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Research Report

Language Promotes False-Belief Understanding

Evidence From Learners of a New Sign Language

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ABSTRACT—*Developmental studies have identified a strong correlation in the timing of language development and false-belief understanding. However, the nature of this relationship remains unresolved. Does language promote false-belief understanding, or does it merely facilitate development that could occur independently, albeit on a delayed timescale? We examined language development and false-belief understanding in deaf learners of an emerging sign language in Nicaragua. The use of mental-state vocabulary and performance on a low-verbal false-belief task were assessed, over 2 years, in adult and adolescent users of Nicaraguan Sign Language. Results show that those adults who acquired a nascent form of the language during childhood produce few mental-state signs and fail to exhibit false-belief understanding. Furthermore, those whose language developed over the period of the study correspondingly developed in false-belief understanding. Thus, language learning, over and above social experience, drives the development of a mature theory of mind.*

The capacity to infer other people's mental states, and to use this information to predict behavior, is a central cognitive ability that emerges early in human development. By the age of 2, children demonstrate some implicit understanding of what others believe (Clements & Perner, 1994; Onishi & Baillargeon, 2005; Southgate & Csibra, 2007; Surian, Caldi, & Sperber, 2007), yet they do not reliably use such understanding to explicitly predict others' behavior until 2 years later (Wellman, Cross, & Watson, 2001). Indeed, some researchers have proposed that an explicit understanding of others' false beliefs requires particular linguistic experience (Milligan, Astington, & Dack, 2007; Perner & Ruffman, 2005). If so, what would happen if the relevant language exposure were unavailable until adulthood? Can other life experience support the representation of false belief?

Previous studies have found that the timing of false-belief understanding depends on language in both typically developing and language-delayed children (for a review, see Milligan et al., 2007). However, in this research, language development and life experience have necessarily been conflated; both correlate with educational experience, socioeconomic status, and, most critically, age. Consequently, the nature of the link between language and false-belief understanding remains unresolved. Are particular language milestones prerequisite for false-belief understanding, or do language abilities merely facilitate the development of a theory of mind, a domain of cognition that could mature independently, albeit on a delayed timescale? We examined these questions with a population of adults with minimal language exposure during childhood.

Because Nicaraguan Sign Language (NSL) emerged only recently, deaf Nicaraguan adults provide a natural opportunity to disentangle language exposure and life experience. NSL first appeared in the 1970s among deaf children entering special-education schools (Kegl, Senghas, & Coppola, 1999; Polich, 2005). What began as gesturing among 50 children has grown into a complete language with more than 1,000 users. The first cohort of children, those who arrived in the 1970s and early 1980s, developed an early form of the language, which was expanded by a second cohort of children in the mid-1980s. Even today, the second cohort exhibits a more developed form of the language than the older first cohort (A. Senghas, 1995, 2003; A. Senghas & Coppola, 2001; A. Senghas, Coppola, Newport, & Supalla, 1997; A. Senghas, Kita, & Özyürek, 2004). However, aside from their language differences, the two cohorts have similar histories of social interaction. They attended the same school, for the same number of years, and were taught by many of the same teachers and with the same teaching methods. Even into adulthood, they have comparably sized deaf social networks (Polich, 2005; R.J. Senghas, 1997), with comparable numbers of

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deaf neighbors and family members who sign. They have had access to a modern urban culture, including public transportation and television. The one way in which their nonlinguistic social experience differs is in amount: The first cohort, being older, has had a decade more of it.

With this unique population, we can show the impact of learning an incomplete language on human cognition. In this unusual case, two age cohorts share a sociocultural history, but have very different linguistic knowledge. Thus, any cognitive advantages in the younger cohort can be attributed to their language advantage.

General language ability, the use of embedded sentential complements, and mental-state vocabulary have all been found to predict false-belief understanding (for a review, see Milligan et al., 2007). We selected the production of mental-state verbs as our language measure because it correlates with the acquisition of sentential complements, increases with general language ability, and can readily be measured in a language whose grammar lacks full documentation. Mental-state verbs include terms of belief and knowledge (e.g., *think*, *know*), but not desire (e.g., *want*). We examined the production of such verbs alongside performance on a false-belief measure. If mental-state language, or its correlates, is a prerequisite for false-belief understanding, then those who lack it should also fail tests of false belief. Alternatively, if language merely facilitates this cognitive development, and other social factors can compensate for a lack of linguistic knowledge, then all adults, regardless of language ability, should perform equally well on false-belief tasks.

In 2001, we tested these contrasting predictions in a cross-sectional assessment of mental-state vocabulary and false-belief understanding. When we returned to Nicaragua in 2003 to collect control data for the false-belief task, we reassessed mental-state vocabulary. The resulting data revealed an unexpected pattern of longitudinal change.

METHOD

Participants

Participants at Time 1 (2001) included 8 first-cohort and 10 second-cohort signers (see Table 1). First-cohort participants were defined as those exposed to NSL before 1984; second-cohort participants were defined as those exposed in 1984 or later. At Time 2 (2003), all of the original first-cohort signers, 8 of the original second-cohort signers, and 2 new second-cohort signers participated. All participants were prelingually deaf students or alumni of the school for special education in Managua who had used NSL as their primary language since the age of 6 or younger.

Materials and Procedure

Language Elicitation

We elicited mental state language following the methods of Gale, de Villiers, de Villiers, and Pyers (1996). Each participant viewed six 30-s live-action video clips. Four of these video clips elicited language specifically referring to belief and knowledge (e.g., *think*, *know*) by depicting people making mistakes (Fig. 1). The remaining two video clips elicited desire-state language (e.g., *want*) by depicting individuals trying to obtain a desired object. After participants viewed and described each clip, they repeated the task a second time. If a clip elicited no mental- or desire-state terms, participants were asked why the character performed the action (e.g., "Why did she pick up the flowers?"). For the four mental-state videos, if no target vocabulary was produced after the why question, participants were additionally asked whether the character wanted to perform that action (e.g., "Did she want to pick up the flowers?").

All narratives were videotaped and transcribed. Signs referring to desire, belief, knowledge, and ignorance were tallied (Fig. 2) by the authors, who had a combined total of 18 years of experience with NSL. Two deaf Nicaraguan signers subsequently confirmed that the signs were either desire- or mental-state terms. At Time 1, all participants completed the language-elicitation task. At Time 2, all first-cohort participants and 7 second-cohort participants completed the task.

False-Belief Assessment

To rule out any potential confound between the level of complexity of participants' NSL and their success in understanding a traditional false-belief task, we developed a low-verbal picture-completion task (Fig. 3a) based on Wimmer and Perner's (1983) unseen-displacement task. For each trial, the experimenter laid out five cards depicting a sequence of events. As she placed each card, she pointed at it and labeled the order of the picture (e.g., "first," "second"). She did not narrate the sequence of events. After placing the fifth card, she signed "the sixth is missing," then

TABLE 1

The Two Cohorts' Mean Age, Number of Mental-State Verbs Used, and False-Belief Performance at Time 1 and Time 2

		Time 1 (2001)			Time 2 (2003)		
Cohort	*N*	Age (years)	Mental-state verbs	False-belief performance	Age (years)	Mental-state verbs	False-belief performance
First	8	26.8 (3.3)	1.13 (1.1)	0.5 (1.41)	28.7 (3.1)	3.9 (3.6)	1.5 (1.3)
Second	10	17.5 (1.4)	7.20 (2.6)	3.8 (0.63)	19.1 (1.5)	7.4 (5.5)	2.6 (0.96)

Note. Standard deviations are given in parentheses.

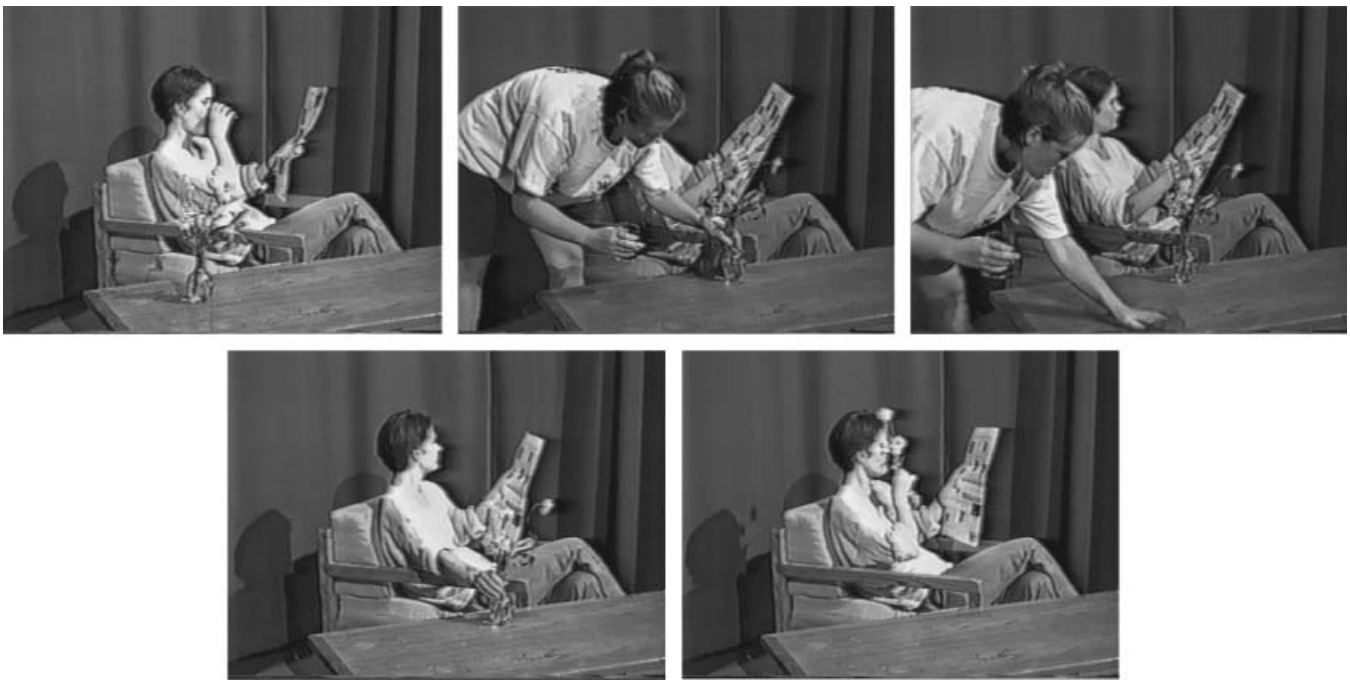

Fig. 1. Example of one of the live-action videos used to elicit mental-state verbs. Here, a woman's drink is replaced with a vase of flowers while she is not paying attention. The woman then mistakenly picks up the vase instead of her drink.

placed two new cards (counterbalanced by position) below the sequence, signed "which one comes next?" and gestured to the participant to move one of the two cards next to the fifth card. The participant then selected one picture to complete the story.

Sessions began with training trials designed to confirm that participants understood the picture-completion procedure. In these trials, participants had to select a picture that showed the outcome of a physical event. At Time 2, participants performed an additional training trial in which one outcome logically preceded the other. All participants passed the training trials.

Each test trial depicted a story in which an object was moved to a new location out of view of the main character. To succeed, participants had to select a picture depicting the character looking for the object in its original location, rather than its new (unobserved) location. The experimenter gave no feedback to participants, ending every trial with a smile and a nod. At Time 1, participants performed four test trials; at Time 2, participants performed three test trials.

At Time 2, we administered three additional control trials in which the main character observed the displacement of the object, and consequently never had a false belief (Fig. 3b). To succeed on these *true-belief* trials, participants had to select the picture depicting the character looking for the object in its new, observed location. These control trials ensured that passers were guided by an understanding of belief, rather than by a heuristic such as always selecting the "tricky" ending or by weighing information

Fig. 2. Examples of mental-state verbs in Nicaraguan Sign Language. The signs for (a) *know* and (b) *doesn't know* are shown.

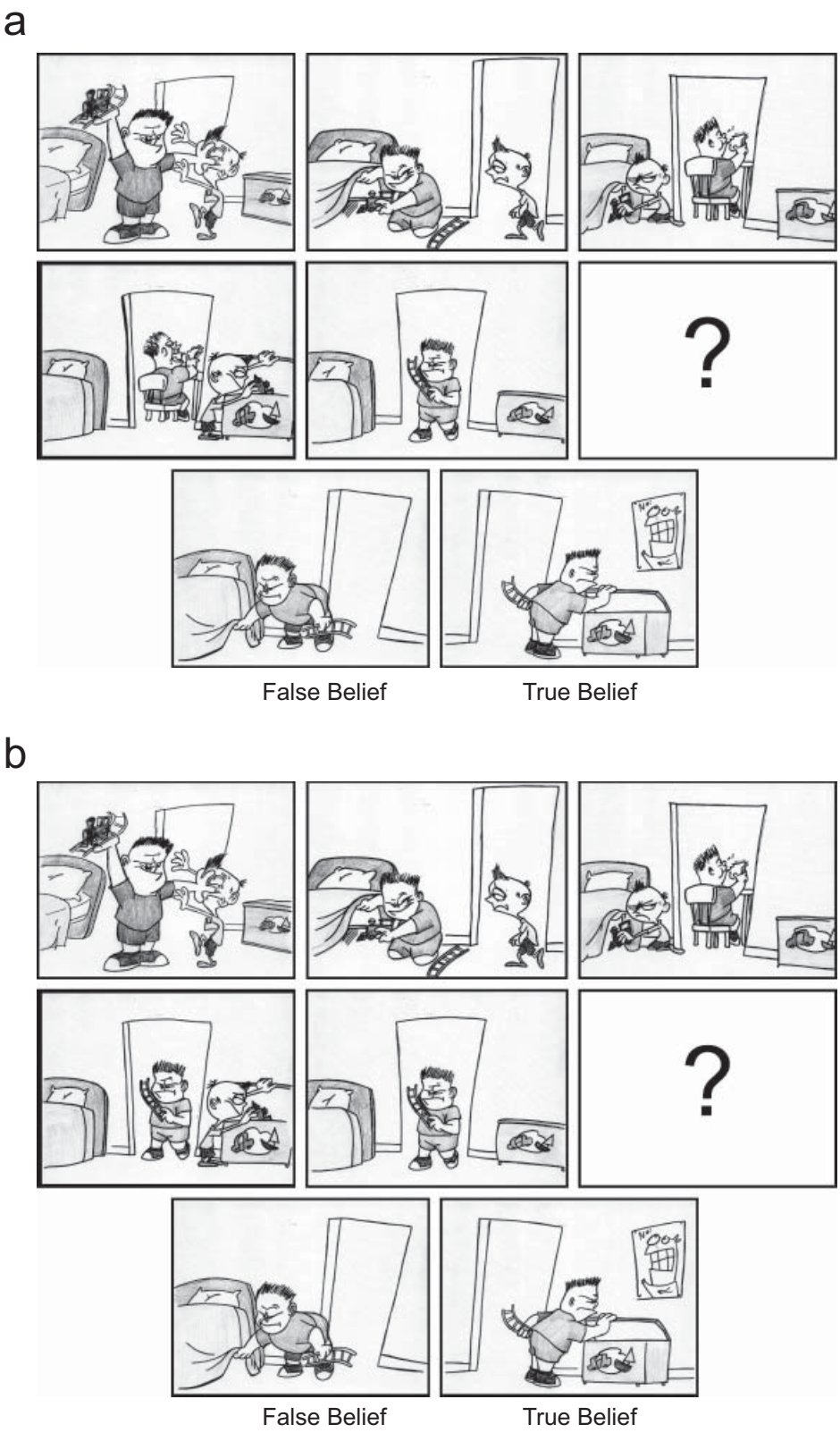

Fig. 3. Examples of the story-card sequences used to assess understanding in the (a) false-belief and (b) true-belief scenarios. In (a), a boy's toy train is moved from under a bed to a toy box while he is eating in the next room. Participants who selected the false-belief card (looking under the bed) to complete the story indicated a mature understanding of the boy's false belief. In (b), the boy watches while his brother places the train into the toy box. In this condition, participants who selected the true-belief card (looking in the toy box) to complete the story indicated that they understood what both they and the boy had seen to be true.

that appeared earlier in the story more heavily. There were six stories in all, each with a false-belief and a true-belief version. The stories were grouped into two sets of three true-belief and three false-belief stories; each false-belief story in the first set had a corresponding true-belief story in the second set, and vice versa. Half of the participants in each cohort viewed the first set, and half viewed the second, all in the same fixed random order. All participants passed the true-belief portion of the task.

The false-belief task was always administered before the language-elicitation task.

RESULTS

At Time 1, first-cohort participants signed significantly fewer tokens of mental-state terms than second-cohort participants (see Table 1; Mann-Whitney $U = 10$, $p = .004$, $p_{rep} = .97$; Fig. 4a), even though their narratives did not differ in length (first cohort: $M = 181.94$ s, $SD = 49.94$ s; second cohort: $M = 218.39$ s, $SD = 60.57$ s; Mann-Whitney $U = 54$, $p = .23$, $p_{rep} = .67$). Half of the first-cohort signers produced no mental-state words at all. In contrast, all signers produced desire-state verbs; there was no significant difference between the cohorts in the number of desire-state verbs produced (first cohort: $M = 8.6$, $SD = 1.77$; second cohort: $M = 8.4$, $SD = 3.4$; Mann-Whitney $U = 31.5$, $p = .96$, $p_{rep} = .11$). Thus, although desire vocabulary was equivalent in the two cohorts, the second cohort had evidently developed mental-state vocabulary that the first cohort lacked.

On the false-belief trials, performance correlated negatively with age ($r_s = -.70$, $p = .001$, $p_{rep} = .99$); the younger, second-

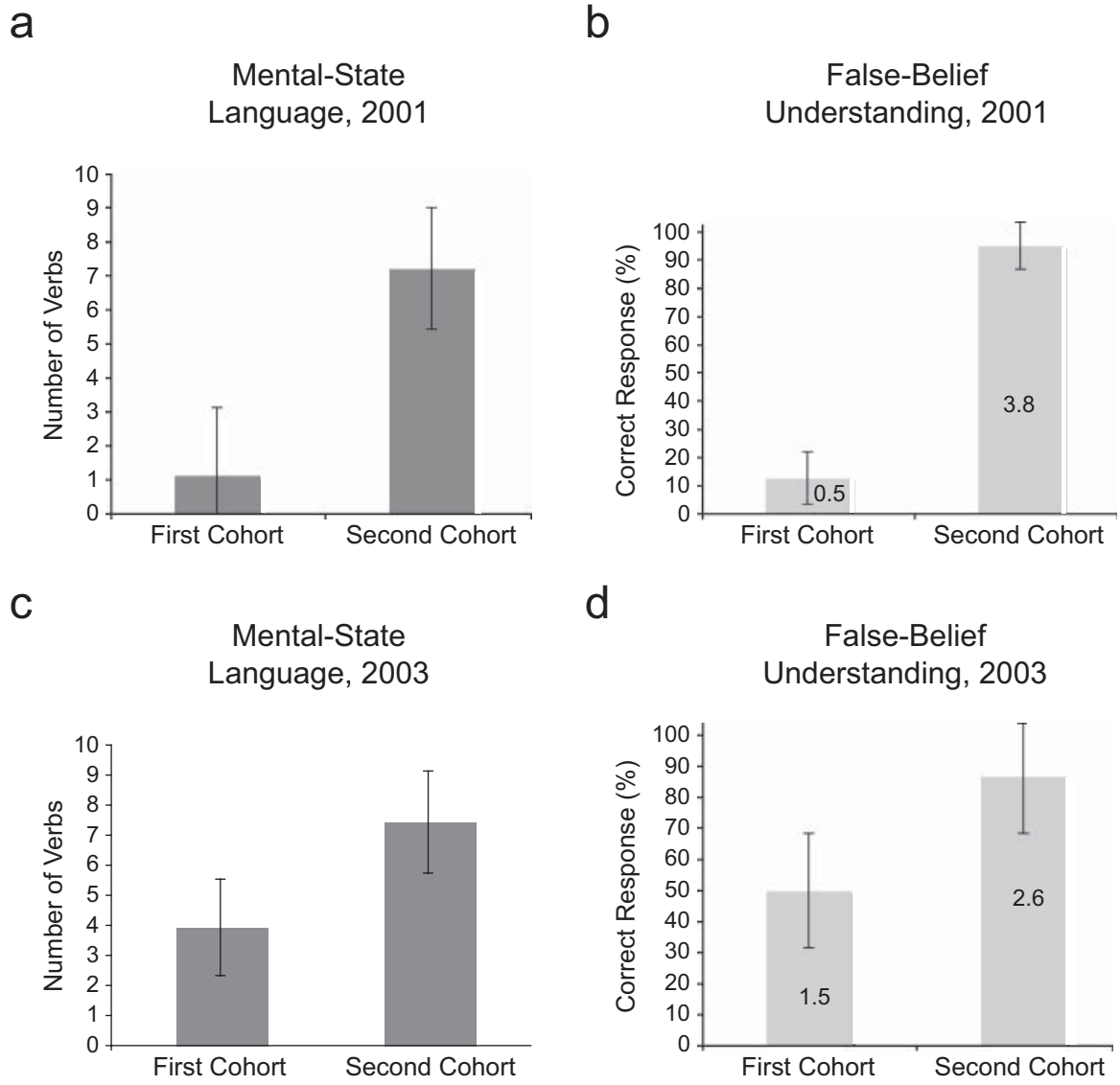

Fig. 4. Mental-state language and false-belief understanding by cohort. The graphs on the left show the total number of mental-state verbs produced per signer in the four narratives in (a) 2001 and (c) 2003. The graphs on the right show the percentage of correct trials on the false-belief task in (b) 2001 and (d) 2003; the numbers within the bars indicate the mean number of correct responses (out of four trials in 2001 and out of three trials in 2003). Error bars represent standard errors.

cohort participants significantly outperformed the older, first-cohort participants (Mann-Whitney $U = 5.5, p = .0025, p_{rep} = .98$; Fig. 4b). An examination of individual performance on the two tasks together revealed that all first-cohort signers who had not produced any mental-state language failed the false-belief task.

At Time 2, when mental language and false-belief understanding were reassessed, the groups no longer differed significantly in their production of mental-state terms (Mann-Whitney $U = 38.5, p = .25, p_{rep} = .68$; Fig. 4c). A post hoc comparison revealed that the first cohort increased their production of mental-state vocabulary from Time 1 to Time 2 (Wilcoxon signed-rank test, $z = 2.2, p = .03, p_{rep} = .91$). At Time 2, every participant produced at least one mental-state word.

First-cohort signers improved significantly in their performance on the false-belief trials from Time 1 to Time 2 (Wilcoxon signed-rank test, $z = -2.1, p = .04, p_{rep} = .89$). With this improvement, the two cohorts no longer differed significantly (Mann-Whitney $U = 22, p = .12, p_{rep} = .80$; Fig. 4d). The correlation between age and false-belief understanding remained negative, but was no longer significant ($r_s = -.29, p = .25, p_{rep} = .68$). Thus, the gap between the cohorts narrowed over the course of the study. This change was due to the first-cohort signers, who developed in both mental-state language and false-belief understanding in the 2 years between assessments.

DISCUSSION

Previous research has established a causal role of language ability in the development of false-belief understanding in children. Our study examined this relationship into adulthood, and revealed that language is indeed a necessary prerequisite, one that cannot be replaced by even 25 years of social experience. Adults who had no congenital cognitive deficits, but whose language was incomplete, failed to fully understand the beliefs of others. With mental-state vocabulary as our language measure, and age as our index of social experience, the pattern is clear: Language, not just social experience, is a prerequisite for the acquisition of false-belief understanding.

The learning profiles of individual first-cohort signers across the two assessment times confirmed that language and false-belief understanding develop hand in hand. If false-belief understanding depends on language, then mental-state language should precede or co-occur with above-chance performance on the false-belief task. When we compared Time 1 and Time 2 performance, we found that mental-state language preceded false-belief understanding in 6 of the 8 first-cohort signers, and co-occurred with false-belief understanding in the remaining 2 first-cohort signers. There was no case in which false-belief understanding came first. Even if we set the criterion for success on the false-belief task at only one out of three correct, it was always the case that the ability to reason about false beliefs—even nonverbally—followed the acquisition of more advanced language.

The circumstances of language emergence in the deaf community in Nicaragua have presented a "natural experiment" in which language, but not social or biological development, is delayed into adulthood. Of course, because we had no ethical means to experimentally manipulate language exposure, this study cannot rule out alternative factors that may have contributed to the delay and subsequent acquisition of false-belief understanding in first-cohort signers. It is encouraging that the pattern of results in this natural experiment parallel those obtained in a controlled experiment with preschoolers (Lohmann & Tomasello, 2003).

Although we have found that language development is necessary to enable a certain kind of cognitive development, we certainly do not argue that it is sufficient to enable this cognitive development. Of course, social experience is crucial to both linguistic and cognitive development (Tomasello, 1999). Indeed, particular social experience was necessary for the eventual acquisition of mental-state terms. Social experience likely operates in conjunction with language to build a mature theory of mind.

As it turns out, we collected our data at a serendipitous time in the emergence of NSL. Between 2001 and 2003, newly adult second-cohort signers began socializing at the deaf association, increasing their interaction with first-cohort adults. We hypothesize that, with the increasing contact, first-cohort signers were exposed to a form of NSL that was richer than their own and that included the new mental-state words produced by their younger peers. Indeed, all of the mental-state verbs produced by first-cohort signers at Time 2 had been observed in the narratives of second-cohort signers at Time 1. With more developed language, first-cohort signers, who may have previously relied on an understanding of emotions and desires to function in daily interactions (Pyers, 2004), now had the linguistic tools to support a more mature theory of mind. Adults who had struggled to understand others' mental states entered what Nelson (1996) called a "community of minds," false beliefs and all.

The specific mechanism by which language drives the development of false-belief understanding remains unresolved, and there is no shortage of hypotheses. Mental-state language in the environment may scaffold learners' social understanding (Bartsch & Wellman, 1995), or it may encourage learners to pay particular attention to the unseen thoughts and beliefs that they have previously ignored (Gopnik & Meltzoff, 1997). Children's own production of mental-state language may lead to a meta-awareness that all linguistic utterances are explicit representations of internal beliefs, and that those internal processes can actually affect human action (Olson, 1988). Alternatively, complex language may be necessary for representing false belief. For example, it may be that the complex syntax that accompanies mental-state and other verbs is a critical representational force (de Villiers & de Villiers, 2000; de Villiers & Pyers, 2002). The sentence "Mary thought she saw a ghost" has a main clause that is true ("Mary thought") and an embedded clause that is false ("she saw a ghost"). Such syntax may give

learners the logical tools for understanding the false beliefs of others (e.g., "I know that she thinks that . . . "). For that matter, some other, not-yet-determined aspect of complex language, indexed by mental-verb production, may be the underlying causal factor. Any of these accounts, from language about unobservable processes, to the specific syntax of embedded clauses, to some other correlate of complexity, would be consistent with the correspondence we have found between mental-verb production and false-belief understanding.

Certainly, the fact that language development is required does not rule out that particular social experience is also necessary. However, it does not appear to be solely the social process of information exchange (cf. Hobson, 2004), nor the experience of seeing others make mistakes due to ignorance, that drives such cognitive maturation. Individuals from both cohorts had years of experience interacting with other people and observing human error; indeed, the first cohort had 10 more years of such experience than the second. Even if the second cohort were somehow more advanced in this way at the outset, any between-cohort differences would be expected to remain constant in the 2 years during which this study was carried out. The period from age 26 to 28 is not typically one of significant social or cognitive development. Nevertheless, it was apparently not too late in life for some first-cohort signers to acquire richer language that enabled the development of a more mature understanding of mental states. Clearly, the richness of one's language must play a key part in driving a mature theory of mind.

Other researchers have recently proposed that an implicit understanding of mental states is available even in the first 2 years of life (Onishi & Baillargeon, 2005; Southgate & Csibra, 2007; Surian et al., 2007). Their conclusions are nevertheless compatible with our finding that, when language is late, aspects of theory-of-mind understanding can be delayed, even into adulthood. Perner and Ruffman (2005) suggest that language experience may enable children to transition from an implicit understanding of mental states to an explicit understanding of false belief. We propose that, in cases where the necessary language is not available during childhood, this transition may occur decades later. Indeed, the flexibility in the timing of relevant environmental factors may have contributed to the survival of such cues on an evolutionary timescale.

Certainly, the dependence of full false-belief understanding on language typically acquired early in life guarantees that most humans will develop a mature understanding of others' thoughts well before adolescence. Only in this most unusual of cases, in which learners matured before their language, must such cognitive development await the linguistic innovations of a new generation of children.

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