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Onset of pointing and the acquisition of language in infancy

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Abstract: Thirteen girls and 14 boys were tested five times from pre-pointing (8 months) to 14 months on the MacArthur Infant Communicative Development Inventory. The age of pointing onset was established to within 2 weeks. Babies were also tested at monthly intervals on a number of tasks designed to study the relation between language acquisition, fine motor skills, handedness and detour problem solving. Acquisition of fine motor control in the pincer grip precedes pointing. Girls pointed slightly before boys and age of pointing onset (*ca* 11.3 months) predicts both the number of gestures produced and the number of sounds comprehended at 14.4 months. Unimanual right-handed problem solving sequences predict MacArthur gestures. Both the relative balance of fine motor activity between the hands, and collaborative bimanual activity with right-hand dominance, predict speech comprehension and speech production at 14.4 months. Detour problem solving does not predict any of the language skills measured by the MacArthur test. These results suggest that onset of pointing may be linked both to gesture and to speech through developmental changes in cerebral dominance. It is possible that there are sex differences in this process.

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Introduction

The aim of this longitudinal study is to investigate the relation between the onset of manual pointing in babies and the origins of language. Manual pointing is defined here as the use of an outstretched arm and index finger to refer to an object in visual space. Although higher primates can be taught to make 'indicative gestures' with the outstretched open hand, only humans redirect the attention of conspecifics with the typical extended posture of index finger and arm (Butterworth, 1991; Povinelli and Davis, 1994). It remains to be established whether index finger pointing is incidental or central to the origins of referential communication in humans.

That pointing is a gesture specialized for social communication has been suggested by Franco and Butterworth (1996), who compared the incidence of pointing and reaching in babies in different communicative contexts. Pointing occurred only under conditions where a social partner was available for communication, even when the partner was another baby, and it was never confused with reaching gestures (Franco *et al.*, 1992). This evidence runs against traditional views of the origins of pointing which stress, either that pointing develops out of prehension (Vygotsky, 1988), or that it is initially performed primarily for the self rather than for purposes of social communication (Werner and Kaplan, 1963).

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The significance of pointing for the acquisition of speech is becoming clearer through studies which suggest that babies depend on the adult's referential acts, including pointing, for the comprehension of language (Baldwin, 1991, 1993). In autism, where deficits in language and symbolic processes are common, there is also evidence for deficits in declarative pointing (Baron-Cohen, 1995). Evidence for an indirect link between pointing and language acquisition has been obtained in a number of longitudinal studies. Communicative pointing at 12 months, before the onset of speech, correlates with the size of the lexicon at 20 months (Bates *et al.*, 1979; Camaioni *et al.*, 1991). A specific link between pointing and speech comprehension has been postulated by Harris *et al.* (1995) who found a highly significant correlation between the first production of manual pointing in six babies (median age 10.7 months) and contextually flexible comprehension of object names. This suggests that receptive comprehension of object names may develop at the same time as the production of pointing gestures and in advance of speech production.

The recent standardization of the MacArthur Infant Communicative Development Inventory provides detailed information on the early development of language between the ages of 8 and 16 months (Fenson *et al.*, 1994). This measure, which is based on parental report, shows a small but significant advantage to girls both in speech production, speech comprehension, and gesture production, although the gender advantage only accounted for between 1.25% and 2.13% of the total variance.

A number of candidate precursor processes exist for language development. Right and left cerebral hemispheres may develop at different rates, and perhaps differently in males and females (Shuchard *et al.*, 1984; Thatcher *et al.*, 1987). The pattern of emergence of handedness between the sexes may, therefore, offer an index of changes in cerebral dominance that could contribute.

Development of the pre-frontal areas of the brain may also assist in the suppression of distraction and in planning elementary instrumental actions, such as might be implicated in intentional communication. Detour tasks are typically used to assess such abilities, although sex differences have not typically been investigated (Moll and Kuypers, 1977; Diamond, 1988).

It is possible that differences between boys and girls in fine motor control may have implications for mastering speech production. As a measure of fine motor control, the emergence of the pincer grip may be related both to speech production and to the onset of pointing. The link with speech production may emerge in gaining fine control over articulatory activity, whereas the link with pointing may arise through the species-typical functions of the index finger, both in prehension and gestural communication (Butterworth and Hopkins, 1993).

Methods

Participants

Twenty-nine babies were recruited from local well-baby clinics and other sources. Two babies were eventually excluded from the study because they failed to complete five visits. The remaining babies, 13 girls and 14 boys, completed between five and seven visits at approximately monthly intervals from 8.5 months (before pointing) to 14.5 months when all save one baby had begun to point. The infants were healthy, full term, and parents were predominantly middle class, as assessed by self-report and according to the father's occupation.

Target variables

The MacArthur Infant Communicative Development Inventory was completed by the parent on the day prior to each visit to the laboratory. The data were combined across subscales into three composite scores: (i) language comprehension (i.e. the number of words understood sometimes or often); (ii) language production (i.e. the number of words produced sometimes or often); and (iii) gesture production (i.e. a composite score of the five gesture production subscales: (a) 'first communicative gesture'; (b) 'games and routines'; (c) 'actions with objects'; (d) 'pretending to be a parent' and (e) 'imitating other people's actions', as in Fenson *et al.*, 1994). The infants' scores on the subscales for 'phrases', 'animal sounds' and 'pretend' subscales were analysed separately.

Predictor variables

Infants visited the laboratory at monthly intervals between the ages of 8.5 and 14.5 months when they participated in a number of tests. The tasks were video recorded for subsequent data reduction. For each of the tasks, scoring was carried out independently by two observers. Inter-observer agreement on response categories varied from 92% to 100%.

Questionnaire for the onset of pointing

Parents were supplied with a brief questionnaire, to establish as precisely as possible the age and context when the baby first produced canonical, arm extended, index finger pointing. The questionnaire differentiated between 'tipping' (i.e. fine exploratory movements of the index finger engaged in tactile inspection) and true pointing. Parents were often able to specify the exact date of first pointing and it was only necessary to make an estimate for three infants. In these three cases the estimated age of pointing onset was accurate to 2 weeks. The questionnaire was supplemented by observations recorded in the laboratory of pointing elicited by a mobile, and automated dolls (the method is as in Franco and Butterworth, 1996). The detailed results of this part of the study will be reported elsewhere, but in general it may be useful to note that, while the opportunity to point was equated across left and right sides, the total number of points obtained over the series of visits was distributed as 2:1 in favour of the right hand (R: 197, L: 101 points).

Tests for development of the pincer grip

Two cubes and two spheres, 0.5 cm and 1 cm edge (or diameter) were used to elicit the pincer grip (i.e. tip to tip abduction of index finger and thumb) and the inferior pincer grip (i.e. tip of thumb to top-most pad of index finger). This classification of pincer grasps is based on Gesell and Halverson (1936) and Touwen (1976).

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The objects were mounted securely on string, and each was presented in random order at the midline once, to give four trials in all. The string was threaded through a hole 16 cm from the inner edge of a semicircular platform 26 cm wide on an infant seat, and it was held secure against the surface for 10 s so it could be safely grasped. This task had been shown reliably to elicit the pincer grip in an earlier study in our laboratory (Verweij, 1988). Other grip types were not classified but the hand used for grasping the objects was noted.

Tests for handedness and other laterality measures

Ramsay (1984) has shown that some tasks elicit unimanual and others bimanually co-ordinated activity from which measures of infant handedness can be obtained. Handedness in infancy may vary from task to task, and it may fluctuate over occasions of testing. Only the main results of the rather complex data obtained will be reported here

Unimanual measures. A basic measure of the handedness of the pincer grip was obtained by noting the hand used to produce the grip during the first 10 s of each trial.

A measure of initial hand preference was derived by noting the hand first used for reaching on each of the four trials, regardless of grip type. A laterality score for reaching (range from +4 to −4) was computed by subtracting the left from right handed reach.

An additional measure of overall laterality was computed by deriving a standard index for any hand contacts made with the object in the 10 s following the first contact. This laterality index was defined as $R - L/\sqrt{(R + L)}$. A standard score of +1.69 indicated predominant right handedness, −1.69 predominant left handedness, and values in between indicate lack of consistent handedness.

Bimanual handedness measure. An attractive small toy was placed in a central partition in a rigid box file (38 × 24 × 7.5 cm) while the baby was watching. The box file was presented with its longest edge toward the baby and the hand used to retrieve the object was recorded. The box had been partitioned so that the toy was near the centre when the lid was open. Infants were free to open the box by collaborative use of two hands, or with a sequence of one-handed movements. A bimanual handedness score was allocated if the object was retrieved with the free hand after the lid was lifted with the other hand, and also if the lid was first lifted with both hands and then one hand was released to secure the object. A unimanual score was allocated if the object was retrieved from the box after a series of one-handed movements (e.g. opening the lid with one hand and putting the same hand into the box).

These scores were also used to establish two additional measures of relative laterality by subtracting left from right handed scores in the unimanual and bimanual categories.

Detour task

The infants were tested on a 'detour task' originally developed by Moll and Kuypers (1977) to assess the role of the frontal lobes in problem-solving in rhesus monkeys.

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The task required the baby to reach through a hole in a vertical transparent perspex screen to obtain an interesting object displaced just to one side of the hole, towards the centre of the screen. The screen measured 49 cm wide × 44 cm high and there were two 10 cm^2 holes cut in the perspex at 4.5 cm from the outer edges. An attractive toy was placed directly behind the left or right hole (easy position) or just beyond the inside edge of the hole (hard position). Attempts by the infant to retrieve the object were scored over four 'easy' trials and four 'hard' trials, to left and right in random order. Here only the handedness of the successful detour solution will be reported.

Results

The data obtained from the 27 infants (13 females, 14 males) were tabulated to yield scores at five age levels, separated by approximately 1 month intervals from: session 1, M = 292 days, SD 23.6 days; session 2, M = 323, days SD = 21.0 days; session 3, M = 357 days, SD=19.33 days; session 4, M = 395 days, SD = 21.0 days; and session 5, M = 432 days, SD = 20.08 days. The ages of boys and girls on the five dates of testing differed by no more than an average of 4.7 days.

The composite scores on word comprehension, word production and gesture production scales of the MacArthur Infant Communicative Development Inventory are summarized in Table 1.

A two-factor analysis of variance was carried out for each of the composite scores with age level as the within-subject factor and gender as the between-subject factor. These analyses showed a significant increment in scores with age for the three composite scales ($F(4, 100) = 40.76$, $p < 0.001$, $F(4, 100) = 16.57$, $p < 0.001$ and $F(4, 100)=117.5$, $p < 001$). Relatively little evidence was obtained for sex differences, perhaps because the sample was small. On average, boys scored higher than girls on word comprehension, but the gender effect was not significant. Girls scored

Table 1. MacArthur Infant Communicative Inventory scores

Test session	1		2		3		4		5	
M (days)	292		323		357		395		432	
Word comprehension										
M (SD)	16.0	(25.4)	36.1	(42.5)	63.2	(63.8)	82.6	(68.1)	116.0***	(72.6)
Girls *M* (SD)	10.4	(12.4)	25.2	(19.8)	45.6	(37.2)	65.5	(53.1)	104.8	(62.5)
Boys *M* (SD)	21.2	(33.0)	46.2	(54.9)	79.5	(79.3)	98.5	(78.0)	126.4	(81.8)
Word production										
M (SD)	1.07	(2.85)	1.92	(4.34)	2.85	(5.50)	5.40	(7.24)	10.14***	(12.24)
Girls *M* ($p < 0.08$) (SD)	1.85	(3.93)	3.46	(5.90)	4.85	(7.38)	8.07	(9.25)	13.23	(12.74)
Boys *M* (SD)	0.36	(0.93)	0.50	(1.02)	1.00	(1.57)	2.93	(3.50)	7.29	(11.47)
Gender $p < 0.08$										
Gesture										
M (SD)	7.85	(7.67)	14.2	(6.60)	21.4	(8.19)	27.4	(9.68)	34.4***	(8.55)
Girls *M* (SD)	8.3	(6.68)	13.6	(6.90)	18.6	(7.58)	27.6	(10.4)	36.3	(9.87)
Boys *M* (SD)	7.4	(8.71)	14.7	(6.53)	23.9	(8.18)	27.3	(9.68)	32.6	(8.55)
gender × age*										

***$p < 0.001$, *$p < 0.05$.

higher than boys on word production as the MacArthur norms predict, but this difference was not quite significant ($F(1, 25) = 3.29$, $p < 0.08$). Boys made more gestures than girls (again as the MacArthur norms show for boys aged 8–14 months), and the interaction of gender × age level was significant, ($F(4, 100) = 2.81$, $p < 0.03$).

Similar mixed design analyses of variance were carried out for three of the remaining MacArthur subscales: phrases comprehended, animal sounds comprehended, and animal sounds produced. There was a significant increase in scores with age level ($F(4, 100) = 109.1$, $p < 0.001$, $F(4, 100) = 32.09$, $p < 0.001$ ($F(4, 100) = 14.64$, $p < 0.001$ respectively), but no significant effect of gender, or interaction of gender × age level. Since only 6/27 babies scored at all on the pretend scale, these data were omitted from further analysis.

Relation between language tests and predictor variables

Table 2 summarizes the correlations between the predictor variables and scores on the MacArthur test.

Table 2. Correlations between MacArthur Infant Communicative Inventory scores and predictor variables

Predictor	Word comprehension	Word production	Gesture	Animal sound comprehension
Pointing age	ns	ns	r –0.56***	r –0.60***
Pincer grip	ns	ns	ns	ns
Laterality[a]	r 0.42*	r 0.39	ns	
Bimanual R[b]	ns	r 0.44*	ns	
Unimanual R	ns	ns	0.64**	
Detour	ns	ns	ns	

*p < 0.05; **p < 0.01; ***p < 0.001; [a]pincer task; [b]box task.

Pointing onset

On average babies pointed at $M = 339.5$ days, SD = 46.5days. Girls pointed 22 days before the boys but this difference was not statistically significant (girls $M = 327.6$ days, SD = 39.23 days boys $M = 350.5$ days, SD = 53.0 days. $F(1, 25)$ 1.81, ns). Age of onset of pointing did not predict MacArthur word comprehension, word production or phrase comprehension. However, age of onset of pointing was significantly correlated with the total gestures produced at 14.4 months (r –0.56, $p < 0.01$), and with the total number of animal sounds comprehended (r –0.60, $p < 0.02$). Thus, pointing onset *ca* 11.3 months is related both to the frequency of gesture, and to auditory-vocal comprehension of animal sounds at 14.4 months.

Pincer grip

The distribution of pincer grips by age and gender is shown in Table 3. There was no significant correlation between the number of right-handed, left-handed, or the total pincer grips, and the MacArthur test scores. That is, the pincer grip as a measure of onset of fine motor control did not predict MacArthur speech production or the other language measures.

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Table 3. Average proportion of right-handed pincer grips × session

	1	2	3	4	5
M age (days)	292	323	357	395	432
Females *M* (SD)	0.47 (0.21)	0.55 (0.17)	0.48 (0.24)	0.54 (0.28)	0.55 (0.32)
Males *M* (SD)	0.43 (0.30)	0.50 (0.32)	0.50 (0.23)	0.46 (0.28)	0.40 (0.23)

The pincer grip was invariably in the infant repertoire before pointing onset. There was no evidence that the pincer grip develops earlier on one side than the other (21/27 infants showed both L- and R-handed pincer grips in the session that the grip was first observed). Table 3 shows the average number of pincer grips by test sessions. There were no overall sex differences in the incidence of the pincer grip, and only slight evidence for a sex difference in onset. Although a similar number of male and female babies had the pincer grip in their repertoire by 9.7 months (9/13 girls and 10/14 boys), the girls made significantly more left-handed pincer grips than boys at this age (girls, $M = 3.8$, SD 4.18; boys, $M = 1.5$, SD 1.8, $t\,(25) = 1.91$, $p < 0.03$ one-tailed).

Unimanual handedness

In the pincer grip task, the hand first selected to reach for the small sphere and cube at the midline on each of four trials was recorded. There was no population level preference for infants to use the right hand. The total number of left-handed ($M =$ 9.55) or right-handed reaches across all sessions ($M = 9.33$) was similar and did not predict any of the MacArthur scores.

The simple hand preference score at 14.4 months (derived by subtracting first L- from R-handed reach regardless of sign), correlated significantly with total word comprehension and word production (r 0.42, $p < 0.03$, and r 0.29, $p < 0.04$). The absolute difference between first choice of R- or L-handed reach on four trials shows that 23/27 babies had some lateral preference (L = –4 $n = 4$, R = +4 $n = 3$, L = –2 $n = 9$, R = +2 $n = 7$, 0 $n = 4$). Girls made significantly more right-handed reaches than boys at 14.4 months (girls, $M = 2.23$, SD = 1.36; boys, $M = 1.43$, SD = 1.09, $t(25) = 1.70, p < 0.05$ one-tailed). Thus, the relative balance between the unimanual use of left and right hands on this simple task predicts speech comprehension and production, and girls tend to be more likely to prefer the right hand.

The standardized laterality index obtained over the first 10 s of each trial enabled the infants to be classified as showing an overall hand use preference. On this measure four babies showed a consistent left preference by 13.2 months, and so these babies may have been left-handed (two males and two females). The remaining babies were classified as right-handed or unlateralized. Although the scores for left-handed babies may affect measures of laterality, since handedness showed such major fluctuations across the ages and the different tests, the data for potentially left-handed babies were pooled with the remainder of the sample.

Table 4 summarizes the data. It shows that females appear to pass through a U-shaped developmental function. Girls begin by making significantly more right-handed than left-handed contacts with the object in the first two sessions ($t = 2.07$,

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Table 4. Laterality index and object contacts over 10 s in the pincer task

M age (days)	292	323	357	395	432
Females					
M index	1.59	1.06	0.46	1.08	1.39
M R contact	13.48*	11.53*	9.09	10.16	7.65
SD	8.71	4.93	2.92	6.19	5.10
M L contact	6.42	6.96	8.24	8.2	6.16
SD	2.73	2.63	5.32	5.13	4.15
Males					
M index	0.81	0.63	–0.18	–0.75	–0.64
M R contact	15.02	13.26	9.07	6..94	6.38
SD	6.12	5.68	4.06	4.68	4.82
M L contact	11.35	10.51	10.39	10.02	8.72
SD	8.42	6.97	6.4	4.99	4.29

*$p < 0.05$. Difference between left- and right-handed contacts with small objects presented at midline over first 10 s of four trials.
Laterality index: +1.6 = Predominately right-handed; –1.6 = Predominately left-handed.

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$p < 0.05$, $t(25) = 2.16$, $p < 0.05$), followed by the lowest proportion of lateralized responses at 12 months, and then a renewed tendency to right lateralized responding. Boys showed no consistent lateralization over the period of the tests, and no significant difference in the number of left- or right-handed contacts with the objects.

A subset of data from the same task comprised the scores for the pincer grip. An absolute laterality score was derived by subtracting the total left-handed from total right-handed pincer grips over all five sessions. The value ranged across infants from –28 (i.e. strong left preference) to +10 (i.e. strong right preference), with an average of –1.74 (i.e. slight left preference overall). The absolute value, regardless of sign, correlated not quite significantly with age of pointing onset, which imples that pointing onset may also be related to the bilateral control of fine motor movements (r 0.35, $p = 0.07$).

The MacArthur speech production score, and the relative laterality of the pincer grip, also showed a not quite significant correlation at session five, which suggests again that bilateral control of fine motor movements may be related to speech production (r 0.36, $p < 0.06$).

Bimanual responses on the file box task

A bimanual response on the file box task was scored for collaborative use of the hands in object retrieval, the bimanual score being allocated to the hand which retrieved the object. Half the sample showed bimanual collaboration on the box task by age 12.9 months. The proportion of the 27 babies who succeeded in obtaining the toy with a bimanually co-ordinated response at each age level was 0.18, 0.37, 0.52, 0.59, 0.55 (R and L combined).

Right (but not left) bimanual responses summed over the five test sessions were significantly correlated with the MacArthur speech production score (r 0.44, $p < 0.02$). Boys made more right bimanual responses than girls but the difference was not significant (boys, $M = 4.35$, SD = 3.75; girls, $M = 2.61$, SD = 1.85).

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Unimanual responses on the file box task

A unimanual score was obtained if only one hand was used in a sequence of movements to obtain the object. Right- (but not left-) handed unimanual solutions to the box task correlated significantly with the MacArthur gesture score at session five (r 0.64, $p <$ 01). Boys were significantly more likely than girls to make unimanual right-handed responses on this task (boys, M = 6.5, SD = 3.80; girls, M = 3.85, SD = 3.08, $t(25)$, $p < 0.05$).

Absolute laterality measures, derived by subtracting, respectively, the unimanual or bimanual left responses from the unimanual or bimanual right responses, did not predict any of the MacArthur scores. The total R bimanual scores were uncorrelated with the total R unimanual scores, which suggests that these responses are independently organized.

The detour task

The detour task generated a great variety of responses of which only successful object retrieval in the 'hard' position will be considered here. It was not until the fourth session at M = 13.2 months that more than half the sample could solve the problem.

Successful detour retrieval was not significantly correlated with any of the MacArthur language scores, nor with the age of onset of pointing, nor were there any significant sex differences in performance.

There was no evidence of a significant advantage to the right hand in the detour task. The proportion of the 27 babies making a right-handed successful retrieval (from the right side) by age level was 0.11, 0.21, 0.41, 0.70, 0.77. The proportions for left-handed successful retrieval (from the left side) by age level was 0.03, 0.26, 0.48, 0.63, 0.66. The proportion of infants for whom the first success was with the right hand was 0.29; first success with the left hand 0.22; both hands in same month 0.41; never successful 0.07. Boys made slightly more successful retrievals than girls but the difference in average scores was not significant (boys, M = 7.64, SD = 3.67; girls, M = 5.84, SD =4.2, $t(25)$ = 1.18 ns).

An absolute laterality measure, derived by subtracting the total number of ipsilateral left-handed from ipsilateral right-handed detour retrievals, did not correlate significantly with age of pointing or with any of the MacArthur scores. There was no sex difference in this laterality measure (girls, M = 1.38, SD = 1.26; boys, M = 1.92, SD = 1.59, $t(25)$ = 0.98 ns).

Discussion

The study was designed to establish more about the relations between pointing, language development, fine motor control and various measures of unimanual and bimanual handedness. The MacArthur Infant Communicative Development Inventory was used as a convenient way to monitor very early language acquisition

On average, babies began pointing at 11.3 months, and age of onset of pointing was significantly correlated with MacArthur gestures at 14.4 months. This suggests,

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fairly obviously, that pointing is related to the development of gestural communication. It is of interest, however, that age of pointing is also correlated with the number of animal sounds comprehended at 14.4 months. It is possible, although unlikely, that this result is an artefact of the parental report method of the MacArthur test, but there is independent evidence which makes it more likely that pointing not only relates to communication by means of gestures, but also to the auditory-vocal channel. Pointing in babies is often accompanied by vocalization, and the link between pointing and comprehension of animal sounds may simply arise because these are speech sounds. Alternatively, the link may be with the referential functions of pointing, if the animal sounds serve as object names, as Harris *et al.* (1995) have suggested. This link between pointing and the auditory-vocal channel may also be consistent with long-range correlations, such as the finding that index finger extension in 3-month-old babies is correlated with speech-like syllabic vocalization (Masataka, 1995), and that frequency of pointing at 12 months predicts speech production at 20 months (Camioni *et al.*, 1991).

Fine motor control as evidenced by the pincer grip precedes pointing in development for both boys and girls. All the babies had the pincer grip in the repertoire either before or at the same time as pointing onset, and none of the babies who could point lacked the pincer grip. The incidence of the pincer grip did not predict any of the language measures, which suggests that acquisition of fine motor control *per se* is not sufficient to explain the beginning of speech production. Nor was there any relation with language measures when the pincer task was scored as a unimanual index of R- or L-handedness.

However, the relative balance of pincer grip activity between the hands, regardless of its direction, was significantly correlated with speech production at 14.4 months. This laterality index may therefore measure collaborative inter-hemispheric control of fine motor movements, which implies that such a system may also be implicated in speech production. Furthermore, there was a suggestion of a correlation between the overall laterality index for the pincer grip and the age of onset of pointing, which again implies that pointing is related to the pincer grip. Inter-hemispheric control of pointing may also help to explain why both right- and left-handed points (in the ratio 2:1) were obtained in this study.

Results for the box task tend to support this conclusion. Clear bimanual co-operation, implying inter-hemispheric control, ending with right-handed retrieval, predicted the MacArthur speech production score (but not the word comprehension score). In contrast, unimanual right-handed retrieval in the box task predicted gesture production but not speech production. Thus, gesture production and speech production appear to reflect different control systems, both possibly related to the dominant cerebral hemisphere, but with greater evidence for inter-hemispheric collaboration in speech than in gesture production.

There was no evidence that performance on the detour task predicted any of the MacArthur gesture or language measures. Thus, not all the tasks administered yielded equivalent results, when expressed in terms of handedness or relative lateralization scores. However, the detour task is a complex measure of means–ends behaviour, and successful solutions proved infrequent before the fourth visit, at 13.2 months, whereas successful bimanual solutions of the box task, which did predict language measures, were available to the majority of infants 1 month earlier. Given that the detour task was first developed to assess prefrontal lobe functions in monkeys, who show similar patterns of performance to human infants, it is possible that development in this domain is unrelated to language acquisition (Diamond, 1988).

Although the sex differences in age of onset of pointing and speech production were not quite significant, both were in favour of girls. Girls tended to show a U-shaped pattern in relative right lateralization of reaching over test sessions, whereas boys remained relatively unlateralized throughout. Such U-shaped developmental patterns are often taken to indicate a stage-like reorganization of the underlying constituent systems (Butterworth, 1989). Thus, when sex differences in speech production are found, as in the MacArthur inventory standardization, this may reflect sex differences in the development of mechanisms of inter-hemispheric collaboration related to the onset of speech production.

There was also some evidence for a developmental difference in favour of boys in MacArthur gestures. This sex difference tended to be predicted by unimanual measures, which again might be consistent with lesser inter-hemispheric collaboration in boys at the ages tested.

The lack of any sex difference in MacArthur comprehension scores is consistent with the standardization study, since the advantage to girls emerges clearly only at 16 months, and it accounts for only 1.33% of the variance. It may be that word comprehension at this early age depends on relatively global processes which are not the same as those that operate in adults. These may eventually be displaced by differentially lateralized mechanisms which mediate more mature forms of speech comprehension (Bates, 1993; Locke, 1993).

In conclusion these results suggests that the onset of pointing may be a bridge to language acquisition, both by a gestural and an auditory-vocal route. Changes in inter-hemispheric cerebral dominance may be involved in the developmental transition linking the onset of pointing to speech production. It seems likely that there are sex differences in this process.

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References

Baldwin, D. (1991) Infants' contribution to the achievement of joint reference. *Child Development*, **62**: 875–890.

Baldwin, D. (1993) Early referential understanding: infants' ability to recognise referential acts for what they are. *Developmental Psychology*, **29**: 832–843.

Baron-Cohen, S. (1995) The eye direction detector and the shared attention mechanism: two cases for evolutionary psychology. In: Moore, C. and Dunham, P. J. (Eds), *Joint Attention: its origins and role in development*. Erlbaum, Hillsdale, NJ.

Bates, E. (1993) Comprehension and production of speech in early language development. *Monographs of the Society for Research in Child Development*, **58**: 222–242.

Bates, E., Benigni, L., Bretherton, I., Camaioni, I. and Volterra, V. (1979) *The Emergence of Symbols, Cognition and Communication in Infancy*. Academic Press, New York.

Butterworth, G. E. (1989) On U shaped and other transitions in sensori-motor development. In: Ribaupierre, A. de (Ed.), *Transition Mechanisms in Child Development: the longitudinal perspective*, pp. 283–296. Cambridge University Press, Cambridge.

Butterworth, G. E. (1991) The ontogeny and phylogeny of joint visual attention. In: Whiten, A. (Ed.), *Natural Theories of Mind*, pp. 223–232. Basil Blackwell, Oxford.

Butterworth, G. E. and Hopkins, B. (1993) On the origins of handedness in human infancy. *Developmental Medicine and Child Neurology*, **35**: 177–184.

Camaioni, L., Castelli, M. C., Longobardi, E. and Volterra, V. (1991) A parent report instrument for early language assessment. *First Language*, **11**: 345–360.

Diamond, A. (1988) Differences between adult and infant cognition: is the crucial variable presence or absence of language? In: Weiskrantz, L. (Ed.), *Thought without Language*, pp. 337–370. Oxford University Press, Oxford.

Fenson, L., Dale, P. S., Reznick, L., Bates, E., Thail, D. and Pethick, S. J. (1994) Variability in early communicative development. *Monographs of the Society for Research in Child Development*, **59**: 5.

Franco, F. and Butterworth, G. E. (1996) Pointing and social awareness: declaring and requesting in the second year of life. *Journal of Child Language*, **23**(2) (in press).

Franco, F., Perruchini, P. and Butterworth, G. E. (1992) Pointing for agemates in 1–2 year olds. Poster presented at the VIth European Conference on Developmental Psychology, Seville, Spain, September.

Gesell, A. and Halverson, H. M. (1936) The development of thumb opposition in the human infant. *Journal of Genetic Psychology*, **488**: 339–361.

Harris, M., Barlow-Brown, F. and Chasin, J. (1995) Early referential understanding. *First Language*, **15**: 19–34.

Locke, J. L. (1993) *The Child's Path to Spoken Language*. Harvard University Press, Cambridge, MA.

Masataka, N. (1995) The relation between index-finger extension and the acoustic quality of cooing in three-month-old infants. *Journal of Child Language*, **22**: 247–257.

Moll, L. and Kuypers, H. G. J. M. (1977) Premotor cortical ablations in monkeys: contralateral changes in visually guided reaching behaviour. *Science*, **198**: 317–319.

Povinelli, D. J. and Davis, D. R. (1994) Differences between chimpanzees (*Pan troglodytes*) and humans (*Homo sapiens*) in the resting state of the index finger. *Journal of Comparative Psychology*, **108**: 134–139.

Ramsay, D. S. (1984) Onset of duplicated syllable babbling and unimanual handedness in infancy: evidence for developmental change in hemispheric specialization? *Developmental Psychology*, **20**: 64–71.

Shucard, D. W., Shucard, J. L. and Thomas, D. G. (1984) The development of cerebral specialization in infants. In: Emde, R. and Harmon, R. J. (Eds), *Continuities and Discontinuities in Development*, pp. 293–314. Plenum, New York.

Thatcher, R. W., Walker, R. A. and Giudice, W. S. (1987) Human cerebral hemispheres develop at different rates and ages. *Science*, **236**: 1110–1113.

Touwen, B. C. L. (1976) *Neurological Development in Infancy*. Heinemann, London.

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Verweij, E. (1988) Development of grasping in full term infants. Honors thesis submitted to the Faculty of Human Movement Sciences, Free University of Amsterdam.
Vygotsky, L. S. (1988) Development of the higher mental functions. Reprinted in: Richardson, K. and Sheldon, S., *Cognitive Development to Adolescence*, pp. 61–80. Erlbaum, Hove.
Werner, H. and Kaplan, B. (1963) *Symbol Formation: an organismic-developmental approach to language and the expression of thought*. Wiley, New York.

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