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PAPER

The influence of language on theory of mind: a training study

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Abstract

This study investigated the role of language in the development of theory of mind. It was hypothesized that the acquisition of the syntactic and semantic properties of sentential complements would facilitate the development of a representational theory of mind. Sixty preschoolers who failed false belief and sentential complement pretests were randomly assigned to training on false belief, sentential complements or relative clauses (as a control group). All the children were post-tested on a set of different theory of mind tasks, sentential complements and relative clauses. The main findings were that the group trained on sentential complements not only acquired the linguistic knowledge fostered by the training, but also significantly increased their scores on a range of theory of mind tasks. In contrast, false belief training only led to improved theory of mind scores but had no influence on language. The control group, trained on relative clauses, showed no improvement on theory of mind post-tests. These findings are taken as evidence that the acquisition of sentential complements contributes to the development of theory of mind in preschoolers.

Introduction

The early acquisition of a theory of mind has become a central focus of research in developmental psychology. The child's capacity to attribute mental states, such as beliefs, desires and intentions, to self and others helps to make sense of and predict behavior, thus transforming understanding of social behavior (Astington & Jenkins, 1995). The roots of this cognitive capacity can be traced to the first year of life (e.g. Bretherton, McNew & Beeghly-Smith, 1981; Wellman & Lagattuta, 2000); however, throughout the early years, children become more aware of their own minds and the minds of others, as well as how to mediate between the two. Crucial changes in theory of mind understanding occur at age 4 when children begin to be able to accurately interpret the contents of other minds, especially belief states (Astington & Gopnik, 1991; Perner, 1991; Wellman, 1990; Wellman & Lagattuta, 2000; Wimmer & Perner, 1983). At this point, children demonstrate that they understand that the mind is a representational system, which does not simply reflect reality. Much of the emphasis of developmental research has been on this aspect of theory of mind: What brings about the changes at this stage that allow the child to understand and reason about human action in such a fundamentally new way? In this paper we focus on the role that language plays in fostering the developmental changes in theory of mind that take place at around 4 years of age.

The most widely used measures of a metarepresentational theory of mind are false belief tasks. Dennett (1978) argued that the ability to acknowledge that people hold beliefs of a simple, factual nature is an appropriate criterion for measuring theory of mind because this acknowledgement evidences a conception of another's mind as holding a certain belief. The false belief task dissociates belief from reality, tapping children's conception of mind as opposed to their reporting of reality. Following Dennett's suggestion, Wimmer and Perner (1983) were the first to introduce a location change false belief task, which has become the standard in developmental research. Using dolls and props to enact a sequence of events, they asked children if a boy, whose mother changed the location of a bar of chocolate in his absence, would know where the chocolate was when returning to the scene. Wimmer and Perner (1983) found that children aged 4 and older answered correctly by saying that the boy did not know where the chocolate was and that he would look for the chocolate in the place where he had left it. Younger children could not reconcile the conflict between reality and their own knowledge of the truth (the chocolate is now in the green

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cupboard), and the boy's false mental state (he believes the chocolate is where he put it because he did not see it moved). This major change in performance at around the age of 4 has been replicated in well over 100 studies, under various conditions, making it one of the most robust findings in the developmental literature (Wellman, Cross & Watson, 2001).

A number of different theoretical approaches have been proposed to explain the developments that take place in theory of mind at this stage, including nativist, conceptual change and simulation theories (e.g. Fodor, 1992; Gopnik, 1993; Gordon, 1996; Harris, 1992; Leslie & Roth, 1993; Perner, 1991; Russell, 1996; Wellman, 1990). Two main classes of theories have come to dominate the empirical literature: the 'theory theory', which argues that at this stage children undergo fundamental conceptual changes in their understanding of mind (e.g. Gopnik, 1993; Perner, 1991; Wellman, 1990); and performance-based approaches which claim that developments in theory of mind are the results of other more general cognitive changes, rather than domain-specific conceptual change. Performance-based accounts divide into two groups: nativist modular theories, which claim that much younger children have a metarepresentational concept of belief, but are limited by other cognitive factors in their performance on false belief tasks (e.g. Fodor, 1992; Leslie & Roth, 1993); and executive function theories, which claim there are fundamental conceptual changes in theory of mind that take place at 4, that are brought about by developments in executive processes such as working memory and inhibitory control (cf. Russell, 1996).

The 'theory theory' has focused extensively on accounting for the particular changes in performance that are found during the preschool years. On this view, cognitive development, particularly conceptual change, is conceived in terms of theory formation (Carey, 1985). The assumptions that form the basis of this framework include the idea that concepts are organized in intuitive theories; these concepts are inter-defined and mutually supportive; and these concepts are coherent and domain specific (e.g. biology, physics, psychology). Theory development results primarily from structural factors internal to the theory, such as a drive for simplicity and the need to incorporate new evidence (Gopnik & Wellman, 1994; Wellman & Gelman, 1998).

Several studies have been conducted to provide empirical support for the 'theory theory' in relation to the development of a representational theory of mind. The emphasis in most of these studies has been to show that some kind of change in performance takes place as a result of exposure to new information, not just simple maturation. One methodological approach that has successfully been used involves training children to facilitate conceptual development by providing evidence and counter-evidence that enhances theory formation. For example, Slaughter and Gopnik (1996) employed a training paradigm to investigate the effects of direct evidence on theory of mind development. In their first experiment, Slaughter and Gopnik (1996) trained children either on concepts of belief or on the concepts of desire and perception by giving children mental state tasks, such as reporting their own or another's earlier desires and perceptions, and providing feedback. They found that both training groups performed significantly better than controls on a location change false belief post-test. The second experiment used the same procedure as the first experiment; however, the post-tests were expanded to include different measures of a representational understanding of mind, including location change false belief, unexpected contents (cf. Perner, Leekam & Wimmer, 1987; Gopnik & Astington, 1988) and appearance-reality (cf. Flavell, 1986; Flavell, Flavell & Green, 1983). Slaughter and Gopnik (1996) found that the children trained on some mental concept (either belief or desire/perception) improved across all these tasks, thus supporting the hypothesis that a child's representational theory of mind is an intuitive theory, rather than a set of isolated concepts. Across both experiments, evidence for domain specificity was provided by the absence of any relationship between theory of mind performance and number conservation training.

In a later training study, Slaughter (1998) compared mental representation (within theory of mind) and pictorial representation (which also involves knowledge of representations, but outside the domain of theory of mind; cf. Zaitchik, 1990). Children were randomly assigned to training on false belief, false picture or number conservation. At post-testing, children scored highest on the tasks that they had been trained on. In contrast to the transfer effect found among theory of mind tasks (Slaughter & Gopnik, 1996), in this study no transfer was found between false belief and false picture tasks suggesting that there is no relation between children's understanding of mental and pictorial representation.

Among performance-based theories, the nativist perspective claims that much younger children understand the concept of belief (Fodor, 1992; Leslie & Roth, 1993; Scholl & Leslie, 1999). Both Fodor and Leslie argue that children younger than 4 fail false belief tasks because they lack the computational resources needed to solve the tasks. Leslie (2000) proposes that there is a domain-specific theory of mind mechanism (ToMM) which operates in conjunction with a more general cognitive mechanism, called the selection processor, in the solution of false belief and related problems. Thus failure on false belief tasks is not the result of conceptual or representational limitations, rather it is due to performance factors (cf. Bloom & German, 2000).

The primary evidence for this performance-based theory comes from studies that demonstrate the role of other factors on younger children's ability to solve false belief and related tasks. Examples of performance factors cited by Leslie and his colleagues include conversational skills (Siegal & Beattie, 1991; Siegal & Peterson, 1994; Surian & Leslie, 1999), inhibitory control (Carlson, Moses & Hix, 1998; Leslie & Polizzi, 1998; Roth & Leslie, 1998) and memory (Freeman & Lacohée, 1995; Mitchell & Lacohée, 1991). Studies in which these factors have been manipulated have been shown to improve the performance of younger children on false belief tasks. Studies also have demonstrated that there is a strong relationship between executive functions and theory of mind performance (e.g. Carlson & Moses, 2001; Carlson *et al.*, 1998; Hughes, 1998), which is often taken as evidence in favor of executive function theories of theory of mind. However, the evidence from these studies is also consistent with Leslie's theory.

While the literature on theory of mind development during the preschool years has been dominated by the theory theory and performance-based accounts, other researchers have focused on the role of language in bringing about changes in children's ability to understand false belief. Numerous studies have found a significant correlation between standardized language measures and performance on theory of mind tasks in preschoolers (e.g. Jenkins & Astington, 1996; Cutting & Dunn, 1999; Hughes & Dunn, 1997). Astington and Jenkins (1999) conducted a longitudinal study in order to identify the direction of this relationship. Their findings confirmed that language predicted later performance on theory of mind tasks but not the reverse. Furthermore, their standardized measure of syntactic knowledge, summed across the receptive and expressive *syntactic subtests* of the Test of Early Language Development (Hresko, Reid & Hammill, 1981), was the sole independent contributing factor to later theory of mind; semantic knowledge was not a significant additional predictor in their regression analyses.

What is significant about syntax in relation to a representational understanding of mind? Jill de Villiers and her colleagues (de Villiers, 1995, 2000; de Villiers & de Villiers; 2000; de Villiers & Pyers, 1997) argue that a specific linguistic construction, sentential complements, is a necessary prerequisite to the child's acquisition of a representational theory of mind. Sentential complements, which allow for the embedding of tensed propositions under a main verb, have unique syntactic and semantic properties. Two classes of verbs take sentential complements: verbs of communication (e.g. John *said* that Fred went shopping) and verbs of mental state (e.g. Mary *thought* that Fred went to the movies). In sentential complements the embedded clause is an obligatory linguistic argument that may have an independent truth value. Therefore, the main clause may be true (e.g. John said X; Mary thought Y) while the embedded clause may be false (e.g. Fred did not go either shopping or to the movies). The syntax and semantics of sentential complements allow for the explicit representation of a falsely embedded proposition. Complements uniquely provide the means for discussing contradictions between mental states and reality. As de Villiers (2000) states: 'The complement structure invites us to enter a different world . . . and suspend our usual procedures of checking truth as we know it. In this way language captures the contents of minds, and the relativity of belief and knowledge states. These sentence forms also invite us to entertain the possible worlds of other minds, by a means that is unavailable without embedded propositions' (de Villiers, 2000, p. 90). de Villiers (2000) has argued for the strong view that language is a *necessary* precursor for the acquisition of a metarepresentational theory of mind, citing as evidence data from oral deaf children who without rich access to a natural language, are significantly delayed in their acquisition of theory of mind (Gale, de Villiers, de Villiers & Pyers, 1996; Peterson & Siegal, 1995).

A few studies have documented a significant correlation between knowledge of sentential complements and performance on theory of mind tasks in preschool aged children (e.g. de Villiers & Pyers, 1997; Tager-Flusberg, 1997, 2000). In one longitudinal study, carried out over the course of a year, de Villiers and her colleagues (de Villiers, 2000; de Villiers & Pyers, 1997) found that knowledge of sentential complements predicted later theory of mind performance independent of general language change, but that the reverse did not hold. They argued that this study provides strong evidence for the role of the acquisition of sentential complements on theory of mind. There is, however, a potential confound in their study. The tasks they used to measure mastery of sentential complements and theory of mind both included test questions containing mental state verbs (e.g. *think*). It may be that it is lexical/semantic knowledge of these specific verbs, denoting cognitive mental states, that is driving the developmental relationship between language and theory of mind, rather than the linguistic construction of sentential complements.

The goal of our study was to investigate further whether sentential complements are an important influence on the development of theory of mind. Following prior work by Slaughter (Slaughter & Gopnik, 1996;

Slaughter, 1998), we used a training paradigm to test whether training on sentential complements would lead to changes in performance on theory of mind tasks. In order to eliminate the potential confound of mental state verb and complement structure, we included only communication verbs in our complement training. We were also interested in comparing language training on sentential complements, to more direct training on theory of mind, so we also included a group of children who were trained on false belief. This would allow us to test whether sentential complements were necessary for acquiring false belief, as de Villiers has claimed (de Villiers & de Villiers, 2000). However, unlike Slaughter's prior studies, our false belief training did not include mental state verbs in the corrective feedback. In her studies, because the feedback included complement constructions we cannot rule out that there was a major linguistic influence on the theory of mind training. Finally, we tested the specificity of the linguistic influence by including a control group that was trained on a different complex linguistic construction: restrictive relative clauses. Relative clauses also involve embedded propositions but they are embedded under a noun phrase (e.g. *The boy that had red hair . . .*) not a verb phrase. In the form that we presented the relative clauses their syntactic/semantic structure did not allow for different truth values to be assigned to the main and embedded sentences and, therefore, should not provide information relevant to false belief.

Method

Participants

A sample of 72 children was recruited from local preschool programs in the greater Boston area. The children came from diverse racial and social-economic backgrounds and all were native English speakers. The children were pretested to ensure that they had not yet acquired false belief or sentential complements (see below for details of the pretests). Twelve children were eliminated after the pretests; the remaining 60 children (25 girls and 35 boys), were between the ages of 36 and 58 months ($M = 47.0$ months, SD = 5.8). This range is well within the age span of children represented in a recent meta-analysis, which showed that across a large number of studies on false belief understanding, about 55% of children aged 47 months passed the false belief task (Wellman *et al.*, 2001). The 60 children were randomly assigned to one of the three training groups: false belief (FB), sentential complements (SC) and relative clauses (RC). Table 1 presents the ages and pretest scores for the 20 children who were in each of the training groups in the study.

Table 1 *Mean (and standard deviations) of age and pretest scores of participants in each training group*

	Training group		
	FB	SC	RC
Age in months	47 (5.1)	48.4 (5.9)	45.6 (6.3)
False Belief Pretest*	.25 (.44)	.40 (.50)	.40 (.50)
Complements Pretest*	.40 (.50)	.35 (.48)	.35 (.48)
Relative Clause Pretest*	0 (0.22)	0 (0)	.15 (.48)

Note: * Maximum Score = 2.

Equivalence of training groups

A series of one-way analyses of variance was performed to test whether there were differences between the training groups in age, sex or pretest scores. Results revealed that there were no significant differences on any of these variables. For age, $F(2, 57) = .96$; sex, $F(2, 57) = .43$; false belief pretest score, $F(2, 57) = .64$; complements pretest score, $F(2, 57) = .06$; and relative clause pretest score, $F(2, 57) = 1.20$; all p values greater than 0.5.

Procedure

One experimenter conducted the testing and training. Children were tested individually in a quiet room in the their preschools.

Pretests

Each child was first given three pretests, presented in random order. Examples of each pretest are given in Appendix A.

False belief pretest

Children were told a standard false belief location change story that was acted out using props in a diorama. They were asked ignorance and false belief prediction test questions. Children who failed one or both of these questions were included in the study.

Sentential complement pretest

Children were told two stories, each accompanied by two drawings, that were presented in random order. Each story was about a character who says she is doing one activity while really doing something else. The order in which the information was given about what the character said and what she did was counterbalanced across the two stories. At the end of each story, children were asked what the character said. Children had to fail at least one of these test questions to be included in the study.

Relative clause pretest

Children were told two stories that provided two different pieces of information in the form of relative clauses about two similar referents. At the end of each story, children were asked about one of the referents. Scores on this pretest were based on the children's ability to include the relative clause information in their responses.

Training procedure

After randomly assigning the children to one of the three training groups, two training sessions were scheduled within one week of each other. Each training session consisted of four trials. Across the different training groups similar props were used consisting of *Sesame Street* characters. Training for each group consisted of feedback and correction, with every child receiving a total of eight training trials. Appendix B provides examples of the training.

FB group

On each training trial, the experimenter enacted a location change story and asked the child to predict where the main story character would look for the object that had been moved in his absence. Incorrect responses were given corrective feedback with a simple explanation and story re-enactment; correct responses were confirmed by the examiner. At no time were mental state verbs (e.g. *think*, *know*) used in reference to the story characters.

SC group

Each training trial consisted of a story in which a boy did some action toward one *Sesame* character but says he did it to another. Children were asked to report what the boy said (either 'What did he say?' or 'Who did he say he ___?'), which tested for the children's ability to extract the content of the complement. Incorrect responses were corrected by the examiner, while re-enacting the event. Correct responses were confirmed.

RC group

On each trial a scene was enacted with identical twins and a *Sesame Street* character. The *Sesame Street* character carried out different actions on each twin. Children were asked to report on which twin received one of the actions (e.g. 'Who did Bert hug?'). While re-enacting the event, the experimenter modeled complete relative clauses in her corrective feedback to the children; she confirmed all correct relative clause responses.

Post-tests

Children were post-tested between 3 and 5 days after the second training session. The content of all the post-tests differed from the content of the pretest and training stories. Children received all the post-tests, which were presented in random order. Appendix C includes detailed examples for each post-test.

Theory of mind post-test

To test for theory of mind understanding, children were administered a location change false belief task, an unexpected contents false belief task and an appearance–reality task. The location change false belief task was similar to the false belief pretest and was characterized as a near transfer task because it used the same format at both the pretest and training. In contrast, the appearance–reality and unexpected contents post-tests were characterized as far transfer tasks because they used novel measures of a representational theory of mind. Children were asked two questions at the end of each task; thus the maximum theory of mind score was six. The location change post-test also included a justification question, which was scored separately.

Sentential complements post-test

The format of the complements post-test was similar to the pretest and training but included different content and story characters. Children were told six stories in which one character tells Mickey Mouse one thing but does something else. The test question asked children to report what was said. Each correct answer was given one point for a maximum of six.

Relative clauses post-test

Again, the format for this task was similar to what was used in the pretest and training. Children heard six stories, each accompanied by a simple drawing. In each story Minnie Mouse does one action to one object and a different action to a similar, though not identical, object. Children were asked to report on which object Minnie had done one of the actions. Responses were scored as correct if they included a relative clause. Children could receive a maximum of six points on this posttest.

Table 2 *Mean (and standard deviations) percent correct at pretest and post-test for each training group*

	Training group		
	FB	SC	RC
False Belief Pretest	12.5 (22.2)	20.0 (25.1)	20.0 (25.1)
Theory of Mind Post-test	73.9 (28.9)	75.6 (26.2)	18.1 (25.8)
Complements Pretest	20.0 (25.1)	17.5 (24.4)	17.5 (24.4)
Complements Post-test	26.4 (36.4)	74.8 (35.7)	20.6 (28.9)
Relative Clause Pretest	2.5 (11.1)	0 (0)	7.5 (24.4)
Relative Clause Post-test	2.5 (11.1)	0.8 (3.5)	58.0 (33.1)

Results

Training effects: comparison of pretest and post-test scores

The first set of analyses compared the performance of the three training groups from pretest to post-test to investigate whether training led to significant changes in performance in each area of post-testing. These analyses also examined whether training effects were limited to the target of training, or whether there was transfer across either linguistic constructions (across complements and relative clauses) or across language and theory of mind. For each group we calculated the percent correct on the pretest (maximum score on each = 2) and post-test for theory of mind, sentential complements and relative clauses (maximum score on each = 6). The data are presented in Table 2.

A mixed ANOVA was conducted on the theory of mind scores with time (pretest score, post-test score) as the within-subjects factor and training group (FB, SC and RC) as the between-subjects factor. There were significant main effects of time ($F(1, 57) = 62.54$, $p < .0001$) and training group ($F(2, 57) = 15.64$, $p < .0001$), and a significant time by group interaction ($F(2, 57) = 17.29$, $p < .0001$). Post-hoc analyses showed significant differences between the FB and RC groups, Tukey HSD = 24.12, $p < .0001$ and the SC and RC groups, Tukey HSD = 28.75, $p < .0001$, but no difference between the FB and SC groups on change in percent correct from false belief pretest to theory of mind post-test. Thus both FB and SC training led to equivalent significant changes on the theory of mind testing.

A similar ANOVA was conducted on the complements scores. Again, there were significant main effects of time ($F(1, 57) = 24.23$, $p < .0001$) and training group ($F(2, 57) = 7.47$, $p < .001$), as well as a significant time by group interaction ($F(2, 57) = 15.01$, $p < .0001$). Post-hoc analyses showed significant differences between the SC and FB groups, Tukey HSD = 22.95, $p < .01$, and the SC and RC groups, Tukey HSD = 27.12, $p < .005$, on change in percent correct from complements pretest to complements post-test. Thus, only the SC group significantly improved from pretest to post-test on sentential complements.

Finally, a similar ANOVA was conducted on the relative clause scores. There were significant main effects of time ($F(1, 57) = 46.32$, $p < .0001$) and training group ($F(2, 57) = 28.25$, $p < .0001$), and a significant time by group interaction ($F(2, 57) = 44.19$, $p < .0001$). Post-hoc analyses showed significant differences between the RC and FB groups, Tukey HSD = 30.25, $p < .0001$, and the RC and SC groups, Tukey HSD = 32.35, $p < .0001$, on change in percent correct from relative clause pretest to relative clause post-test. These results confirm that only the RC group improved their scores on the relative clause testing.

The post-test scores for each training group are shown in Figure 1, as the mean raw score (maximum = 6) on each post-test. The figure illustrates the significant interaction effects identified in these analyses.

Performance over the course of training

We then explored in more detail the training trajectories for each group, as shown in Figure 2. For each group, percent correct scores at pretest, first and second training sessions, and post-test were compared, using a group by time repeated measures analysis of variance. For this analysis, only performance on the trained task was included (e.g. for the FB group, performance on the false belief pretest, training tasks, and the theory of mind post-test was used). Results showed a significant increase in percent correct over time. The main effect of training over time was highly significant, $F(1, 57) = 58.81$, $p < .000$. There were, however, no significant differences between groups ($F(2, 57) = 2.97$, $p = .06$), and no significant group by time interaction, suggesting that each group trained equally well and at a similar rate over the course of the study.

Performance on the different theory of mind post-test tasks

To what extent might training on either false belief or sentential complements have different effects on the various theory of mind post-tests? Because the pretest and FB training focused exclusively on a location change false belief task, it was important to see whether the positive impact of both the FB and SC training would transfer to the different theory of mind tasks that were included in the post-testing. The data are presented in

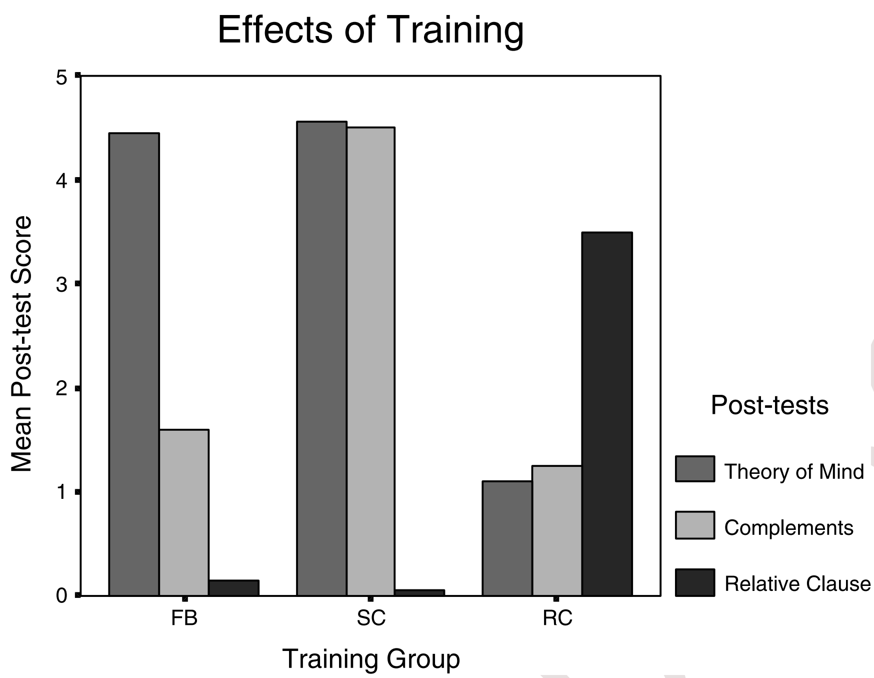

Figure 1 *Comparison of post-test scores for each training group.*

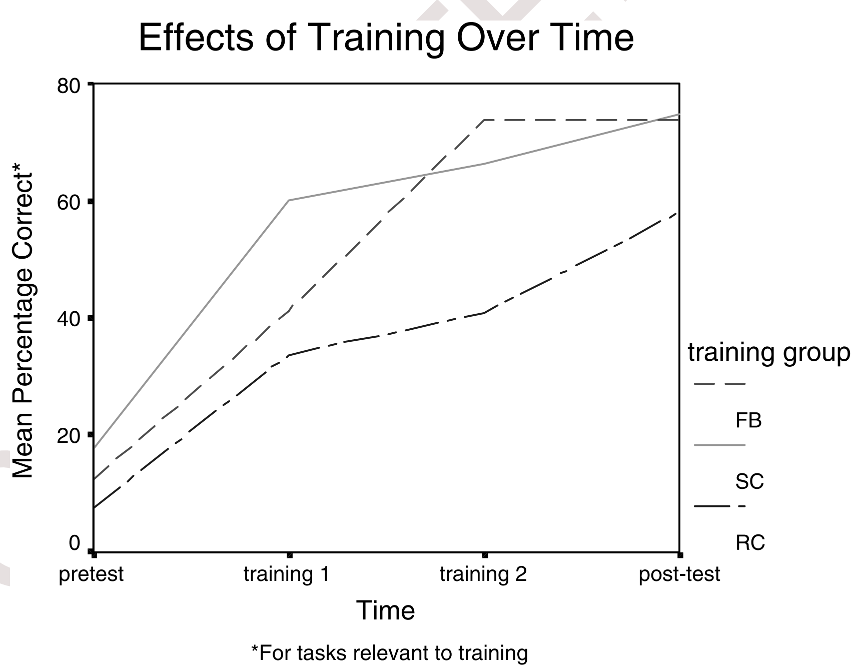

Figure 2 *Changes in performance over the course of training.*

Figure 3. One-way ANOVAs were conducted on each of the theory of mind post-test tasks, with training group as the between-subjects variable. The findings showed significant group differences for the location change false belief task ($F(2, 57) = 30.99$, $p < .0001$), the unexpected contents task ($F(2, 57) = 14.21$, $p < .0001$) and the appearance–reality task ($F(2, 57) = 10.54$, $p < .0001$). Post-hoc tests showed that the FB and SC groups performed significantly better on all three theory of mind tasks than the RC group. There were no significant dif-

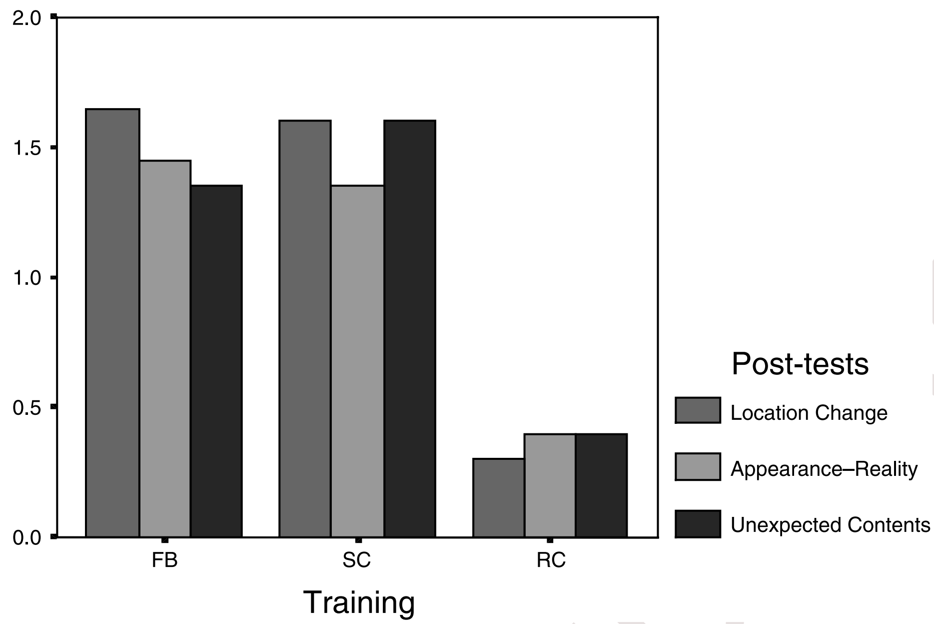

Figure 3 *Breakdown of theory of mind post-test scores.*

ferences between the FB and SC groups on any task. There were significant correlations among all three theory of mind post-test tasks. For location change and appearance–reality: $r(58) = 0.534$, $p < .0001$; for unexpected contents and appearance-reality: $r(58) = .624$, $p < .0001$; and for location change and unexpected contents: $r(58) = .531$, $p < .0001$.

On the location change task we considered the ignorance question a test question of theory of mind; similarly on the appearance–reality task, the reality question was considered a test question. Some studies suggest that these may be simpler than the belief and appearance questions, so there may be some concern that the theory of mind post-tests gave undue credit for these questions. In fact, in the FB and SC groups few children only got one test question correct on these post-tests: 27% (11/40) on the location change task, 15% (6/40) on appearance–reality. Of these, 59% (10/17) were correct on the simpler questions (ignorance and reality) compared to 41% (7/17) on the more rigorous theory of mind questions (belief and appearance). These results suggest that the significant changes in theory of mind performance in the FB and SC groups could not be attributed to the inclusion of these simpler questions.

Location change false belief justification

For the location change false belief post-test, responses to the justification question, 'Why will [Daniel] look there?' were coded, regardless of whether the child correctly answered the false belief test question. Responses were coded as *inappropriate* (e.g. 'Don't know' or 'Because it's there') or *appropriate: location* (e.g. 'Because that is where it was when he left') or *appropriate: mental state* (e.g. 'He thinks it's there'). The number of children in each training group, each of whom received a single justification test question, giving these responses is presented in Table 3.

Table 3 *Number of children in each training group providing appropriate and inappropriate justification responses on location change false belief post-test*

	Training group		
	FB	SC	RC
Appropriate:			
Location	10	9	4
Mental State	2	3	0
Inappropriate	8	8	16

Non-parametric analyses revealed an overall difference between the groups in providing appropriate justifications, $\chi^2(2, N = 60) = 8.57$, $p < .02$. The FB and SC training groups each gave more appropriate justifications than the RC group ($\chi^2(1, N = 40) = 6.67$, $p < .01$, for both comparisons).

Effects of pretest score on post-test performance

Finally, we checked whether there was an effect of giving one correct pretest response on post-test performance. A series of ANOVAs was conducted on the post-test scores with pretest score (0 or 1) as the between-subjects variable. None of the analyses was significant, thus ruling out the possibility that success on post-tests was determined by pretest performance. In other words, children scoring 0 on the pretest measures were as likely to train as those scoring 1. These results also support the use of our inclusion criterion, which defined failing as scoring 1 or 0 on the pretests, taken as denoting chance performance.

Discussion

One of the main goals of this study was to investigate the role of language in theory of mind development. More specifically, we explored whether one specific linguistic construction, namely sentential complements, rather than more general aspects of language, can facilitate the development of a representational theory of mind. Our findings confirmed the main hypothesis, demonstrating that training on sentential complements leads to improved performance on theory of mind tasks, and that this linguistic influence is highly specific and did not extend to children trained on another type of embedded construction, namely relative clauses.

These findings expand on the work of others on the role of language in the development of theory of mind. They confirm that language influences developmental change in this domain, but the reverse does not hold (Astington & Jenkins, 1999; de Villiers, 2000). Thus, in this study training in false belief did not lead to increased performance on the sentential complements post-testing, paralleling the cross-lag regression analyses reported in the earlier longitudinal studies. Our study helps to narrow down the specific linguistic influence on theory of mind to the acquisition of sentential complements rather than to syntactic developments in general (Astington & Jenkins, 1999) or to mental state verbs (de Villiers & Pyers, 1997).

de Villiers (1995, 2000; de Villiers & de Villiers, 2000) has provided a theoretical model within which to interpret why sentential complements should have this developmental influence on theory of mind. As we pointed out in the introduction, sentential complements have special syntactic and semantic features that uniquely provide the means for representing false beliefs. Thus, the parallels in the representational properties of propositional attitudes and sentential complements allow the child to exploit their similar cognitive architecture. More generally, we may take our findings as evidence for the important influence that language may have on cognitive development.

What features of sentential complements might be responsible for promoting the child's understanding of theory of mind? Sentential complements have unique syntactic properties in that the embedded proposition is an obligatory argument. They also are unique semantically in that the embedded argument need not have the same truth-value as the main clause. In this study we did not separate the syntactic and semantic features because our training always involved the presentation of 'false' complements. Further studies are needed to test whether it is the combination of the syntactic and semantic properties or whether the syntactic features alone are important in providing the linguistic structure needed to promote a representational understanding of mind. This can be achieved by comparing the training of children on true complements (in which the syntactic properties of complements are presented, but where the linguistic description matches the reality) and false complements (which trains both the syntactic structure and the semantic possibility by making the linguistic description differ from reality). Although we have not conducted these studies, we speculate that it is the semantic properties that are crucial for providing the child with the means for explicitly representing the embedding of a false statement in the complement construction. Finally, it is important to note that we cannot rule out the possibility that the effects of our complement training on theory of mind were not that specific to the acquisition of this linguistic structure. It may be that the complement training was effective simply because it exposed the children to statements that were false in contrast to the event they had witnessed. Again, future research will be needed to disentangle the precise influence of different types of linguistic and non-linguistic training on the acquisition of theory of mind.

Earlier we raised the concern that de Villiers and her colleagues (2000; de Villiers & Pyers, 1997) were not able to disentangle the role of complements from the role of mental state language in their longitudinal study. Specifically, their measure of sentential complements included examples that had mental state verbs such as *think*, thus confounding the role of mentalistic content with linguistic knowledge in predicting theory of mind performance. Our training of sentential complements was designed to avoid this. We only included communication verbs in our training examples, and the training itself did not provide any motive for the difference between what was said and what really took place. We were careful to word the training script so that there was no inference about deception; our training focused the child's attention on the content of the character's utterance, not the content of his mind. Because of the absence of any deceptive context, or invitation to consider the motives of the false utterance, children would have been most likely to infer the false statement in the complement constructions as mistakes, rather than lies (cf. de Villiers, 1998; Siegal & Peterson, 1998; Wimmer, Gruber & Perner, 1984, 1985). In this way our study provides evidence that it is the training of linguistic knowledge of complement constructions that has influenced performance on theory of mind, rather than inadvertently teaching the child about deception.

At the same time, our data argue against the claim that the acquisition of sentential complements is a *necessary* prerequisite for the development of a representational understanding of mind (cf. de Villiers, 1995, 2000). The children who were trained on false belief showed equivalent developmental changes in theory of mind as did the children trained on sentential complements. At the same time, at post-testing, the false belief training group did not perform well on the sentential complements post-test; in fact, their performance was the same as the group trained on relative clauses, showing no change from pretest to post-test. Clearly these children trained on false belief developed a metarepresentational theory of mind without acquiring explicit knowledge of sentential complements.

The results from this study also demonstrated that all three groups trained equally well and significantly improved their scores over time. This finding replicates work on the efficacy of training in conceptual development (e.g. Slaughter & Gopnik, 1996; but cf. Knoll & Charman, 2000) and extends this to the domain of language, where training studies are rarely undertaken. In this study, language training was limited to highly specific linguistic structures. This specificity of language training was confirmed by the lack of transfer between relative clause and sentential complement training groups at post-testing. Children trained on language only showed improvement on the specific language structure that they were taught.

What does it mean to be able to train children on conceptual understanding and linguistic knowledge? Could any child be trained to perform a task that they are currently unable to do? For example, could we have found similar results with 2-year-olds or with 4-year-old children with autism? We think not. The children in this study were normally developing preschoolers who were already actively acquiring and being exposed to information about theory of mind and language. Although the children all failed the pretests, they were within the developmental window for being able to pass them. We deliberately chose to train children who were on the cusp of grasping false belief and complement understanding. Training has been used, then, to facilitate or trigger this acquisition of understanding and demonstrate that certain evidence, such as the language structure of complementation, is particularly useful in developing understanding whereas other evidence, such as relative clauses, is not.

To what extent can the findings from this study address the dominant explanations for theory of mind, as summarized in the introduction? The theory theory receives support from the results of the FB training group, offering a replication for Slaughter's studies (Slaughter, 1998; Slaughter & Gopnik, 1996). However, the success of training on sentential complements with communication verbs (rather than mental state verbs) which led to changes in theory of mind performance cannot easily be interpreted within the theory theory. The results are also not easily explained within a narrowly defined executive functions account (cf. Moses, 2001; Perner & Lang, 2000); there was no training on inhibitory control, yet the children in both the SC and FB groups were successful on a range of theory of mind tasks.

The findings are more easily interpreted within Leslie's account (e.g. Leslie, 2000; Scholl & Leslie, 1999, 2001) in that he argues that changes in performance on theory of mind tasks require changes in the selection processor, to inhibit the attribution of true beliefs. Leslie's account must be modified, however, to incorporate language as a potential modifier; perhaps the training on sentential complements served to trigger the child's recognition that embedded propositions need not be true. Indeed, the fact that such minimal training (both in false belief and in sentential complements) led to such dramatic changes in the children's performance suggests that training serves to make explicit conceptual and linguistic knowledge that was already represented albeit at a more implicit and less accessible way.

This study is limited in that we did not follow up to test whether the effects of the training on both language and theory of mind concepts would be maintained over time. Post-testing occurred within 3 to 5 days after the second training session. Moreover, the child's participation in the study from pretest through post-test occurred within the span of 2 weeks. This criticism is tempered, however, by the robust findings of transfer effects. Training on complements and false belief was powerful enough to result in improved performance on not just location change false belief but also two other measures of theory of mind.

As results from this study have shown, theory of mind development is fostered by direct training on theory of mind tasks as well as by linguistic training. While the strong influence of false belief training on three theory of mind tasks indicated that within domain factors are sufficient, the significant effects of sentential complement training suggested that knowledge of specific language structures without any mental state content can be equally significant in facilitating theory of mind development.

This finding illustrates the importance of language in influencing children's conception of mind. It suggests that language does not merely reflect or communicate our thinking of others' beliefs, desires and intentions but rather the structural knowledge of specific language constructions actually fosters the ability to explicitly attribute mental states to oneself and others, making the role of language prominent in children's theory of mind development.

Appendix A

Pretests

False belief pretest

The false belief pretest story was about a boy and a girl who, after playing a game, got ready to put the game away. The examiner acted out the following: The girl, Sally, and the boy, Tom, put the game in the desk. 'OK' says Sally. 'I'm going out to play now, but when I come back, let's play that same game.' So, Sally goes out of the room. Then, Tom says to himself, 'Hmmm . . . I better put the game in the cabinet where it belongs.' So, Tom puts the game in the cabinet.

Children were then asked two control questions to verify their understanding of the story: 'Where did Sally and Tom put the game before Sally went out to play?' and 'Where is the game now?' Then Sally comes back to play the game again. But she hasn't gone inside yet. The child was then asked the following test questions:

> 'Does Sally know where the game is?' (ignorance),
> 'Where will Sally look for the game?' (false belief prediction), and 'why?' (false belief justification). Performance on the false belief justification question was not a qualification for inclusion in the study.

Complementation pretest

Children were given two stories, each with one test question. The following is one example. The examiner presented the child with a picture depicting a girl using scissors to cut her hair and with pieces of paper strewn around the floor of the room. The examiner said, 'One day, this little girl took some scissors into her room and cut her hair with them.' The examiner then replaced the first picture with a second one showing just the girl and her father, without any action, hair or paper depicted. The story continued: 'Then, her dad called up to her and asked her what she was doing. The girl said, "I'm just cutting up some paper!" The girl then went to play with her brother.' The child was then asked the test question, 'What did the girl say she was cutting?' A second similar story was told about a boy saying he was eating an apple when he was really eating cookies.

Relative clause pretest

The relative clause pretest included two stories, each with one test question. For each story a picture was presented that depicted the context of the story but no specific actions. For example, the examiner told the following story, accompanied by a picture of a pet store: 'A boy was in the pet store looking at some dogs. The boy petted the dog that was lying down. He tickled the dog that was sitting up. Then he went home.' The test question was, 'What did the boy tickle?' The target answer was one that included a relative clause, such as 'the dog that was sitting up'.

Appendix B

Training

False belief training

In each of the two training sessions, the examiner acted out four stories, each with one false belief prediction question. For example, the following story was acted out with *Sesame Street* characters and Colorforms: 'Cookie Monster loves cookies. He has a plate of cookies. One day he puts his cookies under his bed and goes to sleep. Ernie wants to play a trick on Cookie Monster. He takes the cookies and hides them in the trash can. Then Cookie Monster wakes up.' The examiner acted out the various actions of the two characters with the Colorforms (e.g. Cookie Monster sleeping on the bed, Ernie moving the cookies from the bed to the trash can). The child was asked, 'Where will Cookie Monster look for his cookies?' If the child answered with the new location, the examiner re-enacted the story and replied, 'But remember, Cookie Monster put his cookies under his bed. He did not see Ernie hide the cookies in the trash can. So, Cookie Monster looks under the bed for his cookies.' Other training examples included Ernie playing a trick on Big Bird by moving his book from the desk to the cabinet while Big Bird went out shopping, and Elmo playing a trick on Grover by moving his hat from the coat rack to the couch.

Sentential complements training

For each of the two training sessions, the examiner acted out four stories, each with one question. The following is an example story told with *Sesame Street* characters and a boy. The examiner introduced the child to Big Bird, Grover and the boy. The examiner acted out the boy kissing Big Bird. The examiner then said, 'The boy says, "I kissed Grover."' The examiner then asked the child, 'What did the boy say?' Correct responses were responded to with, 'That's right. The boy said, "I kissed Grover," but he really kissed Big Bird.' If the child provided an incorrect response, the examiner acted out the boy kissing Big Bird again and said, 'But remember, the boy says, "I kissed Grover," but he really kissed Big Bird.' Two of the four training questions were rephrased, 'Who did the boy say he kissed?'

Relative clause training

The examiner presented the child with four stories and four subsequent training questions during each of the two training sessions. The following is an example. The examiner presented the child with identical twin girl dolls and Bert. She enacted the following story, 'Bert hugged the girl who jumped up and down. Bert kissed the girl who shook her head.' The child was then asked, 'Who did Bert hug?' The examiner responded to correct responses with, 'That's right. Bert hugged the girl who jumped up and down.' When the child gave an incorrect response, the examiner re-enacted the story and said, 'Bert hugged the girl who jumped up and down.'

Appendix C

Post-tests

Location change false belief post-test

There were two test questions, ignorance and false belief prediction, as well as false belief justification. The examiner acted out, using dolls and props, the following story about a boy, Daniel, and his mother, who were cleaning up after dinner. Daniel and his mother placed a cup in the dishwasher and then he went out to play. When the dishes were clean, the mother put the cup in the cupboard. Then, Daniel returned to get a drink.

Test Question – Ignorance: *Does Daniel know where the superman cup is?*
Test Question – Belief/Prediction: *Where will Daniel look for the superman cup?*
Justification: *Why will he look there?*

Appearance–reality post-test

There were two test questions, reality and appearance. Children were shown a sponge that looks like a rock and were asked to state what it looks like. The child then felt the object and were encouraged to say that it feels like sponge.

Test Question – Reality: *What is this really and truly?*
Test Question – Appearance: *When you look at this with your eyes right now, what does it look like?*

Unexpected contents post-test

There were two test questions: representational change and false belief. Children were shown a Band-Aid box and asked what they thought was in the box. They were then shown that there was really a baby doll (not Band-Aids) in the box.

Test Question – Representational Change: *What did you think was in the box when you first saw it?*
Test Question – False Belief: *When I show your friend X this box all closed up like this, what will she/he think is in the box?*

Complementation post-test

The examiner read six stories, each accompanied by a drawing, and asked one test question for each. One example: 'One day, Chris was baking some cookies as a surprise for Mickey. Mickey came along and asked him what he was doing. Chris said, "I'm baking some bread." Mickey could smell that he was baking.'

Test Question: *What did Chris say he was baking?*

Relative clause post-test

The examiner read six stories, each accompanied by a drawing, and asked one test question for each. One example: 'Minnie was in the kitchen cleaning up. Minnie washed the plate that had flowers on it. She broke the plate that had a crack in it. Then Minnie read her book.'

Test Question: *What did Minnie wash?*

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