Are “late-signing” deaf children “mindblind”? Understanding goal directedness in imitation

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Abstract

Recent studies with “late-signing” deaf children (deaf children born into families in which no-one uses a sign language) have indicated that they have difficulty performing tasks that require them to reason about other people’s false beliefs. However, virtually no research has so far investigated how far late signers’ difficulties with mental state understanding extend. This paper reports one study that uses an imitation paradigm to examine whether late signers may also have difficulty in interpreting other people’s actions in terms of their goals. Both late-signing (\(N = 15\)) and second generation “native-signing” deaf children (\(N = 19\)) produced a pattern of responses to this task that indicates that they can and readily do view the actions of others as goal-directed. We conclude that this form of mental state understanding (generally seen as a precursor to understanding false beliefs) is intact in late-signing deaf children.

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1. Introduction

As human beings, we have a deep-seated fascination with other people; whether friends, lovers, or even complete strangers, we constantly strive to predict and explain their behaviour. In our efforts to do so, we impute an array of mental states, such as beliefs, desires and intentions to those people. We wonder whether our friends believe our stories, whether...
a lover still desires us, and exactly what a stranger’s intentions toward us really are. The term “Theory of Mind” (ToM—Premack & Woodruff, 1978) encompasses the multitude of ways that we, as adults, attempt to make sense of the mental life of other people.

Understanding mental states such as beliefs, desires and intentions also enables a dazzling variety of behaviours common in children and adults. The ability to learn new words and complex tasks from others, distinguish deliberate from accidental acts, and decide who is trustworthy and who is not are all offshoots of the discovery that human action is governed by invisible mental states (Astington, 1991; Carpenter, Call, & Tomasello, 2002; Tomasello, 1999). However, despite the richness of an adult’s framework for interpreting others’ behaviour on the basis of mental states, the developmental study of mental state understanding has for the most part focused on children’s ability to reason about one key concept, namely, false belief.

Ordinarily, children come to pass tasks involving false belief, which require an understanding that people can, and regularly do, have beliefs that do not accord with reality (and that those beliefs may lead them to act irrationally), by about the age of four (see Wellman, Cross, & Watson, 2001 for a review).

The case of the vast majority of profoundly deaf children is, on the other hand, markedly different. Most deaf children in the UK (some 90%) are raised in environments in which nobody uses a sign language. Such children typically get their first exposure to language only on entering formal schooling. A number of recent studies have shown consistent support for the position that this absence of language early in development delays the performance of these “late signers” on measures of false belief understanding (de Villiers & de Villiers, 2000; Figueras-Costa & Harris, 2001; Peterson & Siegal, 1995, 1997, 1998, 1999, 2000; Russell et al., 1998; Woolfe, Want, & Siegal, 2002).

Importantly, the case of profoundly deaf children raised in environments in which a mature speaker of a sign language is present, is different again. These “native-signing” deaf children show similar rates of development to hearing children. The difference in false belief performance between late-signing and native-signing deaf children persists even when differences in spatial mental age and current ability in sign language are controlled for (Woolfe et al., 2002). Late-signing deaf children are thus held up as a convincing demonstration that lack of early access to conversation results in “mindblindness.”

However, while undoubtedly a vital component of an adult-like understanding of mental states, recognising that “seeing leads to knowing” and its counterpart, that “not seeing leads to not knowing”, is by no means the only concept that one needs to grasp in order to understand other people. The ability to pass a standard false belief task is neither the first step (Baldwin, 1991; Gopnik, 1993; Leslie, 1987), nor the last step (Lalonde & Chandler, 2002) along the road to understanding the human mind. One element of mental state understanding that, in hearing children, is developmentally prior to the understanding of false beliefs is the simple understanding that people are intentional agents, who possess goals they would like to achieve and who act in order to achieve them.

Hearing infants have demonstrated the ability to recognise that other people are intentional agents in both imitation and looking-time studies. Such infants more readily imitate actions verbally marked as intentional (actions accompanied by the actor declaring a satisfied “There!”), than those marked as accidental (those accompanied by a surprised “Woops!”—Carpenter, Akhtar, & Tomasello, 1998). A wealth of data from infant looking-
time studies has shown that hearing infants interpret the movement of people and self-propelled objects as intentional (Csibra, Gergely, Bíró, Koós, & Brockbank, 1999; Gergely, Nádasdy, Csibra, & Bíró, 1995; Woodward, 1999; Woodward & Sommerville, 2000).

There is some evidence which suggests that hearing infants are also able to “read off” from others’ actions exactly what their goals are. Imitation studies (Bellagamba & Tomasello, 2000; Meltzoff, 1995) with hearing infants have suggested that when they view actions that fail to complete a goal, rather than faithfully recreating what they have actually seen (e.g. repeatedly picking up beads and spilling them over the edge of a cup), they are able to go beyond those actions to re-enact what was intended (placing the beads into the cup).

One question that thus arises is: do late-signing deaf children, who evince difficulties with false belief, also have problems with earlier emerging forms of mental state understanding, such as the ability to understand that other people are goal-directed, and the capacity to read off those goals from their actions?

While there now exists a substantial literature on deaf children’s ability (or inability) to reason about the concept of false belief, there has been little attempt to determine whether the lack of early access to communication experienced by late-signing deaf children also leads to difficulties in reasoning about mental states other than false belief. To date only one study has examined this possibility. Scott, Russell, Grey, Hosie, and Hunter (1999) found that deaf children displayed difficulties (relative to hearing children) in determining which of an array of four sweets a protagonist wanted from the direction in which the protagonist was looking. This was true even though the deaf children in Scott et al.’s study were aged between five and eight years and children in the comparison hearing group were aged only four years.

The evidence from Scott et al. (1999) thus suggests that deaf children’s difficulties in understanding the mental states of others do indeed extend beyond problems with false belief, in that they may also misunderstand what it is that others desire. Furthermore, these difficulties may persist in deaf children even up to the age of eight years. However, as Scott et al. note, the problems that the deaf children experienced with their task may have reflected a problem in utilising line of regard, rather than a problem with understanding others’ desires per se. Furthermore, in Scott et al.’s study, no distinction was made between late- and native-signing deaf children. Thus, any conclusions relating to deaf children and the understanding of desires must be regarded, at present, as only preliminary.

The aim of the present research was to investigate the understanding of others as intentional agents among deaf children and to determine whether or not potential difficulties in understanding the goals of others are exhibited by late-signing deaf children (as is the case for false belief understanding). This study examined deaf children aged between four and eight years old. Deaf children of this age have demonstrated difficulties in reasoning about false belief, making this age range an appropriate first step in an investigation into their understanding of other types of mental states. On the one hand, the difficulties with mental state understanding displayed by late-signing deaf children on false belief tasks (in comparison to hearing children or native signers) may extend to difficulties with goals, even in eight-year-olds. On the other hand, it may be that the goal-directed nature of people’s actions is apparent from their behaviour (in a way that the representational nature of beliefs is not), and/or that early linguistic input is not as critical for the development of understanding
others’ goals as it is for false belief understanding. It is therefore plausible that this form of mental state understanding may be intact, even though performance on false belief tasks has been shown to be delayed in populations of late-signing deaf children.

One problem in testing deaf children is that they may often have difficulties communicating in either spoken or signed language. Imitation paradigms can be especially useful in this regard because they do not require verbal responses. The present study thus used an imitation paradigm developed by Bekkering, Wohlschläger, and Gattis (2000). Bekkering et al. (2000) used their paradigm to determine whether imitation of gestures by hearing four-year-olds relies upon some kind of “direct mapping” of perception onto actions, or whether the perception-action mapping is instead mediated by their interpretation of the goal of those actions. The direct mapping view (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Iacoboni et al., 2001; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996) suggests that the observation of an action activates a corresponding motor program in the observer and thus observed actions are directly mapped from the visible movements of another to the proprioceptively perceived movements of the self. The goal-directed view (Bekkering et al., 2000; Gattis, Bekkering, & Wohlschläger, 2002), on the other hand, suggests that identically observed movements may produce different responses in the imitator, depending on his or her conception of the goal of those movements.

In Bekkering et al.’s task, children are seated opposite a model and asked to copy hand movements made to the ears. In some cases, the model makes gestures confined to a single side of the body (for instance, touching the right ear with the right hand). Young children aged between four and seven years almost exclusively produce mirror responses (touching their left ear with their left hand) in these cases (Bekkering et al., 2000). However, when asked to imitate movements which cross from one side of the body to the other (for instance, touching the right ear with the left hand), rather than producing a mirror response (touching their left ear with their right hand), hearing children sometimes produce a movement confined to one side of the body (touching their left ear with their left hand), a classic finding known in paediatric neuropsychology as the substitution error (Schofield, 1976). Bekkering et al. showed that the substitution error is reduced when children are asked to copy a gesture in which both hands cross the body. If asked to copy a two-handed gesture in which the left hand touches the right ear and, simultaneously, the right hand touches the left ear, then children accurately mirror the hand movements. That is, rather than touching their left ear with their left hand and their right ear with their right hand, they accurately mirror the crossing-over of hands performed by the adult.

The direct mapping hypothesis has difficulty in accounting for these results because the hands cross the body in both the unimanual and the bimanual gestures. The motor program for one of the hands is thus the same for both types of gesture (involving a movement of the hand across the body to touch the ear on the opposite side) and yet this movement is more accurately reproduced in the bimanual rather than the unimanual trials. Bekkering et al. interpreted the difference between imitative performance on unimanual and bimanual trials as evidence that goals mediate the mapping between perception and action. When the gesture set includes actions directed at one of two objects (the two ears, for example), children infer the goal of the task to be to touch a particular object. Therefore, when a trial involves contact with only one ear, they make contact with their corresponding ear (the mirror ear). However, because they focus on the perceived goal of touching an ear,
children sometimes neglect to replicate the movement of the hand with which the ear is touched. On such trials children respond to a movement of the left hand to the right ear with a movement of the left hand to the left ear and make the substitution error. However, when a trial demonstrates hand movements to both ears at once, there is no choice about which ear to touch. Children thus infer the goal of the task to be to reproduce the pattern of hand movements involved in the gesture. Children therefore attend to, and reproduce, the particular motion of the hands.

The malleability of the substitution error demonstrates that imitation in hearing children is not simply a motor copy of a visual input. Rather, at least some forms of imitation appear to involve a deconstruction of observed actions into components, which are then reconstructed by the observer (Gattis, Bekkering, & Wohlschlager, 1998). This reconstruction is guided by the observer’s interpretation of the actions as goal-directed behaviour. The results of Bekkering et al. indicate that inferred goals play a major role in the production of imitative behaviour in hearing children.

This goal-directed view of imitation makes an interesting and highly unusual prediction about imitative behaviour in children who have difficulty in inferring the mental states of others. When an observer imitates by inferring the goal of an observed behaviour (such as touching an ear) they may sometimes neglect to replicate other aspects of the behaviour (such as the hand with which it is touched), leading to errors, such as the substitution error. In contrast, when imitation does not involve inferring a goal, because an individual has problems in viewing actions as goal-directed, the substitution error is less likely to occur.

The primary aim of the present study was to use the Bekkering et al. paradigm to investigate whether four- to seven-year-old late-signing deaf children’s imitation reveals an understanding of the goal-directed nature of others’ actions. As already noted, in previous research (Scott et al., 1999; Woolfe et al., 2002), late-signing deaf children of comparable age have demonstrated difficulties in passing false belief tasks and in using eye gaze to infer desires.

Note that the question of interest here relates to the understanding of goals; the present study does not aim to demonstrate whether or not deaf children can imitate. We assume that all deaf children must be able to imitate in order to learn sign language. The suggestion here is that there are different routes to imitation and that some groups of children, such as late-signing deaf children, may have difficulty imputing goals. This may mean that their imitation is performed via direct mapping, rather than being goal-directed.

Based on previous work with this imitation paradigm (Bekkering et al., 2000; Gattis et al., 2002), we expected that the majority of all children’s responses to this task would be mirror responses. However, we also anticipated that the pattern of errors (or non-mirror responses) that children produced would indicate whether or not they were interpreting the experimenter’s actions in terms of goals. In the Bekkering et al. paradigm, sensitivity to goals reveals itself as a reduced rate of the substitution error in bimanual trials in which the hands cross the body compared to corresponding unimanual trials. Thus, if imitation in late-signing children is governed by an understanding of goals, then they should make more substitution errors in unimanual than in bimanual trials. If late-signers’ imitation is not governed by goals, and is instead carried out by some form of direct mapping, then there should be no difference in the rate of the substitution error between unimanual and bimanual trials.
2. Method

2.1. Participants

Thirty-four prelingually profoundly deaf children, aged between four and seven years of age, of whom 19 were native signers and 15 were late signers participated in this study. In addition, 34 hearing children were recruited to act as controls for the deaf children, 19 for the native signers and 15 for the late signers. These two control groups of hearing children were matched to the deaf children in terms of chronological age, mental age and handedness. Two separate groups of hearing controls were included because the native and late signers differed from each other in terms of mental age. The deaf children were recruited from five-day schools in the UK, three mainstream schools with sign language provision and two special schools with bilingual communication in British Sign Language and English. Some of the native-signing children (who make up a small minority of deaf children) were recruited via direct parental contact and were tested in their homes. The hearing controls were recruited from two primary schools in the UK. Participant characteristics are given in Table 1.

As a test of handedness, children were asked to perform five activities (throwing a ball one-handed, kicking a ball, drawing a circle, picking coins from a bowl and hitting a table with a toy hammer) three times each (as in Gleissner, Meltzoff, & Bekkering, 2000) and were given one point for each action that they performed with their right hand. They therefore received scores ranging from 0 (indicating strong left handedness) to 15 (indicating strong right handedness). The children’s (spatial) mental age was calculated from their scores on Raven’s (1962) matrices. Three independent-sample two-tailed t tests confirmed that the native signers did not differ significantly from their hearing controls in terms of their chronological age, \( t(36) = -0.18, p = .86 \), spatial mental age, \( t(33) = .10, p = .92 \), or handedness scores, \( t(34) = 1.34, p = .19 \). Three comparable tests showed that late signers also did not differ from their hearing controls in terms of chronological age, \( t(28) = .06, p = .96 \), spatial mental age, \( t(27) = -0.39, p = .70 \), or handedness scores, \( t(24) = .17, p = .87 \).

Table 1
Mean age, mental age and handedness scores for all children

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean age (months)</th>
<th>Age range (months)</th>
<th>Mean spatial mental age (months)</th>
<th>Spatial mental age range (months)</th>
<th>Mean handedness score</th>
<th>Handedness range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native signers</td>
<td>77.26 (12.63)</td>
<td>50–95</td>
<td>89.19 (18.63)</td>
<td>60–120</td>
<td>13.35 (2.32)</td>
<td>6–15</td>
</tr>
<tr>
<td>Controls for native signers</td>
<td>78.00 (13.07)</td>
<td>52–94</td>
<td>88.42 (24.01)</td>
<td>48–132</td>
<td>12.05 (3.36)</td>
<td>3–15</td>
</tr>
<tr>
<td>Late signers</td>
<td>74.47 (13.44)</td>
<td>56–94</td>
<td>64.71 (15.06)</td>
<td>42–84</td>
<td>12.36 (3.38)</td>
<td>6–15</td>
</tr>
<tr>
<td>Controls for late signers</td>
<td>74.20 (12.33)</td>
<td>55–93</td>
<td>66.93 (15.85)</td>
<td>41–90</td>
<td>12.13 (3.56)</td>
<td>3–15</td>
</tr>
</tbody>
</table>

N.B. Standard deviations are in parentheses. Due to procedural error four children did not receive mental age scores (3 native signers and 1 late signer) and 6 children did not receive handedness scores (2 native signers and 4 late signers).
2.2. Procedure

All children were tested individually in a quiet room of their home or school by a deaf experimenter who, while also speaking fluent English, was a native signer of British Sign Language (BSL). Children sat at a table across from the experimenter and were told: “You copy me”, in English or in BSL as appropriate (“you copy me” translates directly into BSL). Previous research has shown that different types of verbal instruction (e.g. “Try to be my mirror”, “You do what I do,” or no instruction at all) make little difference to children’s responses to this task (Bekkering et al., 2000; Gattis et al., 2002), so the instructions in the present study were chosen to be as simple as possible. The experimenter then demonstrated three blocks of six gestures (see Fig. 1) involving movements of the hands to the ears, with a pause between each gesture for the child to respond.
Fig. 2. Children’s possible responses to a movement of the right hand to the left ear.

The order in which the six gestures occurred in each block was randomised and the children’s responses were videotaped for later analysis. All children touched at least one ear on every trial. Each of the children’s gestures was classified as either a mirror response (hand movement and ear choice mirrored the model’s), or one of three types of substitution:

1. Movement Substitution (or the “classic” substitution error)—ear choice, but not hand movement (across the body versus confined to one side) mirrored the model’s,
2. Location Substitution—hand movement, but not ear choice matched the model’s,
3. Movement and Location Substitution—neither hand movement nor ear choice matched the model’s.

Fig. 2 illustrates each type of response when the demonstrated gesture is a movement of the right hand to the left ear.

Following the imitation task, children were given the coloured version of Raven’s progressive matrices (Raven, 1962) and the short test of handedness (Gleissner et al., 2000).

3. Results

All imitation trials were coded from videotape by the first author. Only completed gestures, where the children actually made contact with their ears, were scored. Half-completed gestures, where the children’s hands approached but did not touch their ears, were not scored. For trials in which the children produced more than one completed gesture, the final gesture
was used for the purpose of analysis. A random sample of approximately 10% of the children’s responses to the imitation task were re-coded by a second judge. Agreement between the judges was 100%.

The majority of all four groups of children in this study were strongly right-hand biased. However, preliminary analyses revealed that the children’s pattern of responses to this task did not differ if the minority of children who were left-hand biased were excluded from the dataset. Thus, for the sake of statistical power, the following analyses are based on the results of all children, whether right- or left-hand biased.

The proportion of each type of response (mirror or one of three types of substitution) that children made is given in Table 2 separated into bimanual and unimanual trials. The proportion, rather than raw number, of each type of response is presented in Table 2 because each child was exposed to twice as many unimanual as bimanual trials.

Table 2 demonstrates that the predominant response to this task was, as expected, to produce mirror responses. That said, Table 2 shows that both groups of deaf children made fewer mirror responses (and thus more substitutions of all types) than their respective control groups. A two-tailed Mann–Whitney U test, collapsing across trial type (bimanual versus unimanual) confirmed that the deaf children made a smaller number of mirror responses (and hence a higher number of substitutions) than the hearing controls, $z = -2.22, p < .05$.

Examination of the particular types of non-mirror responses (or errors) that the children made reveals that all four groups of children made a smaller proportion of movement substitutions (the classic “substitution errors”) in the bimanual trials than in the unimanual trials. Four separate Wilcoxon Matched-pairs signed-ranks tests revealed that the proportion of movement substitutions was significantly lower in the bimanual trials than in the unimanual trials for the native signers, $z = -2.80, p < .01$, and their controls, $z = -2.09, p < .05$, and for the late signers, $z = -2.02, p < .05$, but not for their controls, $z = -1.35, p = .18$. 

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**Table 2**  
Proportion of mirror responses and substitutions made by native- and late-signers and their hearing controls

<table>
<thead>
<tr>
<th>Type of trial</th>
<th>Proportion of mirror responses</th>
<th>Proportion of movement substitutions</th>
<th>Proportion of location substitutions</th>
<th>Proportion of movement and location substitutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native-signers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bimanual</td>
<td>.98</td>
<td>.02</td>
<td>-.a</td>
<td>-.a</td>
</tr>
<tr>
<td>Unimanual</td>
<td>.82</td>
<td>.10</td>
<td>.06</td>
<td>.01</td>
</tr>
<tr>
<td>Controls for native signers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bimanual</td>
<td>1.00</td>
<td>.00</td>
<td>-.a</td>
<td>-.a</td>
</tr>
<tr>
<td>Unimanual</td>
<td>.89</td>
<td>.05</td>
<td>.04</td>
<td>.01</td>
</tr>
<tr>
<td>Late-signers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bimanual</td>
<td>.96</td>
<td>.04</td>
<td>-.a</td>
<td>-.a</td>
</tr>
<tr>
<td>Unimanual</td>
<td>.78</td>
<td>.15</td>
<td>.05</td>
<td>.02</td>
</tr>
<tr>
<td>Controls for late-signers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bimanual</td>
<td>.97</td>
<td>.03</td>
<td>-.a</td>
<td>-.a</td>
</tr>
<tr>
<td>Unimanual</td>
<td>.91</td>
<td>.07</td>
<td>.01</td>
<td>.01</td>
</tr>
</tbody>
</table>

* Because they are directed at both ears, bimanual trials cannot produce location substitutions (i.e. there is no “incorrect” or non-mirror ear in these trials).
These group-level analyses were supported by analyses at the level of the individual. The majority of individuals in both groups of deaf children made more movement substitutions during unimanual trials than during bimanual trials. For the native signers, 10 out of 19 children made more unimanual than bimanual movement substitutions. A further eight native signers made no movement substitutions during either type of trial, while the final child made the same number of bimanual as unimanual movement substitutions. A one-tailed “sign test” confirmed that a significantly greater number of native signers made more unimanual than bimanual movement substitutions than demonstrated the reverse pattern ($p < .005$).

For the late signers, 9 out of 15 children made more unimanual than bimanual movement substitutions. A further four late signers made no movement substitutions during either type of trial, while only two children made more bimanual than unimanual movement substitutions. A one-tailed “sign test” confirmed that a significantly greater number of late signers made more unimanual than bimanual movement substitutions than demonstrated the reverse pattern ($p < .05$).

For both groups of hearing children, the majority of children produced performance that contained no movement substitutions. Of the controls for the native signers, 15 of 19 children made no movement substitutions. Of the controls for the late signers, 9 of 15 made no movement substitutions. Nevertheless, for both control groups, where movement substitutions were made, most children made them more often during unimanual than during bimanual trials. All four native controls who produced them made more unimanual than bimanual movement substitutions, as was the case for five of the six late controls who made movement substitutions.

Both samples of deaf children thus exhibited a decreased rate of the substitution error for bimanual as compared to unimanual trials, demonstrating goal-directed imitation.¹

4. Discussion

The samples of native- and late-signing children were well matched with their respective control groups in terms of chronological and mental age, as well as handedness. In both the deaf samples and their hearing controls, the same pattern of responses to the imitation task was observed. All groups of children made more movement substitutions in the unimanual trials than in the bimanual trials (although this difference was not significant for the late

¹ Non-parametric statistics were used throughout this paper because the data were not normally distributed (the data were left-hand skewed, with most children producing 0, 1 or 2 substitutions and fewer children producing 3, 4, 5 and so on). Nevertheless, equivalent parametric analyses to the non-parametric ones presented here produced equivalent results. A 2 (hearing status; deaf versus hearing) × 2 (signing status; native versus late) ANOVA on the number of mirror responses revealed that hearing status was the only significant factor, $F(1,67) = 5.57, p < .05$, confirming that deaf children made fewer mirror responses overall than hearing children. Additionally, a 2 (hearing status; deaf versus hearing) × 2 (signing status; native versus late) × 2 (trial type; bimanual versus unimanual) ANOVA with repeated-measures on the last factor on the (arcsine transformed) proportion of movement substitutions confirmed that the only significant factor was trial type (bimanual versus unimanual), $F(1,64) = 20.03, p < .001$. This confirmed that children in all groups made significantly more movement substitutions in the unimanual than in the bimanual trials.
signers’ control group because of the small number of all types of substitutions made by these children). This suggests that the deaf children (like the hearing children) viewed the adult demonstrator’s actions as goal-directed and that their responses were guided by the goals they inferred. In the unimanual trials, children interpreted the goal of the task to be touching the mirror ear and thus sometimes neglected to produce the same hand movement as the experimenter. In the bimanual trials, when the goal of touching a specific ear was removed (because both ears were touched), the particular movement of the hands was more accurately reproduced. Thus, the evidence from this study suggests that even late-signing deaf children understand that people are goal-directed agents.

If the responses of the late signers had been governed by some form of direct mapping between perception and action, rather than by goal-directed mapping, we would have expected them to have made a similar number of movement substitutions in the bimanual and unimanual trials. However, this was not the case. The path from perception to action in the imitation of late signers, as with native signers and hearing children, is not directly mapped, but is instead mediated by goals.

One unexpected result that emerged from this study was that the deaf children (both late- and native-signers) made a smaller number of mirror responses in general than their hearing controls. Given that the deaf children were matched to their hearing controls for age, spatial mental age and handedness, the most likely explanation for this lies with the deaf children’s exposure to British Sign Language. Many signs in BSL require a dominant hand to enact the key element, such that a right-handed signer learning a sign from another right-hander opposite them must perform an isomorphic mapping so that the sign is correctly produced. Thus, it is plausible that exposure to BSL may have prompted the deaf children to make more substitutions in which they used the same, rather than the mirror hand when responding to the test gestures. Nevertheless, it is clear that the deaf children in this study did not approach the imitation task as they would have approached learning a new sign. If the deaf children had treated the task as an exercise in sign language learning, we would have expected the majority of their responses to have been location substitutions, in which they re-enacted the movement of the experimenter’s gesture with the same, rather than the mirror hand. Instead, the majority of the deaf children’s responses to this task were mirror responses. The gestures produced in this task had no clear communicative purpose and all children seemed to approach the task as an interesting game, rather than an exercise in learning new signs.

Irrespective of the difference between the deaf and hearing children in terms of the number of substitutions of all types that they made, both sets of deaf children showed the specific pattern of results indicative of understanding the goals of others, producing more movement substitutions in the unimanual than bimanual trials.

The present study has shown that, like hearing children, both native- and late-signing deaf children interpret people’s actions in goal-directed terms. While later components of mental state understanding seem to be substantially delayed in late-signing deaf children, this initial component is present, at least by middle childhood. On the one hand, these results suggest that, unlike performance on false belief tasks, an understanding of the goal-directed nature of other persons is potentially unaffected by the absence of early language exposure. However, note that the youngest deaf children tested in the present study were four years old. One question that still remains is whether deaf children’s understanding of goals is present
as early as that of hearing children. It has been argued (Carpenter, Nagell, & Tomasello, 1998; Tomasello, 1999) that hearing children come to understand others as goal-directed agents by about 9 to 12 months of age. Nevertheless, as a first step to broadening our picture of deaf children’s mental state understanding, this study has shown that deaf children readily view other people’s actions in terms of goals and do so at an age at which they demonstrate robust difficulties with false belief reasoning.

The fact that both native- and late-signing deaf children interpreted the experimenter’s actions as goal-directed in this study, and that late signers have been shown to be delayed on false belief tasks in other studies, suggests that an understanding of goal-directedness can be displayed in the absence of false belief understanding. Direct evidence that this is the case comes from 20 of the 34 deaf children from this study (12 native signers and 8 late signers) who, as part of a separate investigation (Woolfe et al., 2002), were tested on pictorially presented false belief tasks. The native signers amongst these children achieved a mean false belief score on these pictorial tasks of 1.33 out of 2, while the late signers scored only 0.25 out of 2 (a difference that was statistically significant, $t_{(18)} = -4.06, p < .001$). Thus, whilst both sets of deaf children displayed an understanding of goal-directedness in this study, only the native signers showed much success when tested on false belief tasks.

Therefore, as well as demonstrating that late-signing deaf children are not entirely “mind-blind”, this study also underlines the importance of developing a broader picture of the relationship between early and later emerging aspects of mental state understanding. Some tasks involving mental state understanding, such as pretend play, are good predictors of children’s understanding of the difference between mental representations and reality (as measured by the False Belief Task; Youngblade & Dunn, 1995). The results of this study suggest that the understanding of goal-directedness is probably a necessary, but not sufficient precursor to reasoning about false belief (see Bloom & German, 2000). Future longitudinal work that examines the emergence of the understanding that others are goal-directed and false belief understanding should have the power to disentangle such developmental connections between early- and late-emerging forms of mental state understanding.

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References


