In: J. Nadel & G. Butterworth (Eds) 1999
Imitation in Infancy Cambridge U. Press

2 Genesis and development of early infant mimesis to facial and vocal models

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Introduction

This chapter describes a longitudinal study, starting from when babies were less than 1 hour old, undertaken to investigate the origins and development of facial and vocal imitation during the first 6 months of life (Kugiumutzakis, 1985, Study V). The longitudinal design allows study not only of what happens during the newborn period, but also of whether imitation disappears, as certain reflexes do (Abravanel and Sigafoos, 1984; Jacobson, 1979); whether imitative responses to different models follow a nonlinear course (Maratos 1973, 1982) and whether infant imitation develops in the way Piaget (1962) described.

Piaget (1962) argued that development progresses from absence of imitation (1st month), to sporadic imitation of vocal, head-and-hand models (1–4 months), systematic imitation of known sounds and of visible gestures (i.e. that babies can see themselves make, 4–8 months), and, finally, imitation of non-visible facial models (8–12 months). Thus, Piaget assumes a developmental course from non-imitation to imitation, and also that self-imitation precedes and leads to hetero-imitation. This means that Piaget considers imitation to be, at first, an intrapersonal phenomenon, which gradually becomes an interpersonal phenomenon in infancy, until at 2 years of age it becomes again intrapersonal as interiorised imitation. For Piaget, imitation during the first 8 months of life is not essentially different from circular reaction because the infant considers the actions modelled by another person as a kind of continuation of her own activity. True, spontaneous imitation, based upon active, spontaneous assimilation appears later in development, while 'pseudo-imitation' of a facial model does not last, says Piaget, except under the influence of continual stimulation. True imitation, however, lasts, that is, it does not disappear 'even when it is only sporadic' (1962, p. 18). After the eighth month (stage IV, 8–12 months) Piaget relies on the passive process of association for the further development of imitation, because the active processes of assimilation and accommodation cannot explain the appearance of facial imitation. Piaget notes that 'training in imitation is necessary, especially when it is a case of imitation of movements which the child cannot see himself make' (p. 41).The basis for facial imitation is the co-ordination of secondary circular reactions, parental training and the constitution of a system of 'mobile indices' which function as mediators between the facial model and the infant's own behaviour. Piaget excludes by definition rather than by observation (see Kugiumutzakis, 1993, p. 24) the possibility of neonatal imitation, the contribution of intermodal co-ordination and the contribution of representation in the development of early infant imitation (see also Kugiumutzakis, 1985, 1988, 1993,1998; Maratos, 1973, 1982, 1998; Meltzoff and Moore 1977, 1983, 1989, 1992).

We know today that both Piaget's theory and his observations during the neonatal period are inadequate to explain the origin of human imitation. The fact of neonatal imitation indicates that human imitation is, from the start, an interpersonal phenomenon in which newborns actually imitate facial models 8 to 12 months earlier than Piaget had proposed (Bard, 1994; Field, Woodson, Cohen, Greenberg, Garcia and Collins, 1983; Field, Woodson, Greenberg and Cohen, 1982; Fontaine, 1984; Heimann and Schaller, 1985; Kugiumutzakis 1985, 1998, 1993; Legerstee, 1991; Maratos, 1973, 1982, 1998; Meltzoff and Moore 1977, 1983, 1989, 1992; Reissland, 1988; Vinter, 1986). This fact creates serious problems for Piaget's theory that imitation develops in six invariably ordered stages.

Bain (1855, cited in Miller and Dollard, 1941) observed 'disappearance' of imitation in early infancy. Piaget also made an observation in this respect, but he did not try to interpret this interesting phenomenon (1962, pp. 9–10, obs. 2, 3). Maratos (1973) observed a decline in imitative behaviour towards different models at different age levels. Various hypotheses have been offered for the decrease in early infant imitative behaviour. It may occur because the babies' capacity for processing incoming information is momentarily lost (Maratos, 1982), or because after the second month the 'matching' ability disappears, as is the case with certain neonatal reflexes (Jacobson, 1979), or because the mother does not reinforce certain socially unacceptable behaviours such as tongue protrusion (Dunkeld, 1978), or because there is a relationship between the decline in infant attentiveness and the decrease in imitation of facial models (Field, Goldstein, Vega-Lahr and Porter, 1986; Fontaine, 1984; Heimann, 1989), or because each imitative response reaches its zenith and declines as the child seeks 'fresh stimuli' (Guillaume, 1925/1971). Given the interesting results and stimulating disagreements obtained in previous studies, the development of infant imitation during the first 6 months invites further investigation.

Methods of studying the development of imitation in the first six months of life

Since there has been much controversy over the existence of neonatal imitation, the methods adopted by the author for its study will first be described in some detail. The procedure is sensitive to the newborn and young infants' interests, needs, individual differences and communicative readiness at the moment of the test. The method was based on two pilot studies, one carried out with 40 babies less than 45 minutes old in a maternity hospital in Iraklion, Crete, and another by Olga Maratos, with 18 infants, 2 to 8 months old, in the Metera Babies' Center in Athens (see Kugiumutzakis, 1985).

The procedure during the first examination in the maternity hospital and the visits to the infants' homes was as follows. With the permission of the doctors and the parents-to-be, the writer was present at the births of the infants. In the delivery room, the mother and the pediatrician were asked for permission to test the baby. The time of birth and the Apgar scores were noted and the experimenter attended the baby's first pediatric examination and first bath conducted by the midwife. About 10 to15 minutes after the birth, the infant met the father, grandparents and other relatives in a room close to the lying-in room. There, with the help of the clinic's staff, the permission of the father and grandparents to test the baby was obtained. This granted, the father, or more often he and the grandmother(s), took the newborn to the laboratory and placed the infant gently on the baby bed. Relatives and the pediatrician observed the testing on a soundless TV screen located at the corner of the room, behind a black screen out of sight of the baby.

The laboratory was an isolated and warm room, where other crying babies were out of earshot. The baby bed was set at about 10 degrees to the horizontal. Behind and above the bed a large vertical mirror reflected the experimenter's face and hands. Beside the bed there was a dimmer control, to regulate the lighting. The bed, the mirror, a small table and the experimenter's seat were surrounded by a black screen ($2.0 \times 2.0 \times 2.0$ m) ensuring that the experimenter's face would be the brightest object in the baby's visual field. For the same reason, the experimenter wore a black shirt during the test. A video camera with high light sensitivity was located behind the black screen, directed to the baby's face and the mirror, recording simultaneously the movements of experimenter and the baby (Kugiumutzakis, 1985, 1988; see also Meltzoff and Moore, 1977, 1983). At the babies' homes, the camera-person was situated at a distance of 2.0–2.5 m from the baby and she attracted very little attention from the infants. Four babies, during the second and the third month, looked at the camera rather than at the experimenter. In those cases the test was stopped and the babies were visited again on the next day. During the test the parents were out of the visual field of the baby.

Since the baby's state depended to some extent on the posture, a flexible approach was adopted since it was necessary that the baby be calm for the presentation of the facial models. It was observed in the delivery room that a change of posture of a whimpering baby often stimulated a calm state and it was natural for the midwives to change the baby's posture in an effort to calm the baby. This is a practice also adopted intuitively by parents during the neonatal period (see Ronnqvist, 1993; Stratton, 1982).

The first test, with facial models, was with the newborn baby either lying down on the baby bed or, if the baby did not like this posture (as judged from whimpering or a facial expression of uneasiness), the experimenter held the baby upright with the head in one hand and torso in the other. At home, the posture of the infant on each visit was regulated following the mother's advice. The babies were examined either lying down on a sofa with a pillow under the head or in an inclined infant seat. In cases where the infants did not tolerate the seat, the session was conducted with the baby held upright by the experimenter, with the head supported in one hand and torso in the other. In this way, the procedure was adapted to the infants' postural needs at the moment of the test.

The lighting conditions were also carefully modified during the test of the newborns to allow for the difficulties of many babies for visual adaptation to the new environment immediately after birth. The experimenter either lowered or turned off the light, put his hands around the baby's face or stood between the baby's eyes and the source of the light. If helped in one of the above ways, the neonates in the delivery room were observed to open their eyes in less than 40 seconds. It was decided that if the eyes of the baby were closed when they entered the laboratory, the experimenter would lower or turn off the light with the dimmer control in an effort to help the infant's visual adaptation. Again the design was adapted to the babies' visual functioning and responsivity at the moment of the test (see also Attkinson and Braddick, 1982; Prechtl, 1982; Stratton, 1982; Trevarthen, 1986).

Testing, in the first examination, began with an adaptation period of 40 to 100 seconds with the baby alone on the baby bed and the experimenter out of sight. Until this moment, the baby had no opportunity to observe the experimenter's face. This adaptation period was introduced to help the babies to adapt to the room's lighting, or to adapt the room's lighting with the dimmer control to the baby's visual system and to determine whether the facial models could be presented with the baby lying down or with the baby held upright.

Masters (1979) proposed that responses of the newborn during presentation of the standard model should be ignored, because the experimenter might actually be imitating the baby. In the pilot study, each model was presented five times and then the experimenter waited for the baby's response. The majority of the babies (77%) reacted after the fifth presentation of the model while the remainder reacted (imitatively or not) after either the first, second, third or fourth model presentation. Masters' advice was not followed here because (a) each model was presented as soon as the baby was entirely motionless and silent, (b) the digital timer on the video recording makes it easy to decide who influences whom, and (c) Masters' criterion ignores entirely the individual differences in communicative readiness of neonates and young infants in early interactions.

It was clearly necessary to choose a maximum number of presentations of the models (say five times), but some babies did not need all five model presentations – some needed four, and some only one. Thus, it was decided that when the baby started reproducing the model (for instance tongue protrusion) or emitted other scored responses (mouth opening, blinking, etc.), the modelling stopped regardless of the number of presentations already made. In natural mother–infant interactions, coactions are the exception rather than the rule. Again, the design was suited to the babies' communicative readiness at the moment of the test (Kugiumutzakis, 1985, 1988, 1993, 1998, Stratton, 1982).

Longitudinal study of the origin and development of imitation.

Kugiumutzakis (1985) studied fourteen infants who were examined for facial and vocal imitation from just after delivery until the sixth month. The first examination took place in the maternity hospital with the newborns less than 40 minutes old. The average age of the babies was 32 minutes (range 19–40 min). The infants (7 girls and 7 boys) were full-term babies ($\bar{x}$ = 39.2 gestational weeks), of normal birth weight ($\bar{x}$ = 3570 g) and of normal Apgar scores (1-min Apgar: $\bar{x}$ = 7; 5-min Apgar: $\bar{x}$ = 9.2). Eight out of the 14 babies were first-born and 6 were second-born. The study took place in Iraklion, Crete.

In the subsequent examinations, the infants were visited in their houses every two weeks from the time they were 15 days old until they were 180 days old. Thus a total of 13 examinations were made of each infant. All sessions both in the hospital and at the babies' homes were videorecorded. The home environment was prefered to a standard laboratory setting since this avoided having to familiarise the infant to anything more than the experimenter. Since it is difficult to control the reinforcing

behaviour of the mother during the test, the experimenter rather than the mother administered the models. To avoid practice of the modelled actions between the sessions, the parents were told that the aim of the study was to observe the reflex behaviour of the babies. Despite this precaution, one cannot, of course, be sure that all parents refrained from practicing the models and from playing imitative games in parent–infant interaction (Kugiumutzakis, 1993; Pawlby, 1977; Trevarthen, 1977, see also Trevarthen, this volume). The visits to the infants' homes took place during the half hour immediately following feeding because this is an optimal time for social games and there are few spontaneous oral movements.

Facial models presented for imitation were mouth opening (MO), tongue protrusion (TP) and eye movements/blinking (EM). Vocal models were rhythmical emissions of the sounds /m/, /a/ and /ang/. There were three criteria for admission to the study: (a) The infants were not 'at risk' babies, (b) they should be less than 40-minutes old on the first examination and (c) at each age level each baby would be exposed to all the models once. The experimental design of a series of five studies of babies less than 45-minutes old is described fully in Kugiumutzakis ,1985, 1988, 1998.

Each model was presented up to five times for a duration of 15 seconds. Given individual differences in infant visual and auditory functioning, and in responsivity and communicative readiness, the actual stimulus time depended on when the baby looked at the experimenter (for facial models). The average stimulus time was 10 seconds and, as noted above, the frequency of model presentation and the reaction time was controlled by the baby, with an upper limit of 15 seconds. The facial models were presented at a distance of 20–23 cm from the infant's face, when the infant was entirely calm with open eyes, regular respiration and lack of gross movements or vocalisation. The vocal models were presented when the baby was silent, but whether the infant looked at the experimenter or not was not taken into account. The models were presented in random order with a different order for each baby.

Two judges scored the six facial and vocal responses in the following way. Mouth Opening: the lips of the baby must be widely separated and form an O. Yawning was not scored. Tongue Protrusion: the tongue must be seen to leave the mouth and then to re-enter the buccal cavity, a clear forward thrust of the tongue beyond the lips. Eye Movements: the two eyelids must be seen to close and open making a clear observable blink. Sounds /m/ (consonant), /a/ (vowel) and /ang/ (vowel–consonant combination): any vocal response containing clearly the sounds /m/, /a/ and /ang/ respectively. To assess the intrascorer reliability, the judges

Table 2.1. *Cochran test's Q values for each infant response at each age level (months, except the first one)*

Responses	AGE 32 min	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6
Tongue Protrusion	+++ 10.36	++ 9.14	+++ 13.50	++++ 14.60	+++ 10.36	1.55	1.00	0.00	0.25	0.54	++ 8.90	+++ 12.92	++++ 15.85
Mouth Opening	+++ 9.84	+++ 11.23	+++ 10.66	+++ 12.16	+ 7.16	3.25	1.50	2.33	0.28	1.00	1.00	4.00	2.36
Eye Movement	++ 8.90	+++ 11.23	+++ 9.50	+++ 10.36	++ 8.90	++ 8.60	+ 6.20	+ 7.16	+++ 9.33	4.66	1.55	0.40	0.40
Sound M	2.88	0.00	0.25	0.88	3.71	+ 7.53	++++ 14.72	+++ 13.50	++ 8.76	++ 7.82	3.25	4.00	2.80
Sound A	+++ 10.36	0.25	1.75	2.36	3.71	+++ 11.23	++++ 16.54	+++ 10.36	+++ 10.42	+++ 10.40	2.25	4.33	3.25
Sound ANG	0.36	0.00	1.20	1.00	3.00	++ 8.60	+++ 11.16	+++ 11.63	+++ 11.40	+7.16	2.18	3.60	1.00

Notes:
++++ $p<0.0005$; +++ $p<0.005$; ++ $p<0.01$; + $p<0.025$

scored the data again 15 days later. The first judge's intrascorer reliability ranged from 0.91 to 0.97, and that of the second scorer ranged from 0.93 to 0.98. To assess interscorer reliability the Φ correlation was computed between the scores of the pair of the judges. These correlations were 1.0 in all cases. During the analysis of the infant facial responses, the scorers could see only the baby's image on the screen, while the experimenter's image was hidden by a black cloth.

A general problem with the analysis of this kind of data is that because some responses may occur spontaneously they may be miscounted as imitative. That is, the response frequency after the presentation of the corresponding model (e.g. TP responses to the TP model) should be adjusted to reflect a certain base rate (BR). That is, tongue protrusion (TP) to tongue protrusion models should be decreased by the rate of TP responses to the mouth-opening (MO) and eye-movement (EM) models. Categorical treatment of the data was preferred since there were large individual differences in the frequencies of the infant responses at different age levels. Zero signified the absence of a response and one signified the presence of a response whatever the frequency. For each facial and vocal response at each age level, Cochran's Q test was used to compare the probability of a response after the presentation of the corresponding model with the BR (Siegel, 1956). True imitation can be said to occur only if the babies produce significantly more TP responses after the presentation of the TP model than after the presentation of the other models (MO and EM).

Table 2.1 gives Q values for each response at each age level.

From the first examination in the maternity hospital, the results demonstrate that imitative responses are given significantly more often in the presence of the corresponding model than in its absence, even though these responses also occur in spontaneous neonatal behaviour. On this criterion, neonates, less than 40 minutes old, imitated the facial models of TP, MO and EM. Also, they clearly tried to imitate the sound /a/, but not the sounds /m/ and /ang/. The imitative responses to the sound /a/ were strained. The baby tried hard to emit the sound, and the result was usually an intense explosion of a prolonged and unstructured /a/ sound. The response was sometimes accompanied by stretching hand movements and closed eyes.

Further analysis of the imitators' behaviour during the presentation of the facial models and the sound /a/ showed that neonates used two strategies of attention: the first strategy shown by a majority of the neonates is to try, with a real, observable effort, to direct their attention to the moving part of the experimenter's face. The attention intensifies from a relatively fixed gaze to selective visual exploration. During the presentation of the

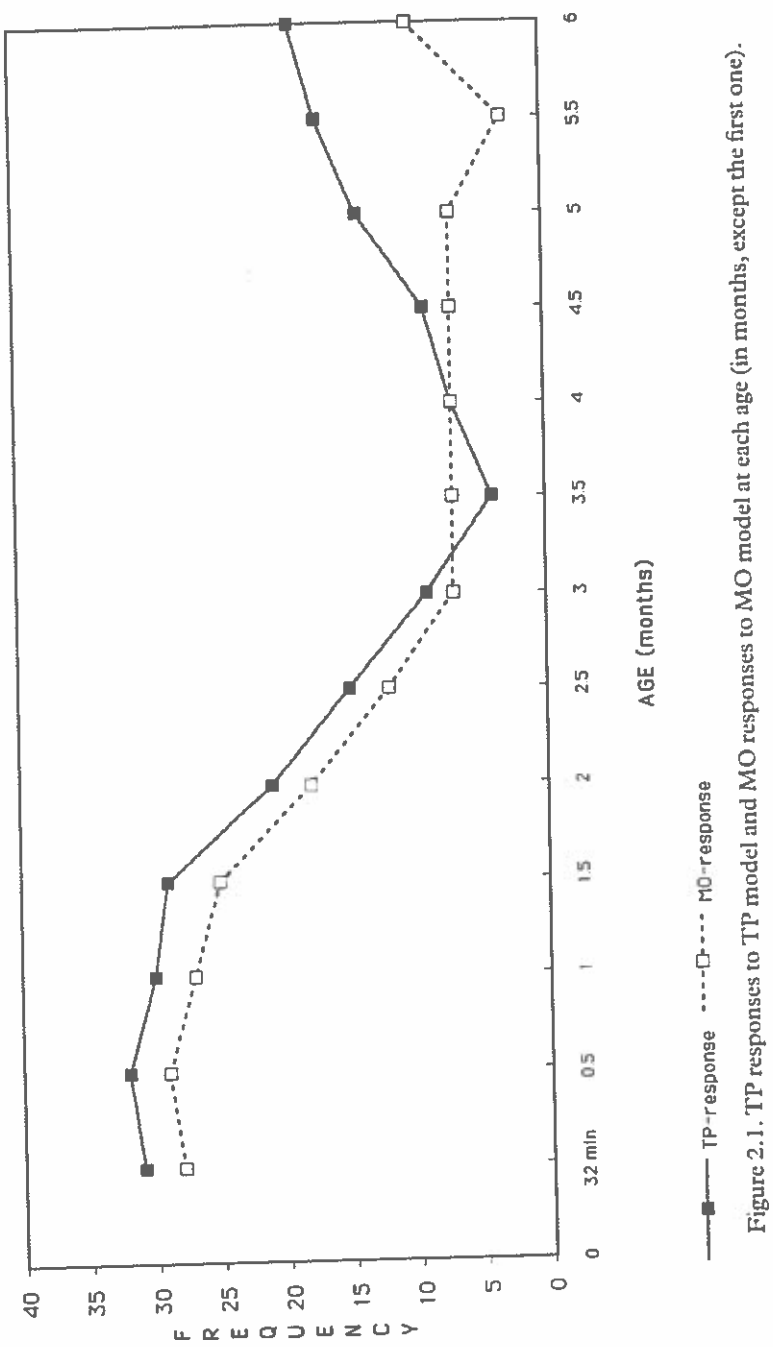

Figure 2.1. TP responses to TP model and MO responses to MO model at each age (in months, except the first one).

sound /a/ model, in the majority of the imitators there was observed a gradual localisation of the sound by head-turning and eye-widening while the brows were held high, a movement which occurs in attentive listening (Rinn, 1984). A second strategy was observed in only a minority of the imitators. In the case of the facial models, the infant looks at the modelled movement hastily, and, as far as one can see from the slow-motion video recordings, it is as if the baby observes only the first presentation and starts reproducing the model immediately. A minority of neonates responded immediately after the first or the second presentation of the sound /a/. Examining the recordings in slow motion, showed eye-widening only during the model presentation time (see Kugiumutzakis, 1985, 1988, 1998).

Three forms of reproductive behaviour were observed in imitation of the facial models: (i) immediate or direct imitation: the neonates reproduce the models once and the similarity of their reaction to the model's action is precise. The EM model was reproduced by the majority of the imitators once. (ii) Successive, improving imitation: the newborns reproduce the model a number of times, and in every additional effort they converge towards a more precise matching. This observation confirms findings reported by Maratos (1973) and Meltzoff and Moore (1977, 1983). The babies follow this pattern mostly when imitating TP and MO models. Sometimes their efforts start with preparatory movements of the tongue inside the buccal cavity. (iii) Successive deteriorating imitation: the first imitative effort is a satisfactory reproduction of the model, and as they continue, neonates do not produce better results. In every additional 'effort' they depart more and more from the result of their first successful effort. It is as if they lose interest in imitation (Kugiumutzakis, 1985). These two strategies of attention and the three forms of reproductive behaviour are not typical either of automatic reflexes or of fixed action patterns.

Figures 2.1, 2.2 and 2.3 represent the frequencies of responses to the corresponding models at each age level.

The development of the imitative responses to the six models as shown by the results (see also Table 2.1) indicate that the infant's ability to imitate remains constant during the first 6 months, but what will or will not be imitated changes. Imitation of TP and MO develops according to a U-shaped curve, imitation of the vocal models in an inversely U-shaped manner and imitation of EM in a negative linear fashion. There was no effect of birth order or gender on imitation.

Smiling, undetermined vocalisations, dinstinct phonemes, tongue protrusions inside the mouth, silent lip and mouth movements, imitation of the rhythm of the vocal models, efforts to grab the experimenter's moving

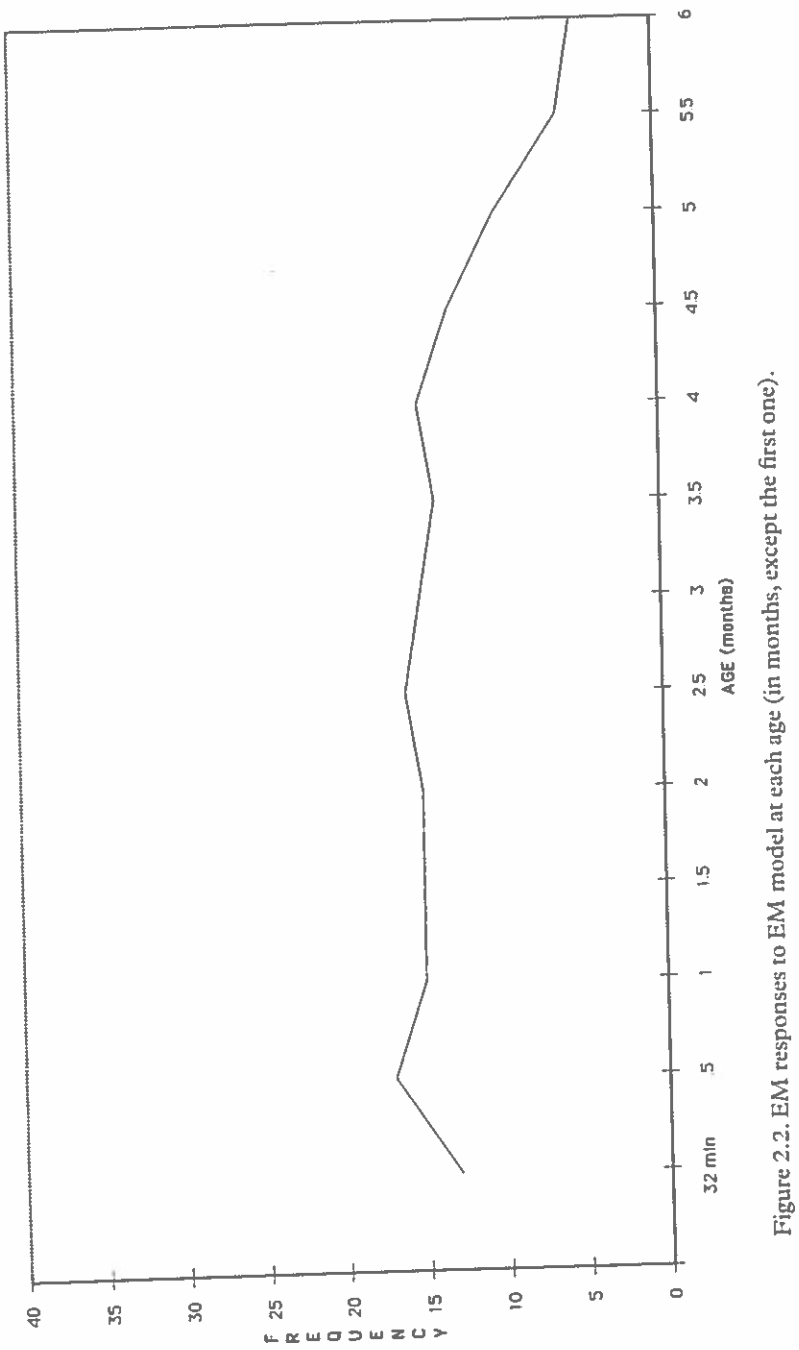

Figure 2.2. EM responses to EM model at each age (in months, except the first one).

facial parts and avoidance responses were observed both when there were imitative responses and when there was no imitation. The first appearance of a smile as a response to the models was observed at 15 days of age. Recently, Kugiumutzakis (1994) observed a smile after the presentation of the models in one infant of two days. The smile appears at all age levels in the longitudinal study, except the first examination in the maternity hospital. Many babies smiled after the presentation of the model and before its imitation, or during and after the presentation of the model, or during the periods of decrease of the different imitative responses.

In addition to the smile, the babies reacted to the models in the periods of decrease of facial imitative responses by cooing, clear vocalisations, inside the mouth TP to the TP model and by yawning to the MO model. Moreover, during the periods of non-imitation and decrease of responses to the vocal models, cooing, silent lip and mouth movements and imitation of the rhythm of emission of the vocal models were observed. Imitation of the rhythm was observed sporadically even immediately after birth, and it appears also during the periods of increase of vocal imitation when the infants imitate both the phonological characteristics of the model and its rhythm. At 5.5 months reaching clearly makes its appearance in imitative interaction. In addition to the accompanying responses, clear avoidance reactions were observed in the infants. They moved their heads or their eyes intentionally away from the experimenter's face. The experimenter then had either to wait a few minutes until the baby decided to return to interact, or to try the examination the next day.

The interconnection between the origin and development of imitation.

The problems of the origin and early development of human imitation have many interconnected aspects. Here, a few of them will be discussed.The longitudinal study confirmed the findings of other writers adding the finding that facial and vocal imitation can occur at even the first 40 minutes after birth (Field et al., 1983; Field et al., 1982; Fontaine, 1984; Heimann and Schaller,1985; Kugiumutzakis, 1985, 1993, 1998; Legerstee, 1991; Maratos, 1973; Meltzoff & Moore, 1977, 1983, 1989, 1992; Reissland, 1988; Vinter, 1986). The results also confirmed Aristotle's notion that human beings imitate by nature, but not his hypothesis that infants are not able to imitate at birth (see Kugiumutzakis, 1998). The present study and four other experimental studies with subjects less than 45 minutes old (Kugiumutzakis, 1985, Studies I – V; 1988; 1998) indicate that the ability of imitation is innate in our species. Given the many functions served by human imitation, its

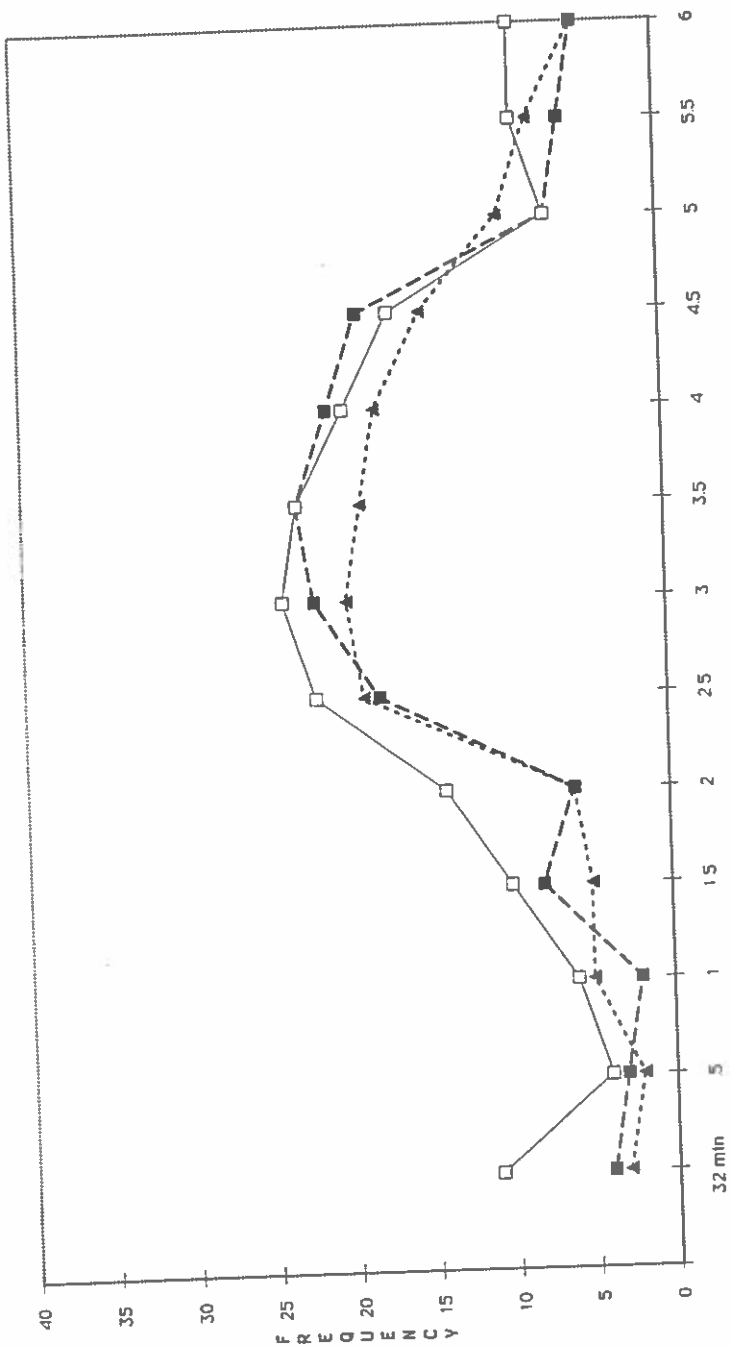

Figure 2.3. Vocal /m-/, /a-/, and /ang-/ responses to /m/-, /a-/, and /ang-/ model, respectively, at each age (in months, except the first one).

innate origin is not surprising. This fact does not exclude either the individual differences in the ability *per se* or the influence of experience in the development of imitation during the lifespan. The contribution of maturation and experience in the development of imitation invites more specific planned, cross-cultural, longitudinal studies, (see Trevarthen, this volume).

In the experimental setting, neonatal imitation is more easily observed under very specific internal states. Namely, a high level of communicative readiness with the baby in a state of quiet alertness (open eyes, regular respiration and lack of gross movements and vocalisation, state 3 in Prechtl and O'Brien, 1982). Secondly, imitation is more readily observed under flexible, experimental conditions. That is, when the modelled movements and sounds belong to the baby's spontaneous repertoire and when the infant regulates the duration and frequency of the stimulus presentation as well as the onset of the response. Similarly, it is observed when the lighting of the experimental room and the posture of the neonate are regulated by the baby's needs and with the facial models presented at a distance of 20–23 cm from the infant's face. The relatively slow accommodation of some quiet, alert newborns to experimental stimuli, flexible adaptation of the presentation of the models to fit the newborns' environmental preferences, changes of alertness and interest and individual differences can greatly improve the predictability and differentiation of responses.

In the present study, as in four other studies with newborns (Kugiumutzakis, 1985, Studies I–IV) two forms of attention were observed during the presentation of the models, three kinds of reproductive behaviour, individual differences in communicative readiness for imitation and active participation of the imitators' whole body. Some alert neonates did not imitate any of the models. This polymorphic emergence undermines the ethological and reflexological interpretations of neonatal imitation. The age of the newborns, the fact that they had no experience that would enable them to learn the correspondences existing in their own face and the face of the experimenter, the fact that they never had seen a mirror, that 75% of the imitators reproduced the models correctly in their first imitative effort and that imitative responses, although present in spontaneous neonatal behaviour, are given significantly more often in the presence than in the absence of the corresponding model, undermine the behaviouristic and Piagetian interpretations on the origin of human imitation (see also Kugiumutzakis, 1985, 1988, 1993, 1998; Maratos, 1973, 1982; Meltzoff and Moore, 1977, 1983, 1989).

Both in the first examination in the maternity hospital and later in the infants' houses, the babies imitated TP and MO models more easily and

more often than EM models which were imitated only once and with clear difficulty by the great majority of the infants. One possible reason is that the oral region is controlled by many agile, small muscles that permit movement in many directions while the upper part of the face is controlled by fewer less differentiated muscles that do not permit movement in many directions. In addition, the muscles that move the mouth and especially the tongue have more proprioceptive receptors than the muscles that move the eyes (Rinn, 1984). Moreover, there are differences in how parts of the face are represented in the so called topographic map of the body's muscles, located in the anterior lip of the central sulcus of the cerebral cortex. The size of the 'representation' of each face part reflects the corresponding degree of fine motor control (Rinn, 1984). The 'representation' of the oral area is much larger than that of the upper face area. Also, in the brainstem there is a column of cell bodies making up the facial nerve nucleus. Specific cell groups in this nucleus map specific peripheral parts of the facial nerve. Those cell groups that innervate the muscles of the mouth are larger than the ones that innervate the upper face (Rinn, 1984). These data suggest that the control of the oral region develops earlier, which may explain why the baby is able to imitate oral models so much better, and why neonates make immediate or direct imitation when they reproduce the EM model.

Also, in the first examination, the neonates imitated (or better, tried to imitate) the sound /a/, but not the sounds /m/ and /ang/. According to Ferguson (1978, pp. 278–9), the progression of myelinisation in the primary motor cortex goes from the back of the mouth to the front. The emission of the sound /m/ requires neuromuscular control of the front part of the mouth and the neonate's vocal system is less mature for such an achievement. The vocal model of /ang/ may, likewise, be too difficult for imitation by babies less than 40 minutes old. The emission of the sound /a/, which is a non-front vowel (see Kugiumutzakis, 1985), is evidently easier for them; the sound appears in crying and in other vocal emissions observed during the first hour of life. Two months later, the babies are able to imitate all three sounds much better, as we have found in the present longitudinal study and in another, naturalistic, longitudinal study (Kugiumutzakis, 1993).

In an effort to offer one possible explanation of this complex, social phenomenon of neonatal imitation, it can be assumed that, after the presentation of the model and before the first, correct, imitative response, the neonate has to try to perceive the models clearly. These observable efforts can be considered as a conscious neonatal activity, seeking and regulating experience. The neonate must also discriminate the self and the other as two separate persons coexisting in the same 3-D

space, both involved within an interacting unit. This is evidenced by the fact that 77% of the neonates in the present study (see also Kugiumutzakis, 1985, Studies I – IV, 1988, 1998) reacted after the fifth presentation of the models, although they had the opportunity to interrupt the experimenters' actions and that 75% of the imitators reproduced the models correctly in their first imitative effort. This initial dualism (see Butterworth, 1981; Kugiumutzakis, 1988, 1998; Neisser, 1993; Trevarthen, 1977, 1993) means that neonates have some awareness of their body parts and of themselves in relation to others as evidenced in turn taking as a core characteristic of the human ability for dialogue. Furthermore, the infant must recognise that his own unseen, unmoving mouth corresponds to the experimenter's moving mouth. This crucial recognition must happen before the start of the reproductive movements, for otherwise one cannot explain the correctness of the first imitative movement. The majority of the imitators made a TP response to the TP model from the start. Whatever this mechanism is called (see Kugiumutzakis, 1985, 1998; Maratos, 1982, 1998; Meltzoff and Moore, 1977, 1983, 1989) it is, by logical and psychological necessity, recognition of face isomorphism, a part of the initial dualism, a pre-condition of neonatal imitation, which supports the idea of a non-reflex intermodal co-ordination functioning at birth (see also Butterworth and Hopkins, 1988). The infant must also detect the experimenter's intention and motivation for communication through imitation, when the model is being presented. It is proposed that the neonate may detect the defining invariants of the experimenter's motivation for communication, which lie behind the kinematic and acoustical surface of the models (Kugiumutzakis, 1985; see also Gibson, 1979; Michotte, 1946/1963; Runeson and Frykholm, 1983; Trevarthen, 1986; Vedeler, 1991). One may speculate that the neonate detects that the modelled movements and sounds are incomplete and that it is the baby's turn and task to act and feel in a complementary way in the form of an imitation (Kugiumutzakis, 1992, 1994, 1998). Direct perception of this psychological invariant may answer the fundamental question: how does the neonate detect that the modelled movements and sounds are presented in order to be imitated ?

Finally, the infant, during the imitative interaction, may feel two emotions: pleasure and interest. The recognition of the modelled movements and sounds as incomplete may evoke the emotion of interest. This requires the infant to be in possession of tools of communication in the behavioural repertoire, while the recognition of the other as a partner for intersubjective games may evoke the pleasure of being together. Both pleasure and interest may motivate the complementary, co-operative,

social, imitative game (see Kugiumutzakis, 1998; Bråten, 1988, 1992, 1994; Maratos, 1998; Nadel, 1980; Trevarthen, 1993).

The longitudinal study also shows that the ability to imitate remains constant during the first 6 months of life despite the fact that what will be imitated changes. Selective imitation never disappears during the first 6 months. When, at 2 months, infants' imitative behaviour to the TP and MO models declined (in a U-shaped curve), the babies continued to imitate the EM model (on a negative linear developmental course), and, at the same age, they began to imitate the vocal models systematically (on an inverse U-shaped developmental curve, Figures 1, 2 and 3). Clearly, one cannot draw general conclusions about the early development of imitation from measurements of just one kind of response. Both linear and non-linear development can be observed, depending on which response is selected. Thus, Jacobson's (1979) hypothesis, that imitative ability declines as certain reflexes do, is not supported because the imitative ability *per se* never declines or disappears. For the same reasons, Dunkeld's (1978) hypothesis that imitation declines because the mothers do not reinforce certain unacceptable behaviours, is not supported. In fact, the infants continued to imitate another model (EM) and they started to imitate systematically new vocal models, while after the fifth month the imitation of the TP model again increases. Field et al.s (1986) hypothesis, that the decrease in imitation of facial models is related to a decline in infant attentiveness, is not supported because the infants continued to imitate the EM model and also continued attending to the TP and MO models, despite the fact that they did not imitate them.

Piaget's (1962) theory of imitative development in six invariably ordered stages is not supported by this (and other) studies, because, contrary to his assertion that sporadic imitation appears after the first month, the present study shows that systematic imitation occurs from the first 40 minutes. Also, he claims that infants imitate first the visible parts of the body (hand models), while the present study shows that they imitate the non-visible parts earlier. Where Piaget asserts that training is necessary for facial imitation at the end of the first year, the infants in the present study imitated the facial models without the aid of training. Where Piaget says that vocal imitation precedes facial imitation the present results show the opposite, and, finally, where Piaget asserts that self-imitation precedes and leads to hetero-imitation, the present data show that imitation of other people occurs immediately after birth. Thus, imitation may develop in stages, but the stages are not the ones Piaget proposed, at least during the first 6 months. Despite Piaget's tremendous work in developmental psychology and his meticulous observation during infancy, his theory of infant imitation needs some fundamendal revision.

The results are in agreement with Maratos' (1973) findings concerning the non-linear course of the MO and TP imitative responses. However, the negative linear course of the EM imitative responses indicates that linear and non-linear developmental changes coexist throughout the 6-month period. Maratos' hypothesis that the decrease in early imitation occurs because the infant's capacity for processing incoming information is momentarily lost, is not supported by the present data. After the decrease of the imitative responses to the TP and MO models, the assumed capacity for processing incoming information is still functional for imitation of the vocal and EM models. However, the longitudinal study is in agreement with Maratos' thesis that the decline of the oral imitative responses coincides with an increase in vocal imitative responses because vocalisation is a more powerful form of communication in mother–infant interaction (see Kugiumutzakis, 1985; Maratos, 1973, 1982; Trevarthen, 1977, 1986). It is also interesting that the pattern of development of the vocal imitative responses is almost the mirror-image of that for the oral responses (Figures 2.1 and 2.3). It is as if the imitation of the oral models (tongue protrusion and mouth opening) is replaced by vocal imitation, that is, by another more productive form of imitation, emanating from the same facial part, the oral cavity. The change of locus of imitation from visual to auditory modality may reflect the onset of maturational changes at the sensory level, a temporary sensory substitution given that imitation of TP starts to increase again after the fifth month and the selective character of early infant imitation is to serve intersubjective communication with the best available means. Despite the stability of imitation during the 6-month period, the ups and downs (linear, non-linear and negative developmental courses) may occur because of periodic reorganisations in the infant's motivational system, a type of development presumably related to anatomical changes in the brain, which are known to be extensive at this early age (Trevarthen, 1982, 1986; Kugiumutzakis, 1993). These reorganisations lead to motor, perceptual, emotional and cognitive changes, motivating the infants to seek 'fresh stimuli' in their imitative games, as Guillaume (1925) proposed many years ago (for alternative hypotheses see Butterworth, 1989).

Recently Maratos (1998, see also Maratos, 1973) described in detail the differences of the imitative response to the TP model during the neonatal period and at around 8 to 9 months. For example, she describes differences in the latency of the TP response, and its accuracy. The present study adds the information that imitation to the TP model appears systematically during the first 2 months, then it decreases to reappear systematically again at 5–6 months (Table 2.1 and Figure 2.1) and then it probably decreases to re-appear systematically at 8 or 9 months. At 5 months, the

infant looks at the model carefully, usually smiles and then, after a very short latency, imitates once and perfectly. Despite the differences in motor and perceptual activity observed in the imitative responses across the three time intervals, these infant reproductions can be regarded as being governed by the same motives and emotions. However, after the second month, imitation serves in a more amusing and teasing way in the smart, free games of confirmation and disconfirmation of the other's expectations, which are characteristic of *homo ludens* (Reddy, 1991).

Neonatal and early infant imitation as a basic means of human interaction does not occur in a communicative vacuum. As noted earlier, smiling, cooing, clear and undetermined vocalisations, distinct phonemes, inside mouth TPs to the TP model, silent lip and mouth movements, imitation of the rhythm of the vocal models, efforts to grab the experimenter's moving facial parts (after the 5.5 month) and avoidance responses were observed in the present study when there were imitative responses as well as when there was no imitation or decrease of imitation. This finding invited further investigation, but experimental studies, even with a flexible design, are not planned to investigate the communicative frame of early imitation (see Trevarthen, 1986). In another naturalistic, longitudinal study we tried to investigate spontaneous vocal imitation in 21 mother–infant pairs from the fifteenth day after delivery to the sixth month, every 15 days, in the home environment, during their free-play interactions (Kugiumutzakis, 1993). The analysis showed that: mothers imitated the vocal sounds of their infants more frequently than vice versa (73% maternal and 27% infant vocal imitative responses); the mean number of vocal imitations was relatively low (one vocal imitation in 3 minutes); vocal imitations were extraordinarily fast (mean 3.2, SD 3.5 sec, a median of 2.2 sec and modes in the area of 1.0 to 1.4 sec). Turn taking was the rule (only 7.3% of the corpus was overlapping imitation); the mothers imitated both sexes to the same extent, no significant differences were found between the vocal imitations of girls and boys while both groups followed the same pattern of significant change in the number of imitations with age. The majority of vocal imitations took place in simple sequences (64% two turns/one round); imitation of speech sounds was significantly more frequent than imitation of non-speech sounds. The temporal pattern remained stable throughout the period of study, with the exception of an interesting increase in the duration of the infant's imitations after the third month, while the number of the vocal imitative episodes changes with age, following approximately a third-degree polynomial curve. The latter finding confirms the present study concerning the inversely U-shaped curve of the vocal imitative responses. The vocal imitations analysed in this naturalistic, longitudinal

study (Kugiumutzakis, 1993) showed the same temporal pattern, the same turn-taking nature, a less relaxed quality and the same pattern of developmental change as has been described for maternal speech to infants in conversational play during the first 6 months (Fernald, 1989; Trevarthen and Marwick, 1986). These social, mirroring, exchanges may be described as a part of the mother–infant intersubjective communication. They were clear, selective vocal games, in which the reproduction of the sound was probably the result of mutual regulation of their central states of motivation. During the early months, the most basic function of imitation (and the first to appear) in mother–infant (and, in part, in stranger–infant) interactions is an interpersonal sense of communicative sharing. But what kind of sharing?

In neonatal and early infant imitation, parents and infants appear to share the same 3-D space, the same companion space, the same tendency to act and interact in turns, the same temporal pattern, the same ability for self–other discrimination, the same ability for recognition of face and voice isomorphism, the same code of communication, the same ability to read each other's motives and intentions, the same transient emotions, the same innate ability to imitate each other's actions and the same developmental changes in early infancy. Certainly they do not share many things, but what they do share is enough for the first emotional contacts (Bråten, 1988, 1992, 1994; Kugiumutzakis, 1985, 1988, 1993, 1998; Trevarthen, 1986, 1993). Developmentally, imitation first serves communication, and then, at around the fifth month in the frame of communication, it begins to serve learning and novelty.

In enunciating the above hypotheses the concept of mutuality is intentionally avoided although it is a basic characteristic of intersubjective communication (Nadel, 1980; Trevarthen, 1980, 1986; Užgiris, 1981). The reason is obvious. The experimenter, even with the flexible experimental design, did not reciprocate by imitating the neonatal and early infant behaviour, as happens in natural parent–infant interactions. Infant imitation in experimental conditions have helped us to reconsider our conceptions about the cognitive, social, perceptual, emotional and motor abilities of neonates and young infants (see also Hobson, 1993; Nadel and Pezé, 1993). At the same time, the lack of spontaneous, mutual imitative behaviour on the part of the adult in all the experimental studies does not permit the babies to experience the mutuality reported from naturalistic studies (Kugiumutzakis, 1993). Experimental neonatal and early infant imitation is a semi-natural kind of interaction that may both release some infant abilities and block others, and for that reason the experimental studies of infant imitation require completion by naturalistic studies.

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