterion can also be explained by the comparator hypothesis. That is, the relative difference between the associative strengths of the elements would be larger when less training has occurred (even more so when trained with PR), and subsequently, over-selectivity would be higher.

In a similar vein to Leader et al.'s (2009) research exploring the effects of different stimuli salience on over-selectivity, Experiments 13 and 14 of chapter 5 failed to find a reduction in over-selectivity when the physical nature of the stimulus (i.e., the colour) was manipulated. A comparator perspective accounts for such a finding in terms of the suspected over-sensitive comparator in individuals with intense cognitive demands. That is, the over-sensitive comparator detects the different salience of the stimuli, and thus more importance is attributed to one stimulus than the other leading to over-selectivity (Leader et al., 2009).

Of course, it is fundamental to emphasise that the current experiments employ a non-clinical sample, and it may be the case that over-selectivity is produced in different ways for different populations. Reed et al. (2009) found different effects of extinction depending on high and low functioning ASC. In particular, they showed an emergence of control by the under-selected stimulus following extinction of the over-selected stimulus, for higher functioning children, but not for severely impaired children. This could indeed suggest that for low functioning individuals, it may be a more attention based problem. This would explain the inconsistent findings in the literature regarding attention in an ASC population (e.g., Lovaas et al., 1971; Pascualava et al., 1998; Plaisted et al., 1998) as it may be that different samples show different attention-shifting deficiencies (Reed et al., 2009). Reed, Savile and Truzoli (in press) also suggest that high-functioning individuals show similar results to a model population, inferring similar mechanisms between these populations, but that it is less clear whether the results from low functioning individuals would be comparable. Subsequently, the severity of the intellectual impairment may impact on the mechanism underlying the over-selectivity; an attention deficit, or a post-processing deficiency.

In a similar vein, McHugh and Reed (2007) suggested that different processes may occur between older and younger populations. They found that extinction of the over-selected stimulus only resulted in an emergence of the under-selected stimulus in younger populations, and concluded that this may imply a comparator mechanism is involved in over-selectivity in younger populations but that it may be a more attention based deficit in the elderly.

Consequently, it is plausible to suggest that the current model may be better applied to high functioning individuals as opposed to low functioning individuals, and to younger populations rather than older populations.

6. 4. Implications for the remediation of over-selectivity

One of the primary purposes of the current thesis was to begin attempting to find potential remediation methods of over-selectivity. Chapter 1 illustrated the range of deficits and behaviours within a variety of populations (particularly individuals with ASC and general learning disabilities) that can be accounted for by over-selectivity. Amongst such deficits and characteristics include; language, speech and communication deficiencies, deficits in social skills and developing appropriate play, problems with emotional behaviour, impaired observational learning and an inability to transfer treatment gains. Therefore, finding a remediation for the effect is vital in order to begin combating some of these detrimental behaviours and characteristics in both clinical and non-clinical groups.

Given that over-selectivity is still a relatively newly investigated phenomenon, all experiments in the current thesis recruited non-clinical populations, in order to develop a model of over-selectivity and to test various potential means of remediation before applying this to a clinical population. It is vital to highlight that the current thesis employs a model population. Using samples from the general population gains both advantages and disadvantages. Beneficially, non-clinical samples are more straightforward to obtain and are easier to work with, as opposed to clinical samples. Similarly, it may be considered unethical to carry out the initial studies on participants with ASC or learning disabilities before the appropriate parameters and procedures to remediate the effect have been identified.

Furthermore, over-selectivity has been demonstrated as a general and universal phenomenon, and in this sense, using a general population may have an advantage in terms of generalisation. On a similar note, generalising to clinical samples should be made with caution. As such, the current research should be replicated using a sample of individuals with developmental disabilities, as well as general learning disabilities, in order to substantiate further evidence and potential implications for remediation.

Despite this, the current experiments allow for a model of over-selectivity, and advances towards the remediation of the effect, to be established. Previous techniques have not always been useful in reducing over-selectivity, for example prompts and prompt-fading have been largely documented, particularly using ASC populations (e.g., Lovaas et al., 1966; Lovaas et al., 1967; Metz, 1965; Ploog & Williams, 1995; Risley & Wolf, 1967; Schreibman, 1975; Schreibman & Charlop, 1981; Schreibman et al., 1982). Some research has revealed the effectiveness of prompt-fading in some situations (e.g., Dube et al., 1991; Matson et al., 1993; Schreibman et al., 1982), however, prompt dependency commonly occurs whereby individuals respond only to the prompt stimulus rather than the training stimulus (Dube, 2009; Lovaas et al., 1979; Ploog, 2010; Rincover, 1978). Subsequently, within-stimulus prompting strategies have been implicated, which have been shown to be effective (e.g., Schreibman, 1975), however, these techniques remain only to be useful in environments whereby learning is based on multiple cues as opposed to a single cue (Schreibman et al., 1982). Therefore, the findings of the current thesis provide imperative, established as well as unique, techniques for the successful remediation of the effect.

6. 4. 1. Observing responses

One technique commonly used to target over-selectivity is the use of observing response procedures (e.g., Broomfield et al., 2008b; Constantine & Sidman, 1975; Dube et al., 1991; Dube & McIlvane, 1997, 1999; Geren et al., 1997; Gutowski et al., 1995; Walpole et al., 2007). Such procedures require all aspects of the discriminative stimuli present to be identified prior to making a response (Wyckoff, 1952). As such, observing response procedures ensure all aspects of the stimuli are initially attended to, and therefore they arguably overcome attention deficits. The application of observing response techniques to MTS tasks (in which over-selectivity has a detrimental effect) in children with learning difficulties has had beneficial results in improving MTS scores (e.g., Broomfield et al., 2008b; Constantine & Sidman, 1975; Dube & McIlvane, 1997, 1999; Geren et al., 1997; Gutowski et al., 1995).

Considering the finding from the present experiments that over-selectivity is unlikely to be caused by a purely attention deficit, and the fact that observing response procedures are attentional based, it is arguable that observing response procedures are not the most effective means of treatment for over-selectivity. This, coupled with findings from previous research that the beneficial effect of observing response procedures are not maintained post-intervention (e.g., Broomfield et al., 2008b; Dube & McIlvane, 1999), deems the observing response procedures inadequate as clinical remediation of over-selectivity.

6. 4. 2. Manipulation of schedules and extended training

Previous research exploring the effect of PR has generated inconsistent results. On the one hand, research has argued that PR increases the breadth of learning (e.g., Sutherland, 1966; Trabasso & Bower, 1968), and consequently should reduce over-selectivity (e.g., Huguenin, 1997; Koegel et al., 1979; Schreibman et al., 1982). Alternatively, research has indicated no beneficial effect of PR in reducing over-selectivity (e.g., Dube et al., 2010; Dube & McIlvane, 1997; Meisel, 1981; Remington & Clarke, 1993; Williams, 1989). The results of Chapter 3 support the finding that employing a PR schedule does not succeed in reducing over-selectivity.

Of course, it may be the case that PR failed to attenuate over-selectivity because the population tested were typically developing adults. It may be that PR will only succeed in reducing over-selectivity, when a low-functioning population is recruited. The potential assumption that the under-lying mechanisms of over-selectivity may vary depending on level of functioning (high- verses low-functioning), follows that the appropriate techniques for reducing the effect are also likely to be different. As a result, the use of PR to attenuate over-selectivity should not be abolished completely, but rather, more research is required to explore this in a clinical population.

Conversely, research began exploring the effect of changing from CRF to PR on over-selectivity (Koegel et al., 1979). Arguably, this switch in reinforcement may result in the perception of error, thus increasing the breadth of attention and reducing over-selectivity. Indeed, research has indicated that providing participants with CRF in initial training, followed by PR in an over-training phase, resulted in an attenuation of over-selectivity (Koegel & Rincover, 1977; Koegel et al., 1979; Schover & Newsom, 1976). However, the findings from Experiment 9 in Chapter 4 fail to support the evidence for a switch from CRF to PR reducing over-selectivity. Additionally, extending such research, Experiment 10 also failed to find remediation of over-selectivity following a switch from PR to CRF.

Furthermore, previous research using rats (e.g., Sutherland & Holgate, 1966; Sutherland & MacKintosh, 1971) adult humans (e.g., Trabasso & Bower, 1968) and children with ASC (e.g., Huguenin, 2000, 2004; Schover & Newsom, 1976) has indicated a reduction in over-selectivity following extended training, although work with non-clinical children has not always found beneficial effects of over-training (e.g., Hale & Taweel, 1974). Of course, comparisons between humans and non-humans must be made with caution as a result of both procedural and species differences. For instance, in terms of procedural differences, research using humans extinguish the over-selected stimulus as well as reinforcing a novel stimulus, whereas research using non-humans only employ extinction of the over-selected stimulus (Broomfield et al., 2010).

The finding in Chapter 4 that overtraining *per se* resulted in an attenuation of over-selectivity supports this previous research indicating a reduction in over-selectivity. The work by Lovaas and Schreibman (1971), although not directly targeted at exploring the effects of over-training, also indicated a reduction in over-selectivity following repeated exposure. Taken together, such findings have important implications for remediation techniques focusing on extended training. Indeed, special education often focuses on over-learning and repetition in order to ensure students are adequately learning the task at hand (Bailey, 1981).

Chapter 4 also suggested that continuing training with the same schedule of reinforcement is most effective in remediating over-selectivity. Schreibman et al. (1977) indicated that extended training *per se* only reduced over-selectivity when a PR schedule was employed. Experiment 10 supported this finding showing high levels of a reduction in over-selectivity when PR was used in initial training and in over-training. This was the case when both phases required participants to give 10 consecutive correct responses, but the effect was even stronger when participants were required to give 20 consecutive correct responses in the over-training phase. These findings provide further support for the use of extended training to reduce over-selectivity. However, it is not the case that extended training will *only* reduce over-selectivity with a PR schedule (as argued by Schreibman et al., 1977), as the results of Experiment 9 also showed reduced levels of over-selectivity using CRF in both initial and over-training (10 trials to criterion).

6. 4. 3. Extinction

Empirical support for the use of extinction procedures has been highly documented in the animal conditioning literature (e.g., Gunther et al., 1998; Kaufman & Bolles, 1981; Matzel et al., 1985; Miller et al., 1992; Reed & Reilly, 1990; Reilly et al., 1996; Wilkie & Masson, 1976). Research has also begun exploring the use of extinction procedures in human participants (e.g., Broomfield et al., 2008a, 2010; Dickinson & Burke, 1996; Leader et al., 2009; Reed et al., 2009; Reed & Gibson, 2005; Shanks, 1985). Previous research has also replicated the beneficial effects of extinction using a MTS paradigm (e.g., Broomfield et al., 2008a). Additionally, research has employed extinction procedures to remediate other disruptive behavioural problems (e.g., Iwata et al., 1994; Koegel et al., 1980). Taken together, the results of Experiment 4 and findings from previous research support the use of extinction and revaluation procedures in remediating over-selectivity.

The theoretical findings from the current thesis, which largely support the assumption that over-selectivity is better explained by a comparator perspective rather than an attention deficit approach, also give rise to the use of extinction and revaluation procedures to remediate over-selectivity. Extinction may be seen as a relatively simple intervention targeted at increasing the number of cues that control behaviour (Reed et al., 2009). This paradigm has an advantage over alternative procedures as the beneficial effects have been shown to remain post-intervention (Broomfield et al., 2008a; Leader et al., 2009), unlike, for instance, the observing response method (e.g., Dube & McIlvane, 1999). According to Reed et al. (2009), the extinction intervention may be classified as a Differential Reinforcement of Alternative Behaviour schedule (Deitz & Repp, 1983; Vollmer & Itawa, 1992). Such a technique focuses on reducing undesirable behaviours and promoting desirable behaviours as a result of reinforcing alternative behaviour and never reinforcing the undesirable behaviour (as opposed to being due to the omission of target behaviours as is the case of Differential Reinforcement of Other Behaviours).

Based on previous research (e.g., Broomfield et al. 2008a, 2010), using extinction procedures to remediate over-selectivity in a clinical setting is only useful when the initial over-selectivity level is high. When over-selectivity levels are low, it may be that the stimulus is perceived as a compound (a configural stimulus) rather than as individual elements. As such applying extinction to the over-selected element may generalise to the under-selected element. When over-selectivity is high, the elements are more likely to have been perceived as individual elements, rather than configurally, and thus generalisation is less likely to occur. This supports the work by Plaisted et al. (1998) who suggest that individuals with ASC show poor configural learning, and hence may be more prone to higher levels of over-selectivity. Furthermore, if the previously over-selected stimulus is not adequately extinguished, the under-selected stimulus is unable to emerge to control behaviour (Broomfield et al., 2008a, 2010). In a similar vein, if there is less initial over-selectivity, that is, both cues are being attended to and neither is acquiring substantial behavioural control, then the 'under-selected' stimulus would not be able to 'emerge' as it is already controlling behaviour to some extent (Reed, 2010).

It is of note that the use of extinction to remediate over-selectivity is not found to be beneficial for all populations. For instance, McHugh and Reed (2007) indicated that for older participants (between the ages of 70-80 years), extinguishing the over-selected stimulus did not result in an emergence of the under-selected stimulus. As a result, it is important to modify and test the procedures on a range of populations; it may be that methods such as mindfulness are more suitable for an elderly population (e.g., McHugh et al., 2010). Furthermore, using the standard simultaneous discrimination procedure, extinction was not found to be a beneficial intervention for children with low functioning ASC (Reed et al., 2009). That is, the under-selected stimulus failed to emerge to control behaviour in children with low functioning ASC compared to children with high functioning ASC. This makes intuitive sense as it may be the case that as the impairment becomes more severe, less learning is likely to occur during initial training; if learning does not accrue to the under-selected stimulus, then this stimulus is not going to have the ability to subsequently dominate behavioural control (Reed et al., 2009).

Of course, inconsistent evidence still remains regarding the usefulness of extinction procedures (e.g., Holland, 1984, 1999; Rescorla & Cunningham, 1978; Speers et al., 1980). Additionally, the reduction of control by one stimulus in order to enhance control by another stimulus may not always be useful, for example, if the stimulus involves letters in a word (Reed et al., 2009). Therefore, replications of experiment 4 (and previous research) are fundamental in order to determine the appropriate parameters of the technique. Despite this, experiment 4 does provide initial support for the use of extinction procedures in remediating over-selectivity.

6. 4. 4. Surprising downward shift in reinforcer value

A final and original means of remediating over-selectivity, identified in the current thesis concerns the finding of a surprising shift in reinforcer value reducing the levels of over-selectivity. Such results indicate the potential use of these procedures in a clinical or educational setting in order to begin attenuating stimulus over-selectivity. Additionally, the results indicate that only a change in the reinforcer reduced over-selectivity, whereas changing the nature of the stimulus failed to do so. This eliminates the use of manipulating qualities of the stimuli in order to remediate over-selectivity, and is consistent with previous research indicating that increasing stimulus salience does not attenuate over-selectivity (e.g., Leader et al., 2009).

6. 4. 5. Implications of the findings for intervention

Taken together, the practical implications of the current findings for the development of new interventions or the evaluation of existing interventions holds paramount importance. The use of discrete trials, prior to future naturalistic experimentation, allows for the parameters of successful intervention to be understood and the foundation of potential interventions to be developed.

In terms of the implications for existing interventions, as discussed above, many interventions designed to combat over-selectivity focus on the attention deficit perspective, such as observing response procedures (e.g., Broomfield et al., 2008b; Constantine & Sidman, 1975; Dube et al., 1991; Dube & McIlvane, 1997, 1999; Geren et al., 1997; Gutowski et al., 1995; Walpole et al., 2007). Given the current findings indicating very little support for the attention deficit theory, this thesis points towards alternative interventions that are not all based on this perspective. That is not to say that observing responses should be ignored completely, but rather that in the current context, their effectiveness due to their basis in the attention deficit perspective, remains to be questioned. It is important to acknowledge that it is likely to be the case that different interventions may all be helpful in reducing over-selectivity; however, their effectiveness may be restricted to different contexts. For instance, PR may only be effective in reducing over-selectivity in a low-functioning population only and more research exploring this possibility is required.

In this sense, generalisation to other populations, such as individuals with developmental disabilities or learning disabilities should be made with caution and research is required in such populations before strong conclusions regarding the effectiveness of the interventions can be made. Section 6. 4. (Implications for the remediation of over-selectivity) discusses the advantages and disadvantages of using a non-clinical population in the current experiments. Whilst taking this in consideration, it remains likely that the successful remediation techniques explored in the current thesis, such as over-training in a consistent schedule of reinforcement, a downward shift in reinforcer value and extinction procedures, would be beneficial for individuals with developmental or learning disabilities and they highlight optimism in remediating over-selectivity.

In summary, the usefulness and implications of the remediation strategies explored and developed in the current thesis successfully extend knowledge and understanding of current (and future) interventions targeted at reducing over-selectivity.

6. 5. Implications for future work

The field of stimulus over-selectivity continues to necessitate further research in a range of areas. The most fundamental requirement for future work is the need to replicate the current research with a clinical sample. As has been discussed, the current experiments employed typically developing individuals. It is potentially the case that over-selectivity is caused by different mechanisms in different populations. As such, the current research should be replicated, in particular, employing individuals with ASC and general learning disabilities. It is important to emphasise that even within populations, such as individuals with learning disabilities, diverse differences between individuals remain. For instance, over-selectivity levels may differ for an individual with a learning disability that is primarily a reading deficit compared to an individual with a learning disability centred on arithmetic deficits. Additionally, it may be beneficial to explore stimulus over-selectivity in individuals diagnosed with attention deficits (for example, ADHD). As pointed out by McHugh and Reed (2007), a comparison of performance by children with ASC and children with ADHD may provide insights into the behavioural differentiation of the two disorders.

Four of the most essential topics for future work, considered the most interesting as well as important, are outlined below.

6. 5. 1. Extinction

Firstly, more work is required exploring the extinction and revaluation procedures as a potential means of remediating over-selectivity. Although, evidence in the current thesis and previous research (e.g., Broomfield et al., 2008a, 2008b, 2010; Leader et al., 2009; Reed, 2010; Reed et al., 2009; Reed & Gibson, 2005) support the reduction of control by the over-selected stimulus and increase in control by the previously under-selected stimulus, much work remains essential in order to explore the parameters of this effect. Additionally, extinction is not always straightforward to implement in a naturalistic environment and therefore further research exploring its application to a clinical sample is fundamental.

6. 5. 2. Retrieval Induced Forgetting

Future work is required to further explore the relationship between RIF and conditioned inhibition. One proposal for future work involves the techniques used to explore inhibition. The current research (Chapter 3) employed techniques typically designed to explore conditioned inhibition (a summation test and a retardation test). Therefore, future work should utilise techniques specifically designed to explore inhibition following RIF.

A further recommendation for future work in terms of the implications for over-selectivity may involve differentiating the theoretical views of the phenomenon based on the predictions that they may make regarding RIF. Pre-existing theories of autism and the comparator hypothesis would make contrasting assumptions about the existence of RIF. A comparator perspective, which suggests that learning itself is not deficient, would maintain that enhanced RIF is likely to occur. RIF assumes that within a category, within compound associations occur as the representation of one stimulus activates the representation of another stimulus. Likewise, within-compound associations are required for a comparator to work. As there is potentially strong inhibition, stronger members of a category will suppress weaker members much more strongly, and as a result, there would be strong RIF.

In contrast, a pre-existing theory of autism, Weak Central Coherence Theory, also argues that learning itself is not deficient, but rather individuals with ASC have difficulties integrating detailed information into a coherent whole (e.g., Frith & Happé, 1994; Happé & Frith, 2006). Such a view would suggest that there are no within compound associations, therefore for individuals with ASC, the category is largely fragmented. As a result, regardless of the amount of training to one element of a category, there will no effect on the other members of the category. Consequently, this theory would suggest there would be no RIF.

6. 5. 3. Stimulus duration

The duration for which the stimuli are presented, as well as the inter-stimulus intervals, are known to effect levels of learning, with greater learning being produced by long inter-stimulus intervals, and shorter stimulus presentation times (Gibbon & Balsam, 1981). Thus, these conditions are the ones that should be associated with less over-selective responding according to comparator-based views (Reed, 2010). Moreover, stimulus duration may interact with the level of cognitive strain. For example, those with a concurrent load may attend either more, or less, to the stimuli, either increasing, or decreasing, the actual CS exposure time, which is known to impact this effect (Sissons, Urcelay & Miller, 2009). Such hypotheses should be investigated by measuring stimulus fixation time using an eye-tracking device. Therefore, the level of over-selectivity could be assessed as a function of actual stimulus duration.

6. *5. 4. High verses low functioning*

A final suggestion for future research involves exploring the differences between high and low functioning individuals. It has already been discussed above that it may be the case that over-selectivity involves different mechanisms for higher- and lower- functioning individuals. As such, it is necessary to replicate the current findings, in particular the manipulations of training schedules of reinforcement and the use of extinction as remediation techniques, whilst comparing high- verses low-functioning individuals. It would be reasonable to assume that if the mechanisms underlying over-selectivity are different for high- and low- functioning individuals, this may impact on the effectiveness of different remediation techniques. Due to limited sample sizes in the current experiments, such a comparison has not been undertaken.

6. 6. Limitations of the current thesis

There are various potential weaknesses in the current research, each of which deserves consideration below. These should be taken into account when generalising the results from the thesis, as well as when designing future work in the field.

- *Non-automated procedures*

Experiments 1-8 employed non-automated procedures, which are often used regularly in behavioural research. The use of 'table top' procedures allows interaction and can aid those individuals whom require prompting in order to learn the task at hand. However, this may result in the experimenter unintentionally influencing the task, and providing cues for the participants (see Dymond et al., 2005). Furthermore, when using a non-automated procedure, it can be difficult to ensure that the positioning of the stimuli cards are counterbalanced in a random manner. The requirement of the experimenter to record the participant responses by hand may also be a factor in influencing the participant's response. Subsequently, inter-observer agreement scores should be employed (Dymond et al., 2005), however due to an unavailability of resources, the experiments utilising this method were unable to recruit a second observer. Therefore, the automated procedures used in the remaining experiments may have been more appropriate in avoiding such biases.

- *Generalisation of results*

All participants used in the current thesis were volunteers from a typically developing population, including University of Swansea students along with members of the general public. Of course, generalisation must be made with caution, taking into account that the current samples are not an accurate representation of the target populations.

Additionally, the work generated over-selectivity using simultaneous discrimination procedures, in an experimental setting, as opposed to assessing pre-existing over-selectivity in a natural environment. Such controlled environments question the validity of applying the current results to a clinical setting. It is likely to be much more complex to maintain the attention of a child with ASC in order to implement the remediation methods outlined above on pre-existing over-selectivity, than it would be to maintain the attention of a non-clinical participant in an experimental setting. As such, clinical studies are fundamentally required before generalisation can be made.

- *Remediation techniques*

Barthold and Egel (2001) highlight the fact that the majority of research exploring over-selectivity and the remediation of the effect, has utilised a discrete trial format with arbitrary stimuli (e.g., Dube & McIlvane, 1999) and some with a functional stimuli (e.g., Burke & Cerniglia, 1990). Very little research (e.g., Matson et al., 1993) has explored the effect in applied, naturalistic environments and subsequently, it may be argued that over-selectivity itself is simply an artefact of discrete trial learning (Barthold & Egel, 2001). As a result, more research is required in applied settings, such as incidental teaching environment, in order to ensure the generalisability of the effect and the potential means of remediation.

In terms of extinguishing the over-selected stimulus through the use of novel stimuli (Experiment 4, Chapter 3), Reed (2006) points out that responding to the novel stimuli may simply be due to the fact that such stimuli were not presented in the test trials. A MTS procedure may overcome this problem as it ensures that every element in the comparisons are presented an equal number of times, as either a reinforced comparison or a non-reinforced comparison, depending on which sample stimulus is used on that particular trial (Reed, 2006).

It is also important to note that the extinction procedure employed in Chapter 3 may not accurately represent an extinction procedure, in that the 'no' feedback provided when the over-selected stimulus was selected, may involve an element of punishment. It is therefore questionable whether it was, in fact, the punishment that resulted in the over-selected stimulus being chosen less.

6. 7. Conclusions

Taken together, the results of the current thesis, along with previous research employing clinical and non-clinical samples, allows the conclusion that stimulus over-selectivity is a highly robust and universal phenomenon that deserves further exploration. The fifteen experiments comprising the current thesis successfully explored the processes and mechanisms of the effect, and began investigating three potential therapy techniques: manipulation of training and reinforcement schedules, extinction and revaluation, and a downward shift in reinforcer value. The development of well-researched remediation procedures is imperative in order to aid in remediating over-selectivity, and subsequently reducing a range of detrimental characteristics and behaviours evident in a range of disorders and situations. Results indicate that PR *per se* during training failed to reduce over-selectivity. Additionally, it can be concluded that shifting schedules of reinforcement (from PR to CRF, or from CRF to PR) also does not reduce over-selectivity. Taken together, remaining consistent with the same schedule of reinforcement shows the highest reduction in over-selectivity. Secondly, it can be concluded that the use of an extinction technique in order to remediate over-selectivity has been supported with much research evidence and needs to be replicated with a clinical sample in a naturalistic setting. Thirdly, in terms of remediation, supporting findings from the associative learning literature, results indicate a reduction in over-selectivity following a downward shift in reinforcer value. However, manipulating the stimuli qualitatively did not reduce over-selectivity. Theoretically, the thesis concludes that inhibitory status does not accrue to the under-selected stimulus. Additionally, the experiments failed to find objective evidence for an attentional deficit perspective of over-selectivity, particularly due to the cognitive load generating over-selectivity, the successful extinction and revaluation findings, the failure of PR to reduce over-selectivity and the failure to reduce over-selectivity by modifying the nature of the stimuli. On the other hand, the findings allow the conclusion that over-selectivity may be better explained as a retrieval or performance deficit. Such a theory successfully explains the revaluation findings; something that is not inherent in other theories. Future work remains essential, particularly by replicating the current work employing a clinical sample, within a naturalistic environment. As well as exploring the differences between high- and low- functioning children with ASC, research is also recommended in the fields of the extinction technique, further examination of RIF in over-selectivity, and an investigation of the effects of stimulus duration. The current thesis is not without its weaknesses, however, the results provide an important insight into the processes and mechanisms of the over-selectivity effect, and add to the current literature in terms of both the theoretical findings, and the potential remediation of the effect.

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