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Toddlers' pointing when joint attention is obstructed*

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ABSTRACT

The aim of this study was to examine toddlers' ability to take their social partner's line of sight into account when engaging in joint attention. If pointing involves an understanding of the relationship between seeing and knowing, then specific modifications in communication should appear when joint attention is obstructed. In this study, obstacles were introduced in order to manipulate object visibility for the toddler's social partner.

Thirty-two toddlers aged 18–23, 24–29, and 30–36 months were tested with an adult social partner and two animated clown mannequins. In Task 1, whereas both clowns were always visible to toddlers, there were three conditions varying the number of targets visible to the adult social partner (both, one, or none). In Task 2 toddler and social partner were sitting face-to-face, each having a clown fully visible (in front) and one not visible (behind).

When attempting to communicate about an object not visible to the social partner, toddlers show increased levels of the following behaviours: pointing frequency; proportion of pointing accompanied by visual checking with the adult; anticipatory visual checking (just before pointing initiation); frequency of vocalizations associated with pointing; and frequency of language both associated with

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pointing and isolated. This pattern consolidates in the observed age range, with the stronger age effects being related to language.

In conclusion, specific alterations appear in communication when one or both targets are not visible to the social partner. While showing the toddler's heightened effort to engage the 'blind' adult in shared reference, such alterations suggest an understanding of the link between seeing and knowing.

INTRODUCTION

The aim of this study was to investigate toddlers' ability to take another person's line of sight into account when initiating joint attention. The main focus is on the pointing gesture, although vocalizations and language are also considered. The rationale of the study is as follows: if pointing involves an understanding of the relationship between seeing and knowing, then specific modifications in communication should appear when joint attention is obstructed. Specifically, pointing and related behaviours should re-organize in function of the targets in the environment which are/are not shareable between toddler and social partner.

The way in which communication and social cognition are related has been increasingly studied within the framework of the development of joint attention. In particular, two lines of investigation appear to have attracted more research efforts. The first line investigates infants', toddlers' or chimpanzees' comprehension of joint attention behaviours. The second line investigates the development of communication (mostly production) in relationship with (a) joint attention and (b) the acquisition of language. As to methods, measures and caveats, the first line of research is rather more homogeneous than the second line. However, the results in the second line often lead to more 'mental' interpretations of infants' behaviour, in that some understanding of 'mental' states is attributed earlier, to younger babies.

Two reasons come to mind for more 'mental' interpretations emerging from production than from comprehension studies of joint attention. Firstly, comprehension and production processes might be relatively independent (Mundy & Gomes 1998) and therefore follow partly different pathways or progress at different speeds. Secondly, the eternal methodological dilemma between favouring internal vs. external validity may also be responsible for partly different results. In fact, comprehension studies are typically strictly experimental because they investigate infants' or children's *responses* to adults' looking or gesturing behaviours. It is therefore necessary to control adults' behaviour carefully, and this

at times requires a degree of artificiality that may compromise the chances of the younger participants succeeding. In contrast, production studies are focused on infants' or toddlers' spontaneous behaviours, while experimental control is limited to aspects of the setting or context. Most importantly, the adult partner's behaviour is more natural than in comprehension studies, which may support babies' existing abilities at best.

The present study aims to contribute to each line of investigation by examining directly a theme more typical of comprehension studies (Do toddlers keep track of someone else's visual attention? Is this ability related to the understanding of attention as a mental state?) within a production framework. Consequently, we combined methodological aspects of both traditions and tried to achieve a balance between experimental control (manipulation of the visibility of objects for one of the interactants) and ecological validity (naturalness of the social partner's behaviour). In the following sections different aspects of the relevant theoretical background will be examined.

The relationship between seeing and knowing: production studies

The most direct predecessor of this study is perhaps the work by O'Neill (1996). She tested 'old' and 'young' 2-year-olds in contexts where the toddler's parent had or had not seen where the experimenter had placed an object. When asking the parent to retrieve the object for them, toddlers named object or location and gestured more when the parent did not know where the toy was and what it was. These results can be interpreted as showing either toddlers' understanding of the seeing-knowing relation, or, as more conservatively proposed by O'Neill, toddlers' sensitivity to the engagement/disengagement state of the parent; once disengagement has been detected, a toddler would update the parent in order to resume interaction. However, from the 'production' line of investigation we find support for the former interpretation. For instance, Golinkoff (1986, 1993) showed that 11- to 19-month-olds systematically 'repair' unsuccessful communication. If the mother fails to respond to (or misunderstands) an infant's signal, the likely consequence for the baby will be (a) augmenting the signal gesturally, or (b) repeating the signal with additional vocal emphasis, or (c) substituting another signal. These results were interpreted as evidence of the infants wishing to share the *contents of one's mind*, but Shatz & O'Reilly (1990) offered an alternative, non-mental interpretation: communication repairs may be simply a manifestation of wishing to attain *material goals*. Clearly, the debate here revolves around motivation issues and the pragmatic meaning of communication. A

later study by Shwe & Markman (1997) supported Golinkoff's interpretation: toddlers engaged in behaviours to ensure their communicative act had been understood *irrespective of whether they were achieving an overt, material goal.* Therefore, these sets of results are compatible with a view that considers toddlers are aware of the impact their communicative signals have on other people. More specifically, and consistently with O'Neill's findings (1996), toddlers appear to take into account their partners' knowledge state. However, Shwe and Markman's sample (30 months) was older than Golinkoff's. Therefore, the interpretation concerning toddlers in their second year of life may require further support.

Other sources of evidence appear to converge in identifying around 18 months a toddler's ability to 'take responsibility' for monitoring the social partner's attention, both in comprehension and production. Tomasello (1995) provided, perhaps, the most comprehensive account of how communication and social cognition are intertwined and develop in infancy. One of the milestones in such development is the understanding of other persons as intentional agents, as observed, for instance, in intentional declarative communication from the end of the first year of life. In such communicative acts infants are sharing attention to something with another person, that is, the pragmatic purpose relies on an implicit understanding of others as independent agents with psychological states or intentions, such as attention. Franco & Butterworth (1996), for example, described in these terms infant declarative pointing accompanied by visual checking of the social partner. During the second year, the limitation concerns the understanding that 'the intentions of persons may on occasions not match with the current state of affairs (analogous to 4-year-olds' understanding of false belief)' (Tomasello 1995: 114). Full understanding of this would take place between 18 and 24 months as shown by both developments in comprehension (see below, Baldwin 1995) and new aspects characterizing production. For instance, from 16 to 18 months of age, manual pointing begins to be systematically *preceded* (rather than just accompanied or followed) by visual checking with the social partner. This behaviour suggests the presence of at least an elementary understanding that other people may be having their own attentional agenda, and that shared reference (resulting from pointing) can be achieved only after shared (mutual) attention has been established (Desrochers, Morissette & Ricard 1995, Franco & Butterworth 1996).

It has, however, been suggested (Corkum & Moore 1995, 1998, Moore & Corkum 1994) that the same type of infant behaviours could be learned by conditioning. Thus, declarative pointing accompanied by

looking at the social partner would be the result of having been rewarded with smiles and other interesting behaviours by the adult. Tomasello (1995) argued that if this was the case, then it should also be possible to condition chimpanzees to produce declarative gestures – but this has never been observed in a natural habitat and is virtually absent also in enculturated animals (see also Leavens & Hopkins 1998, Leavens, Hopkins & Bard 1996). Moreover, social rewards could not easily explain the change of timing in visual checking associated with pointing (from after or during the gesture to *before* it).

Comprehension studies

Notwithstanding the relatively coherent picture emerging from production studies, suggesting the advent of the 'mentalizing' era certainly by the second half of the second year, comprehension studies appear to support more cautious interpretations of joint attention behaviours in infants.

Lempers, Flavell & Flavell (1977) reported that over half the 2-year-olds in their study were able to identify which of three objects an adult was looking at. Virtually all 3-year old children were successful. This was one of the first studies of young children's ability to follow another person's line of sight, but has been subsequently criticized for methodological limitations. Since then, researchers and theoreticians have been debating whether young children understand attention or are simply able to use cues (e.g., eye direction, head orientation) to track down someone else's target. For instance, Butterworth and colleagues (Butterworth & Cochran 1980, Butterworth & Grover 1988, Butterworth & Jarrett 1991) found that 12-month-olds are able to follow another person's gaze until they can find a visual target. But only around 18 months does this ability become specific and systematic enough to identify the other person's target (not just any object along that line of sight), even if this is located outside the baby's visual field (behind). More recently, Deàk, Flom & Pick (2000) suggested that, providing the adult's head orientation movement is visible and large enough, even 12-month-olds can turn to look at an adult's target located behind the infant. Therefore, from this point of view, infants show an understanding of the link between looking and seeing (i.e., attention) from 12 months of age, although improvements are described in the second year of life.

A different view has been supported by Moore & Corkum (1994) and Corkum & Moore (1998), who proposed an explanation of gaze-following based on instrumental conditioning. They claimed that infants may learn to follow an adult's gaze simply because this is usually rewarded by finding some interesting object. Recently Moore &

Povinelli (2000) highlighted an important difference in the gaze-following behaviour of 12- and 24-months-olds. In the perceiver-object relationship established by someone else's looking, the younger infants appeared biased towards the object-end of the relationship (i.e., as far as an interesting object was activated, they kept turning towards it irrespective of the adult's looking behaviour), but the older toddlers appeared biased towards the perceiver-end of the relationship (i.e., they turned to look at the objects less if the adult was not looking at them). Thus, only the older children would show an appreciation of the referential link between a perceiver's look and the object of that look (see also Povinelli & Eddy 1996). Along the same line, elsewhere Moore (1999) has referred to developments in information-processing abilities resulting in a change from exogenous to endogenous control over infant's attention around 18 months. The implications of such a transition would be extensive, for example for the development of language (Baldwin 1995, see below: Language and joint attention).

In an attempt to analyse the pendulum between more or less conservative interpretations, two considerations appear relevant. Firstly, that most inconsistencies are found within the age group 16–24 months, which is a transition age (e.g., shift from mostly pre- to verbal communication). The second consideration is that we do not know enough of the specific demands characterizing different joint attention tasks, which makes it difficult at times to compare across studies. An example of this problem is presented by the different interpretations offered in the following studies concerning *older* children or adults.

In Doherty & Anderson's experiments (1999), using mostly schematic drawings of faces in comprehension tasks, children well into their fourth year of life failed to identify the target that was looked at or even if they were looked at themselves. On this basis, the authors argued against the hypothesis that toddlers and young children have an understanding of the (mental) significance of eye direction, an ability with which 2-year-olds are credited in studies utilizing more naturalistic tasks (e.g., Povinelli & Eddy 1996). On the other hand, in different tasks varying the type of cue (eyes only, eyes + head movement, flat vs. elongated nose mask, arm/point, etc.), Butterworth & Itakura (2000) found that both 4- and 5-year-old children and adults show no high precision in identifying another person's visual target. The various types of cues all contribute in different ways to increase accuracy, with eyes only at the lowest and manual pointing at the highest end of the spectrum. However, following someone else's line of attention seems to involve something like the identification of 'zones of space' more than the extrapolation of precise 'linear vectors through visual space'. In

fact, if we look at the production side of the story, older children and adults continue to use pointing gestures in combination with speech, that is pointing (the most powerful joint attention tool) fulfils an orienting function, while other information is verbally conveyed. In other words, failure to identify the correct target of someone's attention in particular experimental contexts with particular task demands does not necessarily mean a lack of a general understanding of attention.

To sum up, the literature reviewed in this section has drawn attention to (a) a transition age group (16–24 months), which for this reason is included in the present study, and (b) methodological aspects characterizing different types of task, which may be the origin of different interpretations of toddlers' abilities. Both within and between production and comprehension, a number of factors vary across different tasks, which may all contribute to affecting infants and young children's performance. For instance, sitting positions are often not controlled, that is the relative position of infant (or child) and experimenter varies unsystematically across studies, perhaps contributing to different results. It is quite possible that different testing conditions present more or less taxing joint attention demands; different opportunities for mutual gaze (i.e., to establish mutual attention or gather emotional information by social referencing); and different opportunities to monitor the social partner-environment relationship (see Deàk, Flom & Pick 2000). In order to increase inter-study comparability and consistency, in the present study the spontaneous production of pointing and related communicative behaviours was observed in a context previously used in other studies (e.g., Franco & Butterworth 1996, Franco & Wishart 1995), while specific manipulations were introduced concerning the visibility of targets for the toddler's social partner.

Language and joint attention

Finally, some studies have addressed the question of the relationship between developments in joint attention skills and language acquisition. Tomasello & Farrar (1986) had identified a higher rate of lexical acquisition in joint attention episodes between toddlers (15–21 months old) and their mothers, in both naturalistic and experimental contexts. Later, experimental studies by Baldwin (1995) furthered our knowledge of the child's contribution to the link between comprehension of joint attention and language acquisition. Baldwin showed that only toddlers older than 18 months can learn a new word produced by an adult looking at a target different from the one that the child is looking at. This is possible because at that age a toddler systematically checks what is the social partner's focus of attention.

Other studies were dedicated to understanding the developmental relationship between infant's *initiating* joint attention and language acquisition. Bates, Thal, Whittesell, Fenson & Oakes (1989) reported that, between 12 and 16 months, gesture production (particularly pointing or gestures representing objects) was highly correlated with word comprehension and moderately correlated with expressive language. In a longitudinal study more specifically investigating pointing, Desrochers *et al.* (1995) found that early production of communicative pointing (point + look to social partner) in 6- to 18-month-olds predicted both expressive and receptive language at 24 months. No relationship was found between non-communicative pointing and later language development.

Desrochers *et al.* (1995) also found that comprehension of pointing was not correlated with either communicative (point + look) or non-communicative (point alone) pointing production. Carpenter, Nagell & Tomasello (1998) in a longitudinal study of 9- to 15-month-olds found that two-thirds of the babies followed a point before or in the same month as they pointed themselves, while the rest of the sample showed the reverse sequence (production preceding comprehension). Therefore, pointing comprehension and production appear not to be one and the same thing, as a study by Mundy & Gomes (1998) also suggests. They tested children twice in their second year with a four-month gap between session 1 (< 18 months) and session 2 (> 18 months). Their results show that initiating joint attention in session 1 predicted expressive language in session 2, whereas following someone else's attention at session 1 predicted receptive language at session 2. These results were interpreted as indicating at least partially independent development for production and comprehension processes in joint attention, and their relationship with language acquisition.

In the present study, we aim to examine one aspect that has not been extensively investigated, that is the relationship between vocal/verbal and gestural communication in a joint attention task, at the crucial age of the transition to language.

Summary and predictions

In this study, obstacles were introduced in a declarative-facilitating context (following Franco & Butterworth 1996) in order to manipulate the visibility of a toddler's targets to an adult social partner. Toddlers aged 18 to 36 months watched, with the social partner, simple, interesting events produced by two target objects. The general prediction was that, when joint attention is obstructed, toddlers will alter their communication pattern, thus showing a deliberate effort to enhance the likelihood to engage the social partner in joint attention.

The main communication variables analysed in this study were: pointing; visual checking occurring before, during or after pointing, or being absent; and four types of vocal behaviour (see General method). There were many possible combinations of each of these variables with frequency change states, viz. remaining the same, increasing or decreasing frequency when the social partner cannot see the child's target with respect to when she can. Of these possible combinations, there were three meaningful alternatives:

(a) Same frequency of pointing, checking and vocal behaviour. If no significant differences were found between conditions with target visible or invisible, there would be no evidence of toddlers taking notice of the social partner's perspective, which is different from their own.

(b) More pointing, increased checking and same or more language in the target invisible than target visible condition. As based on the selective insistence on the invisible (for the addressee) target, this pattern of alterations is consistent with the hypothesis of extra efforts being made by the toddler in order to establish shared attention with the adult. This may be expected of a mostly non-verbal group, in which the limited language competence could not support sustained, exclusively verbal communication.

(c) Less pointing but more language in the target invisible than target visible condition: language can be heard, and supplement or replace gestures to an invisible (for the addressee) target. This may be expected of children of fully (or mostly) verbal level. Similar to (b), this pattern of alterations is consistent with the hypothesis of extra efforts being made in order to establish shared attention with the social partner, but here the emphasis is on verbal communication. In the invisible target condition, the addressee cannot see the target of a point, hence pointing may decrease; but s/he could apprehend the toddler's target existence, activity or qualities via verbal communication rather than via perceptual exploration, hence language may increase.

We expected that the younger participants would behave according to prediction (a) or (b), and the older participants according to prediction (c). We also envisaged the possibility of a transition stage where a mixture of (b) and (c) could be observed (more pointing, increased checking, more language), possibly corresponding to the first semester of the third year of life.

Two tasks were used, in which different types of visual obstruction were employed. Aspects of the method common to tasks 1 and 2 are reported in the 'General method' section. More specific methodological details and the results of the two studies will be analysed separately but discussed jointly at the end.

With respect to the background examined above, this study aims to provide the following.

1. An attempt to combine aspects of both comprehension and production studies of joint attention.
2. An attempt to help to clarify a transition stage where inconsistencies between studies are found (toddlers do/do not understand the link between seeing and knowing), by including a group aged 18–24 months.
3. An attempt to control and study context effects carefully; a previously used task was chosen as basis for inter-study comparisons, in which we introduced specific manipulations. Moreover, two different types of manipulation of the independent variable (visual obstruction) were used for intra-study comparisons.
4. An attempt to elucidate the link between pointing (the main tool for initiating joint attention in infancy) and other attentional behaviours (visual checking) as well as vocalizations and language.

GENERAL METHOD

General aspects of the method are analysed here whereas details concerning each task are given in the specific sections.

Sample

Thirty-two toddlers in 3 groups aged 18–23 (N = 11), 24–29 (N = 11), 30–36 months (N = 10) were tested with an adult social partner (a female experimenter). There were similar numbers of boys and girls in each age group. All children had been recruited at the nursery school they attended. Parents were informed that the study concerned the development of communication in normally developing children and were aware that their children would be taken briefly out of the class by the experimenter. They could visit the testing room if they wished and could also watch the film of their child on the day of her/his test.

Procedure

The experimenter spent a week at the nursery school in order to

participate in all the day's activities and become familiar to all children. A room was set up for testing with a control boot hiding both the equipment and a second experimenter (a part-time teacher at the school) whose task was to videotape the session and activate the objects (see below). Apart from the control boot and two shelves, the room contained only materials used in the experiment. All sessions were video-recorded.

The testing layout was as in Franco & Butterworth (1996) and Franco & Wishart (1995), where it had been shown to facilitate the emergence of declarative communicative acts. Two animated, remotely controlled clown mannequins were used at a distance of 250 cm from participants. The clowns were mounted on stands 160 cm tall, and they were identical. They were activated singly or as a pair from the control boot according to a pre-established sequence of movements (7 s each) and inter-movement pauses (lasting 7 or 14 s). During the movement phase, the arms and legs of the clowns were moving.

Children were tested individually, with the experimenter collecting them from the class at a convenient time and taking them to the testing room. No participant was distressed at being removed from the class, as children were used to occasional changes in group/room to take part in various activities. During the experiment, the child sat in a high-chair while the social partner sat on a stool. Before the experimental session began, a warming-up period was allowed, during which toddler and social partner were freely interacting while already sitting at their places. Each child was presented with two types of task:

1. *Visibility obstructed by distal obstacle* (*Distal*): whereas both clowns were visible to toddlers throughout this task, there were three conditions varying the number of targets visible to the social partner who was sitting next to the child: none of them (None, henceforth), one clown only (One), or both clowns (Two).

2. *Visibility obstructed by spatial obstacle* (*Spatial*): child and adult were sitting face-to-face; a clown mannequin was positioned behind each interactant. In this way the child and experimenter each had: (a) one target fully visible in front of them, and (b) one target *not* visible because located behind them (but the target was visible to the other interactant).

The tasks were separated by ten minutes, including two further tasks (not analysed here) and a brief pause for free interaction. The Distal and Spatial tasks will be analysed separately and further

methodological details will be provided in their specific sections (see below).

CODING SYSTEM AND DEPENDENT VARIABLES

Continuous coding of the data was carried out from videotapes. The coding system for the dependent measures was as in Franco & Butterworth (1996).

Gestures

Although pointing was the main target, exhaustive coding was also carried out for gestures defined as follows.

Pointing: both arm and index finger extended in a conventional pointing posture.

Indicating: these gestures lack the full pointing posture, but they have sometimes been considered functionally equivalent to pointing (e.g., Lock, Young, Service & Chandler 1990): (a) finger-point, the finger alone, but not the arm, is extended towards the target, usually with a quick movement (as in 'point slipping out' category of Lock *et al.* 1990); (b) arm-point, the arm is extended towards the target while the hand assumes various postures (e.g., hand held with all fingers extended, or fingers tightly clenched).

Reaching: arm extended with the hand palm in a downward, open-handed reaching posture.

'*Other*': other gestures (e.g., bye-bye, pick-me-up, clapping, all-gone).

Analysed data consist of the frequency of gestures in each category. In condition One of the Distal task, the direction of pointing, indicating and reaching was also noted (i.e., which of the two clowns was singled out).

Visual checking

Timing: the incidence of the first look to the social partner's eyes associated with a gesture was classified as follows: within 2 s before gesture initiation (before), during gesture execution (during), and within 2 s after gesture completion (after).

Multiple checking: gestures in which the infant looked at the partner on at least two occasions within the same temporal window described above (e.g., during and after the gesture).

Analysed data consist of the proportion of gestures associated with visual checking (before, during or after) and multiple checking.

Vocalizing

A vocalization was defined as any sound separated from adjacent sounds by an audible interruption in phonation (/baba/ was counted as one vocalization, while /ba/ interruption /ba/ was counted as two), with the exclusion of both vegetative (e.g., hiccups, burps, etc.) and fussy/cry sounds. Two separate counts were made for: *vocalizations associated with gesture*, that is produced within a 2-s time window with respect to a gesture; *isolated vocalizations* (i.e., not accompanying a gesture). Analysed data consist of the frequency of vocalizations in the two categories.

Language

Any vocal production recognizable as a word of the mother tongue was counted as one word. This means that, for instance, three words were counted in multiword utterances such as 'Look, clown there!' and 'Clown, clown there!', and two words were counted in 'Clown jumps'. Two separate counts were made for: *language associated with gesture*, that is produced within a 2-s time window with respect to a gesture; *isolated language* (i.e., not accompanying a gesture). Analysed data consist of the frequency of words in the two categories.

Reliability

Interobserver agreement was tested on 25% of the data randomly selected from both tasks. Reliabilities produced by a judge naïve to both hypotheses and participants' ages concerning the above-mentioned dependent measures ranged between 0.75 and 0.90 (Cohen's κ agreement corrected for chance).

TASK 1: VISIBILITY OBSTRUCTED BY DISTAL OBSTACLE

Figure 1 illustrates the three conditions presented within this task, varying the number of targets visible to the social partner (experimenter). Whereas both clowns were visible to toddlers throughout this task, the social partner could see none of them (None), one clown only (One), or both clowns (Two). The different conditions were created by orienting a large screen between target/s and social partner in different ways, so that the screen would/would not be an obstacle along the adult's line of sight towards the target/s. The second experimenter came out of the control boot to change the position of the screen.

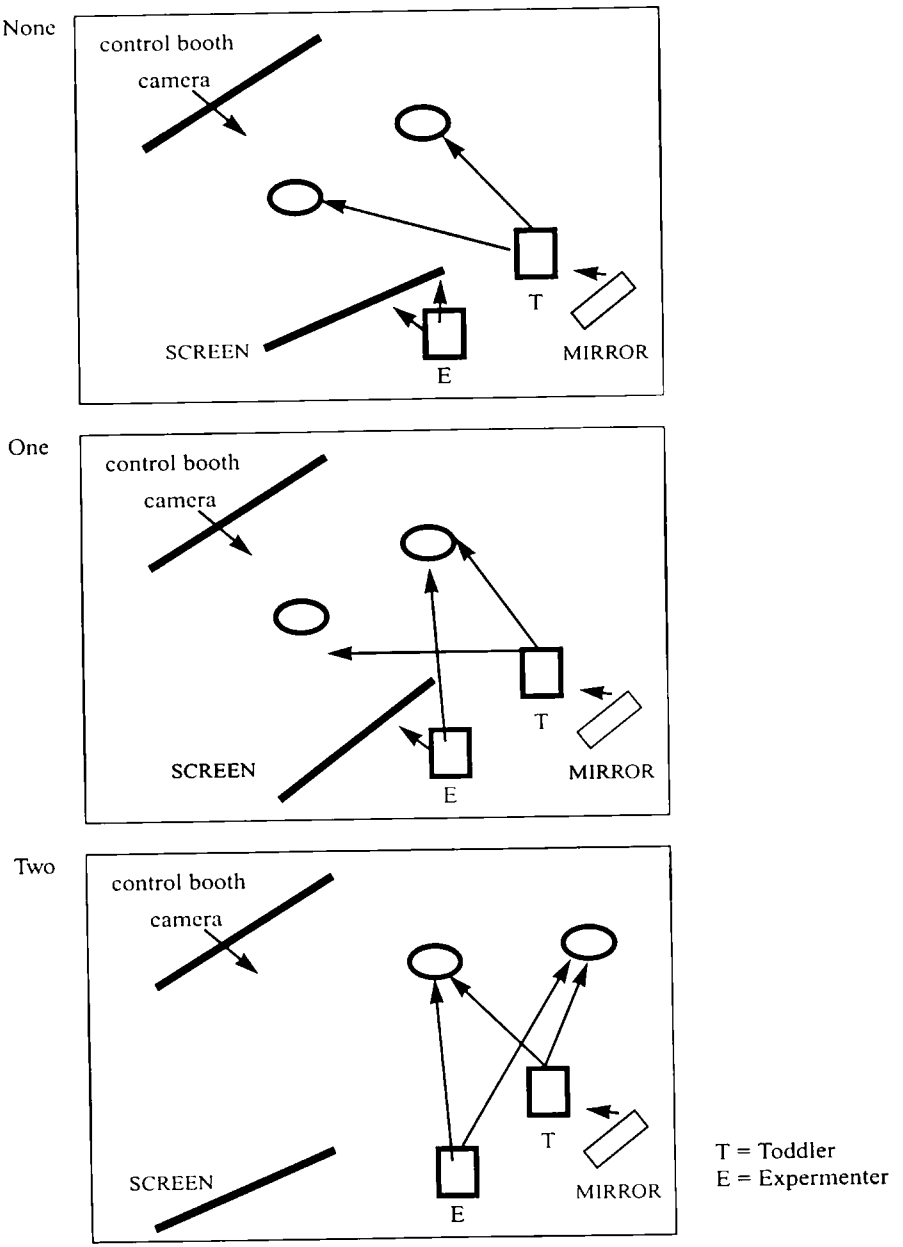

Fig. 1. Three conditions varying the number of targets visible to a toddler's social partner (the experimenter)

As explained in the Introduction, it was predicted that in condition None (when the experimenter could not see the objects) there would be increased levels of communication with respect to condition Two (when toddler and experimenter were able to see the same two target objects). Condition One was instrumental in interpreting the results; as it presented a target conflict (one being visible to the experimenter while the other was not), it allowed us to check which target was the referent of toddlers' communicative acts. Thus, if heightened levels of communication in condition One concern the object *invisible* to the experimenter, heightened levels of communication in condition None can be explained as a reaction to the obstruction in joint attention, rather than to possibly somewhat different behaviours by the social partner.

During the experiment, the child was sitting in a high-chair while the social partner was sitting on a stool slightly behind and at about 90° from the child; in this way eye contact between child and adult was always possible, but a voluntary action (head-turn) was necessary if the child wanted to look at the experimenter's eyes/face. A mirror was placed behind participants in order to capture with the camera more details of their facial movements and eye direction, as well as the reflection of the target objects.

In each condition (None, One, Two) there were three movements/pauses of the clowns, for an overall task duration of approximately 4 minutes (including moving screen between conditions). The order of conditions was randomized across participants. Throughout the session, the experimenter tried to maintain sufficient interaction with the child in order not to appear 'odd' or 'switched off' from the task. However, the initiative to communicate was left to the child, the experimenter being mostly socially responsive.

Results

Gestures Fewer than 20% of participants produced any reaching and indicating. Averaging across conditions, there was an incidence of 5.2 for pointing, 1.6 for other gestures, but 0.18 for reaching and 0.53 for indicating. Therefore, reaching and indicating were not considered any further. A $2 \times 3 \times 3$ hierarchical log-linear analysis was conducted on the frequency of gestures (pointing and other gestures) in the three visibility conditions (None, One, Two) and each age group (18–23, 24–29, 30–36 months). A saturated model was used, for which tests of partial association are reported.

Figure 2 shows the frequency of pointing and other gestures produced in the three conditions. In all age groups, pointing was much more frequent than other manual gestures ($LR\,\chi^2(1) = 65.03$, $p \leq 0.0001$).

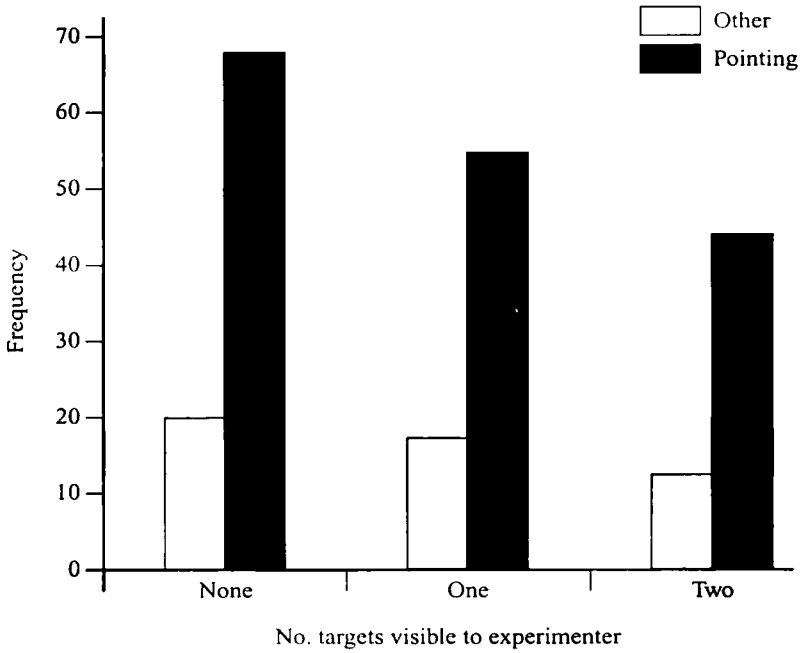

Fig. 2. Production of gestures in the three conditions (None, One, Two)

The highest frequency of gestures was produced in condition None, while the lowest was in condition Two (LR $\chi^2(2) = 6.68$, $p \leq 0.03$). In condition One, that is, when the social partner could see only one of the toddler's targets, 73% of pointing was directed to the target not visible to the experimenter (respectively, 70%, 80% and 71% in the three age groups).

Although age effects did not reach full significance, it is interesting to note from Fig. 3 that the older children (30–36 months) show the highest incidence of pointing in condition One, that is, they point more often when the social partner can see one rather than none of the targets.

Visual checking with pointing The following analyses concentrate on pointing, as the incidence of checking associated with other gestures was too low for statistical analysis. More than 20% of cells in the table condition (None, One, Two) × age (18–23, 24–29, 30–36 months) × checking (pointing associated with checking before, during, after, or no checking) presented a frequency count of < 5, which violates a basic

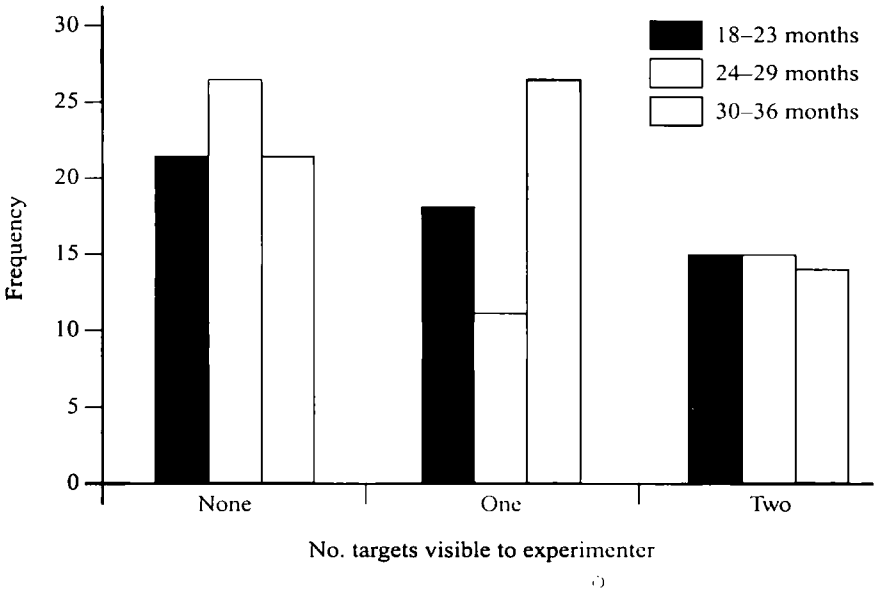

Fig. 3. Production of pointing in the three conditions (None, One, Two) by toddlers of different age groups

requirement for log-linear analysis. Statistical analyses were therefore carried out by using a 3 × 3 × 3 mixed design analysis of variance on the proportion of pointing gestures associated with visual checking of the social partner (before, during, after) on the total number of points per subject in the three conditions and age groups, with checking and condition being repeated measure factors. A similar analysis was carried out for multiple checking, that is when children turn to look at the experimenter on more than one occasion (e.g., before and after pointing).

Figure 4 shows that the proportion of pointing gestures associated with visual checking was higher when the experimenter could see None or just One of the child's targets ($F(2,58) = 5.2$, $p \leq 0.005$). Moreover, the timing of checking varies across conditions, namely checking with the social partner *before* pointing was used significantly more often in condition None ($F(2,40) = 7.52$, $p \leq 0.002$) in the two older age groups. As can be seen from Fig. 5, in the two older age groups, 50–60% of pointing produced in condition None is *preceded* by checking with the social partner, while the least anticipatory checking

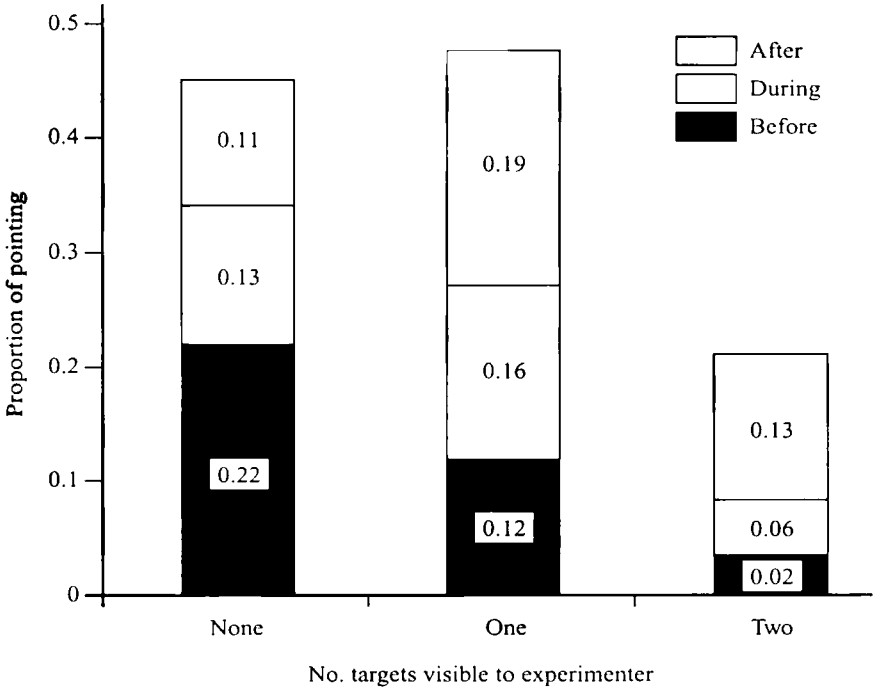

Fig. 4. Proportion of pointing associated with visual checking before, during or after gesture in the three conditions (None, One, Two)

is found in condition Two (checking *before* pointing more frequent in None than One, $p \leq 0.04$, and in One than Two, $p \leq 0.02$).

Furthermore, the average proportion of pointing gestures involving multiple checking (e.g., before and during pointing) was also significantly higher ($F(2,58) = 6.05$, $p \leq 0.005$) in condition None ($X_{None} = 0.18$, $X_{One} = 0.05$, and $X_{Two} = 0.01$ respectively).

Vocalizations and language The following analyses concentrate on pointing, as the incidence of vocal behaviours associated with other gestures was too low for statistical analysis. As to vocal behaviours associated with pointing, two 3 × 3 hierarchical log-linear analyses were conducted, one on the frequency of vocalizations and one on the frequency of language in the three visibility conditions (None, One,

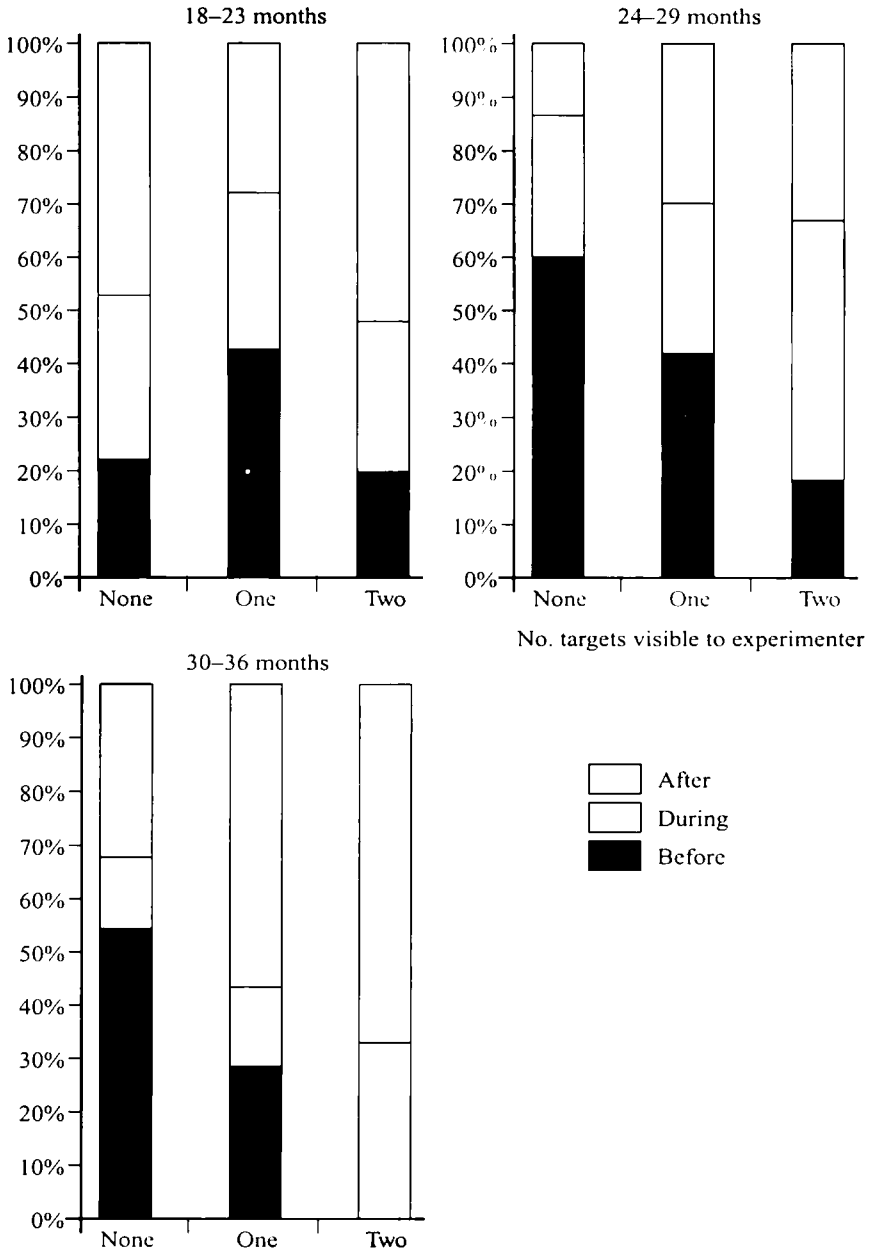

Fig. 5. Pointing with visual checking: percentage of points accompanied by visual checking before, during or after gesture in the three conditions (None, One, Two)

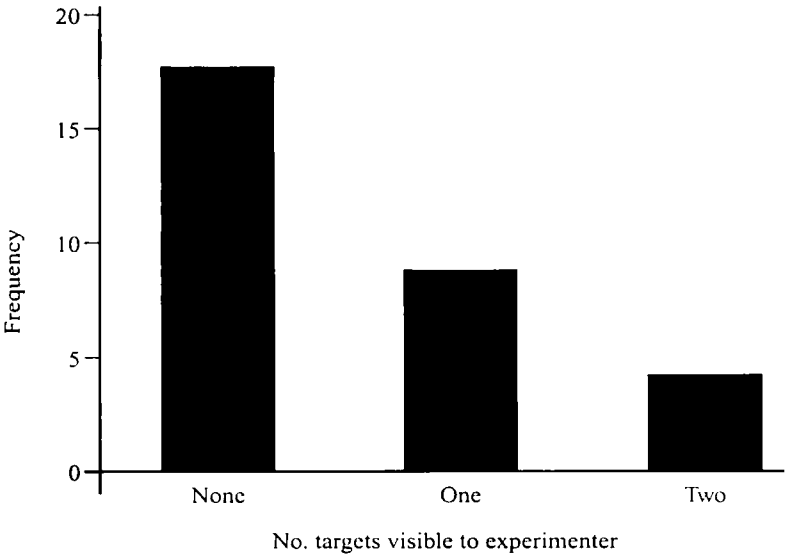

Fig. 6. Frequency of vocalizations associated with pointing in the three conditions (None, One, Two)

Two) and each age group (18–23, 24–29, 30–36 months). A saturated model was used, for which tests of partial association are reported.

Figure 6 shows that the highest incidence of vocalizations accompanying pointing is recorded in condition None and the lowest in condition Two ($LR\,\chi^2(2) = 10.85, p \leq 0.005$).

In the production of words associated with pointing, there is a sharp increase in the older age group ($LR\,\chi^2(2) = 73.18, p \leq 0.0001$). Moreover, the frequency of language with pointing varies across conditions ($LR\,\chi^2(2) = 9.86, p \leq 0.01$). Figure 7 shows that the older children (30–36 months) produce nearly twice as many words in condition One as in the other conditions, while the two younger age groups tend to produce more words in both conditions None and One. Age effects, however, did not interact significantly with condition, possibly because only the older children produced a substantial number of words.

As to isolated vocal behaviours (i.e., not associated with pointing or any other gestures), the count of isolated vocalizations was too low to allow statistical analysis (overall, 5 in None, 9 in One, and 19 in Two).

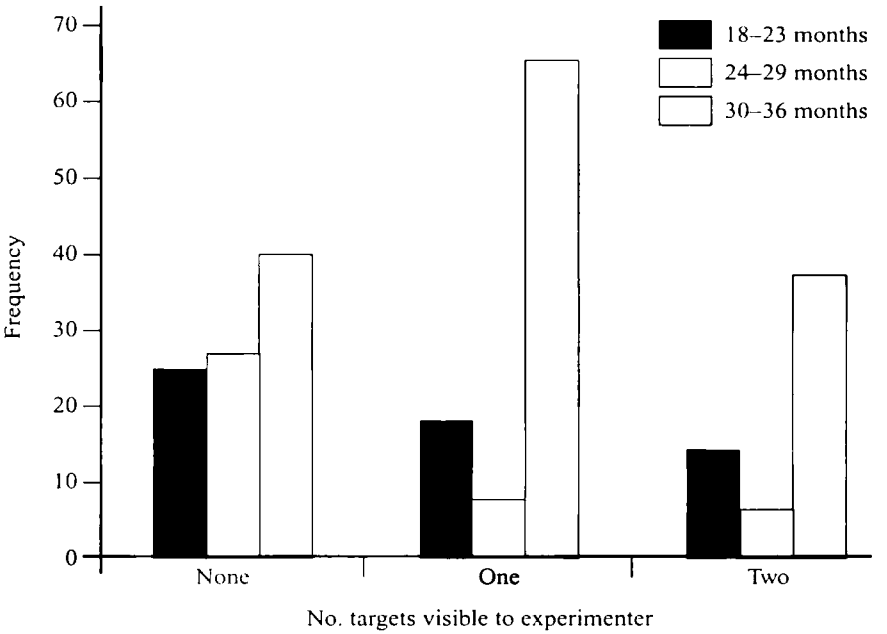

Fig. 7. Frequency of language (number of words) associated with pointing in the three conditions (None, One, Two) at different age levels

But 3 × 3 hierarchical log-linear analyses were conducted on the frequency of isolated language in the three visibility conditions and each age group. A saturated model was used, for which tests of partial association are reported. Predictably, age also affects the production of isolated language (LR $\chi^2(2) = 132.54$, $p \leq 0.0001$). Whereas the pattern for the two younger groups is similar to the above, Fig. 8 shows that the 30- to 36-month-olds have the highest incidence of isolated language specifically in condition None.

TASK 2: VISIBILITY OBSTRUCTED BY SPATIAL OBSTACLE

This task was similar to the first one in that target visibility was obstructed, but there were two differences. First, there were no physical obstacles along the line of sight: visibility was obstructed simply by the specific spatial array (spatial vs. physical obstacle). Secondly, both

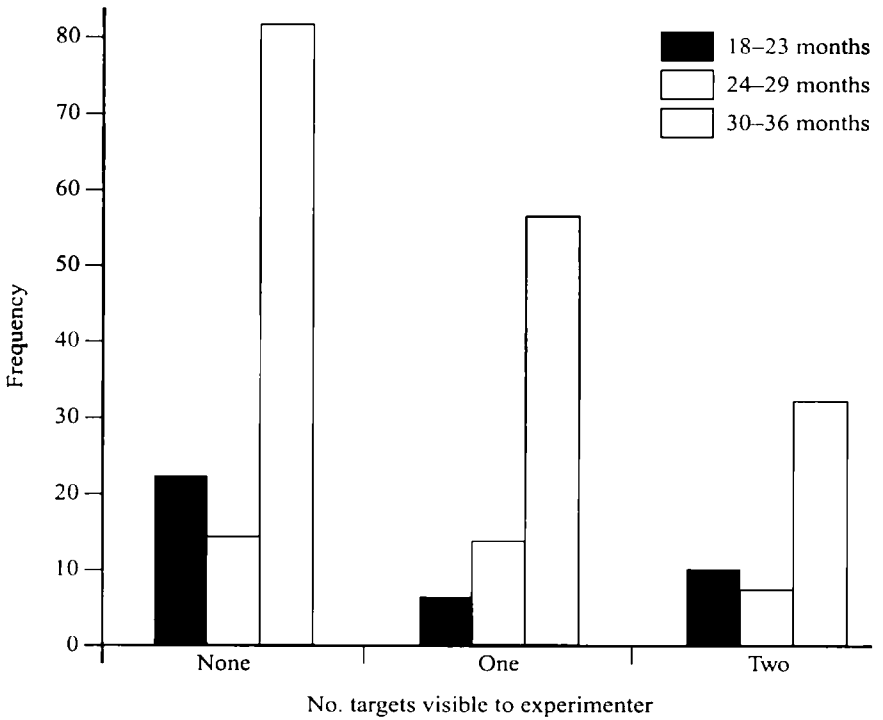

Fig. 8. Frequency of isolated language (number of words) produced in the three conditions (None, One, Two) at different age levels

toddler and social partner did not have direct visual access to one target (equal vs. unequal visibility condition).

The main purpose of this task was to control for specific task effects within an intra-study comparison. As in Task 1, the basic communicative context was a declarative-facilitating one in which joint attention was obstructed. However, the nature of the obstruction was different (Spatial). The predictions were outlined in the Introduction, that is that, similar to the findings in Task 1, there would be heightened levels of toddlers' communicative efforts concerning the object not in the visual field of their social partner. Results similar to those of Task 1 would bring convergent evidence about toddlers' understanding and use of joint attention, whereas discrepancies would highlight specific context effects.

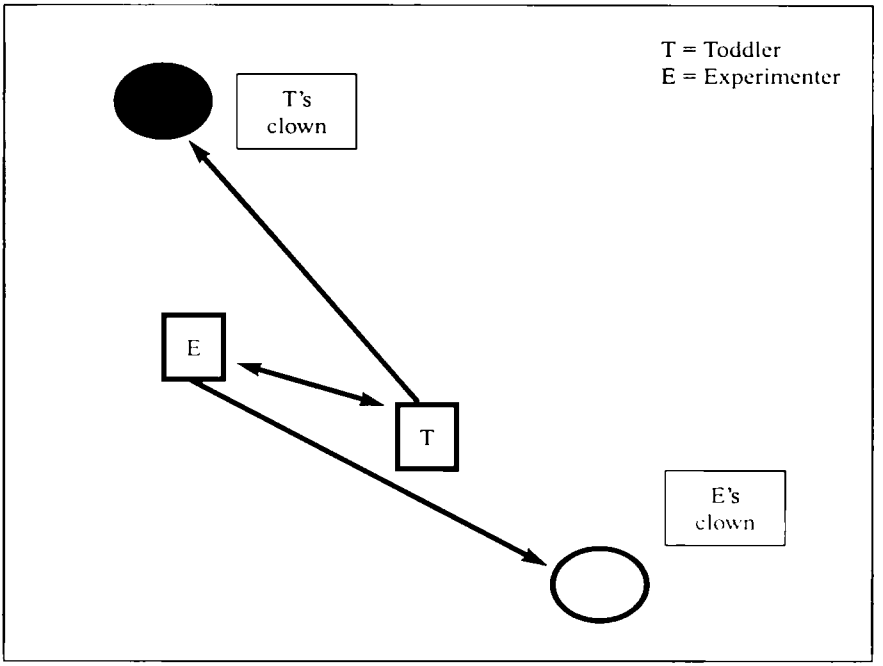

Fig. 9. Layout of Task 2

In Task 2 child and adult were sitting face-to-face. A clown mannequin was positioned behind each interactant. In this way the child and experimenter each had: (a) one target fully visible in front of them (henceforth Toddler's target and Experimenter's target), and (b) one target *not* visible because located behind them (but the target visible to the other interactant). In order to see the latter, a 180° head/torso turn was necessary (see Fig. 9). The two remotely controlled clown mannequins were the same as in Task 1; however, in order to introduce some differentiation between them, one was also wearing a necklace while the other was wearing bracelets. There was a pre-arranged sequence of 3 movement/pause of each clown; the order in which the two clowns alternated their movement phase was randomized across participants, and the overall task duration was approximately 2 minutes.

During the experiment the camera was orientated towards the toddler, so capturing also one side of the Toddler's target, whereas a

mirror was placed behind her/him in order to see the experimenter's facial movements and eye direction. Throughout the session the experimenter was socially responsive to the child and pointed three times to her target. Since the Experimenter's target was placed in front of her, the adult's eye/head direction was not a cue for a child to identify the target non-verbally. Therefore, adult pointing was introduced in Task 2 simply to make sure that all participants had an opportunity to become aware of the Experimenter's target (invisible to them). The timing of the experimenter's pointing was randomized across participants, that is, adult pointing was dissociated from any particular aspect of the event sequence (i.e., whether a clown was moving or not, and whether the current or previous event concerned the Experimenter's or Toddler's target). Participants did follow the adult's point, but no systematic increase (or inhibition) of toddlers' pointing was noticed following an experimenter's point. For data analysis, the same strategy was used as in Task 1.

Results

Pointing A $2 \times 2 \times 3$ hierarchical log-linear analyses was conducted on the frequency of pointing or other gestures directed to the Experimenter's or Toddler's target in each age group (18–23, 24–29, 30–36 months). A saturated model was used, for which tests of partial association are reported. As in Task 1, the great majority of gestures were pointing ($LR\,\chi^2(1) = 78.02$, $p \leq 0.0001$). The frequency of other gestures was very low in this task and is not analysed further.

The frequency of pointing and other gestures varied as a function of the target focused on (Experimenter's or Toddler's). Figure 10 shows that the frequency of pointing to the two targets varies as a function of age ($LR\,\chi^2(2) = p \leq 0.001$). Most pointing is directed to the Toddler's target at 18–23 months but to the Experimenter's target at 24–29 months, while it is equally distributed in the older children.

Visual checking More than 20% of cells in the table target (Experimenter's, Toddler's) × age (18–23, 24–29, 30–36 months) × checking (pointing associated with checking before, during, after, or no checking) presented a frequency count < 5, which violates a basic requirement for log-linear analysis. As in Task 1, statistical analyses were therefore carried out by using a $3 \times 2 \times 3$ mixed design analysis of variance on the proportion of pointing gestures associated with visual checking of the social partner (before, during, after) on the total number of points per subject directed to Experimenter's or Toddler's target in the three age groups, with checking and condition being repeated measure factors.

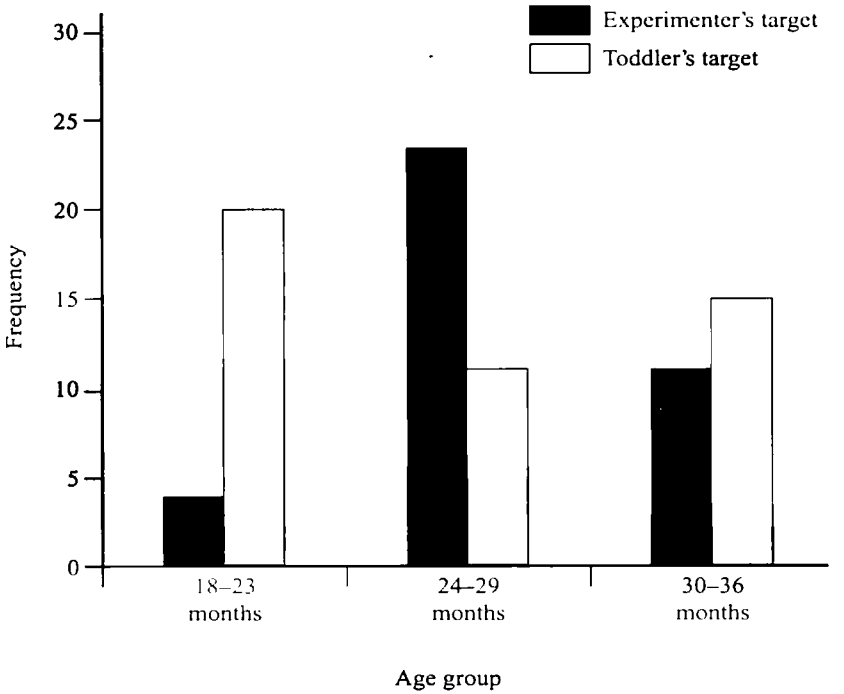

Fig. 10. Frequency of pointing gestures directed to the Experimenter's and Toddler's targets by toddlers of three age groups

The proportion of pointing gestures associated with visual checking of the social partner was higher when pointing was directed to the Toddler's target (i.e., the one that the experimenter could not see). As Fig. 11 shows, this difference is determined by the increase of checking *before* pointing to the Toddler's target ($F(2,58) = 3.18$, $p \leq 0.05$) in all three age groups (respectively, 0.04, 0.05 and 0 to the Experimenter's target, and 0.22, 0.23 and 0.21 to the Toddler's target). Age effects did not reach significance.

Vocalizations and language There was a very low incidence of vocalizations, but most of them accompanied pointing to the Toddler's target (23 isolated vocalizations and 21 vocalizations with pointing, 17

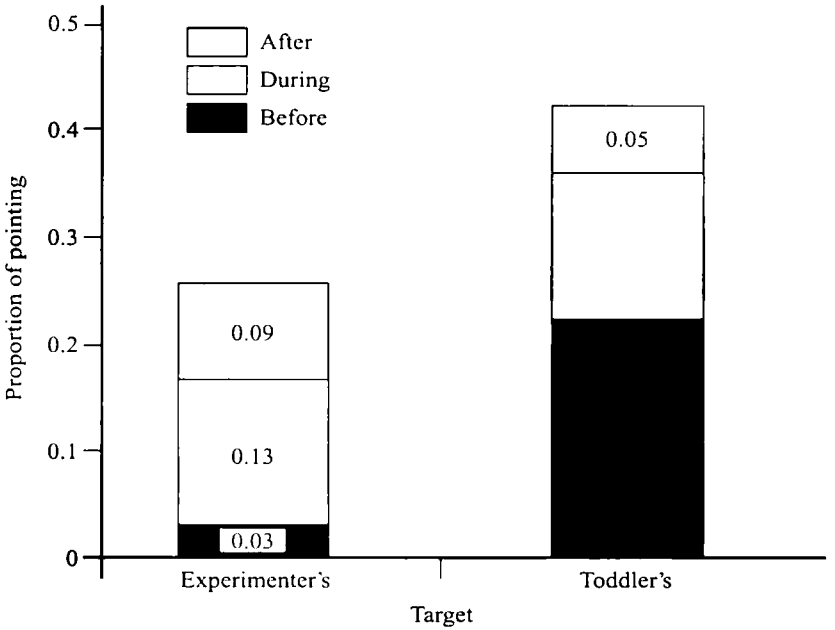

Fig. 11. Proportion of pointing with visual checking before, during or after gesture directed to the Experimenter's or Toddler's targets

of which when pointing was directed to the Toddler's target). A 2 × 3 hierarchical log-linear analyses was conducted on the frequency of words associated with pointing directed to the Experimenter's or Toddler's target in the three age groups. A saturated model was used, for which tests of partial association are reported. The frequency of words associated with pointing increased in the older age group ($LR\chi^2(2) = 59.4$, $p \leq 0.0001$). As can be seen in Fig. 12, more words were used when pointing to the Toddler's target ($LR\chi^2(1) = 4.88$, $p \leq 0.03$).

The frequency of isolated language also significantly increased with age (in the three age groups, 38, 36 and 137, respectively) but it was difficult to establish whether a toddler was referring to the Experimenter's or Toddler's target, and was therefore not analysed further.

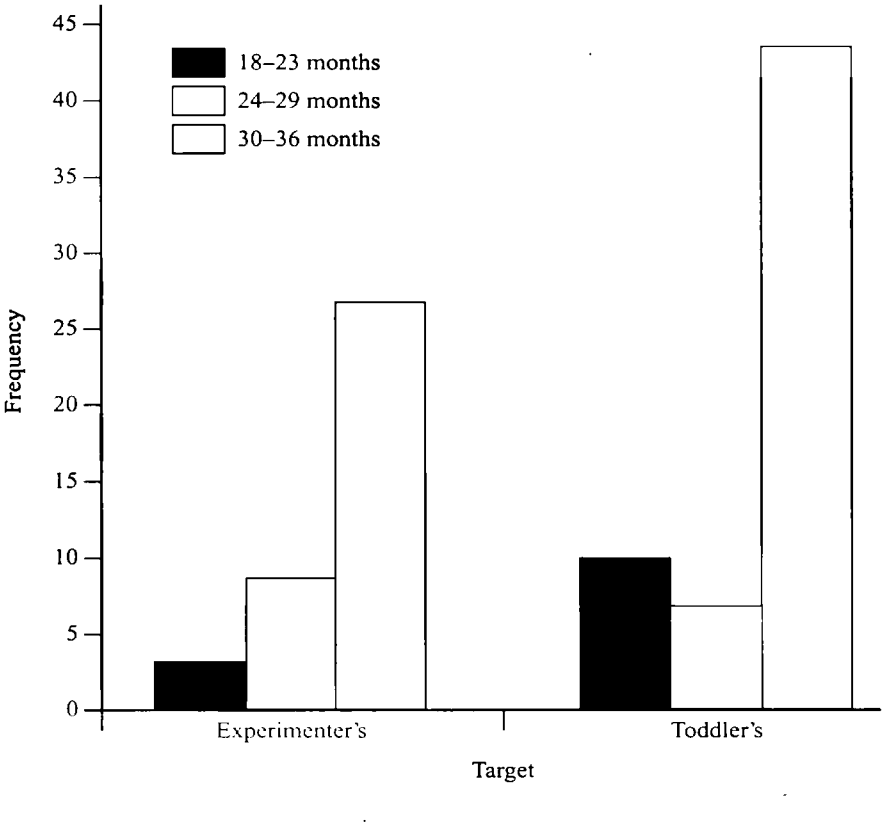

Fig. 12. Frequency of language (number of words) associated with pointing gestures directed to the Experimenter's or Toddler's targets by toddlers of three age groups

COMPARATIVE NOTES BETWEEN THE TWO TASKS

Although the tasks were presented in a fixed order and there were differences in the sitting arrangements between the two tasks, the pattern of results was very similar and coherent with respect to the aims of this study. For example, the overall percentage of pointing gestures which was 'socialized' (i.e., associated with a look to the social partner) is virtually identical: 59.1% in Task 1 and 58.4% in Task 2. General trends linked to age also manifest themselves equally in the two tasks. For instance, the overall percentage of 'socialized' pointing

gestures was lower in the older group: 68.5% at 18–23 months, 59.6% at 24–29 months and 49.2% at 30–36 months in Task 1, and 60.9%, 60% and 53.8, respectively, in Task 2. The increased frequency of language with age is also stable across tasks.

GENERAL DISCUSSION

The results of this study show specific modifications in communication when joint attention is obstructed. In particular, even the younger children in this study (18–23 months) appear to take a social partner's line of sight into account when engaging in joint attention. The general pattern of results is consistent across the two different tasks used in this study. However, some age- and task-related differences did emerge and will be discussed here.

In general, the modifications observed in children's gestural, vocal and gaze behaviour when the social partner cannot see the toddler's target all point to the production of extra communicative efforts. As the social partner remained socially responsive throughout the experiment, the children's behaviours cannot be explained by the desire to re-establish 'normal' interaction or to gain access to social 'rewards'. Rather, we propose an interpretation in terms of the children's desire to base communication on shared reference and their ability to engage in actual informational exchanges.

It must be stressed that the communication context in this study was modelled on the 'referential-declarative' context used by Franco & Butterworth (1996), which was shown to promote declarative rather than instrumental communication. When children communicate about the target which is not visible to their social partner, not only do they produce a declarative communicative act (e.g., a comment), but they also actively engage in the pragmatic 'informational' function. As Halliday (1975) emphasized, this function is characterized by both the declarative aspect and the fact that what is exchanged is *new information*, that is information known to the speaker but not known to the addressee. It is interesting to note how, in a pre-joint attention research era, Halliday had observed that instances of 'informational' communicative acts begin to emerge only late in the second year of life. What the present study shows is that, in the age range 18–36 months, the way in which such 'informational' exchange is realized does change, with a switch from mostly non-verbal to verbal communication acts.

The consistency between the two tasks in the general pattern of results brings converging support to the hypotheses. With respect to our predictions, the possibility of toddlers not showing different

communicative patterns in conditions with varying visibility levels is not supported, as significant differences emerged in all dependent measures. The prediction of finding, when the addressee cannot see the referent, more pointing and checking in the younger toddlers but less pointing and more language in the older toddlers, is only partly supported by the results. In fact, the older toddlers do speak more, but also continue to use more pointing towards the 'invisible' object, which corresponds with what we had anticipated as a transition stage between mostly non-verbal to verbal communicators. It is as if pointing, in its being a literal directive for shared attention, were reiterated because its goal (to make the addressee aware of something visually inaccessible to her) is not achieved. Our results are compatible with three possible explanations: (a) the older toddlers in this study having developed their language to a lesser extent than expected; or (b) being negatively affected in their verbal performance by the particular testing situation, or (c) pointing continues to be an important support to communication even when language is available. Further studies may systematically vary the social partner's type of response (uniformly socially responsive here) in order to find out what would affect initiating joint attention in similar contexts.

If we consider pointing gestures, when the social partner cannot see the toddler's target/s, in all age groups the frequency of pointing is significantly *increased* (e.g. None condition in Task 1 and Toddler's target in Task 2). The fact that children are aware of what the social partner can/cannot see, and specifically try to draw her attention to the target/s invisible to her, is revealed by the results of condition One. Here the experimenter can see only one of the toddler's targets. In this conflict condition, not only is there an increase of pointing with respect to full visibility (condition Two), but also 70% of pointing gestures are addressed to the object which is invisible to the social partner. This means that, in spite of being able to share attention about a visible object, toddlers chose to dedicate 70% of their points to try and signal something about the object invisible to the addressee.

Specific efforts to establish joint attention are also revealed by the pattern of visual checking associated with pointing. The proportion of pointing accompanied by one or several look/s (simple or multiple checking) to the social partner is significantly higher in both tasks when joint attention is obstructed. This means that when the experimenter cannot see the child's target/s, toddlers turn to look at her significantly more often while pointing. In particular, we observe a sharp increase of *anticipatory* checking, that is, looks directed towards the experimenter immediately before pointing (at all ages higher in None/One and

Toddler's). Such anticipatory looks have been interpreted by Franco & Butterworth (1996) as indicating awareness that mutual attention is prerequisite for referential joint attention (see also Desrochers *et al.* 1995). In the present study, it appears that toddlers make this link explicit when the communication context is more demanding for achieving shared reference. Some qualitative observations support this view, as several children not only turned to look towards the experimenter (trying to 'catch her eye') before pointing, but also simultaneously touched her arm or stretched their arm towards her (as if to invite her to follow).

Visual checking shows some age-related development in both tasks. In Task 1 (Distal), a significantly higher proportion of pointing is associated with visual checking when the experimenter cannot see the objects (conditions None and One) only in the two older age groups (i.e., from 24 months). Similarly, anticipatory checking (i.e., immediately before) associated with pointing is highest in condition None from 24 months. In Task 2 (Spatial), more anticipatory checking is associated with pointing to the Toddler's target (the one not visible to the experimenter) in all age groups. Yet it is only in the oldest group that we also find a general increase in the proportion of pointing to this target accompanied by visual checking.

Interestingly, the overall percentage of 'socialized' pointing gestures (i.e., point + look) decreases with age in both tasks (see Comparative notes) and is lower than that observed in younger infants by Franco & Butterworth (1996). One can speculate that during the third year of life, probably in relationship with the development of language, these different behaviours (e.g., gestures, gaze, and their combination) acquire a more specific function in communication. For instance, in older toddlers high levels of visual checking are dedicated to communication in more taxing or ambiguous contexts (where gaze has a specific, strategic function). In more simple communication contexts, when joint attention to a referent could only be sought preverbally by first sharing attention with the social partner (anticipatory checking), once language begins to develop we can rely on a word ('look!') or name ('mum!' 'Ann!') to call someone's attention to ourselves, so that we can then direct it to our intended referent (e.g., by pointing).

Finally, vocal behaviours also indicate the presence of extra communicative efforts when joint attention is obstructed. In both tasks, the incidence of vocalizations and words accompanying pointing, as well as that of isolated language (i.e., language not associated with gestures), significantly increases when communicating about the target/s not visible to the social partner. Predictably, the incidence of

language was significantly higher in the oldest age group in general. However, some interesting developments in both tasks appear more specifically linked to the problem investigated here. For instance, in Task 1 (Distal) the children aged 30–36 months produced significantly more words associated with pointing in condition One (only one target visible to the experimenter) but more isolated language in condition None (when no targets were visually shareable with the social partner).

In sum, with respect to the relationship between joint attention and the transition from non-verbal to verbal communication, two results appear relevant. When the social partner can see only One of the two targets, the older children (30–36 months) both show the highest incidence of pointing and also produce nearly twice as many words accompanying pointing as in the other conditions. However, when the social partner can see None of the targets, they have the highest incidence of isolated language (and twice as many isolated words as words with pointing). Thus, pointing is still used when attempting to disambiguate a referent between two, while verbal communication begins to become predominant when visual attention to the referent cannot be shared. In this latter context, reference cannot be shared visually – hence the information has to be passed verbally.

Finally, the results also contribute to understanding the implications of similar but different joint attention tasks. In this study, involving two tasks differentiated only by the particular way in which one or more objects were not visible, the pattern of results was very similar.

To conclude, this study supports the view that toddlers' and young children's use of pointing involves an understanding of the relationship between seeing and knowing or feeling. This type of understanding is likely to be both the basis for the development of social cognition (including a 'theory of mind') and the most powerful mechanism in early language development. Further studies should extend this methodology to younger age groups.

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