The Development of Tactical Strategy

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ABSTRACT

This thesis considers the development of tactical strategy. Tactically strategic behaviour is employed in competitive interactions in which individuals are trying to obtain the same limited set of resources. Tactical strategy is demonstrated when children try to out-manoeuvre an opponent and in doing so take into account prior knowledge about the way in which others generally behave. Anticipatory switches in guessing strategy were selected as a form of tactically strategic behaviour amenable to experimental analysis.

This thesis reports the development of two novel procedures that allow the assessment of anticipatory switches in guessing strategy. These procedures were based on simple guessing games in which, unbeknown to the child, the experimenter uses a predictable hiding sequence. Children's guessing behaviour was examined to evaluate whether they made anticipatory changes in guessing strategy, once they had discovered the hiding sequence. An exploration of the parameters of these procedures enabled evidence of tactical strategy to be found in progressively younger children.

The experiments reported in this thesis indicate evidence of tactically strategic behaviour in children from the age of 5. This age is rather younger than might be predicted from earlier research. The findings of these experiments suggest that tactically strategic behaviour may emerge at approximately 3- to 4-years of age, implying that the study of this age group would have greatest implications for the understanding of the development of tactical strategy in children.

Preliminary results encourage further research investigating how tactical strategy is related to both theory of mind and executive functions. However, no strong conclusions can be made about such relationships from the findings of the experiments reported here. Future research should also consider the role of social development in tactically strategic behaviour.
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Tactical Strategy in Children

This thesis explores the development of tactical strategy in a competitive context in children. Tactically strategic behaviour is often employed in competitive interactions in which individuals are trying to obtain the same limited set of resources. Tactical strategy is demonstrated when children try to out-manoeuvre their opponent and in doing so take into account prior knowledge about the way in which people generally behave. For example, in games such as chess, in order to win the game, players use their knowledge of the sorts of combinations of moves that usually result in successful outcomes, which inform their expectations about the way in which their opponent is likely to respond. Attempts at out-manoeuvring occur when players manoeuvre their own pieces in a manner that is designed to result in them having an advantage over their opponent, an advantage that is likely to lead to them reaching the goal at their opponent's expense.

Tactically strategic behaviour can involve taking an indirect route to reach a goal. For example, in a game of chess the aim of the game is to attack the opponent's king. The game is won when the other player's king is put in a position of checkmate: checkmate occurs when the opponent is in a position such that they cannot make any legal move to prevent their king being taken. However, a player would be foolish to directly attack an opponent's king. This would simply result in the player's own pieces being attacked and removed from the game. Instead, the player would see attacking the opponent's king as a long term goal and would attempt to out-manoeuvre his or her opponent over the course of the game.

There are similarities between tactically strategic behaviour and deceptive behaviour. Both can be conducted in order to confer a competitive advantage and allow

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1 It should be noted that some degree of cooperation can be found in competitive interactions: participants can cooperate with other participants to form a group, which can then compete with other individuals or groups, but the interaction is competitive if the common goal of the group is to achieve access to limited resources. These resources can be physical entities, for example, food, shelter, or prizes. Alternatively, they can be more abstract, for example, the glory of winning a game.
one person (or group), rather than another, to obtain limited resources\(^2\). In addition, both can also involve taking an indirect route to one's goal. However, deceptive behaviour differs from tactically strategic behaviour in that deceptive behaviour results in the deceived having a misrepresentation of reality. This misrepresentation can be in the form of a false belief about reality.

Thus, for the purpose of this thesis, the distinguishing factor between tactically strategic behaviour and deceptive behaviour is that deceptive behaviour results in misrepresentation of reality and tactically strategic behaviour does not. Tactically strategic behaviour describes attempts to out-manoeuvre others without trying to cause misrepresentation of reality. Tactically strategic behaviour is commonplace in everyday competitive interactions, but has been neglected by prior research.

While, for the purposes of this thesis, tactical strategy and deception are distinct, a distinction can be made about the types of reasoning involved in tactically strategic and deceptive behaviour that can be applied to both. That is, the question of whether reasoning in these situations concerns the mental states of the other or not, or in other words, whether or not theory of mind reasoning is involved. Theory of mind is the ability to attribute mental states to others and the understanding that the mental states of others can be different to one's own (Premack & Woodruff, 1978).

When applied to deception, the question of whether theory of mind reasoning is involved allows deceptive behaviour to be further categorized into, what is termed in this thesis, tactical deception and behavioural deception. Tactical deception occurs when the deceiver intends to implant a false belief in his or her opponent. Behavioural deception occurs when the deceptive behaviour could not be considered to represent understanding of false beliefs. For example, if children have the opportunity to learn the "deceptive" response, their responding could be described at a behavioural level without recourse to mental state reasoning.

Similar distinctions between deceptive behaviour on the basis of the type of reasoning involved have been proposed elsewhere. For example, Mitchell (1986) proposed four levels of deceptive behaviour that can occur in both human and non-human animals. The first two levels in Mitchell's taxonomy describe phylogenetic adaptations in behaviour or appearance that function to deceive, such as a butterfly that

\(^2\) Deception can also be instigated in non-competitive situations. For example, white lies are sometimes used by children to avoid punishment (e.g. Dunn, 1991).
has evolved to appear unpalatable to predators (Brower, 1969) and the worm-like lure of the angler-fish which is conducted only in the presence of prey (Gudger, 1946). These species specific adaptations are beyond the scope of this thesis.

The final two levels in Mitchell's taxonomy describe the difference between behavioural deception and tactical deception. Level three deception includes deceptive acts that have been repeated or modified and are based on trial and error learning. Mitchell provides the example of a captive gorilla that had learned that her owners would come to her cage if she were injured and was observed to act as if her arm was injured when it was not (Hediger, 1955). Mitchell's fourth level deception is characterized by the deceiver understanding the effect of deceptive behaviour on the beliefs of the deceived. An example of such deception is lying, in which the person's intent is that another should believe something that is untrue.

The question of whether behaviour involves theory of mind reasoning also be applied to tactically strategic behaviour. Attempts at out-manoeuvring an opponent could be understood in terms of the mental states involved. For example, when playing chess, players have a long term goal to put the opponent's king into a position of checkmate. The moves that a player makes to achieve this goal may be based only on knowledge of what moves typically result in success under the present circumstances, plus, perhaps, an expectation of what moves their opponent is likely to make under these circumstances. In either case, the player's strategy may be described at simply a behavioural level. However, the player may also consider the opponent's reasoning. For example, if the player thinks that his or her opponent has worked out the game playing strategy and thinks that the opponent knows the next move, the player may use this information and change his or her own game playing strategy accordingly. This is not deception because it is not an attempt to cause a misrepresentation of reality. Rather, beliefs attributed to the opponent can be used to guide the player's actions.

Many interactions in everyday competitive situations do not involve attempts to cause a misrepresentation of reality, instead they involve attempts to out-manoeuvre others. However, much of the research into young children's behaviour in competitive interactions has neglected tactically strategic behaviour, concentrating instead on deception, and more specifically, tactical deception (e.g. Chandler, Fritz & Hala, 1989; Hala, Chandler & Fritz, 1991; Hughes & Russell, 1993; Russell, Jarrold & Potel, 1994; Russell, Mauthner, Shaper & Tidswell, 1991; Sodian, 1991, 1994; Sodian & Frith, 1992; Sodian, Taylor, Harris & Perner, 1991). This focus on tactical deception is probably a
result of the explosion of interest into children's developing theory of mind in the late 1980s and early 1990s (see, for example, collections of papers in Astington, Harris & Olson, 1988; Frye & Moore, 1991). Deception is often assessed in the context of location guessing games, in which children are observed to see if they attempt to deceive their opponent about the location of a hidden object (e.g. Chandler et al, 1989; Hala et al, 1991; Hughes & Russell, 1993; Russell et al, 1994; Russell et al, 1991; Sodian, 1991, 1994; Sodian & Frith, 1992; Sodian et al, 1991).

The present chapter reviews, in a more or less chronological manner, the evidence for the development of deception in competitive interactions. Firstly, tasks that assess deception in multi-trial competitive games are reviewed in Section 1.1. A discussion is presented of whether these early studies provide a test of children's ability to attribute mental states to others. In Section 1.2 a review of the non-human primate literature on deception is presented which contributes to the distinction between tactical and behavioural deception, and the circumstances under which it can be concluded that participants are reasoning on the basis of attributed mental states. Section 1.3 reviews the development of single-trial deception tasks which have enabled tactical deception to be assessed in children. Finally, Section 1.4 specifies the research question that is addressed within this thesis. This thesis is concerned with the development of tactical strategy in children, specifically, whether children in a competitive situation expect their opponent to change from a regular hiding sequence and make anticipatory changes in their guessing strategy. It is argued that the multi-trial competitive games discussed in Section 1.1 may be better suited to investigating the development of tactical strategy than tactical deception. Outstanding research questions generated by this literature are identified and the cognitive abilities that may underlie children's behaviour in competitive interactions are specified before being reviewed in Chapter 2.

1.1 DECEPTION IN CHILDREN IN MULTI-TRIAL COMPETITIVE GAMES

Early studies investigated deceptive behaviour in competitive games (e.g. DeVries, 1970; Gratch, 1964; Shultz & Cloghesy, 1981). Children's behaviour in these games is often argued to be influenced by their role- or perspective-taking capacity. Contemporary researchers would re-interpret concepts such as role-taking or perspective-taking in light of research into theory of mind. However, in the present section it is argued that for many of these studies a simpler explanation based on expectations of behavioural change may be more appropriate than one based on theory of mind.
1.1.1 Simple location guessing games

Observations of an unpredictable game playing strategy have been argued to represent theory of mind reasoning in location guessing games. Unpredictability has been argued to be "the best defence against predictive mindreading" (Miller, 1997, p. 313). The developmental trend from regular to irregular, and thus unpredictable, guessing and hiding strategies in simple location guessing and hiding games has been argued to indicate children's growing awareness that their opponent can mindread their intention to deceive (e.g. DeVries, 1970; Gratch, 1964).

In these simple location hiding and guessing games, an object (e.g. marble or coin) is hidden in one of two hands and the opponent must guess in which hand the object has been hidden (e.g. Baron-Cohen, 1992; DeVries, 1970; Gratch, 1964). The child and opponent compete for the desirable hidden object. The child and an experimenter take turns to play the roles of hider and guesser, and the types of hiding and guessing strategies employed by the child are recorded. Two predictable, regular hiding and guessing strategies have been reported - perseveration and alternation, and one unpredictable, irregular strategy. Perseveration in guessing and hiding is demonstrated by continually indicating (guessing or hiding) the same hand (e.g. LLLLLLL). Alternation is shown by switching regularly between hands on each turn (e.g. LRLRLR). Irregularity is shown by switching between hands in a manner suggestive of no predictable pattern (e.g. LLRLRRL).

A reliable developmental trend in guessing behaviour has been observed (Baron-Cohen, 1992; DeVries, 1970; Gratch, 1964). From the ages of 2 to 6 years, children use regular guessing patterns (with a developmental trend from perseveration to alternation at about 3 years). Children aged 6 and above tend to use an irregular guessing strategy. A similar developmental trend has been observed in hiding behaviour. Three- and four-year-old children tend to use regular hiding patterns (with a trend from perseveration to alternation at age 4). Children aged 4 sometimes use an irregular hiding strategy and from the age of 6 this is used exclusively.

It has been argued that the developmental trend from regular to irregular hiding and guessing strategies demonstrates children's developing understanding that their opponent may try to deceive them, or children's understanding that their opponent may be aware of the children's own attempts to deceive the opponent. Gratch (1964) argued

3 L = left hand, R = right hand; each L or R equates to one guess or one turn at hiding.
that an irregular hiding strategy "explicitly involves the taking of multiple perspectives in that the hider is a deceiver, i.e. he knows where the marble is, but has to act in such a way as not to reveal this to the guesser" (p.50), while DeVries argued that irregular hiding demonstrates "a recognition of the need to be unpredictable in order to achieve the goal of fooling the guesser" (p.769). Alternatively, if a child guesses in a regular manner, he or she "would not be taking the hider into account as a competitor who was trying to outwit him" (Gratch, 1964, p.50). That is, guessing or hiding irregularly is argued to represent the development of perspective taking.

However, irregular guessing and hiding strategies may be better described as attempts to out-manoeuvre another rather than attempts to deceive another. Hiding or guessing in an irregular manner need not represent an attempt to manipulate either the behaviour or beliefs of another. Thus, these tasks may provide better evidence for tactically strategic behaviour than tactical deception.

In addition, such strategies need not be indicative of theory of mind reasoning. Children may use unpredictable, irregular hiding and guessing strategies because they have experienced success when implementing such strategies in the past. Baron-Cohen (1992) acknowledges that the hand guessing game is one that occurs "naturally in child-child and parent-child interaction" (p. 114). Thus it is likely that children have been pre-exposed to the game and it is possible that they may have learned that unpredictable, irregular behaviour is likely to result in task success. If, as could well be the case in these tasks, children have the opportunity to learn the game response, their response could be described at a behavioural level.

1.1.2 Card guessing games

Other researchers have also argued that children's game playing behaviour is indicative of mental state understanding. Shultz and Cloghesy (1981) argued that children's change of game playing strategy in a card guessing game was evidence of a "recursive awareness of intention". That is, they argued that children's game playing behaviour was influenced by their understanding that their opponent was aware of their intentions to deceive them. However, this interpretation went beyond what could reliably be concluded from their data.

Shultz and Cloghesy had children aged 3, 5, 7 and 9 play a simple card guessing game against an experimenter. Children and the experimenter played both a pointing and a guessing role in turn. Two cards, one red and one black, were turned face up on the table. The pointer (experimenter first) turned over the top card of a deck of cards
(without the child seeing) and pointed to either the red or black card on the table to signal the colour of the new card from the pack. The pointing was either deceptive or truthful; that is, the pointer, holding for example, a red card indicated either the red card (truthful pointing), or the black card (deceptive pointing). On the basis of this pointing, the guesser had to decide the colour of the top card, keeping it if correct, but losing it to the pointer if the guess was incorrect. The player with the most cards won the game.

The experimenter began by playing truthfully, consistently pointing to the same coloured card as the target card. Once the child had won four consecutive cards, the experimenter changed strategy to deceptive pointing (pointing to differently coloured card). Such strategy changes were continued every time the child won four consecutive cards, up to a maximum of 30 trials at which point the players changed roles and the child pointed. Once again, the experimenter switched between the truthful and the deceptive strategy every time that the child won four consecutive cards. That is, when using the truthful strategy the experimenter chose the card to which the child pointed, and when using the deceptive strategy the experimenter chose the card other than that to which the child pointed.

The number of times over the 30 trials that the children adjusted their behaviour in response to the experimenter’s strategy changes was assessed (i.e. the number of times that the child reached criterion). Shultz and Cloghesy argued that appropriate adjustments in strategy by the child when the experimenter changed from a truthful to a deceptive strategy demonstrated a "recursive awareness of intention". They argued that, to win, "the child presumably had to strategically disguise his or her intentions by (a) pointing to the incorrect card, (b) guessing the colour opposite to that pointed to by the examiner, and (c) switching these strategies whenever it was appropriate. Such strategic actions would provide evidence that the child knew the examiner was aware of the child's intentional state." (Shultz & Cloghesy, 1981, p.467). That is, it was argued that children switched strategy because they were trying to beat the opponent, and were aware that the opponent would know that they intended to beat him or her, and therefore adjusted their strategy accordingly.

Children were not very successful at switching guessing strategy appropriately. In the thirty trials it was possible to make four consecutively correct guesses 7 times. Children aged 9 made four consecutively correct guesses an average of three times, this occurred twice for 7-year-olds, once for 5-year-olds and not at all for 3-year-olds. On
the basis of this data, Shultz & Cloghesy argued that 'recursive awareness of intention' was shown by children aged 5 and above.

However, it seems more likely that switching strategies in response to a change in task success is indicative of learning the appropriate response and changing this response when it is no longer successful. In Shultz and Cloghesy's game, the experimenter changed his strategy from truthful to deceptive (or vice versa) every time a child reached criterion. Thus, children learned what action would result in task success. After this response had been successfully implemented on four consecutive trials, the experimenter changed his or her behaviour. The experimenter's behavioural change resulted in the learned response no longer being successful. If children were to succeed again, they needed to implement a different response. Rather than trying to "strategically disguise his or her intentions", the children may simply have been learning a guessing or pointing response that resulted in task success and changing this response when it no longer resulted in task success.

1.1.3 Interim Conclusions

Gratch (1963), DeVries (1970) and Shultz and Cloghesy (1981) all favoured an interpretation of children's behaviour in their games which suggested that game success was indicative that children were role-taking or had an understanding that their opponent would be aware of children's intent to deceive. The behavioural measures adopted in their studies cannot provide conclusive evidence of this. Research that was contemporary to the studies discussed here that provided a direct measure of mental state reasoning in deceptive tasks provided evidence of theory of mind reasoning only in older children (Flavell, Botkin, Fry, Wright & Jarvis, 1968).

Flavell et al (1968) used verbal reports of strategy in a simple guessing game to assess children's tactically strategic reasoning. Older children's reasoning suggested that they considered the beliefs of their opponent when planning their game playing strategy. Children aged from 6- to 16-years played a game in which they were shown two inverted cups, one of which had a five cent coin attached to the bottom (on the outside), while the other had a ten cent coin attached to the bottom. Each of the two cups covered a coin which corresponded to that attached to the inverted bottom of the cup. Children were told that the opponent would choose one of the cups and would keep the contents of the cup that he chose. They were encouraged to remove the money from the cup that they expected their opponent to choose, in order to prevent him from winning any money. Children were also asked to explain why they selected a particular cup: "Now
we’ll try to *fool* him - we’ll try to *guess* which cup he’ll choose and take the money out of *that* one. Now of course he *knows* that we’ll try to fool him, he *knows* we’re going to try to figure out which one he’ll choose - think hard (S indicates one of the cups). Tell me *why* you think he might pick that one” (Flavell et al, 1968, p. 45-6, emphasis present in original).

Children’s verbal report of the reasons underlying their cup-emptying strategy suggested motivations of differing complexity. The simplest strategy referred to financial gain; children emptied the ten cent cup because they reasoned that their opponent would choose the cup containing the most money. Children who adopted the second strategy explained that their opponent would know that they thought the opponent’s motivation was financial gain; this influenced the child’s deceptive strategy - they emptied the smaller cup. This is best illustrated by example from the text; “he’s gonna know that we’re gonna fool him – or try to fool him – and so he might think that we’re gonna take the most money out so I took the small one [five cents]” (Flavell et al, 1968, p.47).

The most complex strategy involved an addition to the above. Children reasoned that their opponent would be aware of their intentions to deceive him, and that the opponent would expect them to try the bluff described above, for the reasons described above. Because they thought that their opponent expected them to empty the five cent cup, they emptied the ten cent cup. An example of a child’s reasoning reproduced from the text may help to illustrate this; “he might feel … that we know that he thinks that we’re going to pick this cup [five cents] so therefore I think we should pick the dime cup [ten cents], because I think he thinks … that we’re going to pick the nickel cup [five cents], but then I think he knows that … we’ll assume that he knows that, so we should pick the opposite cup [ten cents]” (Flavell et al, 1968, p.47).

These more complex strategies are difficult enough to describe and understand here, so it is not surprising to find that they were reported by only the older children. While children from the entire age range (6 years to 16 years) reported the simplest financial gain strategy, only children from the age of 11 reported the second strategy and only a few 15- and 16-year-old children reported the third strategy. Unfortunately, the reliance on verbal report is necessary because behavioural observations in the Flavell et al procedure would not allow the distinction between children using the simplest and the most complex strategies, as they both result in the same outcome (selecting the five cent cup) (Perner & Wimmer, 1985).
Flavell et al's (1968) failure to find evidence of mental state reasoning while children aged less than 6 years undertook a deception task might appear to lend support to the behavioural, non-mentalistic account for children's performance in multi-trial competitive games advanced in Sections 1.1.1 and 1.1.2. However, Flavell et al's reliance on verbal reports may have underestimated children's ability. The question of under what circumstances behaviour is indicative of mental state reasoning has been addressed with experiments using a non-human primate population. This is discussed next.

1.2 Deception in Non-Human Primates

Deceptive behaviour may be indicative of an understanding that others have beliefs about the world that can be manipulated with respect to reality. Thus, it may show evidence of theory of mind. Because of this, the question of whether non-human primates, henceforth primates, can tactically deceive has been extensively studied in order to consider whether such primates have a theory of mind (e.g. Byrne & Whiten, 1990; Coussi-Korbel, 1994; Heyes, 1998; Kummer, Ansenberger & Hemelrijk, 1996; Menzel, 1973; Tomasello & Call, 1997; Whiten & Byrne, 1988 - target article and commentaries).

It is very easy to mis- or over-interpret observed behaviour as providing evidence of mental state reasoning. The problem of over- or mis-interpretation of behaviour has been addressed in some detail in the primate literature. Debate has raged over whether examples of strategic behaviour in primates provide evidence of mental state reasoning or not (e.g. Byrne & Whiten, 1990; see target article and commentaries to Whiten & Byrne, 1988, Heyes, 1998). For example, Byrne and Whiten (1990) reported a series of anecdotal observations of primate behaviour collected by primatologists who considered that these behaviours might have provided evidence of mental state reasoning. However, in many, if not all, cases a simpler explanation was possible (e.g. see commentaries to Whiten & Byrne, 1988; Heyes, 1998). Therefore, this literature provides good examples of how pervasive the mental state explanation may be.

One of the most often cited examples of tactical deception was reported by Menzel (1973) and concerned two chimpanzees engaged in counter-deception; a dominant male, Rock and a female, Belle. These chimpanzees were in competition with each other for food. The experimenters revealed the location of hidden food only to Belle. Because Rock was the dominant male, he would steal food from her. Therefore, Belle avoided going for the food when Rock was nearby. Belle's behaviour changed
over time and became more successful at preventing Rock from obtaining the hidden food. For example, she would lead the other chimpanzees away from the location at which the food was hidden, wait for Rock to start searching this area and then try to go to the real location of the food.

However, as Belle changed her behaviour, so too did Rock. For example, Rock began to walk away from Belle and then spin around quickly to see if she had started towards the real location of the food. This has been interpreted as evidence that "Rock understood Belle's (deceptive) intentions and can anticipate her thoughts" (p. 133, Byrne, 1994). However, Tomasello and Call (1997), amongst others, argue that there is no need to conclude "that these strategies are directed at the psychological states of others, that is, at creating false beliefs in others" (p. 237). Rather, amongst others, they propose an alternative explanation that both chimpanzees learned about the way in which the other behaved and was able to use this to predict the other's behaviour and how the other would behave in response to themselves.

Anecdotes do not provide sufficient evidence of tactical deception because the events surrounding and preceding the observed behaviour often cannot be ascertained and it is possible that reported behavioural observations occurred by chance. Experimental evidence is necessary if it is to be concluded that non-human animals can tactically deceive. Attempts to experimentally demonstrate tactical deception in primates have shown that some primates can deceptively indicate a location to misdirect a competitor to an empty location. For example, chimpanzees have been shown to deceptively indicate a non-target location (e.g. Woodruff & Premack, 1979), whereas other animals, such as longtail macaques, have not demonstrated such behaviour (Kummer et al., 1996). One interpretation of this behaviour is that it was an attempt to implant a false belief in the other concerning the location of the hidden object. However, in the examples in which deceptive behaviour was observed, it occurred after many trials and over a long time period, suggesting that such behaviour was a product of associative learning, or that such behaviours occurred as a result of inferences about observable features of the situation, rather than as an attempt to create false beliefs (e.g. Coussi-Korbel, 1994; Heyes, 1998; Tomasello & Call, 1997).

The debate in the primate literature has influenced the design of tasks used to assess tactical deception in children. For example, one feature of tactical deception tasks is that they should be single trial in order that children do not have the opportunity to learn the response that functions to deceive. In addition, verbal evidence of an attempt
to manipulate the beliefs of the other is sought. In order to check that children understand the effect of their deceptive behaviour on the beliefs of their opponent, they are commonly asked to predict the location at which their opponent would think the hidden object is hidden, or the location at which their opponent would search for a hidden object (such "look" questions are often used to index an understanding of belief).

1.3 Deception in Children in Single Trial Competitive Games

The proliferation of studies examining children's developing theory of mind from the early 1980's (e.g. Astington et al, 1988; Frye & Moore, 1991) lead to a concentration on tactical deception in the deception literature. Informal observations suggest that deceptive behaviour starts early in childhood. For example, Dunn (1991) describes an interaction between a mother and her 21 month old child in which the child appears to attempt to mislead her mother in order to get hold of some soap by pretending to have soiled her nappy. Deception is also widespread in the games that older children and adults play. For example, the very name of the game "hide and seek" or the card game "cheat" suggests attempt to cause misrepresentation of reality. However, older children may be more aware of the outcome of their behaviour than their younger counterparts. It is possible that the deceptive behaviour of older children may be tactical, while the deception of younger children may be behavioural. The development of tactical deception in children has been assessed using single-trial competitive games (e.g. Chandler et al, 1989; Hala et al, 1991; Hughes & Russell, 1993; Russell et al, 1994; Russell et al, 1991; Sodian, 1991, 1994; Sodian & Frith, 1992; Sodian et al, 1991). Evidence from three such tasks is described in the present section.

1.3.1 Windows task

It has been argued that children's behaviour in the windows task shows evidence of tactical deception from the age of 4 (Hughes & Russell, 1993; Russell et al, 1994; Russell et al, 1991). The windows task assessed children's ability to misinform an adult competitive opponent about which one of two boxes contained a desired object that had been hidden by a second experimenter was assessed. If children successfully misdirected their opponent they would obtain the hidden object. Responding in a deceptive manner, either by lying about which box contained the hidden object or by deceptively pointing to the incorrect box, was argued to represent an attempt to make the opponent falsely think that the object was hidden at a location other than that at which it was really hidden.
Russell and colleagues found a reliable developmental trend in behaviour on the first test trial in the windows task. Four-year-old children reliably indicated the empty box and kept the hidden object, while three-year-old children reliably indicated the baited box and lost the hidden object to their opponent. Three-year-old children not only failed to indicate the empty box on the first test trial, but continued to do so on many of the following twenty test trials. It has been suggested that these children's difficulty with indicating the empty box in the windows task may be a result of the executive demands of the task (Hughes & Russell, 1993; Russell et al, 1994). The relationship between executive functions and deception is discussed in Chapter 2 (Section 2.2).

Children's behaviour on the first test trial was of particular interest, because their responses to later test trials could be influenced by their performance on earlier test trials, rather than indicating an attempt to manipulate the beliefs of the opponent. The arguments in the animal literature illustrated the interpretative problems presented if deceptive behaviour is demonstrated over multiple trials (see Section 1.2). However, the first test trial was preceded by a training period (of about fifteen trials). It is possible that children succeeded on the first test trial because they were able to infer from the training trials the behaviour likely to result in task success.

In the training trials neither the child nor the adult opponent could see the contents of either box: the boxes were windowless. In these trials, children learned that the adult always selected the box indicated by the child: if the child indicated the baited box, the adult kept the contents, whereas if the child indicated the empty box, the adult selected that box and the child kept the contents of the baited box. Before, during and after each training trial, the child was told that "he or she could get the chocolate by making the competitor go to the empty box" (Russell et al, 1991, p.336). In the test phase, the windowless boxes were substituted for boxes with windows, through which the contents could be seen. These windows faced towards the child and away from the opponent. Therefore, only the child could see which of the two boxes contained the hidden object and he or she was told that "it would now be easier to make the competitor go to the wrong box" (Russell et al, 1991, p.336).

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4 Russell et al (1991) included 15 training trials but the number of training trials included by Russell et al (1994) varied between 18 and 20: after 15 trials they tested children's understanding of the relationship between the child's pointing response and outcome and the training trials finished when children correctly answered these questions on three consecutive trials, or when the child reached 20 trials. If the child reached 20 training trials without making correct responses on three consecutive trials, their data was excluded from the analysis.
Russell et al (1991) argued that pointing to the empty box on the first test trial with windows could not be a consequence of previous reinforcement because children had not previously been reinforced for pointing to a box that they knew to be empty (in the training trials the boxes are windowless and, at the moment at which the child points to a box, he or she does not know which of the two contains the object). Although it is true that children were not reinforced for knowingly pointing to an empty box in the training trials, these trials provided the opportunity for children to learn two pieces of information crucial for deceptive behaviour in the test trials. During training, children learned firstly that their opponent selected where the child pointed, and secondly, that their opponent kept what he or she found. In order to act 'deceptively' on the first test trial, the child had to put these two pieces of information together and make the inference that they could obtain the hidden object by making their opponent look in the empty box.

The task instructions may have provided information that would facilitate this inference. Children were urged three times on every training trial (before, during and after) to get their opponent to look in the empty box, and then they were told before the first test trial with windows that "it would now be easier to make the competitor go to the wrong box" (Russell et al 1991, p.336). This might have implicitly suggested that they should use the windows to guide the behaviour that they were taught on the previous fifteen trials. Thus, it remains possible that rather than intending to manipulate the information presented to the opponent in order that the opponent should think that the object is hidden in a box other than its true location, children simply learned the rule 'point to the one that you do not want'.

1.3.2 False tracks tasks

Although the inclusion of a number of training trials may make the argument that the windows task assesses tactical deception problematic, similar developmental trends in performance between the ages of 3 to 4 have been observed in tasks in which it can be more confidently concluded that tactical deception is involved.

The false tracks task (Chandler et al, 1989; Hala et al, 1991; Sodian et al, 1991) required children to deceive an adult about the location of hidden treasure in order to keep it for themselves. A doll was used to hide the treasure. The doll was moved across a white board in order to hide the treasure in one of five plastic containers. As the doll moved across the board, a trail of inky footprints marked which container was visited. These inky tracks could be manipulated in order to deceive a competitive opponent.
about the location at which the item was hidden; children could both lay false tracks, and/or use a cloth to wipe existing tracks.

False tracks leading to an empty location may make the opponent falsely believe that the object was hidden at that location. In order to ensure that children understood the effect of their apparently tactically deceptive behaviour, they were asked to predict the effect that misleading tracks would have on the searching behaviour or beliefs of their opponent. If children did not understand the influence that false tracks would have on their opponent’s beliefs, it could be argued that the laying of false tracks was an attempt to lure the opponent away from the real location of the hidden object, rather than an attempt to make the opponent falsely think that the object was hidden in a location other than that at which it was really hidden.

The task was comprised of two conditions. In a competitive condition children had to deceive the adult opponent about the location of the hidden treasure by laying false tracks, wiping true tracks or lying. In a cooperative condition children had to help an adult find the hidden treasure by laying true tracks. The cooperative control condition was included to ensure that children intended to deceive their competitive opponent, rather than track manipulations simply functioning to deceive without there being an intention to do so. Unfortunately, in some cases other task parameters were confounded over these two conditions which may have encouraged children to manipulate the tracks in the competitive condition, but not in the cooperative condition (Sodian et al, 1991).

Chandler et al (1989) argued that children as young as 2 and 3 years were able to tactically deceive their competitive opponent about the location of the hidden treasure. However, later experiments found that 3-year-old children only manipulated the tracks when particular task conditions encouraged such behaviour (that is, when they were confounded over competitive and cooperative conditions). In addition, 3-year-old children required a great deal of verbal encouragement from the experimenter before they manipulated the tracks (Sodian et al, 1991). Thus, only those children aged 4 years and older showed evidence of tactical deception in the false tracks task (Sodian et al, 1991).

1.3.3 Box Tasks

Findings using a further set of deceptive tasks, the one box and two box tasks (Sodian, 1991, 1994; Sodian & Frith, 1992), also suggest that 4-year-old children can
tactically deceive another by misinforming them about the location of a hidden object, while 3-year-old children cannot.

In the box tasks an object was hidden and children were required to deceive a competitive opponent about the location of the hidden object in order to prevent the opponent finding and keeping the object (competitive condition). In a cooperative control condition, children had to help a collaborator to find the hidden object, who would then give the object to the child. Appropriate responding in a pair of cooperative and competitive trials ensured that children were purposely deceiving their competitive opponent, rather than any apparently deceptive behaviour being fortuitously so. Both the two box and one box tasks included a deceptive and a sabotage condition, and each of these task conditions included a pair of cooperative and competitive trials. In the sabotage condition, rather than misinforming the competitor about the location of the hidden object, children were required to physically prevent the competitor gaining physical access to the baited box by locking it, or help a collaborator to gain access by not locking the baited box. The sabotage condition was considered a simpler form of deceptive behaviour than the deception condition.

These conditions and the appropriate responses are summarized in Table 2.1, but are described in more detail here. In the one box, sabotage task, the box could either be locked or left open. In order to prevent the robber from obtaining the hidden object and to help the king to obtain the object, children had to lock the box when confronted by the competitive robber and leave the box unlocked when faced with the cooperative king. In the one box deception task, children could not lock the box. To obtain the hidden objects, children had to lie to the competitive robber that the box was locked, and truthfully tell the cooperative king that the box was open. In the two box sabotage task, children were required to lock only one of the two boxes. In order to obtain the hidden objects they had to lock the full box when confronted by the competitive robber, and lock the empty box when faced with the cooperative king. In the deception condition of the two box task, children responded by pointing. Appropriate responding in this condition was to point deceptively to the empty box when the competitive robber appeared and to point truthfully to the baited box when the cooperative king appeared. These responses would lead the robber to open the empty box, with the result that the child kept the contents of the baited box, and would lead the king to open the baited box and give the contents to the child.
Table 1.1: Design of deception/sabotage tasks, and correct responses (adapted from Sodian & Frith, 1992, p.598)

<table>
<thead>
<tr>
<th>TASK</th>
<th>DECEPTION Competitor</th>
<th>Cooperator</th>
<th>SABOTAGE Competitor</th>
<th>Cooperator</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONE BOX</td>
<td>Say that box is locked Tell lie</td>
<td>Say that box is open Tell truth</td>
<td>Lock box</td>
<td>Hinder</td>
</tr>
<tr>
<td>TWO BOXES</td>
<td>Point to empty box Deceptive Pointing</td>
<td>Point to full box Correct Information</td>
<td>Lock full box</td>
<td>Hinder</td>
</tr>
</tbody>
</table>

Sodian and colleagues argued that children’s responses represented tactical deception if they responded appropriately on both trials of a pair (i.e. deceived competitor and helped collaborator). That is, it was argued that pointing to the empty box (two boxes) represented an attempt to manipulate the mental states of the other with respect to reality and make the other falsely think that the object was hidden somewhere other than where it was really hidden, while lying about whether the box was locked (one box) was an attempt to make the other falsely think that the box was locked. Children did not have the opportunity to learn that the deceptive response resulted in task success and “Deceptive action is less easily explained as a routine manipulation of other persons’ behaviour if it occurs in novel situations and is employed flexibly” (Sodian, 1991 p.175).

Experiments employing the box task have revealed that children do not become competent tactical deceivers (as shown by performance in the deception condition) until the age of 4 or 5 (Sodian, 1991). Three-year-old children were able to physically prevent their opponent from obtaining the desired object in the sabotage condition, but failed to deceive their opponent about the location of the hidden object in the deception condition (Sodian, 1991). These younger children understood the competitive versus cooperative condition manipulation, but were only successful in a condition not involving deception.

1.3.4 Interim Conclusions

The review of the literature concerning children’s behaviour in single-trial competitive games suggests that children can tactically deceive another from the age of 4 (Sodian, 1992, 1994; Sodian & Frith, 1992; Sodian et al, 1991). In order to ensure that tactical deception was required, the procedures employed in the false tracks (Sodian et al, 1991) and box tasks (Sodian, 1992, 1994; Sodian & Frith, 1992) required children to predict the effect of their deceptive actions on the deceived, and were limited to one
trial. In single trial experiments, 4-year-old children understand that in order to get what they want they must manipulate the beliefs of their opponent.

In addition to the active deception described above, children's ability to discriminate between different forms of verbal deception has been well researched (e.g. Peterson, 1995; Siegal & Peterson, 1996; Sullivan, Winner & Hopfield, 1995; Winner & Leekam, 1991). Children distinguish between intentionally deceptive and mistakenly deceptive verbal utterances on the basis of whether the speaker intends to be truthful (Leekam, 1991). More complex forms of verbal deception are distinguished on the basis of whether the speaker intends that the listener should believe his false utterance (Leekam, 1991). For example, a liar intends that the speaker should believe the untruth, but a sarcastic remark is made with the intention that the listener should disbelieve the untruth. Children can distinguish between these different types of intended falsehood on the basis of the speaker's intentions concerning the listener's knowledge from the age of four or five (Leekam, 1991; for similar studies on children's understanding of verbal deception and the relation to theory of mind see also, Peterson, 1995; Siegal & Peterson, 1996; Sullivan, Winner & Hopfield, 1995; Winner & Leekam, 1991).

Given that it is now clear that children aged four are tactical deceivers, one may feel less sceptical about the mental state account of the early deception tasks even though these tasks do not provide conclusive tests of the role of theory of mind (Section 1.1). The observational and experimental evidence does not allow one to conclude that non-human primates understand deceptive or strategic actions in terms of the effect they may have on the mental states of others. There is presently no evidence that primates do have the prerequisite theory of mind to allow them to understand that others have mental states that can be different from their own and that can be false (e.g. Call & Tomasello, 1994; Povinelli, Rulf & Bierschwale, 1994; Premack, 1988).

However, from the age of four, human children are able to tactically deceive others and possess a theory of mind (see Section 2.1, Chapter 2). Such mental state reasoning underlies much of our social interaction. Therefore, it is plausible that, from the age at which children are able to attribute mental states to others, they may understand their behaviour in deceptive or strategic interactions in terms of the mental states involved. From this time, this may be computationally more economical than attempting to reason at a behavioural level. The question of whether the task parameters allow a test of such mental state reasoning must be carefully considered.
1.4 Tactically Strategic Behaviour in Children

The deception tasks discussed in Section 1.3 employed only a single test trial in order to allow the conclusion that children's deception was intended to manipulate the mental states of their opponent. However, social interactions in everyday life frequently evolve over multiple interactions. This can be illustrated by the following example. If a mother were trying to hide the biscuit barrel from Johnny, a persistent biscuit thief, the selection of a novel hiding place will be based on all previous interactions concerning the theft of biscuits. Knowledge of previous locations at which the biscuit barrel was hidden and Johnny's success or failure at finding it at each of these locations is likely to inform the choice of a new location, and the likelihood that the biscuits will remain successfully hidden at this new location.

Attempts to out-manoeuvre an opponent are likely to change over the course of multiple interactions and will, in part, be based on how the opponent's behaviour is expected to change over the game. For example, if two people were playing a game such as tennis, their expectations about the way in which their opponent will play the game are likely to influence their own game playing strategy. Many different shots can be played in a game of tennis, but one aspect of game play is used as an example. Consider a rally of shots in which two different types of shots are used. In the example, the options available to player A are to either hit the ball into the furthest corner of the court or drop it just over the net. Playing a set of consistent shots is not a good game playing strategy because it is predictable and allows the opponent to work out what you are doing and may give them an advantage. If player A plays a number of shots in a particular manner, player B may start to expect a change in game playing strategy. Player B may try to pre-empt such a change in A's game playing strategy. After a few shots which require B to run to the farthest corner of the court, B may wait for the next shot very close to the net, in order to attempt to pre-empt a change in shot style. This would be an example of tactically strategic behaviour because player B is trying to out-manoeuvre player A in order to win the game point. Similar examples can be observed in many different settings.

The aim of the research reported within this thesis was to investigate the development of such anticipatory changes in game playing strategy in children, using a novel experimental paradigm. Research reviewed earlier in this chapter (Section 1.1.2) suggested that children are able to adapt their game strategy in a multi-trial procedure, but changes in game playing strategy were confounded with changes in the response
required for task success (Shultz & Cloghesy, 1981). In assessing the development of anticipatory changes in game playing strategy, one observation of children's game playing behaviour reported by Shultz and Cloghesy (1981) was used to guide the way in which such anticipatory changes were assessed. Some of the children tested by Shultz and Cloghesy were reported to switch their guessing or pointing strategies before their opponent changed strategy: that is, children's strategy change did not always occur in response to the change in game contingencies. Although not formally analyzed, this spontaneous switching was reported to be a "commonly used tactic" (Shultz & Cloghesy, 1981, p.470).

It is possible that children may have switched their guessing or hiding strategy in Shultz and Cloghesy's game as a pre-emptive strike in anticipation of their opponent changing the hiding or guessing sequence. If this were the case, it would provide evidence of tactical strategy because it would involve children applying to their current behaviour knowledge about the way in which their opponent was likely to behave. However, it would be premature to make such a conclusion from Shultz and Cloghesy's procedure because this spontaneous strategy switching was not formally assessed.

Tactically strategic behaviour should be observed only in competitive interactions. For example, players should not implement tactical strategies such as irregular guessing or hiding strategy in a cooperative condition in which both players are not competing for resources. One outstanding research question is to consider the extent to which tactical guessing strategies are only employed by children in competitive games. The experiments presented in this thesis explored this question by including a cooperative control condition.

The majority of the experiments reported in this thesis used a location guessing game procedure in which children's game playing behaviour was assessed in order to see if they made anticipatory changes in game playing strategy. This procedure adopted a location guessing game similar to those reviewed in Section 1.1.1. Children's guessing and hiding behaviour in location guessing games shows evidence of unpredictable game playing strategies from early to middle childhood (from the ages of 4 to 6: Baron-Cohen, 1992; DeVries, 1970; Gratch, 1964). This thesis explores a different type of tactically strategic behaviour than that assessed in the location guessing games reported in Section 1.1.1. However, similar developmental trends may be observed.

Developmental trends in the use of unpredictable guessing and hiding behaviour occur at a similar age to that at which the literature reviewed in Section 1.3 showed that
children use theory of mind reasoning to deceive another. Children are able to tactically deceive another (deceptively manipulate the beliefs of another) from the age of four. It is possible that children of this age may understand tactically strategic behaviour in terms of the beliefs of themselves and their opponent. For example, children who show anticipatory guesses in Shultz and Cloghesy's task may do so because they think that their opponent has worked out that they know the game rule. Children may expect that the experimenter will change his or her strategy because the experimenter does not want the child to know the game rule. This would involve theory of mind. In the above reported literature the behavioural account of children's performance in these tasks cannot be ruled out.

The single-trial competitive tasks discussed in Section 1.3 were specifically designed to assess theory of mind reasoning. The development of theory of mind and its role in deception and tactical strategy is discussed in Chapter 2. Other types of cognition, such as executive function may also underlie children's performance in competitive interactions. Both theory of mind and executive function have been considered with respect to the way in which they can account for children's deceptive behaviour and are discussed in Chapter 2. Chapter 2 also presents a discussion of the way in which these accounts can be applied to the development of tactically strategic behaviour.
A Theoretical Framework

The preceding chapter reviewed the evidence for tactical strategy and tactical deception in children and considered the question of whether mental state reasoning underlay such behaviour. Chapter 1 related the development of deception and tactically strategic behaviour to theory of mind (Section 1.3). However, there are also non-mentalistic accounts of the development of deception (Russell et al., 1994). The development of executive functions has also been proposed as an account for children’s developing ability to deceive. This chapter reviews both theory of mind and executive function accounts of the development of deception and presents a discussion of whether they should be considered as complementary or alternative explanations of children’s developing ability to deceive (Section 2.3). The discussion in this chapter necessarily concentrates on the tactical deception literature, because it is within this literature that theoretical progress has been made. The final section in this chapter discusses the ways in which theory of mind and executive functions accounts may predict children’s behaviour in the tactical strategy experiments reported in this thesis.

2.1 Theory of Mind

A theory of mind is the ability to attribute mental states such as beliefs to others and to use these attributed mental states to predict behaviour (Premack & Woodruff, 1978). As discussed in Chapter 1, tactical deception occurs when a false belief is implanted in another. Therefore, tasks in which tactically deceptive behaviour is demonstrated assume that children who tactically deceive possess a theory of mind.

Children’s theory of mind is commonly assessed by false belief tasks (e.g. Baron-Cohen, Leslie & Frith, 1985; Dennett, 1978; Wimmer & Perner, 1983). Some researchers have argued that deception may facilitate demonstration of false belief understanding (e.g. Chandler et al., 1989). This is because deceptive tasks may be “a good candidate for a ‘naturalistic’ context in which false belief representation may emerge in young children” (Sodian, 1991, p.174). The tactical deception research
reviewed in Chapter 1 (Section 1.3) found that children can tactically deceive another from the age of 4. The present section compares this to the age at which children's understanding of false beliefs is demonstrated in false belief tasks.

2.1.1 Assessment of children’s theory of mind

The problem of inferring understanding of mental states from observed behaviour was discussed in Chapter 1 with reference to the potential misinterpretation of behaviour as evidence of mindreading in animals (Section 1.2) and children (Section 1.1). Standard theory of mind tasks require children to predict the behaviour of a protagonist on the basis of a false belief (e.g. Baron-Cohen et al, 1985; Dennett, 1978; Wimmer & Perner, 1983). The prediction of a false belief is required because false beliefs do not correspond with reality. Behavioural predictions that are made on the basis of an attributed true belief that corresponds with reality could be made solely with reference to the actual state of reality and without any reference to the beliefs of the protagonist. However, if reality and the protagonist’s belief about reality do not correspond, the attributed false belief will be the only reliable indicator of behaviour.

This is best illustrated by example. In the two following examples, the question "Where will John look for his wallet?" relies firstly on the attribution of a true belief and secondly, on the attribution of a false belief. 1) John puts his wallet in his coat pocket. Jane removes the wallet to take out some money, and puts it back in his coat pocket. 2) John puts his wallet in his coat pocket. Jane removes the wallet, takes out some money, but instead of putting it back in his pocket she puts it in the drawer of the dresser. The answer to the question “Where will John look for his wallet?” should be the same in the two stories; John will look in his coat pocket because that is where he thinks the wallet is located. However, in story one it is possible to accurately predict John's behaviour with reference only to the real state of affairs (i.e. that the wallet is in his coat pocket), without making reference to John’s belief about the location of his wallet. In contrast, if story two elicits the answer, coat pocket, it is only possible to accurately predict John's behaviour if one refers to John's false belief that the wallet is in his coat pocket. If this question were answered with reference to the real state of affairs, and not John’s mental states, one would predict that John would look for his wallet in the drawer of the dresser (a realism error).
2.1.2 The development of theory of mind

The false belief test has become paradigm of choice for assessing theory of mind. This test has been used particularly with individuals whose theory of mind abilities may be in doubt, for example children, or people with autism (e.g. Baron-Cohen et al, 1985). Using such comprehension style tasks, it has been possible to chart developmental changes in children's ability to attribute mental states to others. Before the age of four, children tend to make realism errors on the false belief task and predict the protagonist's behaviour on the basis of reality. Around the age of four, normally developing children begin to answer with reference to the target character's false belief (see, for example, Baron-Cohen, et al, 1985; Hogrefe, Wimmer & Perner, 1986; Perner, Leekam & Wimmer, 1987; Wimmer & Perner, 1983). Children with autism generally have difficulty attributing mental states to others and fail false belief tasks (e.g. Baron-Cohen et al, 1985).

There is debate over the nature of this developmental improvement in understanding of false beliefs. Some argue that this demonstrates a radical change in the child’s understanding, in the form of a conceptual shift (e.g. Gopnik & Astington, 1988; Gopnik & Slaughter, 1991; Perner, 1988, 1991; Perner & Ogden, 1988; Sodian, 1991, 1994; Sullivan & Winner, 1991; Wimmer & Hartl, 1991). However, others argue that, rather than a conceptual shift taking place, the three to four year shift in performance on the false belief task occurs because the task underestimates younger children’s abilities (e.g. Bartsch & Wellman, 1989; Chandler et al, 1989; Hala et al, 1991; Lewis & Osbourne, 1990; Mitchell & Lacohee, 1991; Siegal & Beattie, 1991).

The review presented in Chapter 1 (Section 1.3) suggested that children's ability to tactically deceive another develops about the same age as that at which they pass the false belief test. Children are able to tactically deceive others by misinforming them about the location of a hidden object from about the age of 4, the same age at that at which they stop making realism errors on the false belief task (Sodian, 1991; Sodian & Frith, 1992; Sodian et al, 1991).

Formal testing of children’s ability to attribute false beliefs to others also suggests a relationship between ability to misinform a competitor and performance on a false belief task. Sodian and Frith (1992) found that success on the false belief task predicted children’s ability to tactically deceive another in both the one box task, in
which they had to lie to the competitive opponent, and the two box task, in which children had to deceptively point to the incorrect location when faced with the competitive opponent. The majority of three-year-old children and children with autism failed the false belief task and did not deceive an opponent, while four-year-old children passed the false belief task and tactically deceived an opponent.

Second order mental states

The false belief test described above assesses children's ability to attribute first order mental states (I think that he (falsely) thinks x). Older children and adults often use more complex mental state attributions to explain and predict the behaviour of others. An additional level of recursion can allow the attribution of second order mental states, which enables children to understand that others can attribute mental states to them and to others. Such mental state attributions of the type, "I think that she (falsely) thinks that I think x" are termed second order.

Second order false belief tasks involve an additional level of complexity to the first order false belief tasks described above: not only must the child report a belief, but a belief about a belief. For example, Sullivan, Zaitchik and Tager-Flusberg's (1994) "Birthday Puppy" story involved three characters, Mum, Peter and Grandma, and a surprise present. Mum buys Peter a puppy for his birthday and hides it in the basement, but she tells him that she bought him a toy. Unbeknown to Mum, Peter finds the puppy. The child is asked certain questions about Mum's knowledge of Peter's knowledge concerning his surprise present. This involves second order mental state attributions because the child must attribute Peter's knowledge to Mum.

Modifications to second order false belief tasks, mainly in the form of reducing complexity, have resulted in a steady decrease in the age at which children stop making realism errors. Originally, Perner and Wimmer (1985) found that some 6-year-old children and most 7-year-old children could attribute second order mental states. However, more recently, Sullivan et al (1994) have shown that some 4-year-old children, and most 5- and 6-year-old children could attribute second order mental states in the Birthday Puppy task. As with the attribution of first order mental states discussed above, the ability to attribute ignorance has been found to precede the ability to attribute false belief in second order false belief tasks (Hogrefe et al, 1986; Sullivan et al, 1994).

Thus, there appears to be a developmental delay between the age at which
children are able to attribute first order mental states (around the age of 4), and the age at which children have consistently been found to attribute second order mental states (5 or 6 years). It has been suggested that this may be a result of the increased information processing demands of second order theory of mind attributions, which may be dealt with more easily by older children (Sullivan et al, 1994). Sullivan et al (1994) found that reducing the information processing load of the tasks, by shortening the stories and involving fewer characters, locations and episodes, resulted in children successfully avoiding realism errors at an age younger than that at which this had previously been demonstrated.

It is possible that second order mental state attributions may underlie children's strategic behaviour in games. For example, Shultz & Cloghesy (1981; see Chapter 1, Section 1.1.2) argued that children's behaviour in their game was motivated by a recursive awareness of intention. Instead of the attribution of beliefs about beliefs, a level of recursion is involved, in the sense that an intention to deceive is attributed to another (although, as discussed earlier, a behavioural account cannot be ruled out). Similar second order attributions may be involved in children's reasoning in the experiments reported in this thesis. This idea is discussed further in Section 2.4 and in Chapter 3.

2.1.3 Summary

Children's ability to tactically deceive another develops at the same time as that at which they pass false belief tests, that is, at about the age of four (e.g. tactical deception development: Sodian, 1991; Sodian & Frith, 1992; Sodian et al, 1991 - theory of mind development: Baron-Cohen et al, 1985; Hogreve et al, 1986; Perner et al, 1987; Wimmer & Perner, 1983). These associations suggest that children who fail to tactically deceive another may do so because they lack the theory of mind skills.

However, other developments in children's cognitive abilities also take place around the age of four. For example, executive functions develop throughout childhood and adolescence, and this includes early developments around the age at which children develop theory of mind and pass tactical deception tasks (Dempster, 1981; Hughes, 1998a, 1998b). Thus, a second account of young children's failure to tactically deceive their opponent proposes that this occurs because they do not have sufficient executive control of their behaviour. This position is addressed next.
2.2 EXECUTIVE FUNCTIONS

Executive functions are higher order cognitive control processes, such as working memory, planning and inhibition. Temple (1997) defined executive functions as processes including “the ability to shift from one concept to another; the ability to modify behaviour, particularly in response to new or modified information about task demands; the ability to synthesize and integrate isolated details into a coherent whole; the ability to manage multiple sources of information; and the ability to make use of relevant acquired knowledge” (p. 287). These functions are generally considered to be carried out by the frontal lobes (e.g. Shallice, 1988). Developmental assessment of executive functions in childhood has revealed at least four functions: working memory, inhibitory control; attentional flexibility and planning (see, for example, Hughes, 1998a, 1998b; Welsh, Pennington & Groisser, 1991).

It has been proposed that the difficulty that 3-year-old children and children with autism have with tactical deception may be a result of the executive demands of deception (e.g. Hughes & Russell, 1993; Russell et al 1994). Working memory, inhibitory control and attentional flexibility have all been shown to correlate with tactical deception in 3- and 4-year-old children (Hughes, 1998a, 1998b). In addition to changes over later childhood and adolescence, developmental changes in working memory, inhibitory control, attentional flexibility have been found between the ages of 3 to 4 years (Dempster, 1981; Hughes, 1998a, 1998b), the age at which children's ability to tactically deceive another has been demonstrated (see Chapter 1, Section 1.3).

2.2.1 The development of Executive Functions

The development of certain executive functions in children, such as working memory, have been well researched (e.g. Hale, 1990; Kail, 1986, 1988, 1991; Keating & Bobbit, 1978). In contrast, there has been relatively little research considering the development of other executive functions in children, such as inhibitory control. It is only relatively recently that there has been interest in the development of these Executive Functions from early childhood (e.g. DeLoache & Brown, 1984; Diamond & Taylor, 1996; Hughes, 1998a, 1998b; Kochanska, Murray, Jacques, Koenig & Vandergeest, 1996) and into later childhood and adolescence (e.g. Welsh, Pennington & Groisser, 1991; Welsh & Pennington, 1988).
Working Memory

Many studies have shown that children’s working memory improves over childhood. For example, Dempster (1981) found that the capacity of memory showed a steady increase in the number of symbols (numbers and letters) that could be immediately recalled from the age of 2 to 12, and to adulthood. The speed with which information in working memory is processed increases over childhood, but this could be a result of both increases in speed of processing and/or the efficiency with which it is used (e.g. Hale, 1990; Kail, 1986, 1988, 1991; Keating & Bobbit, 1978). The type of memory strategies used over childhood certainly become more effective as children age (e.g. Baker-Ward, Ornstein & Holden 1984; DeLoache, Cassidy & Brown, 1985; DeLoache & Todd, 1988; Justice, 1989; Kreutzer, Leonard & Flavell, 1975; Ritter, 1978; Wellman, Ritter & Flavell, 1975).

Inhibitory Control

Inhibitory control is demonstrated when a prepotent response that has become maladaptive is inhibited (stopped). In a typical procedure assessing inhibitory control, children are rewarded for using a particular response in pre-switch trials, and in post-switch trials they are rewarded for using a different response; their ability to inhibit the former response and use the latter response is assessed. For example, Luria, Pribram and Homskaya’s hand game (1964, reported in Hughes, 1998a) required children to inhibit an imitative response (e.g. point when the experimenter points and make a fist when the experimenter makes a fist), when presented with a hand gesture and instructed to perform the opposite of the experimenter’s actions (e.g. point when the experimenter makes a fist and make a fist when the experimenter points). In order to respond correctly, children had to inhibit a previously appropriate but now inappropriate response when imitative trials were switched to conflict trials, and vice versa.

Developmental improvements in ability to inhibit on this task have been found between groups of 3- and 4-year-old children (Hughes, 1998a). A longitudinal replication showed that these groups of children were better able to inhibit within Luria et al’s hand game when they were 13 months older (i.e. within subject improvements were shown from age 3 to 4 and from 4 to 5, Hughes, 1998b). Age-related improvements in inhibition have also been observed over later childhood. For example, Welsh et al (1991) tested the ability of children aged 7 to 12 and adults to inhibit a
maladaptive response in a card sort task\(^5\). They found that children achieved adult levels of performance on inhibition by the age of 10, with an earlier leap in performance between the ages of 7 and 8.

**Attentional Flexibility**

Attentional flexibility refers to the flexible shifting of attention from one task set to another, in which inhibition of a prior strategy is not involved (or not to such a great degree as in those tasks designed to assess inhibition). For example, card sort tasks require the sorting of cards according to pre-determined rules, which are changed when the child makes a pre-determined number of correct responses (e.g. the Wisconsin Card Sort Test (WCST), Grant & Berg, 1948). Ability to sort according to the new rule is then assessed in order to see if children can flexibly switch their attention from one sorting strategy to another.

Card sort tasks can be used to assess primarily either inhibition or attentional flexibility, depending on the task procedure. Hughes (1998a) argued that if a “total-change paradigm” (Wolf, 1967) is adopted in which a new set of cards is used in the post-switch trials (the trials after the rule change), then children do not have to “inhibit their previously correct (but now inappropriate) response, but had only to shift their attention from one dimension to another” (p. 249). Adopting a new set of cards in the post-switch trials allows a degree of exogenous control of behaviour and consequently children do not have to inhibit the response that was previously successful to a given card. Instead it allows the assessment of whether children can flexibly shift their use of one strategy, for example, sorting on the basis of colour, to another, for example, sorting on the basis of shape. Thus, the total-change paradigm can be used to primarily assess attentional flexibility. Developmental increments in attentional flexibility have been found using the total-change paradigm card sort task. Hughes (1998b) found that 4- and 5-year-old children performed better on this task 13 months after they were first tested (at the age of 3 and 4 respectively).

**Planning**

Planning is a particular cognitive competence that might be expected to influence children’s tactical deception and tactical strategy. Successfully implemented strategies and deceptions are likely to have been planned to be appropriate to the situation. The ability of children to plan behaviour has been assessed using the Tower of London task.

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\(^5\)Note- this card sort task primarily assessed inhibition because a total change paradigm was not adopted see paragraph below concerning attentional flexibility.
(Shallice, 1982). Three balls (red, yellow and blue) are placed on three pegs that differ in height (tall, medium, short). Using a particular number of moves and often in a limited amount of time, children must move one ball at a time from the initial arrangement to match a target arrangement. In order to successfully complete the target arrangement in the particular, limited number of moves available, children must plan their actions before initiating them. The majority (82%) of a group of 5-year-old children were able to solve two out of three 2-move problems, while a slightly smaller proportion of these children (63%) solved all three problems at this level of difficulty (Hughes, 1998b). In contrast, they were less able to successfully plan and initiate solutions to 3- and 4-move problems (with 22% and 16% solving all three of each of these problems respectively). Thus, young children perform well on a test of planning, and their performance on the related Tower of Hanoi task (procedure used in children developed by Klahr & Robinson, 1981) improves over childhood and adolescence (e.g. Welsh, Pennington & Groisser, 1991).

2.2.2 Executive functions and tactical deception

The above review demonstrates that developments in children's executive functions occur around the same age as that at which the review presented in Chapter 1 showed they develop the ability to deceive. Executive function accounts of the development of deception have been proposed. It has been suggested that 3-year-old children's difficulties with deception may arise from a lack of inhibitory control, rather than arising from their inability to represent their opponent's beliefs (Carlson, Moses & Hix, 1998; Hughes & Russell, 1993; Russell et al, 1994). The behaviour of 3-year-old children in the windows task was suggestive of a problem with inhibition (Russell et al 1994). Many of these children not only incorrectly indicated the baited box on the first test trial, but persisted to indicate the baited box over the subsequent twenty test trials. Such persistent perseverative responses are typical of the type of response failure demonstrated by patients with frontal lobe lesions who fail to inhibit (e.g. Drewe, 1974; Nelson, 1976; Stuss, et al, 1983).

Many deception tasks (e.g. Peskin, 1992; Russell et al, 1991; Sodian, 1991; Sodian & Frith, 1992, see Section 1.3, Chapter 1) require children to point deceptively, and this response may make particularly high demands on inhibitory control processes (Carlson et al, 1998). Pointing is established as a means to indicate the location of
something at an early age. By about 10-months of age, children point veridically, both to obtain items that they desire (imperative pointing), and to direct the attention of another to an object (declarative pointing) (e.g. Bates, Camaioni & Volterra, 1975; Bates, O'Connell & Shore, 1987; Leung & Rheingold, 1981; Murphy & Messer, 1977). Thus, veridical pointing may be a prepotent response that children find difficult to inhibit. Carlson et al (1998) found that 3-year-old children had difficulty deceptively finger pointing away from the location at which an object was hidden, but were more successful when pointing with a mechanical pointer; or using a marker to indicate location. Thus, if the inhibitory demands of a task are high children may perform poorly even though they possess the understanding to perform well.

It has been argued that the executive demands of the windows (Hughes & Russell, 1993; Russell et al, 1994; Russell et al, 1991) and box (Sodian, 1991, 1994; Sodian & Frith, 1992) task require that a child "(a) disengage mentally from her current knowledge state and (b) refer away from the goal to another location" (Russell et al, 1994, p.302). Three-year-old children have no difficulty mentally disengaging from an object in a relatively pure test of executive function (the detour-reaching task; Hughes & Russell, 1993). This suggests that the difficulty in the windows task may be indicating the location other than that at which the object is hidden, rather than mentally disengaging from the knowledge of the location.

Russell et al (1994) acknowledge that 3-year-old children's difficulty in the windows task could alternatively be because they find the socially counter-intuitive rule "point to the empty box and I'll give you the sweet in the adjacent box" (p. 310) hard to implement. However, they argue that this is unlikely because older children should find counter-intuitive social rules more difficult to adopt than younger children, because, by virtue of their increased age, older children have a greater acquaintance with social norms.

If young children's difficulty with deception tasks is a result of executive functions rather than theory of mind, then removing the theory of mind component should not remove the difficulty. One way to remove the theory of mind element from these tasks is to remove the opponent, because this removes a person to whom beliefs can be attributed. Removing the opponent in the windows task did not remove the difficulty that 3-year-old children or children with autism have with this task (Hughes &
Russell, 1993; Russell et al, 1994). This suggests that 3-year-old children’s difficulty with this task is not specific to theory of mind.

However, Sodian (1994) disagrees that 3-year-old children’s failure to deceive in the box task is a result of failures in executive functions. Russell and colleague's argument proposes that 3-year-old children's difficulty is with referring away from the location that contains the desired object. Successful responding in the cooperative version of the sabotage condition of the two box task (Sodian, 1991, 1994; Sodian & Frith, 1992) requires children to lock the non-target, empty box. Three-year-old children have no difficulty with this response; thus, Sodian argues that lack of inhibitory control cannot explain 3-year-old children's failure to deceive in the box task.

The dispute between Russell et al and Sodian may be resolved by postulating that pointing is a more habitual response than locking. While pointing or indicating towards a desired object would seem to be a very well established response that may be difficult to inhibit, it is not clear that locking (or not locking) has any well rehearsed association with a desired object. Locking the empty box in the cooperative condition of the sabotage task may not require the same level of inhibition as that required to indicate deceptively an empty box as the location at which an opponent should search.

2.2.3 Summary

Research reviewed in Section 2.2 suggests that children's ability to tactically deceive another develops at approximately the same age as that at which developmental increments in executive functions are observed. Removing the deception element from the windows task did not enable 3-year-old children to pass this task, suggesting that their problem may not be solely at the level of theory of mind. It has been suggested that 3-year-old children's difficulty in deception tasks is a result of difficulty referring away from the location at which the goal object is located (Russell et al, 1994). However, this does not mean that theory of mind is not necessary for deception in these tasks. The question of whether theory of mind and executive function accounts of deception are complementary or alternative explanations is discussed next.

2.3 TOM AND EF ACCOUNTS: COMPLEMENTARY OR ALTERNATIVE?

The theory of mind and executive function accounts of deception discussed above need not be alternative competing accounts of children's developing ability to deceive. The arguments reviewed above suggest that both theory of mind and executive
functions play a role in children's ability to tactically deceive another. In this section, it is argued that that neither account can solely characterize the development of tactical deception by 4-year-olds. For example, it is possible that children may have the prerequisite theory of mind ability to be able to tactically deceive another, but may fail to do so because they lack executive control of their behaviour.

Tactical deception is defined as the ability to deceptively manipulate the mental states of another, and therefore, tactically deceptive behaviour necessarily involves theory of mind. The literature review presented in Chapter 1 showed that children develop the ability to tactically deceive another around the age of four (Sodian, 1991; Sodian & Frith, 1992; Sodian et al, 1991), and the research reviewed in this chapter showed that this is consistent with the age at which children develop the ability to attribute false beliefs to another in comprehension style false belief tasks (Baron-Cohen et al, 1985; Hogrefe et al, 1986; Perner et al, 1987; Wimmer & Perner, 1983).

While theory of mind is necessary for children to be able to tactically deceive another, it may not be sufficient. In addition, children may need sufficient executive control over their behaviour in order to deceive another, and the executive demands of a task may depend on the child's mode of responding (see Section 2.2.2). Referring away from a location that contains a desired object is a common feature of deception tasks which may place considerable demands on inhibitory control functions due to the habitual nature of veridical pointing. Russell and colleagues argued that 3-year-old children's difficulty with windows task was in part due to their difficulty indicating a location other than that at which a goal object was located (see Section 2.2.2; Hughes & Russell, 1993; Russell et al, 1994). This difficulty may be more pronounced when pointing with one's own finger, than when using a mechanical pointer (Carlson et al, 1998; Section 2.2.2).

The theory of mind literature provides an analogous example of the way in which the load placed on executive functions can influence children's task performance. The ability to attribute false beliefs has been shown to be sensitive to executive function load. Four-year-old children, who normally pass standard false belief tasks, failed a false belief task with increased inhibitory demands (Leslie & Polizzi, 1998). Leslie and Polizzi proposed that their findings support the argument that it is the inhibitory demands of the false belief task that make it difficult for 3-year-old children.
The task demand of referring away from a desired object can be observed in tasks requiring both tactical and behavioural deception. Similar demands on executive functions could also be observed in certain tasks assessing tactically strategic behaviour. The experiments reported in this thesis consider the development of tactically strategic behaviour by exploring children's ability to make anticipatory changes in guessing strategy. Making anticipatory changes in guessing strategy requires that children refer away from the location at which a desired object has previously been hidden. These changes may require inhibitory control or attentional flexibility. As discussed previously (Chapter 1, Section 1.4), theory of mind reasoning may also be involved in tactically strategic behaviour.

Inhibitory control and attentional flexibility may not be the only executive function involved in deceptive or tactically strategic behaviour. Such behaviours may also require planning and working memory. Research has considered the role of executive functions in games in which tactically strategic behaviour is involved. For instance, the role played by working memory resources in adult chess playing has been explored (Holding, 1989; Robbins et al, 1996; Saariluoma, 1998). For example, using a dual task procedure, it has been shown that the central executive and visuo-spatial sketchpad components of working memory (Baddeley, 1990) are involved in solving tactical chess problems (Robbins et al, 1996).

There are many cross-sectional associations between early theory of mind and early executive functions (e.g. working memory - Davis & Pratt, 1995; Gordon & Olson; inhibitory control - Carlson, 1997; Leslie & Polizzi, 1998; attentional flexibility - Frye, Zelazo & Palfai, 1995; and planning - Hughes, 1998b). In addition, research has shown developmental links between theory of mind and executive functions. For example, a recent longitudinal study found that performance on executive function tasks predicted later performance on theory of mind tasks, but not the reverse (Hughes, 1998b).

interaction this can be extrapolated to the understanding that others are also agents, and children begin to understand that others have minds of their own. In contrast, Perner (1995, 1998, 1999) argued that the development of children's theory of mind helps children to control their own actions. Perner argued that certain sophisticated executive functions involve meta-representation. These particular executive functions are those which require the representation of the act as maladaptive.

A further theoretical position proposes that theory of mind and executive functions involve the same mechanisms. Frye and colleagues (Frye, Brooks, Zelazo, & Samuels, 1996; Frye et al, 1995) have proposed that there is a common structure underlying theory of mind and executive function tasks that demands a particular cognitive capacity (Cognitive Complexity and Control (CCC) theory). This theory proposes that both theory of mind and executive function tasks can be understood in terms of doubly embedded conditional rules; "if...if...then" rules. However, this theory has been criticized for not capturing the understanding that belief is involved in the false belief task; the arbitrariness in which the conditional rules are applied; and the presence of data suggesting that very young children can understand "if...if...then" rules (Perner, 1999). In addition, double dissociations between executive functions and theory of mind have been empirically observed in the neuropsychological literature (Bach, Happé, Fleminger & Powell, 2000; Fine, Lumsden & Blair, in press), suggesting that, in adults at least, these psychological processes can operate independently.

The above theories are concerned with the very early developmental relationship between emerging theory of mind and executive functions. These theories therefore do not add to the discussion about whether theory of mind and executive function accounts of tactical deception are complementary or alternative because tactical deception requires both faculties to be adequately developed. However, the research reported in this chapter suggests that these accounts are complementary, and that both theory of mind and executive functions play a role in children's ability to deceive, unless of course engaging in deceptive behaviour allows theory of mind and executive functions to develop.
2.4 Tactical Strategy in this thesis

The experiments presented in this thesis were designed to explore the development of children's tactically strategic game playing behaviour. These experiments considered the development of children's ability to adapt their own game playing strategy in anticipation of a change in their opponent's strategy. Because their opponent's strategy did not actually change, it was possible to assess whether children anticipated a change, rather than any change in children's behaviour simply being in response to a change in their opponent's behaviour and indicating learning.

A developmental trend in tactical guessing strategy was predicted, with older children generally expected to be better able to anticipate a change in their opponent's game playing strategy than younger children. Different accounts may underlie such developmental trends, accounts which are not necessarily mutually exclusive. Firstly, it is possible that any observed developmental trends occur as a result of older children having had more relevant social exposure to competitive situations. As children age they are exposed to more competitive situations and have more experience in how actions may change as interactions increase. In playing games with their peers they may learn that particular friends tend to play in a particular manner and that this information may be exploited. For example, a group of friends who regularly play hide and seek may learn the sorts of places that each other tend to hide, and as time passes they may use this information to try to predict the hiding places occupied. In the experiments presented in this thesis, age related differences in the degree of relevant social experiences may influence the tactical strategies employed.

Secondly, it is possible that it is not the amount of social experience of competitive situations per se, but the way in which children are able to interpret this social information that is responsible for developmental change in tactically strategic behaviour. Children of different ages may vary to the extent that they interpret social information in terms of intentions and beliefs. Thus, the development of tactical strategy may be related to theory of mind development. For example, children may expect an opponent to adjust their game playing strategy because they think that their opponent knows that the child is aware of the opponent's strategy. Strategy change may be anticipated because children understand that their opponent does not want them to know the opponent's game playing strategy. Thus, changes in children's game playing strategy
may occur as a result of mental state attributions and the development of theory of mind may underlie developmental trends in tactically strategic behaviour.

Thirdly, aspects of executive function may also be involved in developmental trends in tactically strategic behaviour. Children may lack sufficient executive control of their behaviour to enable them to make anticipatory changes in their guessing strategy. This position would predict that developmental changes in tactically strategic behaviour would be related to the development of executive functions.

Various executive functions may be involved in children's strategy change. For example, inhibitory control may be required in changing from one game playing strategy to another. Other executive functions may also be involved in tactical strategy. For instance, working memory and attentional flexibility may be involved in maintaining and moving between the child's and the opponent's perspectives on the game.

The experiments reported in this thesis explore these different accounts of the development of tactically strategic behaviour. Chapter 3 reports a novel paradigm designed to explore tactically strategic behaviour in 5- to 9-year-old children. Game playing behaviour was observed to consider whether there was evidence of anticipatory changes in guessing strategy. In addition to the tactical strategy task, children were given a second order false belief task. If theory of mind underlies successful tactically strategic behaviour, then an association would be expected between performance on the theory of mind task and the tactical strategy task. This was explored in more detail in Chapter 6. The role of social factors in children's tactical guessing strategies is explored in Chapter 4. Chapter 5 reports an experiment designed to consider the role of inhibitory control in tactically strategic guessing behaviour.
The location guessing game: A procedure for assessing the development of tactical strategy in children

In Chapter 3, the results of one experiment are reported. Experiment 1 employed a novel methodology in order to assess the development of tactically strategic guessing behaviour. This procedure was designed to consider whether participants in a competitive condition would adapt their game playing strategy in anticipation of a change in their opponent's game playing strategy. Thus, one of the objectives of Experiment 1 was to provide a formal demonstration of the type of anticipatory switches in guessing strategy that were anecdotally reported by Shultz and Cloghesy (1981; Section 1.1.2 Chapter 1). It was possible to consider changes in participants' game playing behaviour that occurred independently of changes in their opponent's behaviour, because the game playing strategy of the opponent (the experimenter) remained constant throughout the game (in contrast to previous studies, see Section 1.1, Chapter 1). Such anticipatory changes (switches) in guessing strategy would be indicative of tactically strategic behaviour because they suggest that children are using knowledge about the way in which their opponent is likely to behave in order to out-manoeuvre him or her.

EXPERIMENT 1: THE LOCATION GUESSING GAME

In Experiment 1, children played a five door location guessing game against the experimenter in either a competitive condition or a cooperative control condition. In each of a series of trials, they had to guess behind which one of five doors a sticker was hidden. Children played the game until they reached a criterion of five consecutively correct guesses. Unbeknown to the children, the sticker was hidden according to two predetermined, regular hiding sequences. These were chosen on the basis of previous research (DeVries, 1970; Gratch, 1964) to ensure that even the youngest children sampled would be able to learn them. The two hiding sequences were "same door" (e.g. door two, door two, door two etc.), which was followed by "alternate door" (e.g. door
one, door three, door one, door three etc.). The same hiding sequences were employed in both playing style conditions. These children were also given a second order false belief test.

The critical difference between the cooperative and competitive playing style conditions was whether children were competing against the experimenter. In other respects the two conditions were similar, for example, the same hiding sequences were used. Tactical strategy is only expected in competitive situations. A comparison between playing style conditions thus allows the contribution of tactical strategy to game performance to be evaluated.

The regular hiding sequence employed by the experimenter for both playing style conditions would be expected by a mature player in the cooperative condition, but not in the competitive condition. It might be predicted that this violated expectation of normal competitive behaviour may result in greater trials taken to reach criterion in the competitive condition than in the cooperative condition. This could occur for any of the following reasons. 1 Once they have worked out their opponent's hiding sequence, children in the competitive condition may be more likely to make anticipatory switches in guessing strategy than their counterparts in the cooperative condition. These anticipatory switches may be due to an expectation that their opponent is about to change the hiding sequence. Deviations from the correct hiding sequence would lead to increased trials to criterion. Alternatively, 2 children in the competitive condition may simply expect a more complex hiding sequence than those in the cooperative condition. This may lead to greater trials to criterion because they are more reluctant to guess in a simple way. Alternatively, 3 once they have worked out their opponent's hiding sequence, children in the competitive condition may feel uncomfortable beating the experimenter and deviate from the correct hiding sequence.

A difference between the competitive and cooperative conditions at five consecutively correct trials could result from any of the above possibilities. This criterion was selected in order to be sensitive to not only the discovery of the correct hiding sequence but also any deviations from this sequence. Possibility 2 implies that children in the competitive condition take longer to initially discover the hiding sequence than those in the cooperative condition. Possibilities 1 and 3 both imply that children in the competitive condition learn the hiding sequence and then switch, but do
not differ from those in the cooperative condition in the number of trials taken to
discover the hiding sequence. The more liberal criterion of two consecutively correct
trials may help to distinguish 2 from 1 & 3, by being sensitive to the discovery of the
correct hiding sequence, but not switches. Children in the competitive condition would
be expected to take more trials to reach this more liberal criterion than their counterparts
in the cooperative condition under possibility 2, but not under possibilities 1 or 3.

Children may switch guessing strategy for different reasons. Possibility 1
suggests that strategy switching occurs as children anticipate that their opponent will
change the hiding sequence. Possibility 3 suggests that children switch strategy because
they feel uncomfortable beating the experimenter. Feedback in both playing style
conditions was dependent on the success or failure of the child in finding the hidden
object. In the competitive condition, finding the object resulted in negative feedback
from the experimenter: the experimenter was unhappy to be beaten. It is possible that
children who switch from guessing according to the hiding sequence do so because they
find this negative feedback unpleasant and do not want to upset the experimenter.
Children's behaviour over the game was observed in order to see if they appeared to be
unduly bothered by their game success at the expense of the experimenter's failure.

There are at least two accounts for anticipatory switches in guessing strategy
(possibility 1). A behavioural account would propose that children's switches could be
rule based. That is, children may change their guessing strategy because they expect
their opponent to block them, or make it difficult for them to find the hidden object.
However, children may understand game playing behaviour in terms of theory of mind
reasoning. Such a theory of mind account would propose that children switch guessing
strategy as a result of the second order mental state attribution that they think that their
opponent knows that they know the sequence. As a consequence of this mental state
attribution, children may expect the opponent to change the hiding behaviour.

If theory of mind reasoning underlies strategy switching, group associations
would be expected between performance on the location guessing game and
performance on a theory of mind task. Children who participated in Experiment 1 were

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6 Such observation was not conducted in a fully systematic manner because this was a post hoc rather than an a priori hypothesis. Any observations about children's behaviour were recorded during the game, along with the location at which the child guessed.
given a second order theory of mind task (Sullivan et al, 1994). Previous studies have shown that children can reliably attribute second order mental states to others from about the age of five (Leekam, 1991; Sullivan et al, 1994). Therefore, it was expected that children in the youngest age group tested would succeed on the Birthday Puppy task (i.e. from the age of five).

It should be noted that unless children verbally report theory of mind reasoning it is not possible to rule out the behavioural account. Such verbal report is unlikely because children find it hard to express verbally such theory of mind reasoning (see Chapter 1, Section 1.1.3; Flavell et al, 1968). Associations between switches in guessing strategy and false belief task competence can at best provide preliminary support for the theory of mind account of anticipatory switches in guessing strategy.

Predictions

A group of adults was included in the present experiment in order to consider the mature pattern of behaviour in the location guessing game. It was expected that those adults assigned to the competitive condition would take more trials to criterion than those assigned to the cooperative condition (the playing style effect).

The game playing behaviour of two groups of children was considered in Experiment 1: 5- & 6-year-olds, and 7- & 8-year-olds. On the basis that children aged 6-years guess in an irregular manner in a simple two choice guessing game (DeVries, 1970; Gratch, 1964, Section 1.1.1, Chapter 1), it might be predicted that all of the children in the present experiment would be able to implement a tactical guessing strategy. This would be demonstrated if children assigned to the competitive condition took more trials to criterion than those in the cooperative condition, and if possibility 3 were excluded.

It is hard to predict the number of trials that participants in the cooperative condition may take to reach criterion. This is dependent on the number of trials taken to discover the hiding sequence. This may be influenced by the children's age: it is possible that older children and adults may discover the hiding sequence in fewer trials than the younger children. In addition, because the same door sequence is simpler, it may be discovered in fewer trials, thus reducing the number of trials taken to reach criterion in the cooperative condition in these trials. What is of particular interest is the comparison of trials to criterion over the two playing style conditions.
Table 3.1: Summary of predictions made by three main accounts of competitive vs cooperative effect

<table>
<thead>
<tr>
<th></th>
<th>5 trials criterion playing style effect</th>
<th>2 trials criterion playing style effect</th>
<th>Undue discomfort</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Anticipatory</strong></td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td><strong>Strategy Switching</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2 Expect complex</strong></td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td><strong>sequence</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3 Negative Feedback</strong></td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Strategy Switching</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1 summarizes the different predictions made by the three main accounts discussed in the introduction. In addition, if children understand game playing behaviour in terms of theory of mind reasoning, an association would be expected between strategy switching and performance on the theory of mind task.

**Method**

**Participants**

The children were taken as an opportunist sample from an after school or holiday playscheme in central London. Forty five children participated in the study. However the data from five of these children were not included in the analysis. Three of these five children were excluded because they refused to complete the game and the two others were excluded because they claimed that they could hear where the experimenter was placing the hidden object, which meant that they were playing the game in a different manner to the other children. Forty children contributed data that were included in the analysis; ten from each age group in each condition. Twenty adults also served as participants, all of whom were students at the University of London. Table 3.2 presents the mean ages and the age range of participants in Experiment 1.
Figure 3.1: The five door location guessing game
Table 3.2: Mean age (and range) of participants in Experiment 1

<table>
<thead>
<tr>
<th>Group</th>
<th>Cooperative</th>
<th>Competitive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5- &amp; 6-year-olds</td>
<td>6yrs 2mths</td>
<td>6yrs 1 mth</td>
<td>6yrs 1mths</td>
</tr>
<tr>
<td></td>
<td>(5y6m to 6y11m)</td>
<td>(5y5m to 6y10m)</td>
<td>(5y5m to 6y11m)</td>
</tr>
<tr>
<td>7- &amp; 8-year-olds</td>
<td>8yrs 3mths</td>
<td>8yrs 6mths</td>
<td>8yrs 4mths</td>
</tr>
<tr>
<td></td>
<td>(7y2m to 9y5m)</td>
<td>(7y7m to 9y6m)</td>
<td>(7y2m to 9y6m)</td>
</tr>
<tr>
<td>Adults</td>
<td>20yrs 11mths</td>
<td>23yrs 7mths</td>
<td>22yrs 3mths</td>
</tr>
<tr>
<td></td>
<td>(19y0m to 28y0m)</td>
<td>(19y0m to 31y0m)</td>
<td>(19y0m to 31y0m)</td>
</tr>
</tbody>
</table>

Apparatus

The game was played using a five door box (see Figure 3.1) that was constructed from cardboard. The box was open at the back so that the experimenter could hide stickers in the back of the box without the participant seeing behind which door objects were placed. The box was 32 cm high, 56 cm wide and 29 cm deep. Five holes were cut into the front of the box, 16 cm high and 7.5 cm wide. Four strips of cardboard the same dimensions as the side of the box were placed inside the box to create five inner compartments, one for each door. The holes in the front of the box were covered by cardboard flaps, 21 cm high and 9 cm wide, which were attached at the top of each door and opened upwards. These were made distinctive by being covered in brightly coloured wrapping paper and were numbered 1, 2, 3, 4 and 5, from left to right (from the participant’s perspective). All numbers were 2 cm high and written on squares of white paper (3cm high x 3cm wide). The remainder of the box was covered with brown paper. All exposed surfaces of the apparatus were covered with transparent plastic protective wrapping.

A puppet Squirrel was used in order to maintain the participant’s motivation and to win the proceeds of the game. Brightly coloured circular stickers (1cm in diameter) were used as objects to hide. Stickers have been shown to be desirable things for which to compete in tasks administered to children (see, e.g. Peskin, 1992).
Procedure

Standard Procedure of the Location Guessing Game

Participants were randomly assigned to either the cooperative or the competitive playing style conditions. Each participant, irrespective of condition assignment, was asked if he or she would like to play a fun guessing game with the experimenter. The experimenter and the participant sat facing each other and the five door box was placed between the two, with the doors facing the participant. The participant was asked if he or she would like to help "Sammy Squirrel" to find stickers which were "his favourite things in the whole world", and he or she was then given the puppet to hold. The puppet was used to engage the participant's interest in the task. The experimenter explained that she would hide stickers behind one of the five doors and it was the participant's job to guess behind which door they were hidden. The description of the instructions to the adult participants was preceded by an explanation that the game was designed for children and that the instructions would therefore be childlike.

The participant was then given the particular instructions associated with the playing style condition to which he or she had been assigned. In the cooperative condition, the participant was told that because the experimenter really liked Sammy the Squirrel, she was going to try to make it really easy for the participant to win stickers so that the participant could win Sammy lots and lots of stickers. Thus, the participant and the experimenter had the same goal: to win stickers for Sammy. In the competitive condition, the participant was told that the stickers were also the experimenter's favourite thing in the whole world and therefore she was going to try to make it difficult for the participant to win stickers for Sammy so that she could keep them all for herself. Thus, the participant and the experimenter had different goals: the participant wanted to win stickers for Sammy and the experimenter wanted to win stickers for herself.

Directly following these instructions the participant was given four practice trials, irrespective of playing style condition, in order that playing competitively or cooperatively could be demonstrated. A two choice hand guessing task was employed (e.g. Gratch, 1964, see Chapter 1 Section 1.1.1). The participant was told that, in order to practice the game, the experimenter was going to hide an object in one of her hands and the participant had to guess in which hand it was hidden. Two practice trials were
"sure-win" (stickers hidden in both hands), followed by two "sure-lose" (no stickers hidden).

Feedback appropriate to the playing style condition accompanied the outcome of each trial. For example, in the cooperative condition, winning a sticker was accompanied by the comment "Wow, you've won another one" and the participant was encouraged to count the stickers that had been won, "You've won n stickers, that's really good. Shall we try and win some more?" Appropriate verbal responses were also provided to participants assigned to the competitive condition. For example, winning a sticker was accompanied by comments such as "You've won n stickers. That's no good you're beating me".

Participants assigned to both playing style conditions experienced the same hiding sequence and the same experience of winning and losing. The only difference between playing style conditions was the feedback relating to the goals of the experimenter. These practice trials were included in order that the participants were engaged in the cooperative or competitive nature of the game before starting the game proper.

Following the practice trials, the participant was told that now they were going to play the proper game and were reminded that the experimenter would hide the sticker behind one of the five doors and that the participant must guess where it was hidden. Five locations were chosen in order to allow ample freedom for choices that deviate from the correct sequence. Irrespective of playing style condition, after each trial in the location guessing game the participant received feedback concerning the location of the hidden object. If the participant guessed correctly, he or she lifted the flap covering the door and removed the sticker. If the participant guessed incorrectly, the experimenter reached into the space behind the door, picked up the sticker and pushed the flap open from behind, thus demonstrating to the participant that the sticker was behind that particular door. This was accompanied by an announcement of the correct door number, for example, "it was behind door 3". Verbal feedback appropriate to the playing style condition (as described for the practice game) continued to be provided throughout the game and appropriate happy, sad, determined encouraging, and fed-up faces were pulled.

Two hiding sequences, same door and alternate doors were used. For the same door trials the stickers were consistently hidden behind the same door until the
participant made five consecutively correct responses. For half of the participants the sticker was hidden behind door 2, and for the remainder the sticker was hidden behind door 4. For the alternate doors trials, the sticker was placed behind two doors alternately until criterion was reached. For half of the participants the sticker was hidden behind doors 2 and 4, and for the remainder it was hidden behind doors 1 and 3.

When a participant reached criterion in the same door trials, the participant was told that he or she was winning lots of stickers and was encouraged to count the stickers that he or she had won. Then the participant was told that the experimenter would try something new because the participant was getting so good at winning stickers. At that point the alternate doors trials began. On reaching criterion a second time the participant was again encouraged to count the stickers that he or she had won and was given a coloured star for participating in the experiment.

Theory of Mind task

After participating in the location guessing game, the two groups of children (but not the adults) were given Sullivan et al's (1994) second order false belief task. The full story and questions are reproduced in Appendix A. Within the context of a story about a surprise birthday present for a boy named Peter, it assesses children's ability to attribute second order ignorance (this requires children understanding whether Mum thinks that Peter knows what he is really getting for his birthday) and second order false belief (this requires children understanding that Mum falsely believes that Peter thinks he is getting a toy for his birthday) These questions are located in the story, along with a number of control questions which check that children understand the story and remember the key events (results for which are shown in Appendix B). If children answered the control questions incorrectly, they were corrected. The two test questions were administered firstly using an open-ended format, but if the child failed to answer they were given a forced choice version. The theory of mind task was not administered to the adults because research shows that children can correctly answer the task questions by the age of 5 or 6 years (see Chapter 2, Section 2.1.2). Therefore, it was expected that all of the adults, all of whom were university students, would correctly

7 No difference was found between the two same door or alternate door sequences on the number of trials to criterion in the cooperative and competitive conditions. Therefore, effects of door are not discussed further.
answer the task questions.

**Results**

*Location Guessing Game*

All of the children and adults seemed to enjoy playing the game. They appeared to enter into the spirit of the cooperative or competitive conditions (laughing when beating the competitive opponent etc.) and looked as if they enjoyed playing with the puppet.

*Alternate Door Trials*

**Trials to discover the hiding sequence**

Trials to discover the hiding sequence was the number of trials taken to make two consecutively correct guesses. Table 3.3 presents mean trials to discover the hiding sequence for each group in the alternate door trials. These data appear to indicate that there were no differences between playing style conditions for any of the age groups. These impressions were supported by the analysis.

A two factor between subjects ANOVA with age group and playing style condition (cooperative or competitive) as factors was conducted on the data. There was a main effect of age group, $F(1,54)=5.911, p=.005$. Neither the main effect of playing style condition, $F(1,54)=1.214, p=.215$, nor the interaction, $F<1$, were significant. Following the main effect of age group, post hoc Tukey's (HSD) tests revealed that the adults took fewer trials to discover the hiding sequence than both the 5- & 6-year-old children, $p=.008$, and the 7- & 8-year-old children, $p=.017$.

A priori simple main effects were conducted, at each age group, to compare trials to discover the hiding sequence for the cooperative and competitive conditions. These indicated that there was no difference in the number of trials taken to discover the hiding sequence between playing style conditions for any of the three age groups (5- & 6-year-olds, $F(1,54)=2.33, p=.133$; 7- & 8-year-olds, $F<1$; adults, $F<1$).

These findings suggest that children assigned to the competitive condition do not take more trials to make two consecutively correct guesses than those in the cooperative condition. Thus, the data do not support possibility 2, which proposed that children assigned to the competitive condition would take more trials to discover the hiding sequence.

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8 For the validity of the analysis of simple effects in the absence of a significant interaction see Howell (1987, p.376).
sequence than those in the cooperative condition.

Table 3.3: Mean trials (SD) taken to discover the hiding sequence in the alternate door trials in Experiment 1

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Cooperative</th>
<th>Competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>5- &amp; 6-year-olds</td>
<td>6.6 (2.59)</td>
<td>8.2 (3.39)</td>
</tr>
<tr>
<td>7- &amp; 8-year-olds</td>
<td>7.1 (1.97)</td>
<td>7.3 (3.2)</td>
</tr>
<tr>
<td>Adults</td>
<td>5.0 (.67)</td>
<td>5.2 (.42)</td>
</tr>
</tbody>
</table>

Trials to criterion

Trials to criterion was the number of trials required to make five consecutively correct guesses. The number of trials taken to reach criterion was designed to be sensitive to switches in guessing strategy. Children assigned to the competitive condition were expected to take more trials to reach criterion than those in the cooperative condition.

Figure 3.2 presents mean trials to criterion for each group in the alternate door trials. These data appear to indicate that participants of all ages required more trials to reach criterion if they were assigned to the competitive condition than those assigned to the cooperative condition, but the 7- and 8-year-old children seem to show the largest difference between conditions.

A two factor between subjects ANOVA with age group and playing style condition as factors was conducted on the transformed data (trials to criterion$^{15}$). This transformation was selected by using the procedure described by Box and Cox (1964) in order to achieve homogeneity of variance$^{10}$. Overall, more trials to criterion were

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9 A similar analysis was conducted for each of the experiments in which the playing styles manipulation was included (Experiments 2, 3, 4, 6, & 7). In none of these experiments did children assigned to the competitive condition take more trials to discover either the alternate door or same door hiding sequences than those in the cooperative condition.

10 In all of the experiments in which a transformation was necessary, the data were checked after the appropriate transformation had been conducted to ensure that the transformation successfully achieved homogeneity of variance.
Figure 3.2: Mean trials to criterion (±SE) in the alternate door trials, by age group and playing style condition in Experiment 1.
taken by those participants assigned to the competitive condition than those assigned to the cooperative condition, $F(1,54)=14.887$, $p=.001$. A statistically significant main effect of age, $F(1,54)=15.822$, $p=.001$, indicated that the age groups reached criterion in differing numbers of trials. Although the difference in mean trials to criterion between playing style conditions appeared bigger for the 7- and 8-year-old children than the two other groups, the interaction between age group and playing style condition did not reach statistical significance, $F<1$.

*A priori* simple main effects were conducted, at each age group, to compare trials to criterion for the cooperative and competitive conditions. These simple main effects indicated that both 7- and 8-year-old children, $F(1,54)=9.78$, $p=.003$, and adults, $F(1,54)=5.33$, $p=.025$, who were assigned to the competitive condition took significantly more trials to reach criterion than those from the same age groups who were assigned to the cooperative condition. No statistically significant effect of playing style condition was found for the 5- and 6-year-old children, $F(1,54)=1.55$, $p=.219$.

Following the main effect of age group, post hoc Tukey's (HSD) tests were conducted to examine the effect of age on overall trials to criterion. These revealed that differences between the adults and both groups of children were responsible for this main effect. Collapsing the data over the cooperative and competitive conditions showed that the adults tended to reach criterion in fewer trials than both the 5- and 6-year-old children, Tukey's test, $p=.001$, and the 7- and 8-year-old children, Tukey's test, $p=.001$.

**Pre-criterion runs of consecutively correct guesses**

A complementary way of assessing switches in guessing strategy is to consider the presence of pre-criterion runs of consecutively correct guesses over the cooperative and competitive conditions. This is used to examine further the guessing behaviour that leads to an increased number of trials to criterion for participants in the competitive condition. A pre-criterion run was defined as a run of two, three or four consecutively correct guesses that did not form part of the criterion run of five consecutively correct guesses. Children who spontaneously switch guessing strategy would be both more likely to make pre-criterion runs and take more trials to reach criterion than those who do not switch guessing strategy.
A combined analysis of the results of several experiments was conducted and is reported here. Meaningful patterns in pre-criterion runs cannot be uncovered in any single experiment due to a small number of observations and the frequency nature of this data. However, the data for Experiment 1, as well as those for the other experiments included in the combined analysis, are reported by experiment in Appendix C.

**Combined analysis of pre-criterion runs**

The pre-criterion runs data was combined across Experiments 1, 2, 3 and 4. Using the trials to criterion analyses as an indicator of strategy switching, participants were grouped according to whether or not they switched strategy in the alternate door trials. That is, participants from the four experiments who, as an age group, took significantly more trials to criterion if they were assigned to the competitive condition than those assigned to the cooperative condition were categorised as switchers, while those groups who took a similar number of trials to criterion regardless of the playing style condition to which they were assigned were categorised as non-switchers. Data for the alternate door trials are presented here: participants were grouped as switchers or non-switchers separately for the alternate door and same door trials.

In the alternate door trials of Experiments 1, 2, 3, and 4 there were 7 groups of participants assigned to the competitive condition who did switch strategy\(^{11}\) and 3 groups of participants who did not\(^{12}\). Table 3.4 presents the frequency of participants making pre-criterion runs by those assigned to the competitive condition in Experiments 1, 2, 3 and 4, who switched and who did not switch guessing strategy, and those in the cooperative condition in Experiments 1, 2, 3 and 4. The frequency of participants making runs in these conditions is reported as a function of the number of trials that participants took to reach criterion.

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\(^{11}\) These were the 7- & 8-year-old children and the adults in Experiment 1; the 7- & 8-year-old children in Experiment 2; the 5- & 6-year-old children in Experiment 3; the 7- & 8-year-old children in the same door→alternate door condition of Experiment 4; the 5- & 6-year-old and 7- & 8-year-old children in the alternate door only condition of Experiment 4.

\(^{12}\) These were the 5- & 6-year-old children in Experiment 1; the 5- & 6-year-old children in Experiment 2; the 5- & 6-year-old children in the same door→alternate door condition in Experiment 4.
Table 3.4: Frequency of pre-criterion runs made by participants in the competitive condition in the alternate door trials, by playing style condition, switches and trials to criterion

<table>
<thead>
<tr>
<th>Condition</th>
<th>Runs</th>
<th>&lt;11</th>
<th>11-14</th>
<th>15-18</th>
<th>19-22</th>
<th>&gt;22</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switchers</td>
<td>no runs</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>N=70</td>
<td>1 run or more</td>
<td>2</td>
<td>15</td>
<td>7</td>
<td>6</td>
<td>28</td>
<td>58</td>
</tr>
<tr>
<td>% 1 run or more</td>
<td></td>
<td>14</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>83</td>
</tr>
<tr>
<td>Non-Switchers</td>
<td>no runs</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>N=30</td>
<td>1 run or more</td>
<td>1</td>
<td>8</td>
<td>9</td>
<td>1</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>% 1 run or more</td>
<td></td>
<td>25</td>
<td>73</td>
<td>82</td>
<td>33</td>
<td>0</td>
<td>63</td>
</tr>
<tr>
<td>Cooperative</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=100</td>
<td>no runs</td>
<td>44</td>
<td>13</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>63</td>
</tr>
<tr>
<td>1 run or more</td>
<td></td>
<td>8</td>
<td>11</td>
<td>11</td>
<td>5</td>
<td>2</td>
<td>37</td>
</tr>
<tr>
<td>% 1 run or more</td>
<td></td>
<td>15</td>
<td>46</td>
<td>69</td>
<td>83</td>
<td>100</td>
<td>37</td>
</tr>
</tbody>
</table>

The data presented in the Total column of Table 3.4 suggest that the majority (63%) of the participants assigned to the cooperative condition in Experiments 1, 2, 3 and 4 made no pre-criterion runs in the alternate door trials. That is, the guessing behaviour of the majority of the children assigned to this condition was characterised by a run of consecutively correct guesses straight to criterion with no deviation, once they had started to guess according to the hiding sequence.

Participants in the competitive condition of Experiments 1, 2, 3, and 4 appeared to be more likely to make pre-criterion runs of successful guesses if they switched guessing strategy than if they did not switch guessing strategy (strategy switching assessed by the trials to criterion analysis). Overall (again, considering the Total column), a large proportion of those participants who switched guessing strategy made one or more pre-criterion runs (83%), while the proportion of participants who made one or more pre-criterion runs was smaller for the group who did not switch (63%). These
impressions were supported by a Chi-squared test, which revealed a significant relationship between the switcher categorisation and the presence of pre-criterion runs, $\chi^2(1, N=100)=4.52, p=.034$.

The finding that a higher frequency of children who were categorised as switchers made pre-criterion runs than those who were not categorised as switchers was not simply an artefact of greater trials to criterion taken by the former. This is best illustrated by looking at the frequencies of children taking 11-14 and 15-18 trials to criterion (i.e. columns 2 and 3, Table 3.2). A similar number of children from the competitive (both switchers and non-switchers) and cooperative conditions reached criterion within these ranges. However, a greater proportion of these children who were in the competitive condition and categorised as switchers made pre-criterion runs than those in the competitive condition and categorised as non-switchers, and those in the cooperative condition.

**Verbal comments**

Only a few children made spontaneous verbal comments during the game and these comments did not clearly differentiate between those assigned to cooperative or competitive conditions. Comments tended to concern the regularity of the hiding sequence: for example, "It's a pattern, 2,4,2,4" or "I've worked out the pattern". None of the children reported that the motivation for a switch in guessing strategy came from them thinking that the opponent knew that they knew the hiding sequence. This is consistent with research which indicates that children do not begin to articulate complex mental state attributions until adolescence (e.g. Flavell et al, 1968; see Chapter 1, Section 1.1.3).

**Same Door Trials**

*Trials to discover the hiding sequence*

Trials to discover the hiding sequence was the number of trials taken to make two consecutively correct guesses. Table 3.5 presents mean trials to discover the hiding sequence for each group in the same door trials. These data appear to indicate that there were no differences between playing style conditions for any of the age groups. These impressions were supported by the analysis.

A two factor between subjects ANOVA with age group and playing style condition as factors was conducted on the data. Neither of the main effects of age group
or playing style condition, nor the interaction were significant (in each case, $F<1$).

*A priori* simple main effects were conducted, at each age group, to compare trials to discover the hiding sequence for the cooperative and competitive conditions. These indicated that there was no difference in the number of trials taken to discover the hiding sequence between playing style conditions for any of the three age groups (in each case, $F<1$).

These findings suggest that children assigned to the competitive condition do not take more trials to make two consecutively correct guesses than those in the cooperative condition. Thus, the data do not support possibility 2, which proposed that children assigned to the competitive condition would take more trials to discover the hiding sequence than those in the cooperative condition.

*Table 3.5: Mean trials (SD) taken to discover the hiding sequence in the same door trials in Experiment 1*

<table>
<thead>
<tr>
<th></th>
<th>Cooperative</th>
<th>Competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>5- &amp; 6-year-olds</td>
<td>5.0</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>(.94)</td>
<td>(1.51)</td>
</tr>
<tr>
<td>7- &amp; 8-year-olds</td>
<td>5.8</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>(1.48)</td>
<td>(1.34)</td>
</tr>
<tr>
<td>Adults</td>
<td>5.4</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>(1.71)</td>
<td>(.79)</td>
</tr>
</tbody>
</table>

*Trials to criterion*

Findings for the same door trials, which preceded the alternate door trials, showed a different pattern of results to those found in the alternate door trials. Figure 3.3 presents the mean trials to criterion for each group. These data appear to indicate that 5- & 6-year-old children and 7- & 8-year-old children, but not adults, took more trials to reach criterion if they were assigned to the competitive condition than those assigned to the cooperative condition. Furthermore, it seems that overall, participants took fewer trials to reach criterion in the same door trials than in the alternate door trials.

A between subjects ANOVA with age group and playing style condition was
Figure 3.3: Mean trials to criterion (±SE) in the same door trials, by age group and playing style condition in Experiment 1
conducted on the transformed data (trials to criterion\textsuperscript{1,5}). This transformation was selected using the procedure described by Box and Cox (1964) to achieve homogeneity of variance. This revealed a main effect of playing style condition; overall, participants assigned to the competitive condition took significantly more trials to reach criterion than those assigned to the cooperative condition, $F(1,54)=4.403$, $p=.041$. Neither the main effect of age group, $F(1,54)=2.478$, $p=.093$, nor the interaction, $F<1$, reached statistical significance.

Although the ANOVA showed that participants assigned to the competitive condition tended to take more trials to reach criterion than those assigned to the cooperative condition, the data presented in Figure 3.3 suggests that a sub-set of the participants, the 5- and 6-year-old and the 7- and 8-year-old children, may be responsible for this main effect. A priori simple main effects of playing style condition revealed that, when the three age groups were considered separately, children assigned to the competitive condition did not take significantly more trials to reach criterion than those assigned to the cooperative condition. The simple main effects were not statistically significant for either the 5- and 6-year-old children, $F(1,54)=1.983$, $p=.165$; the 7- and 8-year-old children, $F(1,54)=2.42$, $p=.126$; or the adults, $F<1$.

**Combined analysis of pre-criterion runs**

Meaningful patterns in pre-criterion runs in the same door trials over those who switched and did not switch guessing strategy are difficult to infer because, even when data were combined over Experiments 1, 2, 3 and 4, there were very few participants who switched guessing strategy in the same door trials. The trials to criterion analysis was again used as an indicator of whether participants switched guessing strategy in the same door trials. This resulted in one group of participants who did switch guessing strategy\textsuperscript{13} and 7 groups of participants who did not switch guessing strategy\textsuperscript{14}. The data for Experiment 1, as well as those for the other experiments included in the combined analysis, are reported by experiment in Appendix C. Table 3.6 presents the frequency of participants in the same door trials who made pre-criterion runs by competitive

\textsuperscript{13} This group was the 7- & 8-year-old children in the same door→alternate door condition in Experiment 4.

\textsuperscript{14} These were, the 5- & 6-year-old children, the 7- & 8-year-old children and the adults in Experiment 1; the 5- & 6-year-old and the 7- & 8-year-old children in Experiment 2; the 5- & 6-year-old children in Experiment 3; the 5- & 6-year-old children in the same door→alternate door condition in Experiment 4.
(switchers and non-switchers) and cooperative conditions. The frequencies of runs are grouped by the number of trials taken to reach criterion.

Table 3.6: Frequency of participants making pre-criterion runs of consecutively correct guesses in the same door trials, by playing style condition, switches and trials to criterion

<table>
<thead>
<tr>
<th>Condition</th>
<th>Runs</th>
<th>Trials to criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;11</td>
<td>11-14</td>
</tr>
<tr>
<td>Competitive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switchers</td>
<td>no runs</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>n=10</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>% 1 run or more</td>
<td>0</td>
</tr>
<tr>
<td>Non-Switchers</td>
<td>no runs</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>N=70</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>% 1 run or more</td>
<td>53</td>
</tr>
<tr>
<td>Cooperative</td>
<td>no runs</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>N=80</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>% 1 run or more</td>
<td>18</td>
</tr>
</tbody>
</table>

The data presented in the Total column of Table 3.6 suggest that the majority of participants in the cooperative condition in Experiments 1, 2, 3 and 4 (85%) made no pre-criterion runs in the same door trials. That is, the guessing behaviour of the majority of the children assigned to this condition was characterised by a run of consecutively correct guesses straight to criterion with no deviation, once they had started to guess according to the hiding sequence.

Of the few children that switched guessing strategy in the competitive condition, the majority made one or more pre-criterion run (70%). A smaller proportion of participants in the competitive condition who did not switch guessing strategy in the same door trials made pre-criterion runs (40%). However, a Fisher's Exact did not show
a statistically significant relationship between the switcher categorisation and the presence of pre-criterion runs, \( p = .095 \).

**Verbal comments**

Children's verbal comments in the same door trials did not discriminate over the cooperative and competitive conditions and there were few children who spontaneously commented on the task. Comments that were made tended to be reflections on the regularity of the sequence. For example "Why is it always in that one?", "You always put it there", "Is it going to be in door 3 all the time?", and "You can't put it there again, you always put it there".

**Theory of mind task**

Children performed well on all of the control questions of the second order theory of mind task (Sullivan et al, 1994). Details of children's answers to the control questions of this task are presented in Appendix B.

Table 3.7 presents the percentage of children in the different groups who correctly answered the second order ignorance question. Almost all of the 5- and 6-year-old and the 7- and 8-year-old children answered this question correctly. The majority of the children were correct when given the open ended format: only 25% failed to answer this format, and 69% of those who failed succeeded when given the forced choice version.

**Table 3.7: Percentage correctly answering second order ignorance question in Experiment 1**

<table>
<thead>
<tr>
<th>Group</th>
<th>Cooperative</th>
<th>Competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>5- and 6-year-olds</td>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>7- and 8-year-olds</td>
<td>100</td>
<td>90</td>
</tr>
</tbody>
</table>

**Table 3.8: Percentage correctly answering second order false belief question in Experiment 1**

<table>
<thead>
<tr>
<th>Group</th>
<th>Cooperative</th>
<th>Competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>5- and 6-year-olds</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>7- and 8-year-olds</td>
<td>90</td>
<td>100</td>
</tr>
</tbody>
</table>

The percentage of children who correctly answered the second order false belief
question is presented in Table 3.8. Almost all of the 5- and 6-year-old and the 7- and 8- year-old children correctly answered this question. The majority of the children succeeded when given the open ended format: only 30% failed to answer, but 50% of those succeeded when given the forced choice version.

Children were asked to justify their responses to the second order false belief question. The breakdown of their responses is shown in Appendix B. They did not perform well when asked to do this. For example, 22.5% of children refused to respond and very few children used second order reasoning either explicitly (10%) or implicitly (20%) in their answers. However, failure to answer these questions with reference to second order mental states is likely to be due to high verbal demands and a general shyness in front of the experimenter when questioned about a previous answer to a question.

Discussion

The results of Experiment 1 showed clear behavioural differences in guessing between cooperative and competitive conditions in the location guessing game. In the alternate door trials, both the 7- and 8-year-old children and the adults took more trials to reach a criterion of five consecutively correct guesses if they were assigned to the competitive condition than if they were assigned to the cooperative condition. There was no significant effect of playing style condition for the 5- and 6-year-old children. There was no effect of playing style condition in the same door trials for any of the age groups. There was no effect over playing style conditions for a more liberal criterion of two consecutively correct guesses in either the alternate door or the same door trials. All of the children performed well on the second order theory of mind task.

Three possibilities were proposed to explain why children in the competitive condition might take more trials to reach criterion (five consecutively correct guesses) than their counterparts in the cooperative condition. Possibility 1 proposed that the playing style effect occurred because children in the competitive condition make anticipatory switches in guessing strategy. Possibility 2 proposed that children in the competitive condition may take more trials to criterion because they expect a more complex sequence than those in the cooperative condition. This option suggested that children in the competitive condition would take more trials to initially discover the hiding sequence than their counterparts in the competitive condition. Possibility 3
proposed that the playing style effect was a result of switches in guessing strategy by children in the competitive condition, in common with possibility 1. However, in contrast to possibility 1, possibility 3 suggested that switches occurred because the negative feedback associated with success in the competitive condition made children feel uncomfortable pursuing the correct guessing pattern.

The following two sub-sections present a discussion of which of these three possibilities best characterizes the results of Experiment 1. This discussion considers children's performance in the alternate door trials, because it was in this condition that differences in guessing behaviour were observed over playing style conditions. The first subsection presents a discussion of results suggesting that the playing styles condition effect is not due to learning (possibility 2) but is indicative of switches in guessing strategy (possibility 1 and 3). The second subsection discusses children's behaviour in the game suggesting that switches in guessing strategy are anticipatory (possibility 1), rather than occurring in response to negative feedback (possibility 3). In the two subsequent subsections, age differences & children’s behaviour in the same door trials, and the role of theory of mind are discussed.

1) Does the effect of playing style condition assess switches in guessing strategy?

The analyses presented in the results section suggest that it is more likely that children in the competitive condition take more trials to reach criterion than those in the cooperative condition because they switch guessing strategy (possibilities 1 and 3), than because they take longer to initially discover the hiding sequence (possibility 2).

While older children and adults assigned to the competitive condition took more trials to reach a criterion of five consecutively correct guesses than their counterparts in the cooperative condition, such a difference was not found in the number of trials taken to a more liberal criterion of two consecutively correct guesses. Two consecutively correct guesses was argued to be sensitive to children's initial discovery of the hiding sequence. Thus, the results of Experiment 1 suggest that children in the competitive condition do not take longer to initially discover the hiding sequence. These findings were replicated in all of the five experiments in which the playing styles manipulation was employed. In neither Experiments 2, 3, 4, 6, nor 7 did children in the competitive condition take more trials to discover the hiding sequence than those in the cooperative condition. Therefore, these findings suggest that the playing styles effect occurs because
children in the competitive condition switch guessing strategy once they have initially
discovered the hiding sequence.

The analysis of pre-criterion runs of consecutively correct guesses supports the
argument that participants who took more trials to reach criterion in the competitive
condition than in the cooperative condition did so because they deviated from guessing
according to the experimenters hiding sequence. Participants who were categorized as
switching guessing strategy in the competitive condition on the basis of their trials to
criterion data were more likely to make pre-criterion runs than those who did not switch
guessing strategy in the competitive condition. This suggests that such participants who
took more trials to criterion in the competitive condition did indeed deviate from
guessing according to the experimenter's hiding sequence, while those who took fewer
trials to criterion (i.e. those in the cooperative condition, or those who did not switch)
did not deviate from the hiding sequence.

The pre-criterion runs analysis was not adopted as the measure of strategy
switching because the frequency level data are not as sensitive to switches in guessing
strategy as trials to criterion; statistically significant effects were only revealed when the
data from several experiments were pooled. In addition, a substantial minority (37%)
of participants assigned to the cooperative condition made pre-criterion runs. These may
have occurred as participants learned the hiding sequence. What is important is that the
observance of pre-criterion runs was more likely if participants were in the competitive
condition and switched guessing strategy, than if they were in the competitive condition
and did not switch guessing strategy or than if they were in the cooperative condition.

The comparison reported in the results section of data from children over these three
groups who took a similar overall number of trials to criterion suggests that an increase
in pre-criterion runs is not simply an artefact of increased trials to criterion.

2) Are switches in guessing strategy anticipatory or in response to negative feedback?

Informal observation of children's behaviour in the game suggests that children
do not switch guessing strategy to avoid upsetting the experimenter. During all of the
guessing game experiments a record was kept of any unusual behaviour or remarks. In
none of the experiments did any child appear upset or worried when they beat the
experimenter. Nor were any remarks recorded that would indicate such concerns. In
contrast, a more typical response was to appear delighted on beating the experimenter.
In addition, it seems unlikely that adults, who did switch guessing strategy in the competitive condition, would be unduly bothered by beating another adult. In order to totally exclude the negative feedback account a more formal assessment would be necessary, but the records of behaviour during the game make this account seem extremely unlikely. Thus, it is more plausible that switches in guessing strategy are anticipatory than in response to negative feedback.

3) Developmental trends in tactically strategic guessing behaviour and sensitivity of the procedure

The results of the present experiment suggest that children assigned to the competitive condition made anticipatory switches in guessing strategy in the alternate door trials from the age of 7 or 8. However, on the basis of previous research (DeVries, 1970; Gratch, 1964), it was expected that all of the children who participated in Experiment 1 would switch guessing strategy in the competitive condition. It is possible that the task procedure employed in Experiment 1 was not maximally sensitive to switches in guessing strategy in the younger children. There are a number of factors that may have influenced the sensitivity of the task for younger children particularly. For example, it is possible that the same door trials influenced the younger children's perception of the task as competitive. In addition, the task may have placed too great a load on working memory. Furthermore, it is possible that the younger children had difficulty switching guessing strategy because this required too great a level of inhibitory control. These possibilities are considered further in Chapters 4 and 5.

There was no playing style effect in the same door trials for any age group. It is possible that the same door trials were less sensitive than the alternate door trials to switches in guessing strategy because the same door hiding sequence was too simple for all three age groups. A comparison of whether the same door hiding sequence was easier to learn than the alternate door hiding sequence was made by comparing the number of trials to criterion in the cooperative condition over the two hiding sequence conditions. Comparisons are made in the cooperative condition because strategy switching is not expected in this condition and it therefore provides a more direct measure of learning. Participants in the cooperative condition took fewer trials to reach criterion in the same door trials than the alternate door trials. In the alternate door trials, participants took an average of 10.3 (SD=3) trials to reach criterion and an average of
9 (SD=3) trials to criterion in the same door trials. Similar results were found for participants from all three age groups, with the adults taking fewer trials overall. These findings suggest that the same door hiding sequence was marginally easier to discover and learn. It is possible that participants in the competitive condition did not switch guessing strategy in the same door trials because the simplicity of the hiding sequence undermined the competitive manipulation.

4) Are anticipatory switches in guessing strategy indicative of theory of mind reasoning?

The behavioural account of strategy switching proposes that children make anticipatory changes in their guessing strategy because, once they have discovered the hiding sequence, they expect their opponent to make it hard for them to find the hidden stickers. A theory of mind account proposes that anticipatory switches in guessing strategy occur because children think that their opponent knows that they know the hiding sequence. The results of the present experiment cannot distinguish between these accounts. Perhaps surprisingly, second order theory of mind appears to precede the ability to make anticipatory switches. All of the children could attribute second order mental states, but only the 7- and 8-year-old children switched guessing strategy. However, as discussed above, it is possible that the procedure used in Experiment 1 was not maximally sensitive to switches in guessing strategy for the younger children. In any case, associations between performance on the two tasks would provide, at best, supportive evidence that theory of mind reasoning was involved in tactical guessing strategy, because this would be only correlational evidence.

CONCLUSIONS

The results of Experiment 1 suggest that children make anticipatory switches in guessing strategy from the age of 7 or 8. However, it is possible that such tactically strategic behaviour was not observed in younger children because the location guessing game procedure employed in Experiment 1 was not maximally sensitive. A number of different factors may influence the sensitivity of the procedure. These factors are explored in the experiments reported in the next two chapters.
CHAPTER 4

Effects of task manipulations on children's tactically strategic guessing behaviour

The results of Experiment 1 suggested that children aged 7 and 8 make anticipatory switches in guessing strategy in the competitive condition of the location guessing game. In contrast, 5- and 6-year-old children did not show evidence of tactically strategic guessing behaviour, even though previous research might have predicted that they would (e.g. DeVries, 1970; Gratch, 1964). It was proposed in Chapter 3 that the location guessing procedure employed in Experiment 1 may not be maximally sensitive. The three experiments reported in this chapter were designed to modify the task parameters in different ways in order to demonstrate tactical guessing strategy in 5- and 6-year-old children.

Thus, Chapter 4 is essentially a methodological chapter which reports three attempts to adapt the task procedure for the benefit of young children. Experiments 2 and 3 were designed to reduce the general complexity of the location guessing game procedure and, in Experiment 4, potential age differences in the pragmatic understanding of the task as a competitive game were addressed. The ways in which these adaptations may have influenced children's reasoning are also discussed.

EXPERIMENTS 2 & 3: REDUCING BASIC TASK DEMANDS

Playing the location guessing game in both the cooperative and competitive playing style conditions requires that children discover and learn the hiding sequence. This could be considered to be the basic task demands for a successful game playing interaction. If children demonstrate a tactical guessing strategy in the competitive condition, they must satisfy these basic task demands and also reason in a tactical manner about their opponent's behaviour. Thus, the observance of a tactically strategic guessing behaviour could be argued to indicate that children have satisfied tactical or strategic task demands in addition to the basic task demands.
Satisfying both basic and tactical task demands may be difficult for younger children because both place demands on working memory resources that are limited in comparison to those available to older children. Reducing the basic task demands may make possible a redistribution of working memory resources such that the basic task demands require fewer processing resources. This may free working memory resources for the tactical task demands allowing younger children to reason strategically about their opponent's behaviour in a manner not previously possible. This "limited resources" account proposes that reducing the basic task demands would allow 5- and 6-year-old children to implement a tactical guessing strategy in the location guessing game.

The alternative account would argue that 5- and 6-year-old children do not demonstrate tactically strategic guessing behaviour in the location guessing game because they have not yet developed the ability to reason strategically about their opponent's behaviour. This "lack of understanding" account proposes that reducing the basic task demands would make no difference to 5- and 6-year-old children's ability to demonstrate a tactical guessing strategy, because they have not yet developed either the reasoning processes to be able to do so and/or sufficient social development of competition.

It is well established that children's processing capacity, or the efficiency with which it functions, increases with age (e.g. Brown, 1975; Case, 1985; Dempster, 1981; Guttentag, 1984; Kail, 1986; Whitney, 1986). There are many ways in which the basic task demands of the location guessing game could be reduced. Experiment 2 was designed to reduced the basic task demands by making the hiding sequence easier to learn by providing all of the children with memory aids for the location of the hidden object on earlier trials. In all other respects the design was the same as that used in Experiment 1. Experiment 3 was designed to reduce the basic task demands by reducing the number of doors over which the children must search for the hidden object.

The efficacy of the task manipulation in reducing the basic task demands can be assessed by comparing trials to criterion in the cooperative condition with the number of trials taken to reach criterion in the same condition in Experiment 1. A comparison was made in the cooperative condition, because strategy switching was not expected in this condition and therefore trials to criterion in the cooperative condition provide a more direct measure of ability to meet the basic task demands. If the task manipulation
successfully reduces the basic task demands, children assigned to the cooperative condition should reach criterion in fewer trials in the experiment with the procedural manipulation (Experiment 2 or 3), than in the experiment without the procedural manipulation (Experiment 1).

**EXPERIMENT 2: MEMORY AIDS**

Experiment 2 was designed to reduce the basic task demands by employing two memory aids. These memory aids were designed to make the hiding sequence easier to discover and learn. Research has shown that memory aids can help children to remember items more effectively and that children use such memory strategies from an early age (e.g. Baker-Ward, Ornstein & Holden, 1984; DeLoache, Cassidy & Brown, 1985; DeLoache & Todd, 1988; Justice, 1989; Kreutzer, Leonard & Flavell, 1975). Memory aids reduce task difficulty and the amount of processing resources necessary to complete a task successfully because they provide an external representation of aspects of the task that would otherwise be represented internally.

The memory aids used in the present experiment were intended to provide external representation of both the location of the hidden object on the trial previous to the current trial, and the location of the hidden objects over the whole game. These aids were expected to make it easier for children to detect the regular hiding sequences used by the experimenter.

In Experiment 2, children played the five door location guessing game in the same manner as that described in Chapter 3, with the following modifications to incorporate the two memory aids. The first memory aid provided a reminder of the locations at which the stickers were hidden over the entire game. One opaque plastic bowl was placed outside each of the five doors. On each trial one sticker was placed behind one of the five doors according to the hiding sequences defined in Experiment 1. However, after the child had guessed the location at which the sticker was hidden, the sticker was placed in the bowl in front of the door behind which it had been located. The second memory aid provided a reminder of the location at which the sticker was hidden on the previous trial. A freestanding red arrow was placed outside the door at which the sticker was last found.

Combining the information presented by both of these memory aids was expected to enable children to discover and learn the hiding sequence in fewer trials than
in Experiment 1. Two age groups of children participated in Experiment 2; 5- and 6-year-old children and 7- and 8-year-old children. The 7- and 8-year-old children were included in the present experiment to provide a replication of the basic effect.

**Predictions**

According to the lack of processing resources account, if the memory aids make learning the sequence easier than was the case in Experiment 1, and free sufficient working memory resources for the tactical/strategic task demands, 5- and 6-year-old children assigned to the competitive condition in the present experiment would show evidence of a tactical guessing strategy. That is, those assigned to the competitive condition would take more trials to criterion than those assigned to the cooperative condition.

Alternatively, according to the lack of understanding account, 5- and 6-year-old children assigned to the competitive condition in the present experiment would not show evidence of a tactical guessing strategy even if the memory aids make learning the sequence easier than was the case in Experiment 1. That is, those assigned to the competitive condition would not take more trials to criterion than those assigned to the cooperative condition.

If the memory aids make the hiding sequence easier to discover and learn, it would be expected that children assigned to the cooperative condition in the present experiment would take fewer trials to reach criterion than their counterparts who participated in Experiment 1.

**Method**

**Participants**

Forty-one children who attended a holiday playscheme in central London participated in the present experiment. The data from one of these children were excluded; this child admitted to cheating by looking while the experimenter was hiding the object, which implied that he was playing the game in a manner different to the other children. Forty children contributed data that were included in the analysis; ten from each age group in each condition. The mean ages and age range of these participants is presented in Table 4.1.
Table 4.1: Mean age (and range) of participants in Experiment 2

<table>
<thead>
<tr>
<th>Group</th>
<th>Cooperative</th>
<th>Competitive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5- and 6-year-olds</td>
<td>6yrs 3mths</td>
<td>6yrs 3mths</td>
<td>6yrs 3 mths</td>
</tr>
<tr>
<td></td>
<td>(5y6m to 6yllm)</td>
<td>(5y4m to 6yllm)</td>
<td>(5y4m to 6yllm)</td>
</tr>
<tr>
<td>7- to 9-year-olds</td>
<td>8yrs 8mths</td>
<td>8yrs 3mths</td>
<td>8 yrs 5mths</td>
</tr>
<tr>
<td></td>
<td>(7ylm to 9yllm)</td>
<td>(7y4m to 9y2m)</td>
<td>(7y1m to 9y11m)</td>
</tr>
</tbody>
</table>

**Apparatus**

The standard apparatus that was described in Chapter 3 was used in the present experiment, with two modifications to incorporate the two memory aids (see Figure 4.1). Firstly, a red cardboard arrow 10 cm high was employed as a marker. This was free-standing and on each trial the arrow was positioned in front of the door behind which the sticker was last found.

Secondly, a set of five transparent plastic bowls that provided the memory aid for the location of the hidden objects over the whole game were incorporated as follows. A strip of card the same length as the box, but extending 20 cm in front, was attached to the front of the box. The five bowls were secured on this card, one bowl in front of each door. After each trial, the hidden sticker was placed in the bowl outside the door behind which it was hidden. These bowls had a rim diameter of 8 cm, a bottom diameter of 6 cm and a depth of 5 cm. Lines were drawn from the box to the edge of the card separating each bowl from the next and making it clear outside which door the bowl was located. To further emphasise with which door each bowl was associated, the appropriate door number was written on the area of cardboard that extended in front of the bowl.

Two puppets were used when playing the game; Sammy the squirrel & Foxy fox.
Figure 4.1: Apparatus for Memory Aid Experiment. This shows the bowls placed in front of the doors and the freestanding arrow.
**Procedure**

**Location Guessing Game**

The standard procedure of the location guessing game that was described in Chapter 3 was used in the present experiment, with the following modifications to incorporate both the memory aids and an additional puppet to place the memory aid arrow. Children were given "Sammy the squirrel" for whom they would try to win stickers and were introduced to "Foxy fox", a puppet who was described as "Sammy the squirrel's best friend". Each child was told that Foxy wanted to help Sammy win stickers, and to do this he would remind Sammy where the object was last hidden. Foxy was able to do this because he had a red arrow that he was going to place outside the door where the sticker had last been hidden. For example, if the sticker was last hidden behind door one, the arrow would be placed in front of door one.

Foxy's help was incorporated into the playing styles manipulation. Foxy was always Sammy's helper, but his role with respect to the experimenter varied. In the cooperative condition, in which the experimenter wanted to help the child win stickers for Sammy, Foxy was described as helping both the child and the experimenter. However, in the competitive condition, in which experimenter and the child were in competition for stickers, Foxy was described as only helping the child to win stickers: he was not trying to help the experimenter at all. None of the children seemed to have a problem understanding that Foxy could help the child and not the experimenter, even though Foxy was on the end of experimenter's arm! Only one child asked “What if Foxy cheats?” and was told that Foxy would never ever cheat because he was a good honest fox.

Each child was told that after each trial the sticker would be placed in the bowl outside the door behind which it was hidden. This would lead to a build up of stickers outside particular doors. For example, if the alternate door sequence of doors one and three was used, the bowls outside doors one and three would gradually fill with stickers over the game.

Apart from these modifications the game was played in the same way as in Experiment 1: children were randomly assigned to either the cooperative or the competitive condition; four hand-guessing practice trials were played (two sure-win and
two sure-lose); and the same door hiding sequence was followed by the alternate door hiding sequence.

Theory of Mind task

After participating in the location guessing game, the children were given Sullivan et al’s (1994) second order theory of mind task. The full story and questions are reproduced in Appendix A.

Results

Location Guessing Game

All of the children seemed to enjoy playing the game. For both the alternate door trials and the same door trials, two analyses are reported. The first is the standard analysis of trials to criterion over playing style conditions and by age group that assesses the question of whether children switched guessing strategy in the location guessing game.

The second compares the number of trials taken to reach criterion over Experiments 1 and 2 for those children assigned to the cooperative condition. This assesses the efficacy of the memory aid in making the hiding sequence easier to discover and learn.
Figure 4.2: Mean trials to criterion (±SE) in the alternate door trials, by age group and playing style condition in Experiment 2
Alternate door trials

Trials to criterion over playing style conditions

Figure 4.2 presents the mean trials to criterion in the alternate door trials for each age group over the cooperative and competitive playing style conditions. These data appear to indicate results similar to those found in Experiment 1. It seems that 7- and 8-year-old children who were assigned to the competitive condition took more trials to reach criterion than those assigned to the cooperative condition. In contrast, there appears to be little difference in the number of trials taken to reach criterion by 5- and 6-year-old children assigned to the cooperative and competitive conditions. These impressions were supported by the analysis.

A two factor between subjects ANOVA with age group and playing style condition was conducted on the transformed data (trials to criterion\(^{1.5}\)). This transformation was selected by using the procedure described by Box and Cox (1964) in order to achieve homogeneity of variance. The analysis revealed a statistically significant main effect of playing style condition, \(F(1,36) = 5.0, p = .032\). Neither the main effect of age, \(F(1,36) = 1.899, p = .177\), nor the interaction, \(F(1,36) = 2.414, p = .129\), were statistically significant.

A priori simple main effects indicated that the effect of playing style condition was restricted to the older children. While 7- and 8-year-old children assigned to the competitive condition took more trials to reach criterion than those assigned to the cooperative condition, \(F(1,36) = 7.181, p = .011\), no difference in the number of trials taken to reach criterion by the 5- and 6-year-old children was found between the two playing style conditions, \(F < 1\).

Thus, despite the inclusion of memory aids, no evidence of children switching guessing strategy was found for the younger children. In order to investigate the question of whether the memory aids made the hiding sequence easier to discover and learn, a comparison was made between the number of trials taken to reach criterion by children who participated in the cooperative condition in the present experiment and those who participated in Experiment 1.
Figure 4.3: Mean trials to criterion ($\pm SE$) in the alternate door trials by children assigned to the cooperative condition, by age group and Experiments 1 and 2.
Trials to criterion in the cooperative condition in the present experiment and Experiment 1

Figure 4.3 presents mean trials to criterion in the alternate door trials for 5- and 6-year-old children and 7- and 8-year-old children in the cooperative conditions of Experiments 1 and 2. These data suggest that 5- and 6-year-old children who participated in Experiments 1 and 2 took a similar number of trials to criterion in both experiments.

In contrast, 7- and 8-year-old children who participated in the cooperative condition in the present experiment appear to have taken fewer trials to reach criterion than those who participated in the cooperative condition in Experiment 1. These impressions were supported by the analysis.

A two factor between subjects ANOVA with age group and Experiment (1 or 2) was conducted on the transformed data (a reciprocal squared transformation was suggested by the procedure described by Box and Cox (1964) to achieve homogeneity of variance). This revealed a significant main effect of Experiment: overall, children in the cooperative condition of the present experiment took significantly fewer trials to reach criterion than those who participated in the cooperative condition of Experiment 1, $F(1,36)=5.224, p=.028$. Neither the main effect of age group, $F(1,36)=3.385, p=.084$, nor the interaction, $F(1,36)=2.483, p=.124$, reached significance.

Although the interaction was not statistically significant, the data presented in Figure 4.3 suggests that the older children were responsible for the main effect of Experiment (Experiment 1 vs. Experiment 2). A priori simple main effects showed that the 7- and 8-year-old children who participated in the cooperative condition of the present experiment took significantly fewer trials to reach criterion than those who participated in the cooperative condition of Experiment 1, $F(1,36)=7.457, p=.01$. In contrast, no significant difference between Experiments was found in the number of trials taken to reach criterion by 5- and 6-year-old children, $F<1$.

These results suggest that the inclusion of the memory aids in the present experiment made the hiding sequence easier to discover and learn for the 7- and 8-year-old children, but that they did not have this effect for the 5- and 6-year-old children.
Figure 4.4: Mean trials to criterion (±SE) in the same door trials, by age group and playing style condition in Experiment 2
Figure 4.5: Mean trials to criterion (±SE) in the same door trials by children assigned to the cooperative condition, by age group and Experiments 1 and 2
**Same Door Trials**

*Trials to criterion over playing style conditions*

Figure 4.4 presents mean trials to criterion in the same door trials by age group and playing style condition. These data suggest that children assigned to the cooperative and competitive conditions reached criterion in a similar number of trials regardless of their age. These impressions were supported by the analysis.

A between subjects ANOVA with age group and playing style condition as factors was conducted on the transformed data (the procedure described by Box and Cox (1964) suggested a reciprocal cubed transformation to stabilise the variance). This revealed no statistically significant effects: age group, $F(1,36)=1.249, p=.271$; playing style condition, $F(1,36)<1$; interaction, $F<1$.

*A priori* simple main effects revealed that neither the 5- and 6-year-old children, $F<1$, nor the 7- and 8-year-old children, $F(1,36)=1.121, p=.297$, took significantly more trials to reach criterion if they were assigned to one playing style condition rather than the other.

*Trials to criterion in the cooperative condition in the present experiment and Experiment 1*

Figure 4.5 presents mean trials to reach criterion in the same door trials for both age groups of children in the cooperative conditions of Experiments 1 and 2. Inspection of these data suggests that 5- and 6-year-old children who were assigned to the cooperative condition took a similar number of trials to criterion in both experiments, while 7- and 8-year-old children appear to have taken fewer trials to reach criterion if they participated in the cooperative condition of the present experiment than if they participated in the cooperative condition of Experiment 1.

These impressions were supported by the analysis. A two factor between subjects ANOVA with age group and Experiment (Experiment 1 vs. Experiment 2) as factors was conducted. This revealed a main effect of age group, with the older children taking fewer trials to criterion overall than the younger children, $F(1,36)=9.101, p=.005$. The interaction between age group and Experiment approached significance, $F(1,36)=4.045, p=.052$. The main effect of Experiment was not significant, $F<1$.

However, *a priori* simple main effects revealed that 7- and 8-year-old children assigned to the cooperative condition in the present experiment took significantly fewer
trials to reach criterion than those assigned to the cooperative condition in Experiment 1, $F(1,36)=12.642, p=.001$. There was no significant difference between experiments in the number of trials taken to reach criterion for the 5- and 6-year-old children, $F<1$.

**Theory of Mind task**

Children performed well on the control questions of the second order theory of mind task (Sullivan et al, 1994). A full breakdown of their performance is presented in Appendix D.

Table 4.2 presents the percentage of children who correctly answered the second order ignorance question. As expected, these data indicate that almost all of the children (95%) correctly answered this question. Seventy five per cent of children responded correctly to the open ended test question; of the 25% who did not respond to this question format, 60% succeeded when required to answer a forced choice question about the story character's second order ignorance.

Table 4.3 presents the percentage of children who correctly answered the second order false belief question. These data indicate that all of the children correctly answered this question. Sixty per cent of children answered correctly when given the open ended test question; all of the 40% of children who did not respond to this question format succeeded when given the forced choice format.

The large majority of children tested in the present experiment and in Experiment 1 have successfully answered the second order ignorance and second order false belief questions. Therefore, in the remaining experiments the birthday puppy task was not administered unless a group of children younger than the age of 5 was tested.

**Table 4.2: Percentage correctly answering second order ignorance question in Experiment 2**

<table>
<thead>
<tr>
<th>Group</th>
<th>Cooperative</th>
<th>Competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>5- and 6-year-olds</td>
<td>100</td>
<td>90</td>
</tr>
<tr>
<td>7- and 8-year-olds</td>
<td>100</td>
<td>90</td>
</tr>
</tbody>
</table>
Table 4.3: Percentage correctly answering second order false belief question in Experiment 2

<table>
<thead>
<tr>
<th>Group</th>
<th>Cooperative</th>
<th>Competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>5- and 6-year-olds</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>7- and 8-year-olds</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Discussion

The results of Experiment 2 showed similar behavioural differences in guessing between the cooperative and competitive playing style conditions to those found in Experiment 1. While 7- and 8-year-old children assigned to the competitive condition switched guessing strategy in the alternate door trials, 5- and 6-year-old children did not. During the same door trials there was no evidence of switches in guessing strategy in either age group.

These results suggest that, in the alternate door trials, the older children made anticipatory switches in guessing strategy, while the younger children did not. None of the children showed evidence of tactically strategic guessing behaviour in the same door hiding sequence condition. The role of the same door hiding sequence was considered in more detail in Experiment 4, which manipulated its inclusion in the location guessing game procedure.

The results of Experiment 2 present a number of issues for discussion that are considered here. Firstly, the effectiveness of the memory aids at making the hiding sequence easier to discover and learn is discussed. Secondly, developmental differences in the efficacy of the memory aids are considered. Thirdly, developmental trends in tactical guessing strategy suggested by the results of Experiment 2 are discussed.

1) Were the memory aids effective?

The inclusion of the two memory aids in the procedure of the location guessing game did not facilitate 5- and 6-year-old children's discovery and application of the hiding sequences. When trials to criterion in the cooperative condition were compared, 5- and 6-year-old children who participated in Experiment 2 took a similar number of trials to reach criterion in the same door and alternate door hiding sequence conditions as their same age counterparts in Experiment 1. Therefore, the attempt to reduce basic task demands was not successful in the case of the 5- and 6-year-old children.
In contrast, the memory aid manipulation did facilitate 7- and 8-year-old children’s discovery and learning of both the same door and alternate door hiding sequences. When trials to criterion in the cooperative condition were compared, 7- and 8-year-old children who participated in Experiment 2 took fewer trials to reach criterion in both hiding sequence conditions than their same age counterparts in Experiment 1. Therefore, the attempt to reduce the basic task demands was successful for the 7- and 8-year-old children.

2) Developmental differences in the effectiveness of the memory aids

It is possible that the memory aids were not beneficial to the 5- and 6-year-old children because there was insufficient emphasis concerning the importance and value of the memory aids. Research has shown that younger children need more encouragement to use memory aids than older children (e.g. Beal & Fleisig, 1987; Ritter, 1978). For example, in a spatial memory task, 8-year-old children were found to employ a memory aid spontaneously, 5-year-old children did so only after the experimenter had strongly suggested that it would be a good strategy to use a memory aid, while 3-year-olds either did not use a memory aid at all, or only after persistent instruction (Ritter, 1978). Children in the present experiment were instructed about the benefit of the memory aid (they were told that the arrow "shows you where the object was hidden on the last trial" and that the bowls "show you where the object has been hidden over the whole game"), but it remains a possibility that this was not sufficient encouragement for 5- and 6-year-old children to make strategic use of them.

It is also possible that the younger children were more confused by the role of the puppet, Foxy, in providing the memory aid, and were therefore less willing to trust the information that Foxy provided. Thus, the finding that this memory manipulation did not help the younger children does not preclude the possibility that some other manipulation would help them.

However, rather than continuing with memory aids in order to try to find the correct level of emphasis necessary for their use, the next experiment pursues an alternative way of reducing basic task demands that is less likely to be influenced by developmental trends in children’s use of memory strategies.

3) Developmental trends in tactically strategic guessing behaviour

The results of the present experiment suggest a similar developmental trend in
tactically strategic guessing behaviour to that found in Experiment 1. That is, in the alternate door trials, 7- and 8-year-old children showed evidence of a tactical guessing strategy but 5- and 6-year-old children did not. This could be argued to indicate that 5- and 6-year-old children have yet to develop the ability to reason strategically about the behaviour of their opponent (the "lack of understanding" account). However, because the memory aid manipulation was not successful, it remains possible that the particular task parameters prevent 5- and 6-year-old children from demonstrating tactical strategy (the "limited processing resources" account).

The results of Experiment 2 do not discriminate between the lack of understanding account and the limited processing resources account. The lack of understanding account predicted that 5- and 6-year-old children would not switch guessing strategy regardless of whether the memory aids effectively reduced basic task demands. The limited processing resources account predicted that 5- and 6-year-old children would switch guessing strategy if the basic task demands were reduced. Because basic task demands were not reduced, Experiment 2 does not favour either account. Therefore, Experiment 3 included a different task manipulation to reduce basic task demands.

All of the children were able to attribute second order mental states. However, only the 7- and 8-year-old children showed evidence of a tactical guessing strategy. If theory of mind reasoning underlies tactical strategy, associations between performance on the two tasks would be expected. This was not the case in the present experiment. However, the memory aid manipulation was not successful for the younger children and therefore it still remains a possibility that 5- and 6-year-old children did not show evidence of tactical strategy because the basic task demands were too great.

**EXPERIMENT 3: THREE DOORS**

Experiment 3 was designed to reduce the basic task demands required to discover and learn the hiding sequences by reducing the number of doors in the location guessing game. The number of doors was reduced from five to three, but the hiding sequences remained the same. Reducing search options in this way, effectively changes the target to distractor ratio from 1:4 to 1:2. In the five door location guessing game on any given trial there is one target location (that contains the hidden object) and four distractor locations (potential hiding locations that do not in fact contain the hidden
object). If the number of doors is reduced to three, on any one trial there would be one target location and only two distractors. Reducing the number of distractor locations in this way was expected to make the hiding sequences easier to discover and learn because it results in less information to process and remember.

Research using other tasks has shown that reducing the target to distractor ratio results in better task performance. For instance, in letter cancellation tasks in which the participant must search amongst an array of letters for examples of a target letter, fewer errors were made and the task was completed faster when there were fewer distractor letters (e.g. Geldmacher, 1996; 1998; Geldmacher & Hills, 1997; McCormack, 1974; Schneider & Fisk, 1982).

Apart from reducing the number of doors from five to three, the design of the present experiment was the same as that used in Experiment 1. However, because switching strategy in the competitive condition has been well established for 7- and 8-year-old children (in Experiments 1 and 2), only children aged 5- and 6-years participated in the present experiment.

**Predictions**

The limited processing resources account would predict that, if reducing the number of doors makes the sequence easier to learn than was the case in Experiment 1, and frees sufficient working memory resources for the tactical task demands, 5- and 6-year-old children assigned to the competitive condition should switch guessing strategy in the present experiment. This would be demonstrated by those assigned to the competitive condition taking more trials to reach criterion than those assigned to the cooperative condition.

Alternatively, the lack of understanding account would predict that 5- and 6-year-old children assigned to the competitive condition would not switch guessing strategy in the present experiment, even if reducing the number of doors makes the sequence easier to learn than was the case in Experiment 1, because they have not yet developed the ability to reason strategically about the behaviour of their opponent. Failure to switch guessing strategy would result in no effect of playing style condition on trials to criterion.

If reducing the number of doors made the hiding sequence easier to discover and learn, it would be expected that children assigned to the cooperative condition of the
present experiment would take fewer trials to reach criterion than those assigned to the cooperative condition of Experiment 1.
Figure 4.6: The three door location guessing game
Method

Participants

Twenty children aged 5- and 6-years of age who attended a school in Southend-on-Sea, Essex participated in the experiment; ten in each condition. Table 4.4 presents the mean age and age range of these children.

Table 4.4: Mean age and age range of participants in Experiment 3

<table>
<thead>
<tr>
<th></th>
<th>Cooperative</th>
<th>Competitive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>6yrs 1mth</td>
<td>5 yrs 11mth</td>
<td>5yrs 11mth</td>
</tr>
<tr>
<td>Range</td>
<td>(5y8m to 6y6m)</td>
<td>(5y8m to 6y5m)</td>
<td>(5y8m to 6y6m)</td>
</tr>
</tbody>
</table>

Apparatus

The three door location guessing game was similar to the five door game used in Experiments 1 and 2. The apparatus was constructed from cardboard (see Figure 4.6). The box was open at the back so that the experimenter could hide stickers in the back of the box without the child seeing behind which door the stickers were placed. The box was 22cm high, 32cm wide and 23cm deep. Three holes were cut into the front of the box, 12cm high and 6.5cm wide. Two strips of cardboard the same dimensions as the side of the box were placed inside to create three inner compartments, one for each door.

The holes in the front of the box were covered by cardboard flaps, 15cm high and 9cm wide, which were attached to the top of each door and opened upwards. These were made distinctive by being covered in brightly coloured wrapping paper and were numbered 1, 2 and 3 going from left to right (from the child’s perspective). All numbers were 2cm high and written on rectangles of white paper (4cm high x 3cm wide). All exposed surfaces of the apparatus were covered with transparent plastic protective wrapping. The puppet Squirrel was again used in order to maintain the child's motivation and stickers were used as objects to hide.

 Procedure

The standard location guessing game procedure described in Experiment 1 was used, with the following exceptions: Three doors were employed instead of five (a reduction in the unused distractor doors from three to one); and only 5- and 6-year-old children were tested. For the alternate door hiding sequence the stickers were hidden alternately behind doors 1 and 3 and for the same door hiding sequence the sticker was
hidden behind door 2.
Figure 4.7: Mean trials to criterion (±SE) in the alternate door trials by playing style condition in Experiment 3
Figure 4.8: Mean trials to criterion ($\pm SE$) in the alternate door trials by children assigned to the cooperative condition in Experiments 1 and 3
Results

Alternate door trials

Trials to criterion over playing style conditions

Figure 4.7 presents mean trials to criterion in the alternate door trials by playing style condition. These data suggest that playing style condition influenced trials to criterion in these 5- and 6-year-old children. An independent t-test confirmed that children assigned to the competitive condition took significantly more trials to reach criterion that those assigned to the cooperative condition, \( t(9.59) = 4.423, p = .001 \) (Levene's test for equality of variances was significant, \( p = .001 \), therefore equal variances were not assumed).

Trials to criterion in the cooperative condition in the present experiment and Experiment 1

In order to consider the question of whether reducing the number of locations from five to three made the hiding sequence easier to discover and learn, a comparison was made between the number of trials taken to reach criterion by children in the cooperative condition of the present experiment and those 5- and 6-year-old children who served in the cooperative condition in Experiment 1.

Figure 4.8 presents mean trials to criterion in the alternate door trials by children assigned to the cooperative condition in the present experiment and in Experiment 1. The data presented in Figure 4.8 suggest between experiment differences in mean trials to criterion by those who participated in the cooperative conditions. An independent t-test was confirmed that 5- and 6-year-old children who participated in the present experiment took fewer trials to reach criterion than those who participated in the Experiment 1, \( t(12.668) = 3.28, p = .006 \) (Levene's test for equality of variances was significant, \( p = .018 \), therefore equal variances were not assumed). Thus, these results suggest that reducing the number of locations from five to three made the hiding sequence easier to discover and learn for 5- and 6-year-old children.
Figure 4.9: Mean trials to criterion(±SE) in the same door trials, by playing style condition in Experiment 3
Figure 4.10: Mean trials to criterion ($\pm SE$) in the same door trials by children assigned to the cooperative condition in Experiments 1 and 3
**Same door trials**

*Trials to criterion over playing style conditions*

The data presented in Figure 4.9 suggest that children took a similar number of trials to criterion in the same door trials regardless of the playing style condition to which they were assigned. An independent *t*-test supported this impression. No significant difference was found in the number of trials taken to reach criterion by children assigned to the cooperative or competitive conditions, *t*(18) = 1.446, *p* = .165 (Levene's test for equality of variance was not significant, *p* = .228, therefore, equal variances were assumed).

*Trials to criterion in the cooperative condition in the present experiment and Experiment 1*

The data presented in Figure 4.10 suggest that the 5- and 6-year-old children who were assigned to the cooperative condition and participated in the present experiment took a similar number of trials to criterion as those who were assigned to the cooperative condition and participated in Experiment 1. This impression was supported by an independent *t*-test, which revealed no statistical difference between the number of trials taken to reach criterion by 5- and 6-year-old children who participated in Experiment 1 and those who participated in the present experiment, *t*(18) = 0.293, *p* = .773 (Levene's test for equality of variance was not significant, *p* = .214, therefore equal variances were assumed).

**Discussion**

The results of Experiment 3 showed that, for the first time in the experiments presented in this thesis, 5- and 6-year-old children assigned to the competitive condition took more trials to reach criterion than those assigned to the cooperative condition. This effect of playing style condition was observed in the alternate door trials. Children's game playing behaviour in the same door trials was consistent with that observed previously: children in the cooperative and competitive conditions took a similar number of trials to reach criterion.

These results present two issues that are discussed here. The first point considers the influence of the door manipulation on developmental trends in tactically strategic guessing behaviour in the present experiment. The second considers children's
performance in the same door trials, in which the door manipulation had no effect on children's use of a tactical guessing strategy.

1) The influence of the door manipulation on developmental trends in tactical strategy

These results suggest that 5- and 6-year-old children in the present experiment made anticipatory changes in guessing strategy in the alternate door trials. This is similar to the age at which tactical guessing strategies have been reported in the literature (DeVries, 1970; Gratch, 1964). Again, evidence of a tactical guessing strategy was not forthcoming when the same door hiding sequence was used. The role of the same door hiding sequence was examined further in Experiment 4.

These results are consistent with the limited processing resources account. Reducing the number of hiding locations from five to three appears to have reduced basic task demands by facilitating children's discovery and learning of the alternate door hiding sequence. When trials to criterion in the cooperative condition were compared, children in the present experiment took fewer trials to criterion in the alternate door trials than their same age counterparts in Experiment 1. These results suggest that 5- and 6-year-old children are able to instigate a tactical guessing strategy when the general complexity of the task is sufficiently low.

2) Performance in the same door trials

Evidence of tactically strategic guessing behaviour was not observed in the same door trials in common with Experiments 1 and 2. Furthermore, reducing the number of doors did not make the same door hiding sequence easier to discover and learn: a comparison of trials to criterion in the cooperative condition found that children in the present experiment took a similar number of trials to criterion in the same door trials as their same age counterparts in Experiment 1.

It is possible that the manipulation of task parameters in the present experiment and in Experiment 2 did not make the same door hiding sequence easier to discover and learn because a ceiling in the number of trials taken to learn this sequence has been reached. In the present experiment, children took an average of 8.4 trials (SD=1.8) to reach criterion in the same door trials. This means that children made an average of 3.4 guesses (8.4 - 5) before embarking on the run of five consecutively correct trials that form the criterion. It seems plausible that three (or around three) may be the minimum number of trials necessary to discover the same door hiding sequence. If this were the
case, manipulating task parameters would not result in children discovering and learning the same door sequence in fewer trials.

Anticipatory switches in guessing strategy have not been observed in any age group when the same door hiding sequence was used. In Experiment 4 the presence of the same door trials were manipulated in order to consider any differential effect that this may have on the two age groups.

**EXPERIMENT 4: EFFECT OF SAME DOOR TRIALS ON ALTERNATE DOOR TRIALS**

In the experiments reported so far in this thesis, neither children nor adults have made anticipatory switches in guessing strategy in the same door hiding sequence condition. In the discussion of Experiment 1 it was considered that the contradiction between the competitive instructions and the seemingly highly non-competitive same door hiding sequence may undermine the competitive manipulation. That is, because children take very few trials to work out that the experimenter continuously hides the object in the same location and the sequence involves only one location, they may be unconvinced that their opponent is playing competitively. This may explain why children do not show evidence of a tactically strategic guessing behaviour in the same door trials.

In addition, children's experience in the same door trials may influence the way in which they perceive the alternate door trials, which may in turn influence whether they use a tactical guessing strategy in the alternate door trials. The carry over effect of the same door trials may be moderated by the age of the children. That is, it may have the effect of undermining the competitive manipulation completely for younger children, in both the same door and alternate door trials. In contrast, the effect of the same door trials on the competitive manipulation for the older children may be restricted to the same door trials.

The results of Experiment 3 imply that any age-specific carry over effect of the same door trials that undermines the competitive manipulation in the alternate door trials may be specific to versions of the game with more than three doors. In the three door version of the game employed in Experiment 3, 5- and 6-year-old children showed
evidence of tactical strategy in the alternate door trials, although the alternate door trials were preceded by the same door trials. It is possible that either a manipulation of the working memory processing resources or a manipulation of children's pragmatic understanding of the game would be sufficient to enable 5- and 6-year-old children to switch guessing strategy. The five door location guessing game was employed in Experiment 4 in order to examine age-specific effects of the same door trials on children's tactical strategy in the alternate door trials.

Age moderated social experience is proposed as an explanation of why the same door trials may differentially influence whether children from the two age groups tested demonstrate tactically strategic guessing behaviour. The location guessing game procedure requires children to play against an adult experimenter. Adults have different expectations of children of different ages and often moderate their behaviour according to the age of the child. This extends to game playing. The different expectations that adults have of children may be mirrored by children of different ages having varied experiences and expectations of the way in which adults play competitively.

Adults tend to moderate the effort that they put into winning according to the age of the child. Adults are more likely to let younger children win a game than they are to let older children win a game. In addition, younger children's experience of winning easily often occurs despite the adult protesting that he or she is going to beat them. For example, when adults play "chase" with small children, they often run after the child shouting, "I'm going to get you!", while the child escapes despite the adult's superior speed. In contrast, older children may have more experience of adults playing the opponent more seriously.

Such different age-related expectations of competitive games may lead children of different ages to interpret the easy-to-learn same door trials differently, which in turn may influence their interpretation of the alternate door trials in different ways. In the same door trials, children discover and learn the sequence in a few trials. In light of their prior game playing experience, 5- and 6-year-old children may view the location guessing game as one in which the experimenter is going to let them win, regardless of what the experimenter says. Thus, they may not expect their opponent to change hiding sequence as a result of successful guesses. They would therefore not be expected to switch guessing strategy in the same door trials. Success in the same door trials is likely
to do nothing to discourage the view that the location guessing game is a game that the experimenter is willing to lose, or is not trying hard to win. If children were to maintain this view during the alternate door trials they would also be expected not to switch guessing strategy in the alternate door trials.

In contrast, it is possible that 7- and 8-year-old children may think that the experimenter used the same door sequence to try to fool them concerning her competitive intentions. With that section of the game over, they may expect the competitive opponent to really try to beat them.

Experiment 4 was designed to test formally the question of whether the inclusion of the same door trials influences strategy switching in the alternate door trials differently for 5- and 6-year-old children and 7- and 8-year-old children. In other respects, the design was the same as that employed in Experiment 1. In the standard condition, the two hiding sequences employed in Experiment 1 were used; the alternate door sequence was preceded by the same door sequence. In the alternate door only condition, the alternate door sequence was not preceded by the same door sequence. In the alternate door only condition, the alternate door sequence was not preceded by the same door sequence.

Predictions

The manipulation conducted in Experiment 4 was not designed to reduce basic task demands (which was the aim of Experiments 2 and 3). Therefore, predictions concerning the effect of the same door trials on the ease with which children reach criterion in the cooperative condition of the alternate door trials are not clear. It is possible that the same door trials in the standard condition may alert children to the regularity of the sequences. This may enable them to discover and learn the alternate door hiding sequence in fewer trials than if the alternate door trials were not preceded by the same door trials (alternate door only condition).

Alternatively, removing the same door trials may have no effect on children's ability to discover and learn the alternate door hiding sequence. This alternative would predict that the number of trials taken to reach criterion in the alternate door trials in the cooperative condition of the standard condition would not differ from those taken in the cooperative condition of the alternate door only condition.

If, when 5- and 6-year-old children take part in the location guessing game, the same door trials undermine the competitive manipulation for the alternate door trials, removing the same door trials should result in 5- and 6-year-old children assigned to the
competitive condition switching guessing strategy in the alternate door trials in the five
door location guessing game. This would be demonstrated, for the alternate door only
condition, by those in the competitive condition taking more trials to reach criterion than
those in the cooperative condition.

In contrast, if, when 5- and 6-year-old children take part in the location guessing
game, the same door trials do not undermine the competitive manipulation for the
alternate door trials, removing the same door trials would have no effect on 5- and 6-
year-old children's strategy switching in the alternate door trials. Failure to switch
guessing strategy would be demonstrated if playing style condition did not influence
trials to criterion.

Seven- and eight-year-old children assigned to the competitive condition are
expected to switch guessing strategy in the alternate door trials regardless of the
presence of the same door trials. That is, those assigned to the competitive condition
were expected to take more trials to reach criterion than those assigned to the
cooperative condition.

**Method**

*Participants*

Eighty children who attended a school in south east London participated in the
experiment; ten from each age group in each condition. Table 4.5 presents mean age and
age range for the participants in the present experiment.

*Table 4.5: Mean ages (and range) of participants in Experiment 4*

<table>
<thead>
<tr>
<th>Group</th>
<th>Standard Sequences</th>
<th>Alternate Door only</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative</td>
<td>Competitive</td>
<td></td>
</tr>
<tr>
<td>5- &amp; 6-year-olds</td>
<td>5yrs 7mths (5y1m to 6y1m)</td>
<td>5yrs 7mths (5y3m to 6y0m)</td>
<td>6yrs 2mths (6y0m to 6y4m)</td>
</tr>
<tr>
<td>7- &amp; 8-year-olds</td>
<td>7yrs 11mths (7y6m to 8y6m)</td>
<td>8yrs 2mths (7y10m to 8y6m)</td>
<td>8yrs 2mths (7y7m to 8y9m)</td>
</tr>
</tbody>
</table>
**Apparatus**

The standard five door apparatus, puppet and stickers described in Experiment 1 were used.

**Procedure**

The standard procedure was used, with the modification that the sequences used to hide the object were varied. Children were shown either the standard hiding sequences of same door followed by alternate door, or the alternate door sequence alone.
Figure 4.11: Mean trials to criterion (±SE) in the alternate door trials, by hiding sequence condition, age group and playing style condition in Experiment 4
Results

Alternate Door Trials

Figure 4.11 presents mean trials to criterion by playing style condition for each combination of age group and hiding sequence condition (standard sequences or alternate door only). The data presented in this figure suggest that the results for the standard hiding sequence replicate those found previously (in Experiments 1 and 2). Five- and six-year-old children seem to take a similar number of trials to criterion when assigned to either cooperative or competitive playing style conditions, but 7- and 8-year-old children who were assigned to the competitive condition seem to take more trials to criterion than those assigned to the cooperative condition.

In contrast, the data for the alternate door only hiding sequence condition suggest that children from both age groups who were assigned to the competitive condition took more trials to reach criterion than those assigned to the cooperative condition. These impressions were supported by the analysis.

A three factor between subjects ANOVA with age group, playing style condition and hiding sequences as factors was conducted on the transformed data (reciprocal square root transformation). This transformation was selected using the procedure described by Box and Cox (1964) in order to achieve homogeneity of variance. This revealed that, overall, children assigned to the competitive condition took more trials to criterion than those assigned to the cooperative condition, $F(1,72)=44.87, p<.001$.

In addition, children assigned to the alternate door only condition took more trials to criterion than those assigned to the standard hiding sequence condition, $F(1,72)=14.937, p<.001$. The main effect of age group was not significant, $F<1$. A significant interaction was found between age group and playing style condition, $F(1,72)=11.46, p=.001$, suggesting that 5- and 6-year-old children showed smaller differences between playing style conditions than the 7- and 8-year-old children.

Neither of the other two-way interactions reached significance. This significant interaction between age group and playing style condition should be interpreted in light of a three-way interaction between age group, playing style condition and hiding sequence condition which approached significance, $F(1,72)=3.21, p=.077$. This is consistent with the 5- and 6-year-old children failing to show evidence of a playing style
effect in the standard trials condition.

Four a priori simple main effects were conducted to compare the number of trials taken to reach criterion by children assigned to the cooperative and competitive conditions at each combination of age group and type of hiding sequence. These revealed that, in the alternate door trials, the 7- and 8-year-old children assigned to the competitive condition took significantly more trials to criterion than those assigned to the cooperative condition, for those assigned to standard hiding sequence condition, $F(1,72)=40.125, p<.001$, and for those assigned to the alternate door sequence only condition, $F(1,72)=14.214, p<.001$. These children were not influenced by the hiding sequence manipulation.

However, although 5- and 6-year-old children assigned to the standard hiding sequence condition showed no evidence of a playing style condition effect, $F(1,72)=1.290, p=.260$, of the 5- and 6-year-old children who were shown the alternate door sequence alone, those assigned to the competitive condition took significantly more trials to criterion than those assigned to the cooperative condition $F(1,72)=4.769, p=.032$. Five- and six-year-old children were thus influenced by the hiding sequence manipulation.

Trials to criterion in the cooperative condition by hiding sequence conditions

The data presented in Figure 4.11 suggest that the same door trials make the alternate door hiding sequence easier to learn for the 7- and 8-year-old children, but not for the 5- and 6-year-old children. Five- and six-year-old children assigned to the cooperative condition reached criterion in a similar number of trials both when the same door trials preceded the alternate door trials ($M=14.2, SD=4.7$) and when they did not ($M=15.9, SD=5.1$), $F<1$. In contrast, 7- and 8-year-old children assigned to the cooperative condition took fewer trials to reach criterion when the alternate door trials were preceded by the same door trials ($M=9.4, SD=1.6$), than when they experienced the alternate door trials alone ($M=14.5, SD=2.8$), $F(1,72)=4.422, p=.039$. 

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Figure 4.12: Mean trials taken to reach criterion (±SE) in the same door trials, by age group and playing style condition in the standard hiding sequence condition of Experiment 4.
Same Door Trials

Figure 4.12 presents mean trials to criterion by age group and playing style condition for those children who participated in the standard hiding sequences condition. These data suggest that 5- and 6-year-old children took a similar number of trials to criterion in the two playing style conditions, but 7- and 8-year-old children assigned to the competitive condition appear to have taken more trials to criterion than those assigned to the cooperative condition.

A Box and Cox (1964) diagnostic plot did not suggest a transformation that would stabilise the variances. A two factor between subjects ANOVA of the untransformed data with age group and playing style condition as factors revealed a main effect of playing style condition, $F(1,36)=4.816, p=.035$. Neither the main effect of age group, $F<1$, nor the interaction between age group and playing style condition, $F<1$, reached significance.

A priori simple main effects of playing style condition at each age group revealed that 7- and 8-year-old children assigned to the competitive condition took significantly more trials to reach criterion that those assigned to the cooperative condition, $F(1,36)=5.024, p=.031$. However, there was no statistical difference between the two playing style conditions in the number of trials taken to criterion by 5- and 6-year-old children, $F<1$.

Discussion

The results of Experiment 4 show a clear age difference in the effect of the same door trials on anticipatory switches in guessing strategy in the alternate door trials. If the same door sequence preceded the alternate door sequence (standard condition), 7- and 8-year-old children assigned to the competitive condition switched guessing strategy in the alternate door trials, but 5- and 6-year-old children did not. This replicated the results found in Experiments 1 and 2. However, if the same door trials were removed (alternate door only condition), both 5- & 6- and 7- & 8-year-old children assigned to the competitive condition switched guessing strategy in the alternate door trials.

In the same door trials, younger children showed no evidence of a tactical guessing strategy, but evidence of a tactical guessing strategy was observed in the older children. In previous experiments, no evidence of a tactical guessing strategy had been
found during the same door trials. However, the trend has always been for children in the competitive condition to take more trials to criterion than children in the cooperative condition in the same door trials. It is possible that the effect size of the playing style comparison is small, and not sufficiently robust to yield statistically significant findings regularly.

These results show that both age groups of children made anticipatory changes in guessing strategy in the alternate door trials, but the 5- and 6-year-old children did so only when the same door trials were removed. Removing the same door trials did not allow the 5- and 6-year-old children to demonstrate tactically strategic guessing behaviour by making the alternate door hiding sequence easier to learn. Of those 5- and 6-year-old children assigned to the cooperative condition, those who did not experience the same door hiding sequence took a similar number of trials to reach criterion in the alternate door trials to those who did experience the same door sequence.

However, the inclusion of the same door trials made the alternate door sequence easier to discover and learn for older children. Of those 7- and 8-year-old children assigned to the cooperative condition, those who did not experience the same door hiding sequence took significantly more trials to reach criterion in the alternate door trials than those who experienced the alternate door trials alone. The same door trials may have enabled older children to discover and learn the alternate door sequence in fewer trials by alerting them to the regularity of the hiding sequences used by the experimenter.

These results suggest that the same door trials do not influence 5- and 6-year-old children's performance in the alternate door trials by influencing their ability to discover and learn the alternate door sequence. What then, underlies the effect of these same door trials on 5- and 6-year-old children's strategy switching in the alternate door trials?

It was proposed in the introduction to this experiment that an effect of the same door trials that was moderated by age may occur because the same door trials lead children of different ages to have a different pragmatic understanding of the location guessing game as a competitive task.

Age differences in pragmatic understanding of the location guessing game may be due to developmental differences in the type of experience of games. Children of different ages have different experiences of playing games with adults which may
influence their reasoning in this game. Younger children may be more familiar than older children with adults letting them win. Their experience of winning in the same door trials may have completely undermined the competitive manipulation. It is possible that the experience of easy success in the same door trials confirmed a prior expectation for 5- and 6-year-old children that adults do not always set out to win when they say they will.

In contrast, the same door trials may not have undermined the competitive instructions for the older children. They may have interpreted the same door trials as part of a ploy. That is, at the end of the same door trials they may have considered that the real game was about to start, and they may have viewed the same door trials as a ploy to lull them into a false sense of security that the experimenter was playing easy, when really she was about to try to beat them. Such expectations would be consistent with the competitive manipulation for the older children. The role of social experience in the development of tactical strategy is considered further in Chapter 8 (Section 8.5).

**GENERAL DISCUSSION**

The findings of the experiments reported in the present chapter suggest that the five door location guessing game procedure with both same door and alternate door hiding sequences employed in Experiment 1 was not maximally sensitive for the demonstration of tactically strategic guessing behaviour in young children. The experiments reported in this chapter showed that, under certain conditions, 5- and 6-year-old children demonstrated anticipatory switches in guessing strategy in the alternate door trials of the game.

Two manipulations of the task parameters enabled 5- and 6-year-old children to demonstrate tactically strategic guessing behaviour. These were reducing the basic task demands by reducing the number of doors (Experiment 3), and removing the same door hiding sequence but maintaining the number of doors at five. Either one of these factors was found to have sufficient influence on children's guessing behaviour to allow the demonstration of tactical strategy. The influence of these factors is discussed in turn.

**Working memory load**

Experiments 2 and 3 were designed to reduce the basic task demands necessary to discover and learn the alternate door hiding sequence. The results of these experiments suggest that the difficulty of the basic task demands influenced whether
children were able to apply their strategic competence. Five- and six-year-old children were able to implement a tactical guessing strategy (Experiment 3), but if their behaviour was assessed in a context in which it was harder to discover and learn the hiding sequence (as measured by trials to criterion in those assigned to the cooperative condition), they did not do so (Experiments 1 & 2). The three door version of the location guessing game is more sensitive than the five door version. Therefore, the three door version of the game was employed when assessing the tactical strategies of younger children (see Experiment 6, Chapter 6).

These findings support the argument that 5- and 6-year-old children have the capacity to implement tactically strategic guessing behaviour, but that limited processing resources can influence their ability to demonstrate such behaviour. Thus, the results of Experiments 1 to 3 are better described by the limited processing resources account than the lack of understanding account.

Developmental improvements in working memory may have allowed the 7- and 8-year-old children, but not the 5- and 6-year-old children, to process both the basic and strategic task demands in the five door location guessing game employed in Experiment 1. The 7- and 8-year-olds discovered and learned the hiding sequence (basic task demands) and satisfied the strategic task demands and switched guessing strategy. Working memory processing resources are known to improve over the age range from 5 to 8 in terms of capacity, or the effectiveness with which capacity is employed. For example, Dempster (1981) found that 5-year-old children had a memory span that could hold around 4 numbers or between 3 to 4 letters, while 8-year-old children could recall between 5 to 6 numbers or 4 letters.

Pragmatic understanding of the game

In an investigation separate from those examining the effects of doors (Experiment 4), it was found that removing the same door trials had a potent effect on 5- and 6-year-old children's tactically strategic guessing behaviour in the alternate door trials. Removing these trials overcame the lack of sensitivity of the five door version of the location guessing game in assessing tactical strategy in 5- and 6-year-old children (Experiment 4, alternate door only condition).

The interpretation of the effect of the same door trials on the tactical/strategic reasoning of 5- and 6-year-old children is based on the proposal that children's
perception of adults as competitors in games may change with age and that this influences the behaviour that they expect their opponent to demonstrate. Five- and six-year-old children's performance in the alternate door trials may have been influenced by the presence of the same door trials, while the 7- and 8-year-old children's performance was not, because the younger children may have a prior expectation that adults do not always set out to win when they say they will, and their experience of winning easily in the same door trials confirmed this. The finding that 7- and 8-year-old children were not influenced by the same door trials suggest that they might see these trials as a strategic ploy by the experimenter, indicating that they may be capable of more sophisticated expectations and reasoning than that measured in this game.

The proposal that 5- & 6-year-old and 7- & 8-year-old children differ in pragmatic understanding of the location guessing game does not imply that 5- and 6-year-olds cannot and do not perceive an adult experimenter as an opponent in any competitive situation. Their behaviour in tasks such as the box tasks (Sodian 1991, 1994; Sodian & Frith, 1992; see Chapter 1, Section 1.3), and Experiment 3 in this thesis, suggest that they can. Instead, the present proposal maintains that their perceptions of adults as competitors may be more easily undermined than those of older children. However, no research of which I am aware, has addressed children's developing perceptions of adults as competitors. Selman (1980) had children play games against an adult experimenter (to learn the task) before playing with other children, but no comment was made on any differences in the playing behaviour of children when faced with opponents of different ages.

There may be a range of factors that influence children's perception of the adult experimenter and the game as competitive. For example, the familiarity of the adult opponent may influence children's perception of the opponent as competitive. Younger children's expectation that an adult opponent may let them win may be greater if the adult is familiar to them. In the experiments reported in this thesis the adult experimenter had minimal interaction with the children, for example, by spending time in the classroom prior to testing. This meant that she was fairly unfamiliar to the children, but familiarity could be easily manipulated.

Alternatively, increased familiarity may increase children's perception of the opponent as competitive. Younger children may feel more comfortable playing
competitively with a familiar adult and familiarity may magnify the competitive manipulation with the result that 5- and 6-year-old children may demonstrate an understanding of tactical deception in conditions in which they have not previously done so. In addition, children's behaviour when playing against other children, rather than adults, could be explored.

A further way of changing children's perception of the game as competitive could be to manipulate the motivation to win. For example, changing the object that is hidden may increase the competitive perception of the game. If children played for a resource that they and their opponent particularly valued, they may be more competitive themselves and expect greater competitiveness from their opponent. This would increase the expectation of strategy change and may increase the likelihood that children make anticipatory changes in guessing strategy. Moreover, if children played the game to win something for themselves, rather than for a puppet, the competitive nature of the game may be enhanced. These are interesting research questions concerning children's developing perceptions of the social world that could be pursued further.

Removing the same door trials has revealed a more sensitive procedure that could be used with younger children and potentially with atypical populations, for example, children with autism. In future experiments in this thesis the same door hiding sequence is not employed. Considering the behaviour of younger children in the location guessing game may enable elucidation of the relationship between children's tactically strategic behaviour in games and theory of mind as measured by false belief tasks.

The locus of working memory and pragmatic effects

It has been suggested that reducing the number of doors freed processing resources for the strategic task demands and omitting the same door hiding sequence removed the opportunity for children to reinterpret the game as non-competitive. With one or other of these manipulations in place, 5- and 6-year-old children assigned to the competitive condition demonstrated a tactical guessing strategy.

However, the experiments reported in this chapter do not assess which cognitive processes may be involved with these effects. It is possible that the reduction in processing demands allowed children to inhibit their current, successful guessing strategy and switch to a novel guessing strategy. In contrast, it is possible that omitting
the same door trials influenced children's understanding of the game as competitive, rather than allowing them to inhibit their behaviour. The possibility that these manipulations of task parameters influenced children's ability to inhibit and switch guessing strategy is considered in the next chapter.

Tactical guessing strategy and theory of mind

It was suggested earlier in this thesis that tactically strategic behaviour may involve theory of mind reasoning (Chapters 1, 2 & 3). Specifically in the location guessing game, the theory of mind account suggests that children switch guessing strategy because they think that their opponent knows that they have worked out the hiding sequence. In the competitive context of the game, children may understand that their opponent does not want them to know the sequence and this may lead them to anticipate a change in hiding sequence. The experiment reported in Chapter 6 investigates further the relationship between theory of mind and tactical strategy by considering the game playing behaviour of younger children who pass or fail a second order theory of mind test.

CONCLUSIONS

The experiments reported in this chapter suggest that children are able to implement tactically strategic guessing behaviour from the age of 5 or 6. The success of the manipulation of task parameters in enabling 5- and 6-year-old children to employ a tactical guessing strategy support the argument that the procedure employed in Experiment 1 was not maximally sensitive. Processing resources and pragmatic factors appear to have contributed to 5- and 6-year-old children's failure to implement a tactical guessing strategy in Experiment 1. The question of whether the task parameters manipulated in this chapter influenced children's ability to inhibit their current guessing strategy and adopt a novel guessing strategy is considered in Chapter 5.
Inhibition in an adapted location guessing game

The experiments reported in Chapter 4 showed that two changes to the task parameters of the location guessing game employed in Experiment 1 enabled 5- and 6-year-old children to show tactically strategic guessing behaviour. These two manipulations were; reducing the number of doors from five to three and removing the same door hiding sequence. The present chapter reports one experiment designed to assess whether these two manipulations enabled 5- and 6-year-old children to make anticipatory switches by enabling them to inhibit and change a successful guessing strategy.

Evidence suggesting that inhibitory control plays a role in children's deception (in addition to theory of mind reasoning) was reviewed in Chapter 2 (Section 2.2.2) and a brief review of these arguments can inform the hypothesized role of inhibition in the location guessing game. Many deception tasks require children to point deceptively in order to mislead an opponent about the location of a hidden object (Hughes & Russell, 1993; Russell et al, 1994; Russell et al, 1991; Sodian, 1991, 1994; Sodian & Frith, 1992). It has been argued that pointing towards a desired object is a prepotent response; a response that is well-rehearsed and reinforced (Carlson et al, 1998). Children may fail to deceive because they do not have sufficient control over their behaviour and are unable to inhibit the prepotent response of indicating the object of their desire and refer away from that object (e.g. Russell et al, 1994; see Section 2.2.2, Chapter 2).

It could be argued that children's failure to switch guessing strategy occurs because they find it difficult to inhibit their current (successful) guessing strategy (which could be a prepotent response) and try out a novel one. Children's responses to the correct hiding locations (i.e. responses that occur before they make anticipatory switches) may form a prepotent response pattern because these responses have been reinforced and rehearsed during the game. If children do not switch guessing strategy, this could be because they do not have sufficient control over their behaviour and are unable to inhibit the prepotent response of carrying out a guessing pattern that is bringing success.
This use of the term inhibition may be different from that in which it is normally used. Inhibition is often used to refer to the cessation of a prepotent *maladaptive* response (e.g. Burgess & Cooper, 1996). For example, in the windows task, persistently indicating the baited box (as 3-year-old children do) is maladaptive because it results in the opponent obtaining the hidden object, rather than the child (Hughes & Russell, 1993; Russell et al, 1994; Russell et al, 1991, see Section 1.3.1, Chapter 1). Inhibition is demonstrated when children stop making this unsuccessful response.

In contrast, it is argued that switching strategy in the location guessing game requires inhibition, even though the behaviour that leads up to a change in guessing strategy is not unsuccessful. It is suggested that children switch guessing strategy *in anticipation* of it becoming maladaptive. Although this may be different from the way in which the term inhibition is often employed, it is argued in this thesis that inhibitory control processes are required for this behavioural change.

One way of assessing the role of inhibition in children’s failure to use a tactical guessing strategy in the location guessing game would be to examine whether associations exist between performance in the location guessing game and performance in an inhibition task. Such an approach has been taken in the deception literature (e.g. Hughes, 1998a, 1998b). However, this would require alterations to the design of the location guessing game which would enable the evaluation of whether individual subjects switch guessing strategy, rather than relying on group differences. One possible alteration would be a within subjects manipulation of playing style.\(^\text{15}\)

However, an alternative approach adopted for Experiment 5 was to exploit the task manipulations reported in the previous chapter (Experiments 3 & 4) as an opportunity for evaluating the role of inhibition in children’s failure to switch guessing strategy. Experiment 5 tests whether the number of door and hiding sequence manipulations reported in Chapter 4 allowed 5- and 6-year-old children to switch guessing strategy by enabling them to inhibit their current guessing strategy and adopt a novel one.

The design of Experiment 5 employed the number of door and hiding sequence manipulations to consider whether these allowed 5- and 6-year-old children to switch guessing strategy by influencing their ability to inhibit. This experiment employed a conventional style inhibition task in the sense that children’s ability to inhibit was

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\(^{15}\) The benefits of a within subject design are discussed in Chapter 6, and such a design is proposed in Chapter 8.
assessed in a situation in which the motivation to prevent a prepotent response arose from an actual change in hiding sequence, rather than an anticipated change. Thus, changing strategy in the present experiment requires the inhibition of a prepotent response that has become maladaptive, rather than a response that was anticipated to become maladaptive.

The results of Experiment 3 showed that reducing the number of doors from five to three, but maintaining both the same door and alternate door hiding sequences, enabled 5- and 6-year-old children to switch guessing strategy in the alternate door trials. It was suggested that this manipulation was successful because the door manipulation freed working memory resources for the strategic task demands by reducing the processing resources devoted to the basic task demands of discovering and learning the hiding sequence. It is possible that the aspect of the basic task demands that this manipulation operated on was children's ability to inhibit their current guessing strategy and switch to a novel one. In order to evaluate this hypothesis, Experiment 5 assessed the effect of the door manipulation on children's ability to inhibit in a contingency change game.

The results of Experiment 4 showed that removing the same door hiding sequence, but maintaining five doors, enabled 5- and 6-year-old children to switch guessing strategy in the alternate door trials. It was suggested that the same door trials undermined the competitive manipulation for these children with the result that they did not accept the competitive manipulation in the alternate door trials. If this were the case, removing the same door hiding sequence should have no effect on children's ability to inhibit in a task in which inhibition and switching of guessing strategy is not driven by the competitive nature of the game. In order to evaluate this hypothesis, Experiment 5 assessed the effect of the hiding sequence manipulation on children's ability to inhibit in a contingency change game.

**Experiment 5: The Contingency Change Game**

Experiment 5 used a "contingency change" game to assess the effect of the number of doors and type of hiding sequence on children's ability to inhibit in a location guessing game that does not have a competitive context. The contingency game is so called because once children learn that game success is contingent on a particular pattern of responding (the sequence), the contingency changes (the sequence changes) and children need to learn that game success is now contingent on a different pattern of
responding (the new sequence). A change in sequential response-outcome contingencies provides the motivation for the child to switch guessing strategy, rather than an anticipation of change in the experimenter's hiding sequence.

In order to respond appropriately after the change in contingencies, children must inhibit the strategy that resulted in task success before the change in contingencies. The contingency change game is similar to other standard tests of inhibition, for example Luria et al's (1964) hand game (see Chapter 2, Section 2.2). In these tasks, children are rewarded for responding in a particular way in pre-switch trials, the rewarded response is changed (switched) in the post-switch trials, and children's ability to inhibit the former (now inappropriate) response, and switch to a new (appropriate) response, is assessed.

The procedure of the contingency change game is very similar to that used in the location guessing game. Children guess behind which one of five (or three) doors an object has been hidden by the experimenter, and a puppet is used to maintain their interest in finding the hidden object. If children guess incorrectly, they are given corrective feedback concerning the location of the hidden object. The object is hidden according to pre-defined sequences. Thus, children learn the hiding sequence via corrective feedback in the same way that they learned the hiding sequences used in the location guessing game.

There are two procedural differences between the contingency change game and the location guessing game which were necessary in order that the contingency game should test inhibition rather than tactically strategic behaviour. Firstly, the instructions in the contingency game are neither cooperative nor competitive, but neutral. Secondly, motivation to switch guessing strategy is provided by an actual change (rather than an anticipated change) in the hiding sequence. This actual change in hiding sequence divides the game into a pre-switch and a post-switch phase (before and after the change in hiding sequence). When children reach a pre-determined criterion (denoting the end of the pre-switch phase), the experimenter changes the hiding sequence and the game is played until they reach criterion again (the post-switch phase). These pre- and post-switch phases were intended to be equivalent to the phases in the location guessing game in which the children discovered and learned the hiding sequence (pre-switch) and the phase in which they tried a door behind which the sticker had not previously been hidden in anticipation of a change in hiding sequence (post-switch).

Ability to inhibit a guessing strategy that was appropriate in the pre-switch
phase, but is inappropriate in the post-switch phase was assessed in two ways. Firstly, successful inhibition of the pre-switch strategy in the post-switch phase would be indicated by children taking fewer or a similar number of trials to reach criterion in the post-switch phase in comparison to the pre-switch phase. Failure to inhibit the pre-switch guessing strategy in the post-switch phase would be indicated by children taking substantially more trials to reach criterion in the post-switch phase than in the pre-switch phase.

Secondly, successful inhibition of the pre-switch strategy would additionally be indicated if children take a small number of trials before trying a novel location in the post-switch phase (novel in the sense that it was not part of the hiding sequence in the pre-switch phase). Failure to inhibit the pre-switch guessing strategy would be indicated if children take a large number of trials before guessing a novel location in the post-switch phase.

Children played either the five door or the three door location guessing game and the experimenter hid the object using either the standard hiding sequences of same door followed by alternate door hiding sequences, or only the alternate door hiding sequences. The alternate door trials included a pre-switch and a post-switch phase, which involved two different alternate door hiding sequences. The same door trials incorporated only one phase with one same door hiding sequence. Inhibition in these trials was not assessed because 5- and 6-year-old children did not switch guessing strategy in these trials in the location guessing game (Experiments 1 to 4); the same door trials were included because Experiment 4 showed that they influenced guessing on subsequent alternate door trials.

**Predictions**

Different predictions about the effect on children's ability to inhibit are made for the door manipulation and the hiding sequence manipulation. In both cases a failure in inhibition would be indicated by children taking substantially more trials to reach criterion in the post-switch condition than the pre-switch condition. In addition, a relative difficulty to inhibit in a particular condition would be demonstrated by children taking more trials before guessing a novel door in that condition compared to the others.

If the reduction in the number of doors in Experiment 3 enabled 5- and 6-year-old children to make anticipatory changes in guessing strategy by facilitating their ability to inhibit, it would be expected that children would have difficulty inhibiting their
guessing strategy in the contingency change game in the five door condition and not in the three door condition. Alternatively, if the door manipulation had no effect on ability to inhibit, it would be predicted that children would be similarly able to inhibit in both door conditions.

It has been argued that the same door trials affected children’s ability to switch guessing strategy in the alternate door trials by undermining their understanding of the task as a competitive game (Chapter 4). This account predicts that removing the same door trials would not influence children’s ability to inhibit. Any effect of hiding sequence on inhibition would seriously challenge the pragmatic understanding account of the effect of the same door trials.

Method

Participants

Forty 5- and 6-year-old children who attended an Infants school in Southend-on-Sea, Essex, participated in this experiment, ten in each condition. Table 5.1 presents the mean age and age range of these participants.

Table 5.1: Mean age (and range) of participants in Experiment 5

<table>
<thead>
<tr>
<th>Condition</th>
<th>Same doors→ Alternate doors</th>
<th>Alternate doors Only</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three door</td>
<td>6yrs 4mths (5y10m to 6y8m)</td>
<td>6yrs 4mths (5y11m to 6y10m)</td>
<td>6yrs 4mths (5y10m to 6y10m)</td>
</tr>
<tr>
<td>Five door</td>
<td>6yrs 5mths (5y11m to 6y9m)</td>
<td>6yrs 3mths (5y2m to 6y7m)</td>
<td>6yrs 4mths (5y2m to 6y9m)</td>
</tr>
<tr>
<td>Total</td>
<td>6yrs 4mths (5y10m to 6y9m)</td>
<td>6yrs 3mths (5y2m to 6y10m)</td>
<td>6yrs 4mths (5y2m to 6y10m)</td>
</tr>
</tbody>
</table>

Apparatus

The standard three door and five door apparatus, and puppet used in previous experiments were employed in the present experiment.

Procedure

Children were randomly assigned to either the three door or five door condition and either the same door followed by alternate door (standard trial condition) or the alternate door only condition. Each participant was asked if he or she would like to play a fun guessing game with the experimenter. The experimenter and the
child sat facing each other and the three or five door box was placed between the two, with the doors facing the child. Each child was introduced to Sammy the Squirrel and was asked if he or would like to help Sammy the Squirrel find stickers which were "his favourite things in the whole world", and he or she was then given the puppet to hold. The experimenter explained that she would hide stickers behind one of the five (or three) doors and it was the child's job to guess behind which door the sticker was hidden.

In order to maintain a neutral tone in explaining the game, children were not given the competitive or cooperative instructions used in previous experiments reported in this thesis. However, in order to maintain their motivation, some feedback concerning performance was given to each child. When a child guessed correctly, the experimenter said "well done", or similar sentiments, and when the child guessed incorrectly, the experimenter said "bad luck", or similar sentiments.

Children were also given feedback about the location of the hidden object. If the child selected the correct door, he or she opened the flap, reached inside and collected the hidden sticker. If the child selected an incorrect door, the experimenter reached into the space behind the door, picked up the sticker, pushed open the flap and showed the child the sticker. This was accompanied by an announcement of the correct door number, for example, "It was behind door 3". All feedback was delivered in a neutral tone.

In order to maintain similarities in procedure between the location guessing game and the contingency change game, directly following the instructions each child was given four practice trials using the same two choice hand guessing game that was used in Experiments 1, 2, 3, and 4. Two of these practice trials were "sure win" (sticker in both hands), and two were "sure lose" (sticker in neither hand). Following these practice trials, the child was told that now the proper game would begin.

Two types of hiding sequences were used: same door and alternate door. There were two alternate door hiding sequences, one of which was used in the pre-switch phase and the other was used in the post-switch phase. The order of presentation of these alternate door hiding sequences was counterbalanced, but the same door trials (if administered) always preceded the alternate door trials.

The same door hiding sequence involved continuously hiding the sticker behind door 2, and was used until children made reached criterion by making five consecutively correct guesses. After reaching criterion in the same door trials, children were
encouraged to count the number of stickers that they had won (as was the case at the end of the same door trials in the location guessing game). At this point the pre-switch phase began and the experimenter used the first alternate door sequence. For example, in this first alternate door sequence, the sticker was alternately hidden behind door 1 and door 3. The experimenter hid the object according to this sequence until the child reached criterion again, at which point the post-switch phase began and the hiding sequence was changed to the second alternate door hiding sequence.

In this second alternate door sequence, the sticker was alternately hidden behind door 2 and door 3. Door number 3 was used in both the pre- and post-switch phase. This was necessary when the three door box was used, and was used in the five door box condition in order that children in both box conditions experienced the same hiding sequences. On reaching criterion in the post-switch phase, children were encouraged to count the stickers that they had found, and were given a coloured star for participating in the experiment.

**Results**

All of the children seemed to enjoy playing the game. For the alternate door trials, two analyses are reported. The first compares the number of trials taken to reach criterion in the pre- and post-switch phases in the various conditions (three or five doors, and same door→alternate door hiding sequences or alternate door only). The second analysis considers the number of trials taken to guess a novel door in the post-switch phase. In the same door trials, in which there was only one phase, comparison is made of trials to criterion over the different conditions.

The data from one child who participated in the three door, same door→alternate door hiding sequences condition were excluded from the analysis. This child showed clear evidence of persistent perseverative guessing post-switch in the alternate door trials. When the experimenter changed to the second alternate door sequence, this child continued to guess the pre-switch sequence for seven trials following the switch and was excluded from the rest of the analysis because she was clearly behaving in a different manner to the rest of the children. Thirty nine children were included in the analysis; 9 who participated in the three door, same door→alternate door hiding sequence condition and 10 children in each of the remaining three conditions.
Figure 5.1: Mean trials to criterion (±SE) by the number of doors, hiding sequence condition and pre- and post-switch trials in Experiment 5.

Note. Group n are unequal:
Standard trials (same door → alternate door hiding sequences), 3 door, n=9;
Alternate door only, 3 door, n=10;
Standard trials, 5 door, n=10; Alternate door only, 5 door, n=10.
Figure 5.2: Mean trials ($\pm SE$) taken before trying a new door post-switch in the alternate door trials, by number of doors and hiding sequence condition in Experiment 5

Note. Group $n$ are unequal:
Standard trials (same door $\rightarrow$ alternate door hiding sequences), 3 door, $n=9$;
Alternate door only, 3 door, $n=10$;
Standard trials, 5 door, $n=10$; Alternate door only, 5 door, $n=10$. 
Alternate door trials

Trials taken to reach criterion

Figure 5.1 presents mean trials to criterion in the alternate door trials in both the pre-switch and post-switch phase over the door and hiding sequence conditions. These data appear to indicate that children take fewer trials to reach criterion post-switch compared to pre-switch in all conditions.

This impression was supported by the analysis. A mixed model ANOVA was conducted on the data set, with pre- and post-switch phase as the within subject factor and number of doors and type of sequences as between subjects factors. This revealed that, overall, children took fewer trials to reach criterion in the post-switch phase than in the pre-switch phase, $F(1,35)=14.38$, $p=.001$. In addition, overall, children assigned to the same door→alternate door hiding sequence condition took fewer trials to reach criterion than children assigned to the alternate door only hiding sequence condition, $F(1,35)=14.962$, $p<.0001$. Neither the main effect of number of doors reached statistical significance, $F<1$, nor did any of the interactions (all $F<1$).

Trials taken to select a novel door

Figure 5.2 presents the mean number of trials taken in the post-switch phase until the child guessed a novel door behind which the sticker had not been hidden in the pre-switch trials. The hiding sequence used in the pre-switch phase involved hiding the sticker alternately behind doors 1 and 3. Therefore, in the three door condition, the novel door would be door number 2, and in the five door condition, a novel door could be door numbers 2, 4 or 5. The data presented in Figure 5.2 appear to indicate that, although children assigned to the five door condition appear to take slightly fewer trials before trying a novel door than children assigned to the three door condition, regardless of condition, children take very few post-switch trials before indicating a novel door.

These impressions were supported by the analysis. A between subjects ANOVA with number of doors and type of hiding sequences as factors was conducted on the data set. Neither the number of doors, $F(1,35)=1.348$, $p=.254$, nor the presence of the same door trials, $F<1$, nor the interaction of these factors, $F<1$, affected the number of trials taken before guessing a novel door in the post-switch phase.
Figure 5.3: Mean trials to criterion (±SE) in the same door trials, by the number of doors in Experiment 5. Data for the standard trials condition only (same door → alternate door hiding sequences).

Note. Group n are unequal: 3 door n=9; 5 door n=10
**Same door trials**

Figure 5.3 presents mean trials to criterion in the same door trials in the three door and five door conditions for those children assigned to the same door→alternate door condition. These data appear to indicate that children assigned to the three and five door conditions took a similar number of trials to reach criterion. This impression was supported by the analysis. A one way ANOVA found no significant difference in the number of trials to criterion taken by children assigned to either the three door or five door condition, $F<1$.

**Discussion**

The results of Experiment 5 showed that 5- and 6-year-old children had no difficulty inhibiting their guessing strategy in the post-switch phase under any of the door or hiding sequence conditions. Regardless of the condition to which they were assigned, children took fewer trials to reach criterion in the post-switch phase than in the pre-switch phase. This suggests that they did not find it difficult to inhibit the pre-switch guessing strategy in the post-switch phase. Furthermore, children in all conditions took very few trials in the post-switch phase to guess a novel door that had not been used in the pre-switch phase.

Several findings of Experiment 5 are discussed further here. Firstly the finding that neither the number of doors nor the presence of the same door trials affected children's ability to inhibit and switch guessing strategy in the contingency change game is discussed. The finding that the door and hiding sequence manipulations did not affect children's ability to inhibit in the present experiment does not mean that inhibition is not involved in switching guessing strategy in the location guessing game. It simply means that these manipulations did not operate on 5- and 6-year-old children's ability to inhibit. Secondly, ways in which the proposed role of inhibition in children's strategy switching in the location guessing game could be investigated further are considered.

**Number of doors manipulation**

In Chapter 4, it was argued that reducing the number of doors allowed children to demonstrate tactically strategic guessing behaviour because this reduced the working memory processing resources required to meet the basic task demands. It was suggested that this allowed these children to switch guessing strategy when previously they did not (Experiments 1 & 2) because it freed processing resources for the strategic task demands. It was also suggested that a reduction in the number of doors may have
reduced basic task demands by operating on children's ability to inhibit. However, the present experiment showed that reducing the number of door did not affect children's ability to inhibit in the contingency change game which was designed to be similar to the location guessing game.

The lack of an effect of the number of doors on children's inhibition in the contingency change game suggests that an aspect of cognition other than inhibition allowed children to switch strategy in the three door version of the location guessing game. One remaining possibility, which receives some support from these results, is that a reduction in the number of doors freed working memory resources for strategy switching (see Chapter 4). Alternatively, the door manipulation may not have operated on a specific aspect of cognition. It may have had a more general influence on children's ability to process the task demands.

*Same door hiding sequence manipulation*

The results of the present experiment are not inconsistent with the argument proposed in Chapter 4 that the same door trials undermine the effect of the competitive manipulation for 5- and 6-year-old children in the location guessing game (Experiment 4). If the presence of the same door trials had affected inhibition in the alternate door trials in the contingency change game, this pragmatic understanding account would be seriously challenged. However, in the present experiment children had no difficulty inhibiting a previously successful guessing strategy in the post-switch trials either when the alternate door trials were preceded by the same door trials or when they were not, regardless of the measure of inhibition.

*The role of inhibition in strategy switching in the location guessing game*

Although a developing ability to inhibit is not an adequate account for the developmental trends in tactically strategic guessing behaviour observed in the age groups of children tested so far in this thesis, this does not preclude the possibility that developments in inhibitory control may allow children to switch guessing strategy. One way to test this hypothesis would involve identifying the developmental cusp of tactically strategic guessing behaviour. With this identified, it would be possible to consider what it is that allows such behaviour to develop and to be demonstrated. Such an approach was adopted in Experiment 6 which was designed to examine tactically strategic guessing behaviour in younger children and explore the role of theory of mind reasoning in such behaviour. The role of inhibitory control in allowing children to
switch strategy could also be investigated in this manner. Such an approach has been used in the deception literature (e.g. Hughes, 1998a, 1998b).

An additional alternative approach could be to vary the inhibitory load of the location guessing game in some way and see if this affects children's ability to switch guessing strategy. Such an approach has been taken in the theory of mind literature with the false belief task (e.g. Leslie & Polizzi, 1998), and also in the deception literature (e.g. Carlson et al, 1998; Couillard & Woodward, 1999).

**Conclusions**

The results of the present experiment suggest that the two manipulations of task parameters that were reported in Chapter 4 did not enable children to demonstrate strategy switching by influencing their ability to inhibit their guessing strategy and switch to a novel guessing strategy. This experiment did not test the question of whether inhibition was involved in strategy switching in the location guessing game; ways to address this further were discussed above. The next chapter reports one experiment designed to investigate the whether theory of mind reasoning underlies tactically strategic guessing behaviour by considering the game behaviour of groups of children who can or cannot attribute mental states in a second order theory of mind task.
CHAPTER 6

Tactically strategic behaviour in very young children

In Chapter 6, the results of one experiment are reported which was designed to assess the theory of mind account of strategy switching in the location guessing game. By comparing the game playing behaviour of a group of children able to attribute the mental states hypothesized to be involved in tactical guessing strategy with a group of children who have not yet developed such an ability, the question of whether such mental state attributions do in fact underlie strategy switching was investigated. In addition, Experiment 6 allowed the development of tactically strategic behaviour in very young children to be considered.

EXPERIMENT 6: 3- AND 4-YEAR-OLD CHILDREN PLAY THE LOCATION GUESSING GAME

Earlier in this thesis, two accounts of anticipatory switches in guessing strategy were proposed (Chapter 3). The behavioural account proposes that children switch guessing strategy because, once they have discovered the hiding sequence, they expect the opponent to change the hiding sequence. The theory of mind account proposes that, once children have discovered the hiding sequence, they switch guessing strategy as a result of the second order mental state attribution that their opponent knows that they know the hiding sequence.

The theory of mind account would predict that associations would be found between strategy switching and successful performance in a second order theory of mind task. The experiments reported earlier in this thesis are consistent with a relationship between strategy switching and second order theory of mind. Children who were of an age at which the ability to attribute second order mental states has developed (assessed directly in Experiments 1 & 2) also switched guessing strategy in the competitive condition of the location guessing game (Experiments 3 & 4). These experiments show that children aged 5-years and older are competent in both the game and the theory of mind task.

Stronger support for the theory of mind account would be found if it were shown that children who lack second order theory of mind do not switch guessing strategy in a competitive condition while children who possess second order theory of mind do
switch guessing strategy in a competitive condition. Experiment 6 was designed to provide a comparison of the game playing behaviour of a group of children who passed a theory of mind test with a group of children who failed a second order theory of mind test, in order to evaluate further the theory of mind account of strategy switching.

Including groups of children who pass and fail a second order theory of mind test requires that a sample be drawn from a younger age range than those tested in Experiments 1 to 5. On the basis of previous research, children aged 3- and 4-years-old were selected. Experiments reported in this thesis have found that children could attribute second order mental states to others from the age of 5 (Experiments 1 & 2). Previous research reported elsewhere has found that children aged 4 or 5 can attribute second order mental states (e.g. Leekam, 1991; Sullivan et al, 1994, see Chapter 2 Section 2.1). Thus, selecting from the age range of 3- to 4-years was expected to provide a group of children who could attribute second order mental states and a group that could not.

In order that the procedure employed in Experiment 6 should be maximally sensitive to strategy switching in younger children, a simplified version of the location guessing game procedure was employed. The design of this procedure was influenced by the experiments reported in Chapter 4. The procedure adopted in Experiment 6 used a three door location guessing game and included only the alternate door hiding sequence.

The theory of mind account of tactical guessing strategy in the location guessing game proposes that an attribution of second order knowledge underlies strategy switching. This account would therefore predict that ability to attribute second order knowledge in the theory of mind task would discriminate between children who switch guessing strategy and children who do not switch guessing strategy. In contrast, the ability to attribute second order false belief in the theory of mind task would be less likely to discriminate children who switch guessing strategy from those who do not switch strategy. An attribution of second order false belief in the location guessing game would be characterized by the child thinking that his or her opponent thinks that he or she (the child) has a false belief about the sequence. Such an attribution may not be consistent with anticipatory switches in guessing strategy - it is possible that children would have no reason to switch their guessing strategy if they thought that their opponent thought they knew the wrong sequence.
False belief competence would only predict strategy switching to the degree that ability to attribute second order false belief coincides with the ability to attribute second order knowledge. Because the ability to attribute knowledge tends to developmentally precedes the ability to attribute false belief (e.g. Hogrefe et al, 1986; Sullivan et al, 1994; see Section 2.1.2, Chapter 2), the specific role of second order knowledge attribution could be tested only if one sample was comprised of children who could attribute knowledge but had yet to develop the ability to attribute false belief. The performance of such a group could then be compared with additional samples comprised of children who could attribute neither knowledge nor false belief, or who could attribute both. Such comparisons could not be made in the present experiment because the sample included only 6 children who could attribute knowledge but not false belief.

The second order theory of mind task employed in this thesis assesses children's ability to attribute second order ignorance and second order false belief. The theory of mind account proposes that attributions of second order knowledge, rather than ignorance, are involved in strategy switching. However, attributions of knowledge and ignorance are similar in that they both require that children consider what another person thinks, rather than whether their belief reflect reality (as in the case of a false belief). In the Birthday Puppy story (Sullivan et al, 1994, see Appendix A), the second order ignorance question is concerned with what the target character thinks, rather than whether this belief is true or false. Therefore, the theory of mind account would predict that the ability to attribute second order ignorance in the Birthday Puppy task would discriminate between children who switch guessing strategy in the location guessing game and those who do not.

Predictions

The theory of mind account of strategy switching would predict that only a group of children assigned to the competitive condition who passed the second order theory of mind ignorance test would switch guessing strategy; their counterparts who failed to pass the second order ignorance test would not be expected to switch guessing strategy. As previously, switches in guessing strategy would be demonstrated if children in the competitive condition take more trials to reach criterion than their counterparts in the cooperative condition.

The theory of mind account would predict that children's performance in the cooperative condition would not be influenced by their ability to attribute second order knowledge. The cooperative condition provides a control against which behaviour in the
competitive condition is compared and was designed to provide a measure of the number of trials necessary to discover and learn the sequence. Attributions of second order knowledge are not necessary for such learning. The effect of theory of mind status on performance in the cooperative condition was assessed by comparing the number of trials taken to reach criterion in the cooperative condition in those children who passed the second order ignorance test with the number of trials taken to reach criterion by their counterparts who failed the second order ignorance test.

Method

Participants

Forty-seven children from a pre-school nursery in North East London participated in the experiment. Of these children, 27 were 4-years-old and 20 were 3-years-old. All of the children were randomly assigned to either the cooperative or competitive playing style condition. Table 6.1 presents the mean age and age range of these participants.

Table 6.1: Mean age (and range) of participants in Experiment 6

<table>
<thead>
<tr>
<th>Group</th>
<th>Cooperative</th>
<th>Competitive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year-olds</td>
<td>3yrs 5mths</td>
<td>3yrs 5mths</td>
<td>3yrs 5mths</td>
</tr>
<tr>
<td></td>
<td>(3y1m to 3y9m)</td>
<td>(3y1m to 3y11m)</td>
<td>(3y1m to 3y11m)</td>
</tr>
<tr>
<td></td>
<td>n=10</td>
<td>n=10</td>
<td>n=20</td>
</tr>
<tr>
<td>4-year-olds</td>
<td>4yrs 4mths</td>
<td>4yrs 4mths</td>
<td>4yrs 4mths</td>
</tr>
<tr>
<td></td>
<td>(4y1m to 4y7m)</td>
<td>(4y0m to 4y7m)</td>
<td>(4y0m to 4y7m)</td>
</tr>
<tr>
<td></td>
<td>n=13</td>
<td>n=14</td>
<td>n=27</td>
</tr>
</tbody>
</table>

Apparatus

The three door box used in Experiment 3 was used in the present experiment. The standard puppet and stickers were also employed.

Procedure

The standard procedure was used with the following modifications; the game was played using the three door box and the experimenter hid the object using the alternate door sequence only. As before, children played the game until the criterion of five consecutively correct guesses was reached. Playing the game preceded the administration of the Birthday Puppy test.
Results

All of the children appeared to enjoy playing the location guessing game. In the analysis of guessing behaviour in the location guessing game, children were grouped according to their second order ignorance competence. Therefore, the children's performance in the second order theory of mind task is reported first.

Participant's performance in second order theory of mind task

Table 6.2 presents descriptive statistics for participants in the cooperative and competitive conditions when they were grouped by their second order ignorance competence (pass vs. fail). Of the 47 children, 23 correctly answered the second order ignorance question and 24 answered this question incorrectly. The data suggest that the four groups were comprised of children drawn from the full age range of those tested, but the mean age of those who successfully answered the second order ignorance question seems higher than the mean age of those who incorrectly answered this question. The application of an independent groups t-test revealed that those children who correctly answered the second order ignorance question were significantly older than those who answered this question incorrectly, \( t(39.535) = 3.643, p = .001 \) (Levene's test was significant, \( p = .009 \), therefore equal variances were not assumed).

Table 6.2: Descriptive Statistics of participants grouped by performance on second order ignorance question

<table>
<thead>
<tr>
<th></th>
<th>Failed Second Order Ignorance</th>
<th>Passed Second Order Ignorance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative</td>
<td>Competitive</td>
</tr>
<tr>
<td>( n )</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>( \text{Mean Age} )</td>
<td>3;9</td>
<td>3;8</td>
</tr>
<tr>
<td>( \text{Age Range} )</td>
<td>3;1 – 4;7</td>
<td>3;1 – 4;7</td>
</tr>
<tr>
<td>( \text{Age S.D.} )</td>
<td>.52</td>
<td>.59</td>
</tr>
</tbody>
</table>

The pattern of success on the second order ignorance and second order false belief questions was consistent with that found in previous studies (e.g. Hogrefe et al, 1986). Children either succeeded on both \( (n=17) \), or failed both \( (n=23) \), or passed the ignorance but failed the false belief \( (n=6) \). Only one child showed the unexpected pattern of passing false belief and failing ignorance. A Chi-Squared test revealed the association between the ignorance and false belief tests to be significant, \( \chi^2 (1, N=47)=24.177, p<.001 \).
Figure 6.1: Mean trials to criterion (±SE) by second order ignorance competence and playing style condition in Experiment 6

Note. Group n are unequal. Fail ignorance, cooperative condition n=14; Fail ignorance, competitive condition n=10; Pass ignorance, cooperative condition n=9; Pass ignorance, competitive condition n=14.
Behaviour in the location guessing game

Figure 6.1 presents mean trials to criterion by competence on the second order ignorance question (pass vs. fail) and playing style condition. These data appear to indicate that, of the children who correctly answered the second order ignorance question, those assigned to the competitive condition took more trials to criterion than those assigned to the cooperative condition. Of the children who did not correctly answer this question, those assigned to the competitive condition did not seem to take substantially more trials to reach criterion than those assigned to the cooperative condition. These impressions were supported by the analysis.

A two factor between subjects ANOVA with playing style condition and second order ignorance competence (pass vs. fail) as factors was conducted on the data. Overall, children assigned to the competitive condition took more trials to criterion than children assigned to the cooperative condition, $F(1,43)=4.584$, $p=.038$. Neither children's second order ignorance competence, $F(1,43)=2.422$, $p=.127$, nor the interaction, $F<1$, reached statistical significance.

A priori simple main effects were conducted at each level of second order ignorance competence to compare trials to criterion for the cooperative and competitive conditions. These simple main effects indicated that, of the children who correctly answered the second order ignorance question, those who were assigned to the competitive condition took significantly more trials to reach criterion than those assigned to the cooperative condition, $F(1,43)=4.222$, $p=.046$. No statistically significant effect of playing style condition was found for the children who incorrectly answered the second order ignorance question, $F<1$.

Not all of the children included in the above analysis correctly answered all of the five control questions in the Birthday Puppy task (see Appendix E for further details). Although children who gave incorrect answers received corrective feedback, it is possible that those children who gave incorrect answers to the control questions did not fully understand the story. Ideally, data from only those children who answered all the control questions correctly would be included in the analysis. Of the 47 children, 17 answered all five control questions correctly (10 in the cooperative condition and 7 in the competitive condition). This subsample is too small to enable an analysis of the effects of playing style condition and second order ignorance competence including only those children who correctly answered all of the control questions.
However, the findings from an analysis of children who correctly answered at least three of the five control questions were similar to those found for the complete sample. This analysis included only those children who correctly answered three or more of the five control questions in the Birthday Puppy task (the three memory probe questions, the non-linguistic and the linguistic control questions). This was a total of 32 children (failed ignorance, cooperative n=8, competitive n=5; passed ignorance, cooperative n=9, competitive n=10). A between subjects ANOVA revealed a significant main effect of playing style condition, $F(1,28)=5.322$, $p=.029$, with children in the competitive condition taking more trials to criterion than those in the cooperative condition. The main effect of ignorance question, $F(1,28)=2.369$, $p=.135$, and the interaction were not significant $F<1$.

Simple main effects revealed that, of the children from this reduced same who correctly answered the second order ignorance question, those in the competitive condition ($M=16.9$, $SD=4.75$) took significantly more trials to criterion than those in the cooperative condition ($M=12.22$, $SD=3.7$), $F(1,28)=5.903$, $p=.028$. In contrast, there was no difference between playing style conditions in trials to criterion for those who incorrectly answered the second order ignorance question (competitive condition $M=13.4$, $SD=5.59$; cooperative condition $M=11$, $SD=2.78$), $F(1,28)=1.01$, $p=.324$. The lack of a difference between this analysis and the previous analysis does not support the position that the results of the first analysis were due to children not understanding the story.

As expected, theory of mind status did not influence the game playing behaviour of children assigned to the cooperative condition. Children in the cooperative condition took a similar number of trials to reach criterion regardless of whether they correctly or incorrectly answered the second order ignorance question, $t(21)=.645$, $p=.526$.

**Discussion**

The results of Experiment 6 suggested that children may make anticipatory switches in guessing strategy from about the age of four, although this finding would need to be replicated with a larger sample. Ability to pass the second order ignorance test did not have an effect on children's ability to learn the hiding sequence. Children assigned to the cooperative condition reached criterion in a similar number of trials
regardless of whether they were able to attribute second order ignorance. The results are not conclusive with respect to the theory of mind account of tactically strategic behaviour. Although the simple effects analysis suggested that children who could attribute second order ignorance showed the playing styles effect and that those who could not attribute second order ignorance did not, the interaction was not statistically significant. This finding is not inconsistent with the theory of mind account of tactical strategy; it could be that associations between the two tasks were not found because of a lack of sensitivity of the procedure and/or lack of power due to the relatively small sample size.

One way in which potential insensitivity of the location guessing game procedure in assessing tactical guessing strategy in 3- and 4-year-old children could be addressed would be to develop a within subjects version of the procedure. Within subject experimental designs are more sensitive because they remove unexplained variance resulting from individual differences between participants. Moreover, within subject designs allow multiple data points to be collected for each subject. This is likely to increase the power of the test, resulting in fewer participants being required for statistically significant finds for a given effect size. A procedure that employs a within subjects experimental design in order to assess tactical guessing strategy in the location guessing game using is proposed in Chapter 8 (Section 8.1).

Within subject procedures also allow the possibility of assessing the external validity of tasks by considering whether individual differences on one task are associated with individual differences in another. With respect to the location guessing game, this would allow the theory of mind account to be assessed more appropriately than the present procedure by considering whether individual differences on the location guessing game are associated with individual differences on theory of mind tasks. In addition, this approach could be used to consider whether developments in tactical strategy occur at a similar age to developments in related social competencies, such as deception.

A further methodological consideration concerns the performance of children in the control questions of the theory of mind task. In future experiments it should be insured that children correctly answer all of the control questions in the theory of mind task before their data are included in the analysis. In the study in which the Birthday Puppy task was developed, children received corrective feedback if they answered any of the control questions incorrectly (Sullivan et al, 1994). This approach was adopted in
the present experiment. However, more recent studies have excluded children who made errors on the control questions (e.g. Banerjee & Yuill, 1999). Although, in the present experiment, children received corrective feedback if they answered a control question incorrectly, it could be argued that those children who did not correctly answer all of the control questions did not have a full understanding of the story at the point at which they were asked the test questions, and this could have resulted in this measuring instrument providing a less valid test of second order theory of mind for these children. The analysis which included children who correctly answered three or more of the control questions did not show different results from that in which data from all of the children were included, suggesting that the validity of the Birthday Puppy task may not be unduly effected by inclusion of data where control questions were not correctly answered. However, a more rigorous approach would be to replicate the present study using a sample in which all of the children answered all of the control questions correctly.

Aside from the above point about performance on the control questions, children's performance on the test questions of the second order theory of mind task was consistent with that found in previous studies, both in terms of developmental trends in attributing second order mental states generally, and the developmental order of the specific second order mental states of ignorance and false belief. The results of the Birthday Puppy task administered in the present experiment demonstrated that children could correctly answer the second order ignorance and second order false belief questions at about the age of four. This is consistent with previous research which has found that children can attribute such mental states from the age of 4 or 5 (e.g. Leekam, 1991; Sullivan et al, 1994). In addition, the results suggested that second order ignorance developmentally precedes the ability to attribute second order false belief, in common with the findings of previous research (e.g. Hogrebe et al, 1986; Sullivan et al, 1994). Children tended either to answer both questions correctly, or to answer both questions incorrectly, or to answer the ignorance question correctly but the false belief question incorrectly.

CONCLUSIONS

The results of the present experiment suggest that children demonstrate tactically strategic guessing behaviour in the location guessing game from about the age of four. However, they do not provide support for the theory of mind account of tactical guessing strategy because a statistically significant interaction between success or failure on the
theory of mind task and strategy switching was not found. It is possible that a within subject experimental design would provide a more sensitive procedure which would be more suited to an examination of the theory of mind account. The experiment reported in the next chapter assessed the question of whether the development of tactical guessing strategy is specific to the location guessing game procedure.
CHAPTER 7

Tactical strategy in an identity guessing game

The experiment reported in the present chapter was designed to assess the question of whether children's tactically strategic guessing behaviour was restricted to the location guessing game procedure, or whether it would be observed in a similar game with a different context. Experiment 7 was designed to consider whether children would switch guessing strategy in an identity guessing game, in which the strategic context did not involve location.

Location is often used as a context in deception tasks in which the deceptive act centres on the location of a hidden object. For example, the box task, the windows task and the false tracks task discussed in Chapter 1 (Section 1.3) all required children to deceive an opponent about which location contained a hidden object. While many of the everyday deceptive and strategic games that children play involve location, for instance hide and seek, this is not the only setting in which deceptive, or indeed tactically strategic, behaviour may be observed. For example, in card games such as cheat, deception occurs as players try to fool their opponent about which card they hold. In the game employed in Experiment 7, the experimenter used a predictable rule based on the identity of a key game piece and children's game playing behaviour was observed in order to consider if those assigned to the competitive condition showed anticipatory switches in guessing strategy in the same manner as that observed previously in the location guessing game.

EXPERIMENT 7: THE IDENTITY GUESSING GAME

In developing the identity guessing game used in the present experiment, inspiration was taken from Selman's (1980) game "Decoy and Defender". Selman's game was designed to assess levels of perspective taking and relied on verbal report of game playing strategy. Consequently, this procedure underestimated children's understanding. While verbal report is likely to underestimate children's reasoning competence (see Section 1.1.3, Chapter 1), non-verbal behaviour could not be used
to infer the level of strategy employed because strategies classified as a higher level on the basis of verbal report were behaviourally indistinguishable from simpler strategies.

However, "Decoy and Defender" did provide a context in which tactically strategic behaviour could be assessed that was based on identity rather than location. Selman's procedure was rather complex, involving many game pieces and complicated rules. Thus, a pilot study was designed to adapt the context and instructions used in "Decoy and Defender" in order to maximise the sensitivity of the task procedure employed in Experiment 7.

In "Decoy and Defender", the child and the opponent line up six game pieces on each side of a 6x6 chequerboard. Two of these pieces are "flag carriers" and four are "defenders", and the identity of each piece is not visible to the other player. Players take it in turns to move one piece and the aim of the game is to be the first player to get one "flag carrier" to the opponent's side of the chequerboard. In any one game, a player can use a "defender" in a defensive manner to remove one of the opponent's pieces (and their own "defender") from the game. This defensive move is termed a "freeze" and can only be used twice in a game.

The opportunity for deception arises because the opponent does not know which of the player's pieces are "flag carriers" and which are "defenders". For example, the player could attempt to trick his or her opponent into using up one of his or her two "freezes" by trying to mislead the opponent about which of his or her pieces is a "flag carrier" and which was a "defender". Thus, such deceptive acts would give him- or her-self a greater chance of moving a "flag carrier" successfully across the board without being frozen. After playing the game, Selman asked children to reflect upon the motivations for their moves, and the intended outcomes.

Children's verbal reflections on the intended outcome of their moves were used to categorise their behaviour as reflecting a particular level of, what Selman termed, perspective taking. These levels of perspective taking encompassed different complexities of mental state attribution. For example, children categorised as operating at the simplest level were concerned only with reaching the other side of the chequerboard. In contrast, children at the most complex level reported that their game behaviour was intended to deceptively manipulate the beliefs of their opponent.
about the identity of their game pieces; they were also aware that their opponent may recognize their deceptive intent and may not be deceived.

Unsurprisingly, older children reported more complex deceptive strategies than younger children. While such verbal report evidence can provide clear indication that children are employing theory of mind reasoning, it is likely to underestimate the competence of younger children in particular (c.f. Flavell et al, 1968, Section 1.1.3, Chapter 1).

Additionally, it is possible that younger children reported less complex deceptive strategies because they did not understand the somewhat abstract rules of the game. Indeed, Selman reported that "the younger children had more difficulty with [the] rules" (p. 62). Therefore, while the general theme of identity, and the idea of attacking and defending pieces was incorporated into Experiment 7, both the context conveyed by the instructions and aspects of the procedure were altered.

During the development of the game employed in Experiment 7, a pilot study was conducted in which the instructions used in "Decoy and Defender" were modified. This modified procedure, "Kings and Wizards", was similar to, but not identical to, the procedure adopted in Experiment 7. In this novel game the instructions were set in the context of a cover story that would be more familiar to children. For example, the "flag carrier" was replaced by a "king" and a "wizard" took the place of the "defender".

The instructions were designed to be clearer than those used in Selman's "Decoy and Defender" game in two ways. Firstly, the aim of the new game was designed to be clearer by including a rationale explaining why the king, rather than the wizard, should be the first piece to reach the other side of the board. A treasure box containing sticky stars was placed to one side of the board and children were told that only the king could open the treasure box. The wizard could not open the treasure box, and thus the game could not be won by moving the wizard across first. Secondly, in place of the defensive "freeze", the wizard was able to "cast a spell" on one of the opponent’s pieces in order to remove it from the game.
The relative merits of the "Decoy and Defender" and "Kings and Wizards" instructions were assessed by asking children five control questions\(^\text{16}\) which tested their knowledge of the aim and procedure of the game, and comparing the number of correctly answered control questions in the two instruction conditions. The analysis of children's answers to these questions under the two instruction formats revealed that both 5- & 6-year-old children and 7- & 8-year-old children answered more control questions correctly when the instructions were given in the "Kings and Wizards" format than in the "Decoy and Defender" format. In addition, the results of this pilot study showed that younger children did not have as great an understanding of the instructions of the "Decoy and Defender" instructions as older children. No age differences were found in children's understanding of the "Kings and Wizards" instructions.

The less complex "Kings and Wizards" instructions were therefore adapted for the identity guessing game used in Experiment 7. In Experiment 7, children played a five choice guessing game against an experimenter (see Figure 7.1). The child and the experimenter each had a cardboard castle on which their game pieces were located. A cardboard treasure box containing star stickers was located to the side of the castles, and the aim of the game was to win stickers. Only the king pieces could open the treasure box and take a sticker. The child had one king that could use his wand to cast a spell on one of the experimenter's pieces in order to remove it from the game. Only one of the experimenter's visually identical five pieces was a king.

During each trial, the experimenter moved one game piece at a time into the space between the two castles, and the child had to decide whether or not to use his or her spell on that piece. Each game continued until either the child used his or her spell and successfully removed the experimenter's king from the game, or the experimenter's king captured the treasure. Thus, the child had to work out which one of the experimenter's five pieces was the king.

\(^{16}\) These control questions were as follows. 1) How do you win the game? by being the first player to get a flag carrier/king to the other side of the chequerboard. 2) Who has to get to the other side? the flag carrier/king. 3) How many freezes/spells do you have? two per game. 4) What happens when you use a freeze/spell? the piece on which you used the freeze/spell and the piece that used the freeze/spell are removed from the game. 5) What kind of moves can you make? forwards and sideways, but not backwards.
Figure 7.1: The identity guessing game
Each child played a series of games against the experimenter. The hidden identity of the key game piece, the king, could be ascertained in each game because it was moved according to a regular temporal sequence. Across games, the king took a predictable, regular place in the sequence of moves and was moved using an alternation style time-based sequence. Thus, in one game, it was moved first of the five pieces, then third, then first and so on.

As in the location guessing game, the regular sequence employed by the experimenter for both playing style conditions in the identity guessing game would be expected by a mature player in the cooperative condition, but not in the competitive condition. Violating this expectation of normal competitive behaviour was expected to lead to children in the competitive condition making anticipatory switches in guessing strategy, once they have worked out the experimenter's sequence. The presence of such anticipatory switches was assessed by comparing trials to criterion over playing style conditions in the same manner as that used in the location guessing game experiments (Experiments 1, 2, 3, 4, & 6). Switches in guessing strategy would be shown in a particular age group if those in the competitive condition took more trials to criterion than those in the cooperative condition. Criterion was set at the number of games taken to win five consecutive games; children won the game if they used their spell to remove the experimenter's king piece from the game.

The design of the procedure implemented in Experiment 7 was informed by previous experiments reported in this thesis in order to be maximally sensitive to tactically strategic guessing behaviour in 5- and 6-year-old children. Experiment 7 was designed to reflect the design of the alternate door only condition of the location guessing game employed in Experiment 4 in which 5- and 6-year-old children used a tactical guessing strategy. Thus, five game pieces were selected and an alternation style sequence was used to move the game pieces (the king was moved first, third, first etc.).

**Predictions**

If tactically strategic behaviour is not dependent on context, it was expected that both 5- & 6-, and 7- & 8-year-old children assigned to the competitive condition would make anticipatory switches in guessing strategy in the identity guessing game employed in Experiment 7. As in experiments reported previously in this thesis,
strategy switches would be demonstrated if children assigned to the competitive condition took more trials to reach criterion than their counterparts in the cooperative condition.

**Method**

**Participants**

Forty children who attended a school in North London participated in the present experiment. There were twenty 5- and 6-year-old children and twenty 7- and 8-year-old children, and ten children participated in each condition. Table 7.1 presents the mean age and age range of participants in Experiment 7.

**Table 7.1: Mean age (and range) of participants in Experiment 7**

<table>
<thead>
<tr>
<th>Group</th>
<th>Cooperative</th>
<th>Competitive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5yrs 11mths</td>
<td>6yrs 1mths</td>
<td>6yrs 1mths</td>
</tr>
<tr>
<td>5- &amp; 6-year-olds</td>
<td>(5y7m to 6y5m)</td>
<td>(5y8m to 6y6m)</td>
<td>(5y7m to 6y6m)</td>
</tr>
<tr>
<td>7- &amp; 8-year-olds</td>
<td>8yrs 2mths</td>
<td>8yrs 1mths</td>
<td>8yrs 2mths</td>
</tr>
<tr>
<td></td>
<td>(7y10m to 8y6m)</td>
<td>(7y9m to 8y6m)</td>
<td>(7y9m to 8y6m)</td>
</tr>
</tbody>
</table>

**Apparatus**

The game was played using two cardboard castles (see Figure 7.1) which were 7 cm high and 9½ cm wide. Six identical game pieces were constructed from "Fimo", a type of modelling material, and were 2½ cm tall and 1½ cm in diameter. The five pieces used by the experimenter were made from red Fimo and the one piece used by the child was made from blue Fimo. The letter “K” was printed on a small label, ½ cm by ½ cm, that was attached to the back of one of the experimenter's five red pieces and the child's one blue piece; this denoted that this piece was a king. This label was not visible from the child's perspective, and therefore children were unaware during the game which of the five pieces was the king. The child had a "wand" that he or she could use to cast the spell on his or her opponent's piece; this was a spent matchstick covered in aluminium foil. A "treasure box" containing the star stickers was used which was 5 cm high, 5 cm wide and 5 cm deep.
Procedure

Children were randomly assigned to either the cooperative or competitive playing style conditions. Each child, regardless of condition assignment, was asked if he or she would like to play a fun game with the experimenter. The experimenter and the child sat facing each other with the apparatus between them. Each player had a cardboard castle on top of which his or her pieces were arranged. The experimenter had five red pieces, one of which was the king (denoted by the "K" sticker on the back). The child had one blue piece. The treasure box containing the stickers was placed to one side.

The experimenter explained that the child's piece was a king and that the child's king had the treasure box which was filled with stickers. The stickers were the favourite possession of the child's king. Each child was told that the experimenter had five pieces, one of which was a king, and they were shown that one piece had a letter "K" on the reverse. It was explained that only a king could open the treasure box and take the treasure.

Each child was told that the experimenter would send one of her pieces towards the child's castle and that the child had to decide whether or not to use his or her wand to cast a spell on the piece to remove it from the game. The spell could only be used once in any game. To use the spell, the child had to put their king on top of the experimenter's piece. Each time the experimenter moved a piece into the space between the two castles, the child could choose to use the spell and remove that piece from the game, or the child could choose not to use the spell, and let the experimenter's piece move into his or her castle.

Children were told that they should make sure that they use the spell on the experimenter's king, because if they got the wrong piece, the experimenter's king would be able to run and get the treasure and the child's king could do nothing to stop him. It was also made clear that they did not need to use the spell on the first piece that the experimenter moved, if they did not think that was the king they should wait to use their spell.

The child was then given the particular instructions associated with the playing style to which he or she had been assigned. In the cooperative condition, the child was told that there are "baddies" around who want to steal the treasure belonging to the child's king, so he must learn to protect the treasure. The child was
told that his or her king and the experimenter's king were best of friends and the experimenter's king was going to give the child's king some practice at defending his treasure. The experimenter's king was going to try to make it easy for the child to protect the treasure so that the child's king was able to keep the treasure for himself. Thus, the child and the experimenter had the same goal; to help the child's king keep the treasure.

In contrast, in the competitive condition, the child was told that the experimenter's king also really liked the stickers in the treasure box and therefore, the experimenter's king was going to try to steal the treasure. The experimenter's king was going to try to make it difficult for the child to protect the treasure so that the experimenter's king could win all the treasure for himself. Thus, the child and the experimenter had different goals; the child wanted to keep the treasure for his or her king and the experimenter wanted to steal the treasure for her king.

As in the location guessing game, feedback was given that was appropriate to the playing style condition. For example, if the child used the spell on the king piece and kept the treasure, the experimenter would express pleasure in the cooperative condition, and displeasure in the competitive condition. If the experimenter's king piece reached the child's castle and took the treasure, the experimenter would express displeasure in the cooperative condition and pleasure in the competitive condition.

Following these instructions, the child was told that they were going to play the game. The experimenter moved one piece from her castle into the space between the two castles and asked the child if he or she wanted to use the spell on that piece or if he or she wanted to wait. If the child did not want to use the spell they simply had to say so. If the child successfully used the spell on the experimenter's king, the child kept the treasure. If the child successfully did not employ the spell on a piece that was not the king, the experimenter made a new move. However, if the child unsuccessfully used the spell on a piece other than the experimenter's king, the experimenter showed the child that the piece was not the king. Under these circumstances the game continued until the experimenter's king entered the child's castle and took a piece of treasure (a sticker). That is, if the king piece was to be the third piece moved in a game by the experimenter, and the child used the spell on the first piece that the experimenter moved, the experimenter would move the second piece and then the third piece, thus maintaining the king comes third rule. Games
were played until the child correctly used the spell on the experimenter’s king in five consecutive games.

The experimenter used a temporal sequence to move her king towards the child's castle. The king was moved first of the five pieces, then third of the five pieces, then first, and so on. Thus, if the experimenter sent the king first, and the child used the spell on that first piece, that game would be over and the child would win and take a star sticker from the treasure box. If the experimenter sent the king first and the child did not use the spell on that first piece, that game would be over and the experimenter would win and take a star sticker. If the experimenter sent the king third, she would move one of the other pieces towards the child's castle first and second. If the child used the spell on the first piece, the experimenter would show the child that that piece was not the king. She would then move a second non-king piece out, and then move the king in the third temporal position into the child's castle and take a star sticker. Thus, if the child was to win when the experimenter's king was the third piece to move, he or she had to choose not to use the spell on the first and second move, but had to save the spell for the third move.

After each game, the experimenter mixed up her pieces in order that the child would not be able to remember which piece was the king from the previous game. After the child had correctly used the spell on the experimenter's game in five consecutive games, the playing ended. Children were given a coloured star for participating.
Figure 7.2: Mean games to criterion (±SE) by age group and playing style condition in Experiment 7
Results

All of the children enjoyed playing the game and entered into the spirit of the cooperative or competitive conditions. As in previous experiments, the number of games to criterion over playing style conditions was assessed for evidence of switches in guessing strategy. Games to criterion was the number of games taken to win five consecutive games.

Figure 7.2 presents the mean number of games to criterion by age group and playing style condition. The data suggest that, regardless of age, children assigned to the competitive condition took more games to reach criterion than children assigned to the cooperative condition. These impressions were supported by the analysis. It is notable that the differences between the means for the competitive and cooperative conditions are large relative to the differences revealed in the location guessing game.

A two factor between subjects ANOVA with age group and playing style condition was conducted on the transformed data set (reciprocal square root transformation). This transformation was selected using the procedure described by Box and Cox (1964) in order to achieve homogeneity of variance. Overall, more games to criterion were taken by children assigned to the competitive condition than children assigned to the cooperative condition, $F(1,36)=60.468$, $p<.0001$. Neither the main effect of age group, $F<1$, nor the interaction were significant, $F<1$. A priori simple main effects were conducted at each age group to compare games to criterion over playing style condition. These indicated that both 5- and 6-year-old children, $F(1,36)=28.058$, $p<.0001$, and 7- and 8-year-old children, $F(1,36)=32.490$, $p<.0001$, who were assigned to the competitive condition took more games to criterion than those from the same groups who were assigned to the cooperative condition.

The data presented in figure 7.2 appear to indicate that the differences between the means for the cooperative and competitive conditions are large relative to those observed in the location guessing game, particularly for the 5- and 6-year-old children. The appropriate comparison condition is the alternate door only hiding sequence condition of the five door location guessing game employed in Experiment 4 (data presented in Figure 4.11, Chapter 4).

A meta-analytic comparison of the effect size resulting from the identity
procedure and the effect size resulting from the location procedure was carried out according to the procedures described by Rosenthal (1991, equation 4.4, p.65). This was based on the effect size estimator, $g$ (Hedges, 1982). This revealed that, for the 5- and 6-year-old children, the effect size for the identity procedure ($g=2.819$) was greater than the effect size for the location procedure ($g=1.063$), $Z=2.175$, $p=.015$. In contrast, the same analysis for the 7- and 8-year-old children revealed no significant differences in the effect size of the identity ($g=2.226$) or location ($g=2.491$) procedures, $Z=.314$, $p=.377$. 

**Discussion**

The results of Experiment 7 showed that children from both age groups who were assigned to the competitive condition took more games to reach criterion than their counterparts in the cooperative condition. Thus, both 5- & 6-year-old and 7- & 8-year-old children who were assigned to the competitive condition switched guessing strategy in the identity guessing game. Furthermore, the identity guessing game was more sensitive than the location guessing game to the effect of playing style condition on trials to criterion for the 5- and 6-year-old children.

In the present experiment, children in the competitive condition switched from an identity based rule in the same way that previous experiments showed that children switched from a location based rule. The results of Experiment 7 show that children's tactically strategic guessing behaviour is not restricted to location tasks and that identity games may be exploited in research on tactical strategy.

The finding that children from both age groups switched guessing strategy if they were assigned to the competitive condition in the identity guessing game vindicates the parametric choices made. The task parameters of the identity guessing game were selected on the basis of the procedural manipulations conducted in experiments using the location guessing game (reported in this thesis in Chapter 4). This was in order that the identity guessing game would be maximally sensitive to tactical guessing strategy in young children.

The identity guessing game procedure resulted in a larger effect size than the location guessing game for the 5- and 6-year-old children, and is therefore a more sensitive procedure for the demonstration of a tactical guessing strategy in this age group. At first glance this may seem somewhat surprising because the task demands of the identity guessing game procedure seem greater than the task demands of the
location guessing game procedure. The task demands of the identity guessing game require that: children remember the roles associated with their own and their opponent's pieces, that they remember that the defensive move involves "casting a spell", and that they can cast only one spell in a game. In contrast, the task demands of the location guessing game seem simpler. In that game children have no role to remember and there is no defensive move; they simply have to guess a door. Learning a sequence used by the experimenter is common to both procedures.

So why then, is this seemingly more contrived procedure more sensitive to tactical guessing strategy? Two candidate explanations are discussed here. Firstly, two aspects of the procedure of the identity guessing game, taking on the role of the king piece and using a wand, may result in children feeling more involved in the identity guessing game procedure and, if this were the case, this may have increased the competitive edge. Children who played the identity guessing game may have been more motivated to ensure that their king won the treasure than children who played the location guessing game were to win stickers for a puppet. Secondly, role taking games may be more similar than location guessing games to everyday games that children play. For example, computer games, in which the player can take the role of a fantasy character, enjoy a large popularity among children. Hide and seek style location games may be less popular than they once were. Thus, the identity guessing game may have captured the imagination of the younger children in a way that the location guessing game did not, again increasing the competitive nature of the identity procedure.

**Conclusions**

The results of Experiment 7 show that children's tactically strategic guessing behaviour is not restricted to the location guessing game procedure. Not only did children from the age of 5 or 6 switch guessing strategy in the competitive condition, but the identity guessing procedure was more sensitive than the location guessing game to such switches in strategy for these younger children. This increased sensitivity may be a result of children being more engaged in the game, or by them being more familiar with games that involve taking the role of a game character.
Discussion: Children's developing tactical strategy

The aim of this thesis was to consider the development of tactical strategy. Tactically strategic behaviour is employed in competitive interactions in which individuals are trying to obtain the same limited set of resources. Tactical strategy is demonstrated when children try to out-manoeuvre an opponent and in doing so take into account prior knowledge about the way in which others generally behave. Tactically strategic behaviour is commonplace in social interactions, but apart from a few exceptions (DeVries, 1970; Gratch, 1964; Shultz & Cloghesy, 1981), it has not been examined by prior research. Research on children's behaviour in competitive situations has focused on deception (e.g. Chandler et al, 1989; Hala et al, 1991; Hughes & Russell, 1993; Russell et al, 1994; Russell et al, 1991; Sodian, 1991, 1994; Sodian & Frith, 1992; Sodian et al, 1991).

Section 8.1 presents a discussion of the novel procedures developed to investigate tactical strategy in children, and the adequacy of the contingency change game designed to assess inhibitory control in the context of a location guessing game. Section 8.2, considers how the developmental trends in tactically strategic behaviour revealed by experiments reported in this thesis contribute to the existing literature on tactical strategy. Section 8.3 evaluates the contribution of this thesis to the theory of mind literature by evaluating the extent to which children's use of tactical strategy is indicative of mental state attribution. Section 8.4 evaluates the contribution of this thesis to the executive functions literature by discussing the role of executive functions in tactically strategic behaviour in the experiments reported in this thesis. Section 8.5 considers the relationship between social development and tactical strategy, and final conclusions are presented in Section 8.6.

8.1 The methodology used in this thesis

This section presents a discussion of the methodology used in this thesis. The first subsection considers the procedures designed to assess the development of tactically strategic behaviour. These are the location guessing game (Experiments 1, 2, 3, 4 & 6) and the identity guessing game (Experiment 7), which were designed to assess
anticipatory switches in children's guessing strategy. The second subsection discusses the contingency change game (Experiment 5), which was designed to assess children's inhibitory control.

8.1.1 The location and identity guessing games

One contribution made by this thesis to the existing literature on tactical strategy has been the development of two tasks to assess the development of tactically strategic behaviour. Previous research, reviewed in Chapter 1 (Section 1.1), was not able to adequately assess tactically strategic behaviour. For example, research has shown that children implement irregular guessing strategies in simple hand guessing games (e.g. Baron-Cohen, 1992; DeVries, 1970; Gratch 1964; Section 1.1.1), but in order to be certain that this behaviour is a tactical strategy it should be demonstrated that it is carried out only in a competitive condition (Section 1.4, Chapter 1). The inclusion of a cooperative control condition would allow investigation of whether irregular guessing and hiding strategies are carried out exclusively in a competitive condition. Such a cooperative control condition was included in the experiments reported in this thesis.

The location and identity guessing games were designed to assess one specific example of tactically strategic behaviour, which was children's anticipatory switches in guessing strategy. Similar anticipatory switches in game playing strategy were anecdotally reported by Shultz & Cloghesy (1981; Section 1.4, Chapter 1), but were not formally assessed. The guessing game procedures reported in this thesis formally assessed such behaviour. In addition, because in the guessing games the experimenter's game playing strategy remained constant throughout the game, it was possible to consider changes in the children's game playing behaviour that occurred independently of changes in the experimenter's game playing behaviour. In previous studies, the experimenter's game playing strategy changed throughout the game (Shultz & Cloghesy, 1981; see Section 1.1.2, Chapter 1).

Location or identity guessing game procedures were employed in Experiments 1, 2, 3, 4, 6 & 7 in order to assess the development of anticipatory switches in guessing strategy. In these games, unbeknown to the child, the experimenter played according to a predictable rule. Children's guessing behaviour was assessed to consider the question of whether children assigned to a competitive condition would show anticipatory switches in their game playing strategy. If children, after discovering the experimenter's sequence deviate from guessing according to that sequence, they would take more trials
to reach a criterion than those who did not deviate from guessing according to the sequence.

The preferred explanation for the playing styles effect (more trials to criterion in the competitive condition than the cooperative condition) is that children in the competitive condition make anticipatory switches in guessing strategy (Chapter 3). This receives support from the finding that children from Experiments 1, 2, 3, 4, 6, & 7 took a similar number of trials to initially discover the hiding sequence regardless of playing style condition, on the basis of the more liberal two trials to criterion measure. This suggests that it is unlikely that the playing style effect occurred because children in the competitive condition took more trials to initially discover the hiding sequence than their counterparts in the cooperative condition. Support for switching strategy also comes from the finding that children in the competitive condition, who, as an age group, showed evidence of a playing styles effect were more likely to make pre-criterion runs than those who did not show evidence of a playing styles effect. Furthermore, the observation that children did not appear worried or upset when they beat the experimenter in any of the guessing game experiments (Experiments 1, 2, 3, 4, 6, & 7) suggests that children did not switch because negative feedback associated with task success in the competitive condition made them feel uncomfortable pursuing the correct guessing pattern.

The initial guessing game procedure was not maximally sensitive to the assessment of tactically strategic guessing behaviour in young children (Experiment 1, Chapter 3). Therefore, the experiments reported in Chapter 4 were designed to investigate task parameters that influenced the sensitivity of the procedure (Experiments 2, 3 and 4). Two manipulations were found to influence strategy switching in 5- and 6-year-old children. Reducing the number of doors from five to three, but maintaining both the same door and alternate door hiding sequences resulted in 5- and 6-year-old children assigned to the competitive condition switching guessing strategy in the alternate door trials. Additionally, maintaining the number of doors at five, but removing the same door hiding sequence trials resulted in 5- and 6-year-old children switching guessing strategy in the alternate door trials. These manipulations were argued to influence the working memory load of the game and children's perception of the game as competitive.

The effect of the door and hiding sequence manipulations guided the selection of task parameters in the procedure designed to assess tactical strategy in younger children.
(Experiment 6). Experiment 6 used the simplest version of the location guessing game; three doors and the alternate door hiding sequence only. The effects of task parameters on sensitivity were also considered in the design of the procedure of the identity guessing game in order that the identity guessing game would be well suited to the demonstration of tactically strategic guessing behaviour (Experiment 7). Experiment 7 employed five options and one alternation style sequence. The identity guessing game procedure was more sensitive than the location guessing game in 5- and 6-year-old children, and reasons why this may be the case were discussed in detail in Chapter 7. This procedure should be pursued in future research.

A within subjects task design for the guessing game procedures

Although the guessing game procedure was modified throughout this thesis in order that it be maximally sensitive, a within subjects experimental design would be likely to increase the sensitivity further still, and more importantly, allow assessment of the external validity of the guessing game procedure. The need for a within subjects version of the location and/or identity guessing game was identified in Chapters 5 and 6. As discussed in Chapter 6, a within subjects design would allow the consideration of whether individual differences on the guessing games were associated with those observed on tasks assessing other cognitive or social competencies, such as theory of mind and inhibition. This approach would allow investigation of the reasoning involved in tactically strategic behaviour. Within subject experimental designs have other advantages (see the Discussion of Chapter 6), for example, they are more sensitive and the power of the test is likely to be increased.

A within subjects task design was employed in tasks used to assess tactical deception in children (see Chapter 1, Section 1.3). For example, in order to be classified as being able to tactically deceive another in the box task, children had to both deceive an opponent and inform a collaborator about the location of a hidden object (Sodian, 1991; Sodian & Frith, 1992). A similar design could be applied to the location and/or identity guessing game procedures. Each child could play both the cooperative and competitive playing style conditions and performance compared in order to consider whether individual children take more trials to reach criterion in the competitive condition than in the cooperative condition. Thus, anticipatory switches in guessing strategy could be assessed in individual children.

A within subjects design should avoid carry over effects between playing style conditions in order that knowledge of the regular sequences used in the location and
identity guessing games does not unduly influence performance in the second condition in which the child participates. There are a number of ways in which the task procedures could be adapted to avoid carry over effects. For example, a time delay between the administration of cooperative and competitive conditions could be employed.

Alternatively, a total-change paradigm could be employed in order to minimize such carry over effects by creating a new situation for the child in the second of the two playing style conditions. Hughes (1998a) employed a total-change paradigm (Wolf, 1967) in the design of the card sort task used to assess attentional flexibility (see Chapter 2, Section 2.2.1). Application of a total-change paradigm to the guessing games could results in manipulation of procedural features that encourage children to treat the cooperative and competitive conditions as separate games. For example, in the case of the location guessing game, different puppets, different apparatus, and different objects to hide, could be employed in the two playing style conditions. The identity guessing game parameters provide even more opportunity to develop a parallel procedure. For example, an entirely new cover story could be developed, along with different pieces and different props.

If an attempt were not made to reduce carry over effects, the analysis of trials to criterion over playing style conditions would be difficult to interpret unambiguously. If the competitive condition preceded the cooperative condition and children took fewer trials to reach criterion in the cooperative condition, it could be argued that this was because they had been alerted to the use of regular hiding sequences in the competitive condition. This may have allowed them to discover the hiding sequence used in the cooperative condition more rapidly, allowing them to reach criterion in fewer trials than in the competitive condition. Alternatively, if the cooperative condition preceded the competitive condition, children may be alerted to the regularity of the hiding sequence in the cooperative condition and this may undermine the competitive manipulation.

8.1.2 The contingency change game

The contingency change game was designed to assess children's inhibitory control within a similar context to the location guessing game. The development of this task may make a contribution to the executive functions literature by providing another potential measure of inhibitory control. This subsection presents an evaluation of whether the contingency change game adequately assesses inhibitory control by comparing it to established tests of inhibition.
The contingency change game was designed to assess children's ability to inhibit a formerly successful guessing strategy and adopt a novel guessing strategy. In the contingency change game, unbeknown to the child, the experimenter used a predictable hiding sequence to hide a sticker in one of five locations. Over the course of multiple trials (on each trial a sticker was placed in a location different to that used previously), children were able to learn the hiding sequence. When their behaviour demonstrated that they had learned the hiding sequence (at the point at which they made five consecutively correct guesses), the experimenter changed the hiding sequence. Children's guessing behaviour was observed to see if they continued to guess according to the old, now inappropriate sequence, or if they were able to inhibit their formerly successful guessing response and adopt a novel one.

The assumption that the contingency change game assesses children's ability to inhibit could be queried because it is possible that guessing according to the experimenter's hiding sequence does not form a prepotent response. Prepotent responses have been defined as those that are widely used and reinforced (e.g. Carlson et al, 1998). Other tasks that assess inhibitory control require responses that are well rehearsed and reinforced, such as imitation, pointing and categorization. For example, Luria et al's (1964, see Chapter 2, Section 2.2) hand game requires an imitative and non-imitative response. Switching from imitation to non-imitation (but not non-imitation to imitation) would involve inhibition of a prepotent response. Imitation is a widely used and reinforced behaviour in children (Lipsett & Werner, 1981; Meltzoff, 1996). Russell and colleagues' (Hughes & Russell, 1993; Russell et al, 1994; Russell et al, 1991) windows task requires a pointing response, which may be a well rehearsed and reinforced behaviour (Bates et al, 1975; Bates et al, 1987; Leung & Rheingold, 1981; Murphy & Messer, 1977; see Chapter 2, Section 2.2.2). Card sort tasks, such as the Wisconsin Card Sort Task (WCST, see Chapter 2, Section 2.2.1) require children to sort objects into categories on the basis of simple attributes such as colour and size, that are very familiar to children. Children categorize objects according to these and other rules from a very early age (e.g. Gelman & Markman, 1986, 1987; Wellman & Gelman, 1988, 1992), and such sorting according to rules may therefore form a well-rehearsed response.

The rule used to hide the stickers in the contingency change game is similar to the rules used to sort cards in the WCST. It may be that selecting the doors one and three forms a prepotent response in the same way that sorting according to a colour rule
is thought to. The question of whether the contingency change game assesses inhibitory control can be assessed by external validation with other inhibition tasks. This could be achieved by considering whether associations are found between children's behaviour in the contingency change game and their behaviour on more established tests of inhibition, for example, Luria's (1964) hand task (e.g. Hughes, 1998b, see Chapter 2, Section 2.1).

8.2 The Development of Tactical Strategy in Children

The aim of this thesis was to consider the development of tactically strategic behaviour in children. The experiments reported in this thesis clearly suggest that children from the age of 5 or 6 are able to implement tactically strategic behaviour in the form of anticipatory switches in guessing strategy when faced with a competitive opponent. Younger children, from about the age of four, may also employ tactical guessing strategies, but the question of whether these younger children demonstrate tactically strategic behaviour cannot be resolved until a more sensitive procedure has been developed. The first subsection describes the developmental trends in tactically strategic guessing behaviour observed in the experiments reported in this thesis. The second subsection considers the contribution made by this thesis to the existing empirical literature on tactical guessing strategy.

8.2.1 Developmental trends in tactically strategic guessing behaviour observed in this thesis

For young children, evidence for tactically strategic behaviour in the guessing game procedures was found to be dependent on task parameters. When task parameters were manipulated to make the procedure more sensitive (Experiments 3 and 4), 5- and 6-year-old children who were assigned to the competitive condition switched guessing strategy in the location guessing game. However, these children did not demonstrate tactical guessing strategies when a less sensitive procedure was employed (Experiments 1 and 2). The design of the identity guessing game employed the task parameters shown to be most sensitive from previous location guessing game experiments (Experiment 7). Furthermore the identity guessing game procedure was shown to be more sensitive than the location guessing game procedure in 5- and 6-year-old children, but not in older children.

Seven- and eight-year-old children were less susceptible to task insensitivity than their younger counterparts. They demonstrated tactically strategic guessing behaviour when faced with a competitive opponent in all of the experiments using the location
guessing game procedure, regardless of task parameters (Experiments 1, 2 and 4). They also showed tactical guessing strategies in the identity guessing game (Experiment 7). The 7- and 8-year-old children demonstrated a similar pattern of behaviour to that observed in adults (Experiment 1). In Chapter 4, it was suggested that 7- and 8-year-old children may interpret their experience in the same door trials as part of a ploy by the experimenter. This may imply that they are capable of more elaborate understanding than that assessed by the location or identity guessing games, for example, they may interpret the same door trials as being a bluff by the experimenter. This could be addressed by future research.

This thesis reported only initial attempts to demonstrate tactically strategic guessing behaviour in 3- and 4-year-old children. Three- and four-year-old children were tested in Experiment 6, which was designed to consider whether attributions of second order knowledge underlie children's use of tactical guessing strategies. These children were at the developmental cusp of such theory of mind understanding. An analysis of simple effects showed that at least some 3- and 4-year-old children appear to use tactically strategic behaviour. However, the absence of a statistically significant interaction means that no strong claims can be made about which sub-samples of children do and do not show evidence of tactically strategic behaviour. This is discussed in more detail in Section 8.3. In addition, an insufficient number of the children correctly answered the control questions in the theory of mind task, and the procedure may not have been sufficiently powerful. Either the within subjects design proposed in Section 8.1, or the identity guessing game, may provide a statistically more powerful test which would be better suited to addressing this question in future research.

The 3- and 4-year age group provides potentially the most interesting age range in which to consider the development of tactically strategic behaviour. These children appear to be at the developmental cusp of understanding in cognitive capabilities that may underlie tactically strategic behaviour, such as theory of mind (Baron-Cohen et al, 1985; Hogrefe et al, 1986; Perner et al, 1987; Wimmer & Perner, 1983) and executive functions (Dempster, 1981; Hughes, 1998a; 1998b). The role of these cognitive capabilities in tactically strategic behaviour could be explored more fully by considering patterns of associations and dissociations between game behaviour and performance on measures of such cognitive competencies. The extent to which the experiments in this thesis allowed the evaluation of the role of theory of mind and executive functions in
tactical strategy is discussed in more detail in this chapter in Sections 8.3 and 8.4 respectively.

8.2.2 Contribution to existing literature

As discussed earlier in this chapter, one contribution of this thesis to the existing literature on tactical strategy is the development of two procedures that allow the empirical assessment of tactically strategic behaviour (Section 8.1). The location and identity guessing game procedures were designed such that switches in guessing strategy could not be argued to be a response to the changing contingencies of the game, and an appropriate control condition was employed. Procedures employed in previous studies on tactical strategy did not adequately assess tactically strategic behaviour.

Because the existing literature could not adequately assess tactical strategy, only a cautious comparison can be made of age trends in the experiments reported in the literature with those observed in the existing literature. It seems likely that previous studies underestimated children's competence. The experiments reported in this thesis show that children from the age of 5-years, and also some 3- and 4-year-old children, can employ tactically strategic behaviour. Previous research on guessing strategies found that it was only from the age of 6 and older that children used an irregular guessing strategy that may be indicative of tactically strategic behaviour (Baron-Cohen, 1992; DeVries, 1970; Gratch, 1964; see Section 1.1.1, Chapter 1). It is not possible to directly compare the particular developmental trends in anticipatory switches in guessing strategy with those found in previous research because only anecdotal evidence of strategy switching has been reported, with no information on developmental trends (Shultz & Cloghesy, 1981; Section 1.1.2, Chapter 1).

8.3 Theory of Mind and Tactical Strategy

Two accounts of tactically strategic behaviour have been proposed in this thesis (see Chapters 1, 2, 3 & 6). The behavioural account proposes that, once children have discovered the hiding sequence, they switch guessing strategy in expectation of their opponent changing the hiding sequence. The theory of mind account proposes that, once children have discovered the hiding sequence, they switch guessing strategy as a result of the second order mental state attribution that their opponent knows that they know the hiding sequence. The first subsection in Section 8.3 discusses the extent to which the experiments in this thesis favour either the behavioural account or the theory of mind...
account of strategy switching. The second subsection discusses the contribution of this thesis to the theory of mind literature.

8.3.1 The theory of mind account of tactically strategic guessing behaviour

Findings for the 5- and 6-year-old children are not inconsistent with the theory of mind account of tactically strategic guessing behaviour. At this age, children can both attribute second order mental states (tested in Experiments 1 & 2), and switch guessing strategy in both the location guessing game (under optimal procedural conditions in Experiments 3 & 4) and the identity guessing game (Experiment 7). These findings suggest that an association between theory of mind and strategy switching could be found.

The results of Experiment 6, which employed a sample of 3- and 4-year-old children, have most bearing on any association between theory of mind and strategy switching. However, lack of statistical power mean that the results of this experiment have to be interpreted cautiously (see Section 8.2.1). Experiment 6 compared the game playing behaviour of groups of children who either could or could not make the second order mental state attributions hypothesized to be involved in strategy switching. This revealed a pattern of results consistent with a relationship between theory of mind ability and strategy switching. However, this potential relationship must be investigated further with a bigger and more selective sample, who correctly answer all of the control questions in the theory of mind task. The within subjects version of the guessing game proposed in Section 8.1 could be used to consider this further.

The age group of 3- and 4-year-old children is potentially the most interesting group to study in order to consider further the theory of mind account of strategy switching because the results of Experiment 6 suggest that they are at the developmental cusp of the ability to attribute second order mental states. If children who do not possess this ability switch guessing strategy, this would suggest that second order mental state attribution is not necessary for strategy switching. This pattern of findings would lend support to the behavioural account of strategy switching. Alternatively, if children do not switch guessing strategy until they possess second order theory of mind, this may suggest that children do not switch guessing strategy until they have developed the capacity to attribute second order mental states (e.g. that their opponent knows that they know the hiding sequence). This pattern of findings would lend support to the theory of mind account of strategy switching.
There may not be a simple answer to the question of whether second order mental state attribution is involved in strategy switching. The theory of mind and behavioural accounts of strategy switching are both, in principle, valid alternatives. It is possible that there are individual differences among children as to whether strategy switching is motivated at either a theory of mind or behavioural level. Furthermore, an individual's strategy switching may be motivated by second order mental state attributions on one occasion and expectations of behavioural change on another.

In addition, the question of whether second order mental state attribution is involved in strategy switching may be difficult to approach in practice. Even if associations between second order theory of mind and strategy switching were observed, it could not be concluded that children switch guessing strategy because they think their opponent knows that they have worked out the hiding sequence. Associations between tasks may be a result of some other factor, such as age.

8.3.2 Contribution of this thesis to the theory of mind literature

Because the theory of mind account of strategy switching cannot be favoured over the behavioural account, the contribution made by the experiments reported in this thesis to the theory of mind literature is limited. It is possible that children may show theory of mind reasoning earlier in the guessing games than in a comprehension style false belief task (e.g. Chandler et al, 1989). It has been suggested that deception may provide "a good candidate for a 'naturalistic' context in which false belief representation may emerge in young children" (Sodian, 1991, p.174), and it is possible that tactically strategic situations similarly provide a situation in which early theory of mind competence may be demonstrated. In addition, the guessing games may provide a task in which evidence indicative of theory of mind reasoning could be assessed in populations who may find comprehension style false belief tasks computationally demanding.

8.4 Executive Functions and Tactical Strategy

It was proposed earlier in this thesis that executive functions may be involved in tactically strategic behaviour (Chapter 2, Section 2.4; Chapter 5). Specifically, it was suggested that inhibitory control may be required in the guessing games for children to be able to stop guessing according to the currently successful sequence and adopt a novel guessing strategy. In addition, it was suggested that the load placed on working memory may influence children's ability to implement tactically strategic behaviour.
(Chapter 4). The first subsection in Section 8.4 discusses the role of executive functions in children's tactically strategic behaviour. The second subsection considers the contribution of this thesis to the executive functions literature.

8.4.1 Executive functions and tactically strategic guessing behaviour

The assumed role of inhibitory control in strategy switching is currently based on a task analysis. Limited progress was made in assessing the role of inhibition in strategy switching in this thesis. The contingency change game (Experiment 5) was designed to consider whether the task parameters manipulated in Experiments 3 and 4 enabled 5- and 6-year-old children to switch guessing strategy by influencing their ability to inhibit. The results of Experiment 5 showed that children had little difficulty changing their guessing strategy when the hiding sequence changed and the task parameters examined did not influence their performance. In the absence of external validation, it cannot be concluded with certainty that the executive function(s) responsible for switching strategy in the contingency change game is inhibitory control (see Section 8.1). However, the findings of Experiment 5 do not preclude the possibility that inhibition is involved in strategy switching.

The role of working memory in strategy switching in was considered in Chapter 4. In the process of developing the location guessing game paradigm, changes were made to the task parameters that were intended to manipulate working memory load and allow 5- and 6-year-old children to switch guessing strategy (Experiments 2 & 3). One of these manipulations, the inclusion of memory aids (Experiment 2), did not influence children's ability to switch guessing strategy. However, a reduction in the number of doors (Experiment 3), was found to influence children's ability to switch guessing strategy. Reducing the number of doors in the location guessing game enabled children to discover and learn the experimenter's hiding sequence in fewer trials. These findings suggest that the load placed on working memory can influence children's ability to implement tactically strategic behaviour.

Other executive functions, which have not been examined in the experiments reported in this thesis, may be involved in anticipatory strategy switching, such as attentional flexibility and planning. For example, the guessing games require both that the child attends to the experimenter's hiding sequences (basic task demands) and also reasons in a tactical manner about their opponent's behaviour (tactical task demands). Coordinating both of these requirements may involve attentional flexibility.
Any of the above executive functions may play a number of roles in the performance of tactically strategic behaviour. First, it is possible that the role of executive functions is task specific. Evidence that executive functions may limit the expression of tactically strategic behaviour in certain tasks comes from the finding that reducing working memory load enabled strategy switching in the location guessing game. Second, executive functions may play a role in particular types of tactically strategic behaviour. Their role may not generalize beyond anticipatory switches to other types of tactically strategic behaviour, for example, irregular guessing (Baron-Cohen, 1992; DeVries, 1970; Gratch, 1964). Third, executive functions could be intrinsic to all tactically strategic behaviour.

These possibilities could be assessed by implementing a battery of tactical strategy and executive functions tasks and considering patterns of associations in performance between the different tasks. For example, if an executive function was required for tactically strategic behaviour in general, it would be expected that children's executive function ability would be associated with the observance of tactical strategy across the range of tactical strategy tasks.

8.4.2 Contribution of this thesis to the executive function literature

This thesis may contribute to the executive functions literature by providing a new procedure in which inhibitory control can be assessed. The contingency change game (Experiment 5) was designed to assess inhibition in the context of a location guessing game. However, as discussed in Section 8.1.2, this task must be externally validated in order to ensure that it assesses inhibitory control.

If inhibitory control is required for strategy switching, then it is possible that it is implemented in a different manner to the inhibitory control that is more commonly studied. Children who switch guessing strategy in the location guessing game do so in anticipation of their strategy becoming maladaptive. Thus, the motivation for inhibition is endogenous. In contrast, the motivation for inhibition in established tasks is exogenous; inhibition is motivated by the existing strategy becoming maladaptive.

8.5 Social Development and Tactical Strategy

So far, the discussion of the development of tactically strategic behaviour has focused on two aspects of cognition; theory of mind and executive functions. Even if children have sufficiently well developed theory of mind and executive functions, they may not use tactically strategic behaviour because of limitations in their social
development. In this section, the discussion is widened to examine relationships between social development and tactical strategy. The first subsection considers the extent to which prior social experience may influence the way in which children understand the game situation as competitive and therefore appropriate for tactical strategy. The second subsection reviews a model of social competence in order to provide a framework for future research examining the dynamics that may occur in social situations in which tactical strategy may be appropriate. The third subsection considers how the research presented in this thesis might make a contribution to the person perception literature.

8.5.1 Social Experience

The possibility that social experience may influence strategy switching was considered in Chapter 4. It was suggested that age-related experiences of competitive interactions may influence children's understanding of the game as a competitive situation in which tactically strategic behaviour could be employed. Experiment 4 showed that 5- and 6-year-old children switched guessing strategy in the alternate door trials only if they were not preceded by the same door trials, while 7- and 8-year-old children switched in the alternate door trials irrespective of whether they were preceded by the same door trials. It was suggested that the same door trials may have had an effect on children's pragmatic understanding of the game as a competitive situation, and that this effect was dependent on age.

Children's age-related experience of competitors may influence the way that they perceive the same door trials. For example, prior experience may have taught the younger children that adults do not always set out to win when they say they will, and winning easily in the same door trials may have confirmed this. This may have undermined the competitive manipulation in the alternate door trials for the younger children.

Future research could consider further social experience and its relation to the development of tactically strategic behaviour. One possibility that could be pursued is the question of whether adults moderate their competitive behaviour on the basis of the age of the child. If this were the case, it is possible that they do so on the basis of children's understanding. Another possibility is that familial factors may alter children's social experience of competitive situations. It is possible that if children have siblings they may be exposed to qualitatively and/or quantitatively different experiences of competition. Similarly, in the theory of mind literature, having older siblings has been
shown to be beneficial for theory of mind development (Perner, Ruffman & Leekam, 1994).

8.5.2 Social Competence

A model of the way in which the dynamics that occur in social situations lead to social competence could provide a framework for guiding future experiments on tactically strategic behaviour. Dodge and colleagues (Dodge, Pettit, McClaskey & Brown, 1986; Dodge & Price, 1994) proposed an information processing account of children's behaviour in social situations. They were particularly interested in individual differences in social competence and the way in which such individual differences may come about, for example, through interactions with parents and other children.

This model proposes five stages of reasoning and behaviour in children's responses in social situations. The stages are as follows: 1) attending to and encoding the presented social cues; 2) interpreting the cues; 3) searching their current response repertoire for an appropriate response; 4) evaluating the efficacy and likely consequences of the response; 5) enacting the response. Dodge and colleagues argue that these stages are progressed through rapidly in a nonconscious manner. Failure in any one or combination of these stages could result in non-optimal or inappropriate social behaviour.

This model could be used as a framework to guide future experiments in the following way. Failure at any of Dodge's proposed stages could result in children failing to implement a tactical guessing strategy. For example, in the guessing games, children may fail to employ a tactical guessing strategy because they have either failed to attend to, or to encode, the social cues provided by instructions and feedback during the game (stage 1), or failed to interpret these as competitive (stage 2). Alternatively, even if children interpret the situation as competitive, they may not have an appropriate tactically strategic response, e.g. anticipatory switching, within their repertoire (stage 3). This may be a consequence of lack of experience (see Section 8.5.1). Some of these possibilities could be tested by manipulating the social cues present within the game. One example would be to implement a situation in which the competitive nature of the interaction was stressed.

8.5.3 Person perception

Much of the research on person perception considers the way in which children describe others and the way in which these descriptions change as they age. Young
children tend to concentrate on physical characteristics and other external phenomena, for example, the clothes that people wear and hairstyles. Older children tend to describe others in terms of personality traits, motives and attitudes. The shift from physical characteristics to internal psychological properties is conventionally thought to occur around the age of 7- to 8-years (Barenboim, 1981; Damon & Hart, 1988; Livesley & Bromley, 1973; Newman, 1991; Oppenheimer & DeGroot, 1981; Peevers & Secord, 1973).

An alternative to a verbal report methodology would be the indirect approach of examining differences in behaviour which would occur as a consequence of a person perception. The guessing games research provides indirect evidence that children are sensitive to the difference between the characteristics of an adult who portrays herself as a competitor and an adult who portrays herself as being cooperative. Thus, the findings that children from the age of 5-years employ tactically strategic behaviour in a competitive situation suggests that children may be sensitive to the psychological attributes of a person from approximately 5-years, in common with other finding in the person perception literature (Bennett, 1985-6; Berndt & Heller, 1985; Yuill, 1993). Miller and Aloise (1987) have suggested that the verbal report methods often employed to assess children's perceptions of others underestimate their understanding.

8.6 CONCLUSIONS

This thesis reports the development of two novel procedures that allow the assessment of anticipatory switches in guessing strategy, a form of tactically strategic behaviour. An exploration of the parameters of these procedures enabled evidence of tactical strategy to be found in progressively younger children. The experiments reported in this thesis indicate evidence of tactically strategic behaviour in children from the age of 5. This age is rather younger than might be predicted from earlier research. The findings of these experiments suggested that tactically strategic behaviour may emerge at approximately 3- to 4-years of age, implying that the study of this age group would have greatest implications for the understanding of the development of tactical strategy in children. Preliminary results encourage further research investigating how tactical strategy is related to both theory of mind and executive functions. However, no strong conclusions can be made about such relationships from the findings of the experiments reported here. Future research should also consider the role of social development in tactically strategic behaviour.
REFERENCES


and executive functions in a patient with early amygdala damage. *Brain.*


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Appendix A: Sullivan, Zaitchik & Tager-Flusberg's (1994) Birthday Puppy Story, Questions and Answers

When administering this test the original hiding place of the puppy in the basement was changed to the garage. English homes rarely have basements and a garage is the nearest equivalent.

Birthday Puppy Story and Questions
Tonight, it's Peter's birthday and Mom is surprising him with a puppy. She has hidden the puppy in the garage. Peter says, "Mom, I really hope you get me a puppy for my birthday." Remember, Mom wants to surprise Peter with a puppy. So, instead of telling Peter she got him a puppy, Mom says, "Sorry Peter, I did not get you a puppy for your birthday. I got you a really great toy instead."

Control Questions:
Probe Question 1. "Did Mom really get Peter a toy for his birthday?"
Probe Question 2. "Did Mom tell Peter she got him a toy for his birthday?"
Probe Question 3. "Why did Mom tell Peter that she got him a toy for his birthday?"
Now, Peter says to mom, "I'm going outside to play." On his way outside, Peter goes into the garage to fetch his roller skates. In the garage, Peter finds the birthday puppy! Peter says to himself, "Wow, Mom didn't get me a toy, she really got me a puppy for my birthday." Mom does not see Peter go into the garage and find the birthday puppy.

NonLinguistic Control Question. "Does Peter know that his Mom got him a puppy for his birthday?"
Linguistic Control Question. "Does Mom know that Peter saw the birthday puppy in the garage?"

Now, the telephone rings, ding-a-ling! Peter's grandmother calls to find out what time the birthday party is. Grandma asks Mom on the phone, "Does Peter know what you really got him for his birthday?"

Second Order Ignorance question "What does Mom say to Grandma?"
Memory aid: Now remember, Mom does not know that Peter saw what she got him for his birthday.
Then, Grandma says to Mom, "What does Peter think you got him for his birthday?"
Second Order False Belief Question. "What does Mom say to Grandma?"
Justification Question. "Why does Mom say that?"
Answers to questions

Probe Question 1:
Correct: No (she got him a puppy)
Incorrect: Yes

Probe Question 2:
Correct: Yes (she told him she got him a toy)
Incorrect: No

Probe Question 3:
Correct: so he would be surprised, so Peter would not know he had a puppy

Nonlinguistic Control Question:
Correct: Yes (Peter knows)
Incorrect: No-Feedback: Peter saw the puppy in the garage

Linguistic Control Question:
Correct: No (Mum didn't see Peter go to the garage)
Incorrect: Yes-Feedback: Mum does not know Peter saw the puppy in the garage

Second Order Ignorance Question:
Correct: No (Peter does not know what Mum really got him)
If no response: Does Mum know that Peter knows what she bought him for his birthday?
Correct: No
Incorrect: Yes

Second Order False Belief Question:
Correct: Mum tells Grandma that Peter thinks she got him a toy
If no response: Does Mum know that Peter knows that she bought him a puppy for his birthday?
Correct: No

Justification Question: Why does Mum say that?
Appropriate:
Explicit Second order reasoning: e.g. Mum doesn't know that Peter knows she has bought him a puppy
Implicit Second order reasoning: e.g. Mum doesn't know that Peter has seen the puppy
Communicated information: e.g. Mum told Peter she bought him a toy
Location: e.g. The puppy was hidden in the garage

Inappropriate:
First order reasoning: e.g. Peter knows that the puppy is in the garage
Story facts: e.g. Peter wants a puppy
Nonsense: No answer:
APPENDIX B: THEORY OF MIND TASK DATA FOR PARTICIPANTS
IN EXPERIMENT 1

This appendix presents more detailed information concerning the performance on the Sullivan et al's (1994, see Appendix A) Birthday Puppy task of those children who participated in Experiment 1. Data is presented for children's answers to the three memory probe questions asked at the end of the first episode; the two control questions (non-linguistic and linguistic) asked at the end of the second episode; and the type of justifications to the second order false belief question are detailed.

Table B1: Frequency of children in Experiment 1 correctly answering memory probe questions by age group and playing style condition

<table>
<thead>
<tr>
<th>Question</th>
<th>5- &amp; 6-year-olds</th>
<th>7- &amp; 8-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative</td>
<td>Competitive</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>n answering all correctly</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

Note. n = 10 in each condition.

Table B2: Frequency of children in Experiment 1 correctly answering linguistic and non-linguistic control questions by age group and playing style condition

<table>
<thead>
<tr>
<th>Question</th>
<th>5- &amp; 6-year-olds</th>
<th>7- &amp; 8-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative</td>
<td>Competitive</td>
</tr>
<tr>
<td>Non-linguistic control</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Linguistic control</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>n answering both correctly</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

Note. n = 10 in each condition.
Table B3: Frequency of children in Experiment 1 making appropriate justifications by category, age group and playing style condition

<table>
<thead>
<tr>
<th>Category</th>
<th>5- &amp; 6-year-olds</th>
<th>7- &amp; 8-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative</td>
<td>Competitive</td>
</tr>
<tr>
<td>Explicit 2nd order reasoning</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Implicit 2nd order reasoning</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Location</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Note. n = 10 in each condition.

Table B4: Frequency of children in Experiment 1 making inappropriate justifications by category, age group and playing style condition

<table>
<thead>
<tr>
<th>Category</th>
<th>5- &amp; 6-year-olds</th>
<th>7- &amp; 8-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative</td>
<td>Competitive</td>
</tr>
<tr>
<td>1st order reasoning</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Story Facts</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Nonsense</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>No response</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Note. n = 10 in each condition.
APPENDIX C: PRE-CRITERION RUNS DATA FROM COMBINED ANALYSIS

This appendix presents data from groups of participants in Experiments 1, 2, 3 and 4 that was combined to form the data set that was used in the combined analysis of pre-criterion runs reported in Chapter 3. This analysis considered the frequency of participants making pre-criterion runs of consecutively correct guesses and grouped participants according to whether or not they made anticipatory switches in guessing strategy in the location guessing game. Anticipatory switches were defined according to the analysis of trials to criterion over playing style conditions. Groups of participants who took significantly more trials to criterion in the competitive condition than in the cooperative condition were categorized as having switched guessing strategy, and those who showed no significant difference were categorized as not switching strategy.

Participants from Experiments 1, 2, 3, and 4 were grouped as switchers and non-switchers separately for the alternate door trials and the same door trials. The tables presented in this appendix detail the frequency of participants making pre-criterion runs, by each experiment and age group. These tables present the frequency of pre-criterion runs for alternate door and same door trials separately, and describe data for participants in the competitive condition who switched or did not switch guessing strategy, and participants in the cooperative condition.
## Alternate Door Trials

### Alternate Door Trials: Competitive Condition

*Table C1: Frequency of participants who made pre-criterion runs in the alternate door trials for those assigned to the competitive condition, by switchers and non-switchers, Experiment and age group*

<table>
<thead>
<tr>
<th>Experiment and age group</th>
<th>0 runs</th>
<th>1 run or more</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Switchers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment 1, 7- &amp; 8-year-olds</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Experiment 1, adults</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Experiment 2, 7- &amp; 8-year-olds</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Experiment 3, 5- &amp; 6-year-olds</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Experiment 4, standard trials, 7- &amp; 8-year-olds</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Experiment 4, alternate door only, 5- &amp; 6-year-olds</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Experiment 4, alternate door only, 7- &amp; 8-year-olds</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>

| **Non-Switchers**                                |        |               |
| Experiment 1, 5- & 6-year-olds                   | 5      | 5             |
| Experiment 2, 5- & 6-year-olds                   | 3      | 7             |
| Experiment 4, standard trials, 5- & 6-year-olds  | 3      | 7             |
### Alternate Door Trials: Cooperative Condition

**Table C2: Frequency of pre-criterion runs in the alternate door trials for participants assigned to the cooperative condition, by Experiment and age group**

<table>
<thead>
<tr>
<th>Experiment and age group</th>
<th>0 runs</th>
<th>1 run or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 1, 5- &amp; 6-year-olds</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Experiment 1, 7- &amp; 8-year-olds</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Experiment 1, adults</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Experiment 2, 5- &amp; 6-year-olds</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Experiment 2, 7- &amp; 8-year-olds</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Experiment 3, 5- &amp; 6-year-olds</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Experiment 4, standard trials, 5- &amp; 6-year-olds</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Experiment 4, standard trials, 7- &amp; 8-year-olds</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Experiment 4, alternate door only, 5- &amp; 6-year-olds</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Experiment 4, alternate door only, 7- &amp; 8-year-olds</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>
### Same door trials

#### Competitive Condition

*Table C3: Frequency of pre-criterion runs in the same door trials for participants assigned to the competitive condition, by switchers and non-switchers, Experiment and age group*

<table>
<thead>
<tr>
<th>Experiment and age group</th>
<th>0 runs</th>
<th>1 run or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switchers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment 4, standard trials, 7- &amp; 8-year-olds</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-Switchers</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 1, 5- &amp; 6-year-olds</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Experiment 1, 7- &amp; 8-year-olds</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Experiment 1, adults</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Experiment 2, 5- &amp; 6-year-olds</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Experiment 2, 7- &amp; 8-year-olds</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Experiment 3, 5- &amp; 6-year-olds</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Experiment 4, standard trials, 5- &amp; 6-year-olds</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Cooperative Condition

*Table C4: Frequency of pre-criterion runs in the same door trials for participants assigned to the cooperative condition, by Experiment and age group*

<table>
<thead>
<tr>
<th>Experiment and age group</th>
<th>0 runs</th>
<th>1 run or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 1, 5- &amp; 6-year-olds</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Experiment 1, 7- &amp; 8-year-olds</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Experiment 1, adults</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Experiment 2, 5- &amp; 6-year-olds</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Experiment 2, 7- &amp; 8-year-olds</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Experiment 3, 5- &amp; 6-year-olds</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Experiment 4, standard trials, 5- &amp; 6-year-olds</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Experiment 4, standard trials, 7- &amp; 8-year-olds</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>
APPENDIX D: THEORY OF MIND TASK DATA FOR PARTICIPANTS IN EXPERIMENT 2

This appendix presents more detailed information concerning the performance of children who participated in Experiment 2 on Sullivan et al's (1994) Birthday Puppy task. Data is presented for children's answers to the memory probe questions, the linguistic and non-linguistic control questions and children's justifications to the second order false belief question.

Table D1: Frequency of children in Experiment 2 correctly answering probe/memory questions by age group and playing style condition

<table>
<thead>
<tr>
<th>Question</th>
<th>5- &amp; 6-year-olds</th>
<th>7- &amp; 8-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative</td>
<td>Competitive</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>n answering all correctly</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

Note. n = 10 in each condition.

Table D.2: Frequency of children in Experiment 2 correctly answering linguistic and non-linguistic control questions by age group and playing style condition

<table>
<thead>
<tr>
<th>Question</th>
<th>5- &amp; 6-year-olds</th>
<th>7- &amp; 8-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative</td>
<td>Competitive</td>
</tr>
<tr>
<td>Non-Linguistic control</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Linguistic control</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>n answering both correctly</td>
<td>10</td>
<td>9</td>
</tr>
</tbody>
</table>

Note. n = 10 in each condition.
Table D3: Frequency of children in Experiment 2 making appropriate justifications by category, age group and playing style condition

<table>
<thead>
<tr>
<th>Category</th>
<th>5- &amp; 6-year-olds</th>
<th>7- &amp; 8-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative</td>
<td>Competitive</td>
</tr>
<tr>
<td>Explicit 2nd order reasoning</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Implicit 2nd order reasoning</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Communication</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

*Note. n = 10 in each condition.*

Table D4: Frequency of children in Experiment 2 making inappropriate justifications by category, age group and playing style condition

<table>
<thead>
<tr>
<th>Category</th>
<th>5- &amp; 6-year-olds</th>
<th>7- &amp; 8-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative</td>
<td>Competitive</td>
</tr>
<tr>
<td>1st order reasoning</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Story Facts</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Nonsense</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>No response</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

*Note. n = 10 in each condition.*
APPENDIX E: THEORY OF MIND TASK DATA FOR PARTICIPANTS IN EXPERIMENT 6

This appendix presents more detailed information concerning the performance of 3- and 4-year-old children who participated in Experiment 6 on Sullivan et al's (1994) Birthday Puppy task (see Appendix A). Data is presented for children's answers to the memory probe questions, the linguistic and non-linguistic control questions and children's justifications to the second order false belief question.

Table E1: Frequency of children in Experiment 6 correctly answering probe/memory questions by age group and playing style condition

<table>
<thead>
<tr>
<th>Question</th>
<th>Cooperative</th>
<th>Competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>n answering all correctly</td>
<td>10</td>
<td>9</td>
</tr>
</tbody>
</table>

Note. $^a n = 23, ^b n = 24.$

Table E2: Frequency of children in Experiment 6 correctly answering linguistic and non-linguistic control questions by age group and playing style condition

<table>
<thead>
<tr>
<th>Question</th>
<th>Cooperative</th>
<th>Competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Linguistic control</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>Linguistic control</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>n answering both correctly</td>
<td>18</td>
<td>15</td>
</tr>
</tbody>
</table>

Note. $^a n = 23, ^b n = 24.$
Table E3: Frequency of children in Experiment 6 making appropriate justifications by category, age group and playing style condition

<table>
<thead>
<tr>
<th>Category</th>
<th>Cooperative</th>
<th>Competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explicit 2nd order reasoning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implicit 2nd order reasoning</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Communicated Information</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. $^{a}n = 23.^{b}n = 24.$

Table E4: Frequency of children in Experiment 6 making inappropriate justifications by category, age group and playing style condition

<table>
<thead>
<tr>
<th>Category</th>
<th>Cooperative</th>
<th>Competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st order reasoning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story Facts</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Nonsense</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>No response</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

Note. $^{a}n = 23.^{b}n = 24.$