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Testing joint attention, imitation, and play as infancy precursors to language and theory of mind

Tony Charman[a,*], Simon Baron-Cohen[b], John Swettenham[c], Gillian Baird[d], Antony Cox[d], Auriol Drew[d]

[a]*Behavioural Sciences Unit, Institute of Child Health, University College London, 30 Guilford Street, London WC1N 1EH, UK*
[b]*Departments of Experimental Psychology and Psychiatry, University of Cambridge, Cambridge, UK*
[c]*Department of Human Communication Science, University College London, London, UK*
[d]*Bloomfield Clinic and Newcomen Centre, Guy's, St. Thomas' and Kings College Medical School, London, UK*

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Abstract

Various theoretical accounts propose that an important developmental relation exists between joint attention, play, and imitation abilities, and later theory of mind ability. However, very little direct empirical evidence supports these claims for putative "precursor" theory of mind status. A small sample ($N = 13$) of infants, for whom measures of play, joint attention, and imitation had been collected at 20 months of age, was followed-up longitudinally at 44 months and a battery of theory of mind measures was conducted. Language and IQ were measured at both timepoints. Imitation ability at 20 months was longitudinally associated with expressive, but not receptive, language ability at 44 months. In contrast, only the joint attention behaviours of gaze switches between an adult and an active toy and looking to an adult during an ambiguous goal detection task at 20 months were longitudinally associated with theory of mind ability at 44 months. It is argued that joint attention, play, and imitation, and language and theory of mind, might form part of a shared social–communicative representational system in infancy that

* Corresponding author. Tel.: +44-20-7905-2163; fax: +44-20-7831-7050.
E-mail address: t.charman@ich.ucl.ac.uk (T. Charman).

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becomes increasingly specialised and differentiated as development progresses.

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1. Introduction

Social–communicative behaviours that emerge during infancy, including joint attention behaviours, play, and imitation, are concurrently and longitudinally associated with language ability (Baldwin & Moses, 1996; Tomasello, 1995; Travis & Sigman, in press). Less evidence is available to support the view that these infant social–communicative abilities are related to later theory of mind ability. Despite this lack of empirical evidence, various theoretical accounts propose that an important developmental relation exists between these infant abilities and theory of mind ability.

1.1. Theoretical account of theory of mind precursors

Tomasello (1995) proposed that the emergence of *joint attention* skills in the second year of life is evidence for the infant's emerging understanding of others as intentional agents and that this social cognitive ability is the bedrock of a later theory of mind ability (see also Camaioni, 1992). This built on the earlier argument by Baron-Cohen (1989, 1993, 1995) that understanding the mental state of attention in episodes of shared attention may be a critical precursor to understanding mental states.

In contrast, Rogers and Pennington (1991) have suggested that *imitation*, emotion sharing, and theory of mind are increasingly complex expressions of the ability to form and co-ordinate representations of self and others (see also Meltzoff & Gopnik, 1993).

Lastly, Leslie (1987, 1994) proposed that *pretend play* is an early manifestation of the child's capacity for meta-representation, directly linking the cognitive capacities involved in pretending (the ability to represent and manipulate one's own attitudes to information) to the later development of a theory of mind.

None of these three accounts suggests that imitation, joint attention, or pretend play in the second year of life is a sign that the infant possesses a complete theory of mind, in the way that the 4-year-old pre-schooler does (Wimmer & Perner, 1983). After all, 18-month-olds are unable to pass the false belief task. Rather, what is being suggested is that these infant abilities are developmental "precursors" to a theory of mind (Angold & Hay, 1993; Baron-Cohen, 1989; Gomez, Sarria, & Tamarit, 1993; Sigman & Mundy, 1993). That is, the infant ability grows into a theory of mind ability through either innate or experiential factors (Baron-Cohen & Swettenham, 1996).

1.2. Empirical evidence to support the precursor status claims

Surprisingly, little *direct* empirical evidence supports the claims that joint attention, imitation, or play is a precursor to a theory of mind. Two main sources of *indirect* evidence have been used to support the theoretical positions set out above.

First, it has been demonstrated that imitation, joint attention, and play show longitudinal associations with language development. Several studies have demonstrated longitudinal associations between joint attention abilities (including protodeclarative pointing, following gaze, and following pointing) and later language ability in the second year of life (Carpenter, Nagell, & Tomasello, 1998; Mundy & Gomes, 1996; Tomasello & Farrar, 1986). Ungerer and Sigman (1984) found that functional play at 13 months was associated with language ability 9 months later (see also Bates, Thal, Whitesell, Fenson, & Oakes, 1989; Lowe & Costello 1976; McCune, 1995; Watson O'Reilly, Painter, & Bornstein, 1997). Carpenter et al. (1998) demonstrated that the age of emergence of imitation of instrumental gestures was moderately associated with the age of emergence of referential language. There is also evidence that language development is related to theory of mind ability both concurrently (Charman & Schmueli-Goetz, 1998; Hughes & Dunn, 1998; Jenkins & Astington, 1996) and longitudinally (Astington & Jenkins, 1996). While these findings are not direct evidence that imitation, joint attention, and play are precursors of theory of mind, they are at least consistent with such proposals.

A second source of indirect evidence for an association between the proposed precursors and theory of mind is that individuals with autism are impaired in their development of theory of mind ability (Baron-Cohen, Leslie, & Frith, 1985; see Baron-Cohen, Tager-Flusberg, & Cohen, 2000; Yirmiya, Erel, Shaked, & Solomonica-Levi, 1998 for reviews) *and* in all three putative precursor abilities. Many studies have demonstrated impaired imitation (Rogers, Benneto, McEvoy, & Pennington, 1996; Smith & Bryson, 1994), joint attention (Baron-Cohen, 1989; Mundy, Sigman, & Kasari, 1994; Mundy, Sigman, Ungerer, & Sherman, 1986), and play (Baron-Cohen, 1987; Lewis & Boucher, 1988; Ungerer & Sigman, 1984) in individuals with autism. They are also impaired in the pragmatic aspects of language and most have a general language delay (Tager-Flusberg, 1993). Further, theory of mind ability in individuals with autism is related to language ability (Buitelaar, van der Wees, swaab-Barneveld, & van der Gaag, 1999; Happé, 1995). Once again, these data are consistent with the notion that there is a developmental relation between the putative precursors and later theory of mind, but they provide only indirect evidence. The one notable exception is the work of Dunn (1996) and her colleagues who have demonstrated longitudinal (Youngblade & Dunn, 1995) as well as concurrent associations (Hughes & Dunn, 1997) between pretend play with peers and performance on false belief tasks.

As part of a study to identify children with autism prospectively at 18 months of age (Baird et al., 2000; Baron-Cohen et al., 1996), we assessed a small comparison group of typically developing infants on experimental tasks of joint attention, imitation, and play at 20 months (Charman et al., 1997, 1998; Swettenham et al., 1998). The clinical cases were seen again at approximately age 3 1/2, an age at which it is established that a diagnosis of autism can be reliably made (see Cox et al., 1999 for details). Thirteen of the typically developing children were also seen again at this age and theory of mind was assessed in this sample. This afforded us an opportunity to examine cross-sectional and longitudinal associations between the putative precursor abilities in infancy and language and theory of mind in the pre-school years in this small sample of typically developing children. Although data on the experimental measures taken at 20 months are reported elsewhere (Charman et al., 1997, 1998; Swettenham et al., 1998), the present paper is the first to report longitudinal experimental data on the sample. Additionally, while the focus of previous publications from the study has been on children with autism, the present study focuses on the social cognitive development of the small group of typically developing children seen in infancy and the pre-school years.

Previous empirical findings led us to expect longitudinal associations between joint attention and play and later language ability (Mundy & Gomes, 1996; Tomasello & Farrar, 1986; Ungerer & Sigman, 1984; Watson O'Reilly et al., 1997). Although there is good evidence that vocal and gestural imitation is longitudinally associated with language development (Masur & Rodemaker, 1999), we know of only one previous study that has demonstrated a longitudinal association between imitation of actions on objects and age of emergence of referential language (Carpenter et al., 1998). Even then, this was only for imitation of arbitrary gestures, but not imitation of instrumental actions. Therefore, we were more tentative in predicting a longitudinal association between the instrumental imitation measure employed in the present study and later language. Although a single previous study has demonstrated a longitudinal association between pretend play and theory of mind (Youngblade & Dunn, 1995), the longitudinal associations between joint attention and imitation and later theory of mind have not been directly tested previously. We made no a priori predictions about the likely associations, considering the present investigation a preliminary study only.

2. Methods

2.1. Participants

The children described in the present paper formed a comparison group of typically developing children who participated in a study examining social cognitive abilities in a prospectively identified sample of children with autism

Table 1
Age, non-verbal mental age, and language scores of participants

	Time 1			Time 2		
	$N=13$			$N=13$		
Timepoint	Mean	(S.D.)	[Range]	Mean	(S.D.)	[Range]
Age in months	20.1	(0.9)	[18.3–21.3]	44.3	(2.5)	[41.0–49.0]
IQ	103.7	(9.7)	[86.0–120.0]	102.2	(4.6)	[93.0–110.0]
EL[a] (months)	18.9	(3.2)	[14–23]	44.4	(12.7)	[27–80]
RL[b] (months)	20.8	(4.6)	[14–30]	47.0	(10.4)	[36–70]

[a] EL = expressive language.
[b] RL = receptive language.

seen at age 20 and 44 months (see Baird et al., 2000; Baron-Cohen et al., 1996 for details). As part of the project, they had a full clinical assessment and none met criterion for any developmental disorder or disability. The participant characteristics are shown in Table 1. At both timepoints, non-verbal ability was measured using the D and E scales of the Griffiths Scale of Infant Development (Griffiths, 1986) and a non-verbal IQ calculated by dividing the age equivalent score by the child's chronological age (MA/CA). Receptive and expressive language age was assessed using the Reynell Developmental Language Scales (Reynell, 1985).

2.2. Precursor measures at 20 months

Full details of the experimental measures taken at age 20 months are given in Charman et al. (1997, 1998). For the present analyses, only the key variables entered into the current analyses are described.

2.2.1. Spontaneous play task

When the child entered the room, the following sets of toys were available (all at once), spread out on the floor: a toy teaset; a toy kitchen stove with miniature pots and pans, spoon, pieces of green sponge; and junk accessories (e.g., brick, straw, rawplug, cottonwool, cube, box) and conventional toy accessories (toy animals, cars etc.). This combination of objects was based on the earlier studies by Baron-Cohen (1987) and Lewis and Boucher (1988). The child's parents and the experimenters remained seated, and offered only minimal and non-specific responses to child-initiated approaches. Each child was filmed for 5 min. The presence of any functional and pretend play acts was recorded as a dichotomous variable (present/absent).

2.2.2. Joint attention task I — the active toy task

A series of three active toy tasks based on those described by Butterworth and Adamson-Macedo (1987) was conducted. The child stood or sat between their mother and the experimenter. A series of mechanical toys, designed to provoke an ambiguous response — i.e., to provoke a mixture of attraction and uncertainty in the child — was placed one at a time on the floor of the room 1–2 m from the child. The toys were a robot, which flashed and beeped and moved around in circular sweeps; a car that followed a circular path around the room; and a pig that made "oinking" noises and shunted backwards and forwards. The toys were controlled by the experimenter. They were active for a period of 1 min, during which time they stopped and restarted twice. The proportion of trials on which the infant produced the key joint attention behaviour — a gaze switch between the toy and adult (experimenter or parent) — was recorded.

2.2.3. Joint attention task II — goal detection tasks

A series of tasks described by Phillips, Baron-Cohen, and Rutter (1992) was conducted at different times throughout the testing session: *(1) The blocking task.* When the child was manually and visually engaged with a toy, the experimenter covered the child's hands with his own, preventing the child from further activity, and held the block for 5 s. This was repeated four times during the session. *(2) The teasing task.* The experimenter offered the child a toy. When the child looked at the toy and began to reach out for it, the experimenter withdrew the toy and held it out of reach for 5 s. The experimenter then gave the toy to the child. This was repeated four times during the session. The key behaviour recorded on each trial was whether the child looked up towards the experimenter's eyes during the 5-s period immediately after the block or the tease. This task has been variously interpreted as measuring either a goal detection task on the part of the infant ("What are you doing?"; Phillips et al., 1992) or as an imperative gesture ("Give me that back!"; Charman, 1998). The proportion of trials on which the infant looked towards the adult was recorded.

2.2.4. Imitation task

The materials and method for the instrumental imitation task followed those employed by Meltzoff (1988). The child sat opposite the experimenter. Four actions were modelled, all on objects designed to be unfamiliar to the child. Each act was performed three times. At the end of the modelling period (about 2 min in all), the objects were placed, in turn, in front of the child. One non-specific prompt ("What can you do with this?") was given if the child failed to pick up or manipulate the object at once. The response period was 20 s for each object. The proportion of trials on which the infant imitated the modelled action on the objects was recorded. Due to time constraints, one child did not attempt the imitation task.

2.3. Theory of mind measures at 44 months

The initial intention had been to conduct a series of theory of mind tasks, including a standard deceptive box false belief task (Perner, Leekam, & Wimmer, 1987). However, only one of the first seven subjects correctly answered both the "own" and "other" false belief questions. Therefore, the task was considered too difficult for the 44-month-old children and so was discontinued.

Three other theory of mind tasks were conducted.

2.3.1. Level 1 — visual perspective-taking task

The child was shown a card that had a picture of familiar objects, one on each side (three trials: dog/cat, house/flower, cup/ball). They were asked to name the object on each side, which all children were able to do. It was demonstrated that different pictures were on each side of the card. The experimenter then said, "You can see the *dog* and I can see the ___?" By pointing to each side of the card, the child was cued to respond (Flavell, Everett, Croft, & Flavell, 1981).

2.3.2. "Seeing-leads-to-knowing" task

The child was introduced to two doll protagonists (John, Mary) and taught their names. In order to establish that the child knew the name of each protagonist, a red counter was placed in front of John and a blue counter in front of Mary ("Let's give John a red counter and let's give Mary a blue counter") and the child was asked, "Who has the red counter, Mary or John?", and then "Who has the blue counter, John or Mary?" All children correctly identified which protagonist had each counter. The test task involves each protagonist having a box with something inside. On each of three trials, one protagonist opens their box and looks inside and the other picks the box up (with accompanying verbal script, appropriately counterbalanced). The child is then asked "Who knows what is inside the box, John or Mary?" (Pratt & Bryant, 1990).

2.3.3. Situation and desire-based emotion task

On each of six trials, the child was shown two pictures. The first depicted the protagonist with a thought bubble that depicted an object they wanted to eat, a toy they wanted to play with, etc. The second showed the protagonist with either the desired object or another object. Two trials involved simple situation-based emotions (being at a birthday party, falling and hurting your knee), two involved fulfilled desire-based emotion (wanting a banana and getting a banana), and two involved unfulfilled desire-based emotion (wanting a train and getting a jigsaw). The child was told what the protagonist wanted (in the first picture) and what he was given (in the second picture). The protagonist's face in the second picture was left blank, and the child was asked, "Steven wanted a banana and Steven has got a banana. How does Steven feel, does he feel happy or sad?" (Hadwin, Baron-Cohen, Howlin, & Hill, 1996).

Due to time constraints and participant refusal, some participants did not attempt all three theory of mind tasks (two cases missing seeing-leads-to-knowing task, two cases missing situation and desire-based emotion task). Inspection of the associations between the three tasks revealed moderate, although non-significant, correlations (Level 1 — situation and desire-based emotion: Spearman's ρ=.56; level 1 — seeing-leads-to-knowing: ρ=.46; situation and desire-based emotion — seeing-leads-to-knowing: ρ=.21). In order to include all cases and for reasons of statistical parsimony, a composite theory of mind score was calculated. The percentage of trials attempted that were passed across all three tasks was entered into the analysis.

3. Results

The raw scores of the experimental variables are presented in Table 2. The strategy for analysis was to present zero-order correlations, followed by partial correlations with the appropriate variables partialed out for each analysis. For the zero-order correlations, non-parametric (Spearman's ρ) analyses were conducted in order to take account of the sensitivity that small samples have to outlier effects and the limited scale of some variables (e.g., play). For cross-sectional partial correlations, the effect of IQ was partialed out. For longitudinal partial correlations, the effects of IQ and language at 20 months were partialed out. Given the sample size, we did not conduct any regression analysis.

Table 3 shows full and IQ-partialed correlations between the precursor abilities. In terms of full correlations, functional play and pretend play were correlated although this just missed significance (ρ=.53, P=.06). Blocking and teasing scores were significantly correlated with imitation scores (ρ=.58 and .62, respectively, both $P<.05$). Performance on the blocking and teasing tasks was significantly correlated (ρ=.84, $P<.01$). With the effect of IQ partialed out, the same correlations remained significant: functional play-blocking r=.62, $P<.05$; blocking-imitation r=.67, $P<.05$; and teasing-imitation r=.61, $P<.05$. The blocking and teasing task correlation also remained significant (r=.90, $P<.01$), and gaze switching in the joint attention task was correlated with the teasing task score (r=.60, $P<.05$) and the imitation score (r=.61, $P<.05$).

The measures of functional and pretend play, and the scores on the blocking and teasing tasks were highly inter-correlated. In order to reduce the number of variables entered into the analysis, composite scores for the play (functional

Table 2
Scores for all experimental variables

	N		
Functional play	13	Yes = 12	No = 1
Pretend play	13	Yes = 10	No = 3
		Mean (%)	S.D. (%)
Gaze switches	13	87.2	30.0
Blocking task	13	69.9	34.8
Teasing task	13	57.7	44.9
Imitation task	12	81.1	17.7

Table 3
Zero-order and IQ-partialed correlations between the precursor abilities at 20 months

	Pretend play	Gaze switch	Block	Tease	Imitation
Zero-order correlations (ρ)					
Functional play	.53*	− .16	.49*	.37	.47
Pretend play		− .30	.39	.26	.18
Gaze switch			.19	.48	.24
Block				.84***	.58**
Tease					.62**
IQ-partialed correlations					
Functional play	.52*	.12	.62**	.39	.52
Pretend play		− .23	.45	.29	.19
Gaze switch			.42	.60**	.61**
Block				.90***	.67**
Tease					.61**

* $P<.10$.
** $P<.05$.
*** $P<.01$.

score + pretend score) and the goal detection (teasing score + blocking score) tasks were calculated for entry into subsequent analyses.

Concurrent associations at 20 months between the putative precursor abilities and expressive (EL) and receptive language (RL) ability are shown in Table 4. The composite play measure was associated with EL (ρ =.55, P=.05). No other zero-order correlations were significant. When the effect of IQ was partialed out,

Table 4
Cross-sectional zero-order and IQ-partialed correlations between the precursor abilities and language at 20 months

	EL[a] at 20 months	RL[b] at 20 months
Zero-order correlations (ρ)		
Composite play	.55*	.32
Gaze switch	− .14	− .08
Composite goal detection	− .02	− .40
Imitation	.05	− .21
IQ-partialed correlations		
Composite play	.74**	.43
Gaze switch	− .17	− .47
Composite goal detection	.35	− .33
Imitation	.18	− .15

[a] EL = expressive language.
[b] RL = receptive language.
* $P<.10$.
** $P<.01$.

the association between the composite play score and EL remained significant (r=.74, P<.01).

The longitudinal associations between the precursor abilities at 20 months of age and language ability at 44 months of age are shown in Table 5. In the zero-order correlations, the composite play score and the proportion of trials on which a child produced a gaze switch on the joint attention task were not associated with later language ability. The composite goal detection score was significantly associated with RL (ρ=.57, P<.05) and the correlation with EL approached significance (ρ=.51, P=.07). The proportion of actions imitated was significantly associated with EL (ρ=.75, P<.05) but not RL (ρ=.47, P=.12). With IQ EL and RL at 20 months partialed out for the longitudinal associations with language at 44 months, the association between imitation and EL failed to reach significance (r=.60, P=.09). None of the associations with RL at 44 months was significant.

The longitudinal associations between the precursor abilities at 20 months of age and theory of mind ability at 44 months of age are also shown in Table 5. In the zero-order correlations, the composite play score, the gaze switch score, and the imitation score were not associated with later theory of mind ability. The composite goal detection score was associated with later theory of mind ability (ρ=.69, P<.01). With IQ EL, and RL at 20 months partialed out, only the association between the gaze switch score and the composite theory of mind score was significant (r=.67, P<.05).

Table 5
Longitudinal zero-order and IQ- and language-partialed correlations between the precursor abilities at 20 months and language at 44 months

	EL[a] at 44 months	RL[b] at 44 months	ToM[c] composite
Zero-order correlations (ρ)			
Composite play	.18	.05	− .09
Gaze switch	.20	− .06	.33
Composite goal detection	.51*	.57**	.69**
Imitation	.75**	.47	.49
IQ- and language-partialed correlations[d]			
Composite play	.33	.06	− .31
Gaze switch	.12	− .09	.67**
Composite goal detection	.12	.05	.32
Imitation	.60*	.49	.34

[a] EL = expressive language.
[b] RL = receptive language.
[c] ToM = theory of mind composite.
[d] IQ and EL and RL at 20 months partialed.
* P<.10.
** P<.05.

Table 6
Longitudinal zero-order and IQ-partialed correlations between language at 20 months and language and theory of mind at 44 months

	RL[a] at 20 months	EL[b] at 44 months	RL[a] at 44 months	ToM[c] composite
Zero-order correlations (ρ)				
EL[b] at 20 months	.82***	.22	− .23	− .45
RL[a] at 20 months		.06	− .51*	− .75***
EL[b] at 44 months			.49*	.24
RL[a] at 44 months				.44
IQ-partialed correlations[c]				
EL[b] at 20 months	.68**	− .03	− .17	− .21
RL[a] at 20 months		− .36	− .52 *	− .69**
EL[b] at 44 months			.81***	.40
RL[a] at 44 months				.34

[a] RL = receptive language.
[b] EL = expressive language.
[c] ToM = theory of mind composite.
* $P < .10$.
** $P < .05$.
*** $P < .01$.

The longitudinal associations between language at 20 months and language and theory of mind ability at 44 months of age are shown in Table 6. In the zero-order correlations, EL and RL at 20 months were significantly associated ($\rho = .82$, $P < .01$). EL and RL at 44 months were also correlated although not significantly ($\rho = .49$, $P = .09$). EL at 20 months was not significantly associated with either EL or RL at 44 months. However, RL at 20 months was negatively associated with RL at 44 months, although this missed statistical significance ($\rho = -.51$, $P = .08$). With IQ at 20 months partialed out, EL and RL at 20 months were significantly associated ($r = .68$, $P < .05$) and EL and RL at 44 months were also significantly associated ($r = .81$, $P < .01$). For the longitudinal associations with language at 44 months with IQ at 20 months partialed, RL at 20 months was still negatively associated with RL at 44 months, although again this missed statistical significance ($r = -.52$, $P = .08$).

In the zero-order correlations, RL at 20 months was negatively associated with later theory of mind ability ($\rho = -.75$, $P < .05$), and this negative association remained significant when the effect of IQ at 20 months was partialed out ($r = -.69$, $P < .05$).

4. Discussion

There were several cross-sectional associations between the different precursor abilities at 20 months of age. The findings are consistent with the notion that these infant abilities are manifestations of a unitary social cognitive representational ability to understand and interact with people (joint attention, imitation) and objects (play, imitation) (e.g., Bornstein, Selmi, Haynes, Painter, & Marx, 1999; Bruner, 1975; Carpenter et al., 1998; McCune, 1995; Piaget, 1962). The fact that different abilities showed *specific* longitudinal associations with later language and (separately) theory of mind development suggests that, although they may initially share an underlying representational ability, this diverges and becomes more separate as development occurs in the second and third years of life.

Only the composite play measure was concurrently associated with expressive language at 20 months (in both the full and IQ partialed correlations). This is consistent with previous findings of studies of children in their second year of life (Bates et al., 1989; Ungerer & Sigman, 1984). Contrary to our expectations, the measures of joint attention (gaze switch in the active toy tasks and looking to the adult on the goal detection tasks) were not concurrently associated with language ability. Several previous studies have found associations between joint attention and language abilities (e.g., Carpenter et al., 1998; Mundy & Gomes, 1996; Watson O'Reilly et al., 1997), although negative findings do exist in the literature (Desrochers, Morissette, & Ricard, 1995). Performance on the instrumental imitation task was not concurrently associated with either receptive or expressive language ability. This apparently contrasts with at least one previous study that has reported such an association (Bates et al., 1989). Bates et al. (1989) reported that "imitating gestures with objects" was associated with language comprehension and "imitating gestures with arbitrary objects" was associated with language production in 12- to 16-month-olds. However, the actions modelled by the adult and reproduced by the children in Bates et al.'s study are closer to the definition used to score functional and pretend play in the present study. Under this analysis, the findings of Bates et al. are consistent with the present finding that the composite play measure was associated with expressive language.

Imitation of instrumental actions at 20 months was longitudinally associated with expressive language ability at 44 months, although this fell to a non-significant trend when the effects of initial IQ and language were partialed out. Although there is evidence that vocal and gestural imitations are longitudinally associated with language development (e.g., Masur & Rodemaker, 1999), few studies of imitation of instrumental actions on objects and language development have been conducted. However, the present data are consistent with Carpenter et al.'s (1998) finding that imitation of instrumental actions was associated with the age of onset of referential language around 12 months of age. Nagel, Guérini, Pezé, and River (1999) have suggested that imitation of actions on objects may "set the stage" for referential communication by acting as a bridge between primary and pragmatic communication. The present findings suggest that these effects may carry over into productive language competence, even several years later. However, caution should be adopted in the interpretation of this unexpected finding from this small sample. The relation between infant imitation of instrumental actions and of gestures and later language ability is not well understood and should be the focus of further study.

The composite goal detection score was longitudinally associated with receptive language, although again this was not the case in the partial correlation analysis. This is consistent with a number of studies that have demonstrated longitudinal associations between joint attention abilities including protodeclarative pointing, following gaze, and following pointing, and later language ability in the second (Carpenter et al., 1998; Mundy & Gomes, 1996; Tomasello & Farrar, 1986). However, the lack of a longitudinal association between play and language ability contrasts with Ungerer and Sigman's (1984) findings that functional play acts at 13 months were associated with language ability 9 months later.

In contrast to the findings on language, only joint attention behaviours were longitudinally associated with theory of mind ability at 44 months: the composite goal detection task score in the zero-order correlation analysis and the number of gaze switches between an adult and the active toy in the partial correlation analysis. We did not replicate Youngblade and Dunn's (1995) finding of a longitudinal association between pretend play (with peers) and performance on false belief tasks.

Although EL and RL at 44 months were positively associated with the theory of mind composite score measured at the same age, neither correlation was significant, in contrast to the joint attention measures taken 2 years previously. Early language ability was not positively associated with later theory of mind competence, as has been found for older pre-schoolers (Astington & Jenkins, 1996). Surprisingly, receptive language measured at 20 months was significantly negatively associated with later theory of mind ability, even when the effects of initial IQ were partialed out. This counter-intuitive finding may account for the contrasting pattern of significant findings for the two joint attention tasks in the full and the IQ and initial language partialed correlational analyses. It also may indicate an instrument effect on the language measure used, which is discussed in the limitations below.

Differences in the method adopted to measure infant social cognitive abilities, in the age of participants studied, and in the longitudinal time course followed, caution against simple cross-study comparisons. Many previous studies concentrate on the development of play, gestures, and language ability in the second year of life. It may be that the relatively old age of our children at the second timepoint (44 months) reduced the likelihood of identifying associations between the precursor abilities measured in infancy and language ability in the fourth year of life. Indeed, it has been previously suggested, for example, that while play and language associations may be found in the second year of life, their development might diverge after this period (Bornstein et al., 1999). Thus, longitudinal associations might hold across certain timeframes, only to disappear as subsequent developmental forces come into play.

How do the present findings inform our understanding of the theoretical accounts of the precursor-of-theory-of-mind status of these infant social cognitive abilities? The present findings are consistent with accounts that give joint attention a key role in the development of social–communicative competence and understanding of mental states (Baron-Cohen, 1989, 1991, 1994; Camaioni, 1992; Tomasello, 1995). Why might joint attention abilities be more strongly related to later theory of mind development than play or imitation abilities? Joint attention behaviours, in contrast to play and imitation, have a *directly* social goal — to share one's mental state of perception with others ("look at that!" in the active toy task) and to uncover another's goals as mental states ("what are you doing?" in the blocking and teasing task). While play and imitation of actions on objects *can* involve similar social goals, they are also more tied to the infant's developing understanding of objects than is joint attention.

At least two mechanisms are suggested by the notion of a precursor: either the infant ability (e.g., joint attention) grows or is transformed into theory of mind ability, or because of the experiences gained through the infant behaviour (e.g., jointly attending to events in the world), the child acquires a theory of mind. The present study cannot answer questions regarding the mechanism by which joint attention behaviour at 20 months is related to later theory of mind development since under either account, a longitudinal association would be predicted.

The issue of the mechanism by which precursors affect later emerging abilities is significant, in particular when applied to clinical populations. For example, individuals with autism are severely compromised in their development of theory of mind ability, and this has important consequences for their social and linguistic development (see Baron-Cohen et al., 2000 for a review). If specific aspects of the putative precursors can be shown to relate to later theory of mind and language ability, these could provide target foci for intervention programmes for individuals with autism. There is some consensus that imitation and joint attention are appropriate targets for early intervention in autism (see Charman, 1998; Rogers, 1998). There is a need for further study of the role of the putative precursors of theory of mind in the treatment of individuals with autism.

The present study has a number of notable limitations. One is the relatively limited aspects of play, joint attention, and imitation measured, excluding, for example, the examination of joint pretend play (Youngblade & Dunn, 1995) or imitation of arbitrary gestures (Carpenter et al., 1998). The restricted sample size also increases the risk of type II errors. Some of the variables suffered from ceiling effects (imitation) or were dichotomous rather than interval variables (pretend and functional play). The counter-intuitive finding that initial receptive language scores were negatively correlated with later receptive language scores and with later theory of mind scores also raises questions about the reliability of the language measure at the first timepoint. The Reynell scales suffer from psychometric floor effects when a child's language competence is below 18 months age equivalent and the limitations of a single direct assessment of language competence are well recognised. An alternative strategy in future studies would be to include parental report (e.g., the CDI; Fenson et al., 1993) as well as direct assessment of language competence. The long interval between data collection points means that associations that may have held over one time period may have been missed. The follow-up period was dictated by the need to see the clinical cases (not reported here) at an age at which it is established that a diagnosis of autism can be reliably made (Cox et al., 1999). Future studies could follow children from infancy into the pre-school years across a shorter interval. The valuable contribution made by the multiple, monthly assessments in the Carpenter et al. (1998) longitudinal study highlights the benefits of such an approach. Lastly, although the measures from which the theory of mind composite measure was derived are well established in the literature, the "litmus test" of theory of mind ability is false belief tasks (Perner et al., 1987; Wimmer & Perner, 1983) and these were too difficult for our sample of 44-month-olds.

Despite these limitations, the present findings contribute to our understanding of how developmental relations between initially closely associated social cognitive skills may diverge as development proceeds. Joint attention measured at 20 months was the best longitudinal predictor of theory of mind ability measured in the fourth year of life. This effect was not wholly mediated by language. Indeed, imitation, but not joint attention, at the first timepoint predicted later language ability. The identification of the putative precursors predicting shared and unique variance in later language and theory of mind ability will provide evidence about underlying cognitive mechanisms.

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