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STUDIES ON LANGUAGE DEVELOPMENT: COGNITIVE, SOCIAL, COMMUNICATIVE AND CLINICAL ASPECTS

Special Issue edited by

Maria Antonietta Pinto · Simonetta D'Amico

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MOTOR ACTS AND COMMUNICATIVE GESTURES FROM 9 TO 18 MONTHS OF AGE IN IMPERATIVE AND DECLARATIVE CONTEXT: TRACING THE ORIGIN AND DEVELOPMENT OF POINTING

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Jana M. Iverson***

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Abstract *According to Vygotskyan and Werner & Kaplan's perspectives, precursors of pointing gestures can be identified in either reaching or index finger extension. Within the same perspective, Carpendale & Carpendale (2010) found that pointing emerges in daily life as a nonsocial orienting behavior, which eventually becomes a communicative device. The present study shares with Carpendale & Carpendale the aim of investigating the origins of pointing as related to the infant's activity. We observed infant's behaviours in a paradigm devised to elicit communicative pointing, either to request an interesting object by the adult (imperative pointing) or to involve the adult in attending to an interesting object (declarative pointing). The aim was to explore how infants use their behavioural repertoire to achieve these goals and how this repertoire is influenced by the goal to achieve. Ten infants were tested every three months – from 9 to 18 months – with three trials for imperative and three trials for declarative pointing. Each trial was coded considering all behaviors produced by the infant after the activation of the stimulus. The categories used were Pointing, Reaching, Only finger and Motor act. At any age, the frequency of infant productions was much higher in the imperative than in the declarative condition, increasing gradually in both of them. The quality of the infant's participation in interactions changed with age, from non-communicative to communicative modalities, and from motor acts to conventionalized behaviors, such as pointing and reaching gesture. Moreover, the context and the goal of her/his actions influenced the child's behavioral repertoire: imperative intention was expressed by reaching as well as pointing, and declarative intention was expressed only by pointing.*

Keywords: *Communicative development - Declarative pointing - Imperative pointing - Motor system - Infancy.*

1. Introduction

Although there is general agreement about the importance of pointing, controversy and little consensus still exist about how this gesture develops (e.g., Carpendale, & Lewis 2004, 2006); indeed it has been recently noted by an expert

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in the field that 'surprisingly, no one knows where pointing comes from ontogenetically' (Tomasello 2008). Theories can be grouped as to whether they assume that pointing is social from the beginning (e.g., Butterworth 2003), or becomes so through experience and learning (e.g., Bates 1976; Lempert, & Kinsbourne 1985; Lock *et al.* 1990). This latter view is strongly shared by Carpendale and Carpendale (2010) in the most recent paper on that issue. They claimed that "infants point first as part of their own activity and gradually realize the social significance of their action for others" (p. 112), therefore tracing the origins of pointing to infant sensorimotor skills. Another perspective revolves around the functional origins of pointing, whether it emerges, according to Vygotsky (1978), from a previously failed reaching for grasping an object in order to obtain it, or, according to Werner and Kaplan (1963), from an adaptive "reaching-for-touching" an object to refer to it. The sensorimotor origins of pointing appear to be integral to either interpretation, since the precursor of the gesture is located in an abbreviated movement of grasping or in an extended movement of fingering, respectively. The same view of pointing as related to the infant's motor repertoire is evoked by Hannan and Fogel's observation of index finger extension at a very early age, occasionally by 18 days of life (Hannan, & Fogel 1987) and quite often three months later, even for long periods of time. Since no one argues for any social or communicative function played by that behaviour, finger extension can be only considered under the motor inventory and interpreted as a preadaptive behaviour for future development.

Looking for precursors of pointing and also rooting them in practical activity means relating gestural communication to the infant's pre-existing motor repertoire, thereby establishing continuity between pointing and previous body movements. This is not an uncontroversial issue. Tomasello's reasoning about index finger extension suggests that no relationship can exist between that behaviour and later pointing. In his words (2008: 122), infants at early age may be socially motivated and able to engage adults in proto-conversation, but lack the ability of social understanding, which is the basic prerequisite for the emergence of intentional communication, and hence for using the index finger to point. We agree with the immaturity of the infant at three months of age; however, recognizing the lack of communicative intentions at that age does not necessarily imply grounding pointing in the socio-cognitive domain. This perspective supports a "rich interpretation" of pointing, according to which "when pointing first emerges in human infants at around the first birthday, before the emergence of language, it already possesses these foundational components of mature pointing", that is an understanding of the intentions, attention, and knowledge of their partner (Tomasello, Carpenter, & Liszkowski 2007: 720; see also Liszkowski, & Tomasello 2011). This line of reasoning, while definitively denying that pointing might initially serve a non-communicative function, underestimates the relevance of motor skills in gestural development – either spontaneous movements like the index finger extension or purposed acts such as reaching-for grasping and reaching-for-touching – therefore giving up the search for possible motor precursors of pointing.

Carpendale and Carpendale (2010) provided a different proposal. They relate pointing to the infants' daily activity within a social context, rather than to mentalistic attitude towards other persons. The perspective they proposed is based on a diary study starting at 6 months of age, therefore it is based on very suitable

data for analyzing the emergence of pointing. They found that pointing emerges in daily life as a non-social orienting behaviour, which eventually becomes a communicative device through learning and experience. This mechanism of transition from a self-directed action to the other-oriented gesture is provided by a special everyday routine, called in Mead's terms (1934) as "conversations of gestures", in which infants make the act of pointing and adults respond accordingly, allowing the infants to learn the meaning of that action. Their conclusion is that pointing arises in an action-based experience inside the individual mind. Moreover, it is picked up by others who overtly show infants their orientations toward them and the world, therefore being learned without requiring a mindreading ability.

According to the above perspective, communicative development is promoted by an integrated system involving motor as well as linguistic skills (McNeill 1992). Not only gestures are linked to language with both concurrent and predictive relationships in both typical and atypical development (McNeill 1992) but, as recently claimed by Iverson, practicing motor skills is relevant for language acquisition before those skills are recruited for the purpose of speaking. In her proposal, changes occurring in the motor domain over the first eighteen months provide infants with opportunities for acting in the world "that contribute, both directly and indirectly, to the development of communication and language" (Iverson, 2010 2). Moreover, there is continuity between action schemes and language, since meanings expressed earlier by manual and intransitive actions are represented later by gestures and words (Capirci *et al*. 2005).

Our study shares with Carpendale and Carpendale the starting idea of examining the origins of pointing as related to the infant's activity. As in their study, we adopted a longitudinal design extending from before the canonical age of the emergence of pointing to the age when the gesture is fully achieved. Unlike their study, our observations took place in a lab and in an experimental situation, guaranteeing a controlled interactional situation with respect to stimuli and adult communication.

We observed infants' behaviours in a paradigm (Camaioni, Perucchini, Bellagamba, & Colonnesi 2004) devised to elicit communicative pointing, either to request an interesting object by the adult (imperative context) or to involve the adult in attending to an interesting object (declarative context). The goal was to explore how infants use their behavioural repertoires to achieve these goals and how this repertoire is influenced by the goal to achieve. We followed infants every three months from 9 to 18 months in order to observe the developmental course of pointing in a rather intensive way. We interpreted our experimental paradigm as an interactive situation potentially exciting for the infants, since we presented them with objects that were available for acting and sharing. We therefore expected that infants participated in the situation and that the modalities used for participating changed with the advancing age, from non communicative to communicative, with the former consisting of generic behaviours such as motor acts and the latter in conventionalized behaviours such as the pointing gesture, with the supposed precursors of pointing, such as index finger extension and reaching, between the two. In this developmental change, we hypothesized that infants' capacity to coordinate the gaze with the pointing gesture in a communicative way will increase. Moreover, we expected an influence of the

interactional situations (imperative and declarative) on the children's behaviours, in particular on the type and frequency of motor acts and gestures and on the developmental changes.

II. Method

Participants

Ten infants (4 girls and 6 boys) participated in the study when they were 9, 12, 15 and 18 months of age (range 7 days before or after the birthday). Children were recruited from pediatrics' offices, and were all healthy and normally developing; cases of prematurity and bilingualism were excluded. They came from two-parent families of middle and middle-high socio-economic status (as determined by parental educational level), living in two middle-size cities in central Italy.

Procedure and coding

Children were administered the TPOINT (Camaioni *et al.* 2004), a task designed to elicit the imperative and declarative pointing gesture in infants. They were tested individually in a play-room equipped with a one-way mirror and were videotaped through a double camera. Before the testing phase, each child participated with the parent in a familiarization phase in a room next to the laboratory, where toys were available. The TPOINT consists of two experimental conditions involving the infant, the experimenter and a proximal or a distal stimulus in imperative and declarative conditions, respectively. Proximal stimuli were two maracas and a wind toy airplane. Distal stimuli were a mobile Winnie the Pooh and flashing Christmas lights. The conditions consist of 3 trials (for a total of 6 trials) presented in random order. A trial lasted around 90 seconds. The infant sat on the parent's lap at a table in front of the experimenter, a woman, who was the same for all the infants at each age.

At the beginning of the trial, the experimenter made eye contact with the child and said "Hi + the child's name!" In each imperative trial, the experimenter activated a windup airplane (moving for about 10 sec and then stopping) and looked silently at the child for 15 seconds (waiting for the child's reaction). The experimenter said "Isn't it pretty? Do you like it?" and looked silently at the child for 15 seconds (waiting for the child's reaction). Then the experimenter gave the toy to the child.

In each declarative trial, a person in the control room behind the one-way mirror activated Winnie the Pooh hanging from the ceiling. The experimenter looked silently at the child for 15 seconds (waiting for the child's reaction). The mobile moved for about 10 sec and then stopped. The experimenter said "What happens?" without turning to look at the mobile behind her, and looked silently at the child for 15 seconds (waiting for the child's reaction). Then the experimenter turned back to look at the mobile and named it.

All the infant behaviors related to the stimuli were coded from the videotapes using a computer-based observation software (INTERACT). Only those trials in which the stimuli attracted the child's attention were coded (the remaining were considered non valid). Mean percentage of valid trials on trials administered to the 10 subjects was 94%.

Both behaviors and trials were analyzed. To that aim, a two-levels coding scheme was used, with the first level capturing all behaviors produced by the infant after the stimulus activation, and the second level coding the quality of the trial with respect to the type of behaviors produced.

At the first level, the coding system was the following:

– *Pointing*, defined as arm and index finger extension in the direction of the stimulus (and without touching it), while the remaining fingers were curled lightly or tightly under the hand (Franco, & Butterworth 1996).
– *Reaching*, defined as arm and hand extension in the direction of the stimulus with the pal up or down (Franco, & Butterworth 1996).
– *Only Finger*, defined as index finger stretched without the extension of the arm; the hand can be leaned to a surface.
– *Motor acts* of arm/s and hand/s; they included approaching trunk and arms, banging the hand, lifting the arms up, and rubbing.
– *Gaze accompanying the pointing*, defining as the gaze to the experimenter within a 2 second window before/after the pointing gesture or during it.

At the second level, we coded trials as following:

– *One Behavior Trial* (OBT), one or more pointing/reaching/motor act[1] were produced by the infant; it comprises the following sub-categories
  - *Pointing Trial*
  - *Reaching Trial*
  - *Act Trial*
  - *Multiple Behavior Trial* (MBT) different behaviors were produced by the infant; it comprises the following sub-categories:
  - *Pointing+Reaching Trial*
  - *Pointing+Act Trial*
  - *Reaching+Act Trial*
  - *Pointing+Reaching+Act Trial.*

Two judges coded all the sessions. The inter-code agreement was calculated on 20% of the sessions, considering separately all the categories in the two communicative contexts. Values of Cohen were all 0.90 or better. Only one code was counted for each trial so that the maximum frequency of any code in each condition amounts to six. The measure used for the analyses was the frequency of each code.

III. Results

We first analyzed behaviours produced by the infants in imperative and declarative condition at 9, 12, 15 and 18 months. The main goal was to find similarities and differences between the two conditions as well as developmental changes. From the descriptive data (2 infants produced pointing and 5 infants produced reaching) it is apparent that the majority of the infants produced motor acts at all ages considered; at 9 months only a few infants produced pointing and reaching (see Table 1), but at 18 months all of them produced these gestures. A very clear phenomenon is the absence of reaching in the declarative context and the very low presence of the finger extension at all the ages considered. In general, more behaviours were produced in imperative than in declarative context.

[1] Only finger had very low frequency at all ages (mean frequencies less than 1.0) so was not included in this coding level.

We conducted an ANOVA for repeated measures on the gestures frequencies (transformed in square root) with Age (9, 12, 15 and 18 months), Context (imperative and declarative) and Gesture (Motor acts, Pointing, Reaching)[1] as factors. All the main and the interaction effects were significant, except for the Age x Context interaction. Since the Age x Context x Gesture interaction was significant, we present only these results [$F(6, 54) = 2.728$; $p = .022$]: acts decreased at 15 months with respect to 9 months in imperative context ($p = .017$), whereas they remained stable in declarative context. Pointing increased with age in both contexts ($p < .001$); reaching was very similar in frequency to the pointing in imperative context and increased with age ($p < .01$), whereas it was absent in declarative.

At 9 months, acts largely prevailed over the other gestures in both contexts ($p = .001$ with respect to imperative pointing; $p = .028$ to imperative reaching; $p = .018$ to declarative pointing) whereas at 18 months, pointing prevailed acts significantly in the declarative ($p = .024$) just as a tendency in imperative context ($p = .075$).

Although, in general, infants produced more behaviours in the imperative context than in the declarative [$F(1, 54) = 34.741$; $p < .001$], and only at 9 months acts in imperative context prevailed acts in the declarative ($p = .013$). As a tendency, pointing gestures were more frequent in imperative than in declarative condition ($p = .08$).

Table 1. Descriptive data [Means and Standard Deviations (S.D.)] for infants' behaviours in imperative and declarative condition at 9, 12, 15 and 18 months of age.

BEHAVIOURS	*9 mo.*			*12 mo.*		*15 mo.*			*18 mo.*	
	Mean (S.D.)		N	Mean (S.D.)		Mean (S.D.)		N	Mean (S.D.)	
Imperative context										
Act	6.7	(3.65)	9	4.4	(3.24)	2.5	(2.22)	9	4.2	(2.62)
Pointing	0.3	(0.67)	6	4.9	(5.36)	6.6	(4.11)	10	8.7	(5.19)
Reaching	2.0	(3.27)	8	5.1	(4.33)	5.1	(5.30)	9	7.5	(6.75)
Declarative context										
Act	2.7	(2.36)	9	4.0	(3.02)	2.8	(3.55)	8	3.1	(3.87)
Pointing	0.3	(0.67)	9	3.4	(2.12)	6.8	(6.71)	10	5.6	(3.24)
Reaching	0.0	(0.00)	0	0.0	(0.00)	0.1	(0.32)	0	0.0	(0.00)
Total	3.0	(2.11)		7.4	(3.13)	9.7	(9.33)		8.7	(6.60)

We then analyzed trials to examine how age and context affected infant production (see Table 2). We considered both the complexity of trials, with respect to whether they included only one type of behaviour or more, and the quality, with respect to the type of behaviours included. Differences were expected in both aspects, due to the absence of reaching in declarative condition (see above). As to the former aspect, we carried out an ANOVA for repeated measures on the frequencies (transformed in square root) with Age (9, 12, 15 and 18 months),

[1] We excluded the only finger extension from the ANOVA for the low frequencies found.

Context (imperative and declarative) and Trials type (OBTs vs. MBTs). We found a significant three way interaction [$F(1.54) = 34.741$; $p < .001$] which showed that in imperative context One Behaviour Trials (OBTs) were higher than Multiple Behaviours Trials (MBTs) at 9 months and lower in any of the subsequent ages, due to an increase of the MBTs; in the declarative context, OBTs were always much higher than MBTs, independently of the age. Moreover, comparing the two contexts at all the ages considered, MBTs were higher in imperative than in declarative context; OBTs were similar in frequencies except at 18 months when OBTs in declarative context were higher than in the imperative.

Table 2. Descriptive data [Means and Standard Deviations (S.D.)] for type of trials in imperative and declarative condition at 9, 12, 15 and 18 months of age.

BEHAVIOURS	*9 mo.*			*12 mo.*		*15 mo.*			*18 mo.*	
	Mean (S.D.)		N	Mean (S.D.)		Mean (S.D.)		N	Mean (S.D.)	
Imperative context										
One Behavior Trial (OBT)										
Act	2.8	(1.93)	5	1.2	(1.48)	0.6	(0.84)	5	0.7	(0.82)
Pointing	0.0	(0.00)	3	0.4	(0.70)	1.3	(1.64)	5	0.7	(0.95)
Reaching	0.3	(0.95)	5	0.9	(1.03)	0.3	(0.67)	4	0.4	(0.52)
Multiple Behaviors Trial (MBT)										
Act + Pointing	0.0	(0.00)	3	0.7	(1.60)	0.4	(0.48)	6	0.8	(0.79)
Act + Reaching	0.8	(1.03)	5	0.6	(0.70)	0.3	(0.48)	2	0.1	(0.42)
Pointing + Reaching	0.0	(0.00)	3	0.9	(1.52)	1.2	(1.40)	7	1.6	(1.17)
Act+ Pointing +Reaching	0.2	(0.42)	3	0.6	(0.48)	0.8	(0.88)	6	1.0	(1.25)
Declarative context										
One Behavior Trial (OBT)										
Act	1.8	(1.73)	7	1.8	4	0.7	(0.48)	6	0.7	(0.67)
Pointing	0.2	(0.63)	8	1.6	(17)	1.9	(1.60)	10	2.6	(35)
Reaching	0.0	(0.00)	0	0	(0.0)	0	(0.0)	0	0.0	(0.0)
Multiple Behaviors Trial (MBT)										
Act + Pointing	0.1	(0.32)	6	0.8	(0.79)	0.9	(1.29)	3	0.9	(1.73)
Act + Reaching	0.0	(0.00)	0	0.0	(0.00)	0.0	(0.00)	0	0.0	(0.00)
Pointing + Reaching	0.0	(0.00)	0	0.0	(0.00)	0.1	(0.00)	0	0.0	(0.00)
Act+ Pointing +Reaching	0.0	(0.00)	0	0.0	(0.00)	0.0		0	0.0	(0.00)

As to the quality of trials, we analyzed at a descriptive level first OBTs type. The imperative and declarative contexts were similar with respect to the frequency

of trials including only acts or only gestures, either reaching or pointing act trials were much higher than gesture trials at 9 months (respectively, 2.8 vs. 0.3) and decreased gradually, so that at 18 months they were much lower than gesture trials (respectively, 0.7 vs. 0.11; see Table 2). The two conditions differed with respect to the relative proportion of trials with only pointing or only reaching, due to the absence of the reaching in the declarative condition; thus, in this context, gesture trials comprised only pointing. In imperative context, reaching trials were more frequent than pointing trials at both 9 (respectively, 0.3 vs. 0.01) and 12 months (respectively, 0.9 vs. 0.4), whereas the reverse was true at both 15 (respectively, 0.3 vs. 1.3) and 18 months (respectively, 0.4 vs. 0.7).

As to MBTs type, since reaching was absent in declarative condition, the two codes of "Acts and Reaching" as well as "Pointing and Reaching" were also absent in that condition; therefore results strongly differed between imperative and declarative. In the former context, trials including both acts and gestures were rather frequent at every age, even if "Pointing and Reaching" trials increased between 12 to 18 months (0 at 12 vs. 1.6 at 18). In the declarative condition, MBTs, including both acts and pointing, were quite scarce at any age.

To investigate the infants' capacity to coordinate gaze with pointing, we analyzed the frequencies of pointing with gaze at the experimenter. As it is possible to see in Table 3, the pointing accompanied by gaze was very low at 9 months in both contexts and increased with age. Due to the very low frequencies at 9 months, this age was excluded from the analysis. We conducted an ANOVA with Age (12, 15 and 18 months) x Context (imperative and declarative) as factors on the frequencies transformed in square roots. The simple effect for Age was significant [$F(2, 18) = 17.430$; $p < .001$]: the frequency of pointing with gaze increased between 12 to 18 months and no differences were found between imperative and declarative contexts.

Table 3. Descriptive data [Means and Standard Deviations (S.D.)] for pointing with gaze in imperative and declarative condition at 9, 12, 15 and 18 months of age.

CONDITIONS	*9 mo.*		*12 mo.*		*15 mo.*		*18 mo.*	
	Mean (S.D)		Mean (S.D)		Mean (S.D)		Mean (S.D)	
Imperative	0.0	(0.00)	0.5	(0.34)	0.5	(0.26)	0.7	(0.26)
Declarative	0.5	(0.00)	0.3	(0.18)	0.6	(0.27)	0.8	(0.25)

IV. Discussion

Infants responded to the communicative situations provided by the TPOINT experimental paradigm with different behaviours, i.e. motor acts and gestures, and these increased with age. With respect to the hypothesized sensorimotor origin of pointing, we analysed the relationship between gestures and pre-existing motor repertoire, in particular acts of trunk, arms and hands, and two putative precursors, i.e. reaching and index-finger extension. First, we found that at the end of the first year of life, motor acts were the most predominant infants' behaviour shown in communicative contexts, both when the object was near to the infant and when it was distant. In the second year of life, gestures substituted body

acts, even if these were not completely replaced with them. As to relationships between pointing and other gestures, we found that the index-finger extension was very rare at any ages we considered and the reaching emerged at the same age of pointing, showing a parallel development. The analysis of complexity of trials, that is of how infants organized their behaviours in the interaction, shows that they used more behaviours and combined them (motor acts and gesture) to interact with the adult, especially in the imperative context. So we can argue that pointing is not an isolated gesture and that it has a relation both with body acts and with other gestures.

The pointing accompanied by gazing was significantly higher at 15 and 18 than at 9 months. It suggests that when pointing emerges – at 12 months – infants produced it for themselves as well as for the others, and it is from the age of 15 months that they pointed more often for the other than for themselves. Thus, we argue that the infant's awareness of the communicative intent of pointing emerges after the capacity to point.

With respect to the effect of the interactional situations, imperative or declarative – for acting or for sharing with the partner – we compared infant's behaviours in imperative and declarative experimental conditions. We found some differences and some similarities between the two communicative contexts. First, in the imperative compared to the declarative context, infants produced a higher number of acts and gestures, and also a higher number of pointing. As for reaching, we found that it is absent in the context in which objects are too far to be reach, that is, the declarative condition. However, the developmental trends of pointing and of gaze accompanying pointing were similar in the two contexts, highlighting the growing children's capacity to use communicative gestures in different interactional situation, therefore, regardless of the context.

Our results showed the gradual transition of infants' participation to communicative context from being first involved at motoric level and then at the gestural level. They showed a transition at the latter level too, from a non-communicative (pointing per se) to a communicative use of the gesture (pointing for others), as evidenced by the increased capacity to coordinate pointing with gaze to the experimenter. Finally, they showed how the interactional context partially affects the infants' behaviours, in terms of "frequency" and "type": children in the second year of life seem to be able to adequate their communicative behaviours to the interactional context.

In conclusion, using an experimental paradigm devised to elicit communicative pointing, infants observed at 9, 12, 15 and 18 months of age were found to participate to the interaction with the experimenter initially by acting, to continue at subsequent ages by using acts and gestures and to the end of the observational period by using primarily gestures. Following this trend from motor to gestural participation, pointing passed from being used per se to being directed to the other, so showing to improve its communicative function with the advancing age.

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