Infants Learn to Imitate by Being Imitated

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***Abstract* – An account is outlined in which the development of imitation in human infants relies on associative learning rather than on innate knowledge. Initial studies that support this learning account are reported.**

I. Introduction

It is widely accepted among developmental scientists that the ability to imitate is innate and probably inherited. The basis for this belief is a series of reports, beginning in 1977 [1][2][3], that newborn infants will imitate the behavior of an adult model. Specifically, infants have been reported to imitate mouth opening, tongue protruding, pouting, sequential finger movements, and head turning very shortly after birth. Note that, with one exception, these are all behaviors that infants cannot see themselves do. The claim that newborns imitate is therefore a claim that, at minimum, newborns have some way of representing the visual input from the model's behaviors, some way of representing the proprioceptive consequences of their own performance of the same behaviors, and some way of matching those two representations in different modalities. Additionally, and not trivially, it is a claim that newborn infants are motivated or obliged to make that match and to act to reproduce the experience that gave rise to the proprioceptive representation.

Since its first appearance, the claim that imitation is innate has been implausible to many, but to others the evidence has seemed to compel this interpretation. In this paper, I will present an alternative, more parsimonious explanation for the results of newborn imitation experiments. With empirical support for innate imitative abilities seriously weakened, I will outline an alternative developmental account – one that draws heavily on Piaget's [4] description of the development of imitation, and adds associative learning as the major mechanism of developmental change. In brief, I will propose that infants learn to imitate in the context of being imitated by their caregivers – or more accurately, that infants learn in certain kinds of social interactions much of what they need to know in order to be able to mimic the muscle movements of others. Finally, I will summarize the main results of my first attempts to test aspects of this learning account.

A. Reinterpreting the evidence for newborn imitation.

Because the belief in an innate capacity for imitation is so widespread both within and beyond psychology, presentation of the argument against this claim seems a necessary preamble to the presentation of a different developmental account. Although it cannot be shown that newborns *do not* imitate, it can be shown that the evidence that they *do* imitate is poor.

In newborn imitation experiments, infants are typically shown two different behaviors – in a large majority of cases, mouth opening and tongue protruding. Both are behaviors that infants produce spontaneously. In the experiment, however, it is reported that infants selectively increase their production of each behavior after seeing that particular behavior modeled. Thus, for example, infants are said to increase their rates of tongue protruding in the presence of a tongue protruding model, and increase their rates of mouth opening in the presence of a mouth opening model [2].

It is vital that the same infants selectively match two different behaviors in a single experiment if the imitation interpretation of infants' behavioral matching is to go through. If they increased their production of only one behavior, that increase might reflect an increase in the infant's arousal or other generalized response to the model's display. It is important, then, that Anisfeld, in two thorough reviews of newborn imitation experiments [5][6], found evidence for newborn matching of only one behavior across experiments and across different laboratories. That behavior is tongue protruding.

Anisfeld's findings focus attention on the place of tongue protruding in the newborn behavioral repertoire. Anisfeld proposes that tongue protrusions are a product of generalized arousal in the infant [6]. I have argued elsewhere [7][8] that tongue protrusions are more specifically a subset of the tonguing movements that serve oral exploration. This idea is based on evidence from a variety of sources. First, newborns have been shown to learn about objects in their mouths by tonguing and mouthing them [9]. Thus, oral exploratory behavior is functional in the newborn period, and tongue movements are part of it. Second, newborns have been reported to protrude their tongues in response to a number of stimuli outside the mouth, including a touch on the palm [10], the sight of a looming and receding black pen [11], the sight of a box with a bright blue lining opening and closing [12], randomly blinking colored lights [7], and short segments of the Barber of Seville Overture [8]. Thus, tongue protruding is a common response of newborn infants to a wide range of proximal and distal stimuli in different sensory modalities. Third, infants' rates of tongue protruding are higher when the infants show (by their persistent looking) more interest in a stimulus [7]. Finally, two young infants showed a strong tendency to protrude their tongues while looking at interesting objects dangled within arms length. However, this tendency lasted only as long as the infants were unable to produce directed reaches. When the infants succeeded in reaching to and grasping the objects [7], tongue protruding

disappeared. Together, these findings suggest that tongue protruding is an extension of the infant's tonguing and other mouthing behaviors on interesting or arousing stimuli inside the mouth, to objects of interest outside the mouth.

Data showing that tongue protruding is a general response to interesting or arousing stimuli considerably weakens empirical support for the claim that newborns can imitate. Together with evidence that very young infants find a tongue-protruding adult more interesting than a mouth-opening adult [7], the link between interest in or arousal and tongue protruding suggests an explanation for the major finding of neonatal imitation experiments. That is, tongue protruding in response to a tongue protruding model may well be a coincidental match between a stimulus infants find interesting and a characteristic response of interested infants. If so, then it follows that the ability to imitate is not shown to be innate. Instead, it may have a postnatal developmental course worthy of investigation.

B. *A Piagetian/learning account of the development of imitation* [13].

Before the idea that imitation is innate took hold, the dominant account of the emergence of imitative abilities came from Piaget [4]. Briefly, Piaget held that imitation has its roots in the repetitive behavioral sequences ("circular reactions") typical of infants' from about the 2nd to the 8th month – and especially in their vocal repetitions. In his account, young infants happen on behaviors that produce interesting effects, and they repeat those behaviors to recreate or prolong those interesting effects. An infant initially will match a model's behavior only if that behavior is already one of his own well-practiced responses. So, for example, an infant who enjoys repeating the syllable 'ba' will appear to imitate his mother if she makes a 'ba' sound similar enough to his own production to have the same effect – inducing him to produce another instance of the sound – as if he had made the sound himself.

Piaget thus drew attention to the importance of the *caregiver's* imitation of the *infant* in creating the first behavioral matches between the two. Note that at first, there is no reason to suppose that the infant recognizes the match between his own and his caregiver's behavior. Instead, the infant simply repeats behaviors that produce interesting events. Although Piaget did not discuss these events in terms of associative learning, this is clearly an example of operant conditioning.

As a result of the associations acquired in such situations, subsequent encounters with the caregiver's behavior, or with its effects, will cue the infant to produce the associated response. Piaget particularly emphasized the importance of behavioral effects, especially sounds, as cues that could come to elicit behavioral matches from infants. Again, although Piaget did not explain the development of imitation in terms of associative learning, this mechanism is clearly implicated

Caregivers' imitations of their infants' behaviors repeatedly put the sight of a specific behavior together with proprioceptive feedback from production of the same action. This juxtapositioning of the visual with the proprioceptive should lead to the formation of associations between them. In addition, it is possible that infants discover the amodal properties – like rhythm and intensity – common to both experiences, and that perception of these common properties heightens the infant's attention to the pairing of the two behaviors. Thus, the caretaker's imitation of the infant may provide multiple opportunities for the infant to map her own movements and body parts onto those of her social partner. I propose that this kind of learning leads to the ability to mimic the movements of others.

I have begun to look for evidence to test this account. In what follows, I briefly report the results of 3 studies addressing the following predictions:

1) that infants develop the ability to *emulate* a model's behavior – that is, to produce the same outcome, in this case a sound – before they develop the ability to *mimic* a model – that is, to reproduce the specific movements they observe.

2) that infants develop the ability to mimic behaviors they can see themselves perform before they develop the ability to mimic actions – like tongue protrusions – that they cannot see themselves do.

3) that caregivers imitate their young infants but young infants do not imitate their caregivers.

4) that infants detect a difference between the imitative responses of their social partners and other forms of contingent responding.

II. Empirical Evidence

A. *A case study of the emergence of mimicry* [13].

One female infant, Yo-Ann, was videotaped at weekly intervals between the ages of 3 and 16 months in an attempt to capture the emergence of the ability to mimic, and to learn something of its antecedents. At each session, Yo and her mother spent 10 minutes in natural interaction that at later ages included concentrated attempts to elicit mimicry of the mother's actions.

In the first few sessions, Yo's mother was blind to the purpose of the study but knew that I was interested in infant imitation. She spontaneously and unconsciously imitated her baby despite deliberate attempts not to do so. In later sessions, she collaborated in the attempt to elicit behavioral matching from her daughter.

The baby began a little before age 1 to reproduce certain of the mother's behaviors. All were behaviors that Yo had spontaneously and repeatedly produced at home and that her parents had repeatedly imitated. For example, when Yo raised both arms, her parents imitated the action and said "Bonsai!" In laboratory demonstrations of such interactions, the sequence was as follows: mother imitated something the baby did, invariably with an accompanying sound. After many such pairings, the baby reproduced the

action on cue – the cue being either the action with the sound, or the sound alone, but never just the action alone. The strong impression was that the baby was producing the action either in order to reproduce the sound, or in response to a sound cue, but not as an action match to the sight of the mother's behavior. For example, at 10 months, Yo responded to her mother's production of "la-la-la" sounds, made with a wide open mouth and exaggerated tongue movements, with wide-mouthed "la-la-la" sounds of her own. However, when Yo's mother made exaggerated tongue movements without the sounds, Yo did not respond. It seemed clear that Yo did not know what action she herself was doing when she made the "la-la" sounds, and so did not recognize the tongue movements that her mother made and could not reproduce them. Instead, she reproduced the sounds and it just so happened that she moved her tongue to do so. It seemed clear that if Yo had been able to find her tongue at birth, she had lost that ability by 10 months of age.

By 13 months, Yo could reproduce novel behaviors within minutes of their introduction – but sound cues still seemed to be important, and she did not reproduce behaviors she could not see herself do. In particular, despite her mother's extensive training attempts, Yo did not mimic tongue protrusions until 14 months of age.

We were struck by how closely Yo's progress followed Piaget's description. Her first behavioral matches were behaviors (1) that she had spontaneously produced and repeated in "circular reactions"; (2) that her parents had imitated extensively at home; and (3) that produced sounds. Sounds appeared to be the initial link between the parents' movements and Yo's movements: that is, the initial match was between the *outcomes* not the *forms* of behavior. Sounds remained important as cues when Yo began to match her mother's actions. Finally, Yo matched behaviors she could see herself do before behaviors she could not see herself do.

B. A cross-sectional study of the emergence of emulation and mimicry [14].

In this study, I asked whether most infants, like Yo, begin to emulate (to produce matching outcomes) before they begin to mimic specific behaviors, and begin to mimic behaviors they can see themselves do before they begin to mimic behaviors they cannot see themselves do.

"Emulation" is matching an *outcome* produced by a model, with no requirement that the actual motor behavior should match that of the model. For example, a child sees a model push a button using two fingers, and sees a light come on with each push. The child then pushes the button by moving her hand and arm as a unit. The infant reproduces the observed outcome – the light – but not necessarily the specific motor sequence produced by the model.

In order to emulate, the infant must note the model's behavior; note the relation between the model's behavior and the object (the button); note the outcome of the model's behavior; note the relation between the model's action on an object and the outcome; hold all of the above in memory; be motivated to produce the outcome; and be capable of producing some behavior that generates the outcome.

"Mimicry" is behavior that matches or closely approximates the movements of another. There may or may not be a functional outcome of the behavior in addition to reproducing the pattern of movement.

In order to mimic, the infant must note the model's behavior; be motivated to produce the same behavior; be able to identify the part(s) of the body moved by the model; be able to identify those same parts of their own body; recognize the mapping of the body parts of the model and the infant's own body; be able to represent the direction, speed, and "shape" of the movement(s); be capable of producing controlled muscle movements to effect action(s) with the same characteristics.

Infants 8, 10, 12, 14, 16, 18, and 20 months of age, 20 at each age level, participated. Each infant watched as his or her mother modeled 4 different behaviors. Each behavior was modeled for 3 minutes, giving infants ample time to reproduce the behavior if they were able (and motivated) to do so. The behaviors varied on two dimensions – whether or not the action produced a sound, and whether or not the infant could see him or herself do the behavior. The modeled actions in each category are shown in Table 1. Each infant received one of 8 combinations and orders of actions, 1 from each category.

	SOUND	**NO SOUND**
VISIBLE	Tap table Clap hands	Forearm wave Sequentialfinger movements
NOT VISIBLE	'Aaaah' 'Eh-eh'	Both hands to top of head Tongue protrusions
	EMULATION	**MIMICRY**

Table 1. Four categories of behavior modeled for infants by their mothers. Each infant saw 1 behavior from each category.

I measured the numbers of infants at each age level who produced each modeled behavior (1) within the 3 minutes during which that behavior was modeled; and (2) during the modeling of the other 3 behaviors.

The first question is, how common is it to find infants matching their mothers' behaviors across this age range? Fig. 1 shows the extent to which matching was found at each age level, by presenting the cumulative percentages of infants at each age who matched 0, 1, 2, 3, or 4 of their mothers' behaviors.

As Fig. 1 suggests, infants differed little on this measure from 8 to 16 months of age. It was not until 18 months that a majority of infants matched more than 2 behaviors, and not until 20 months that more than half of the infants matched 3.

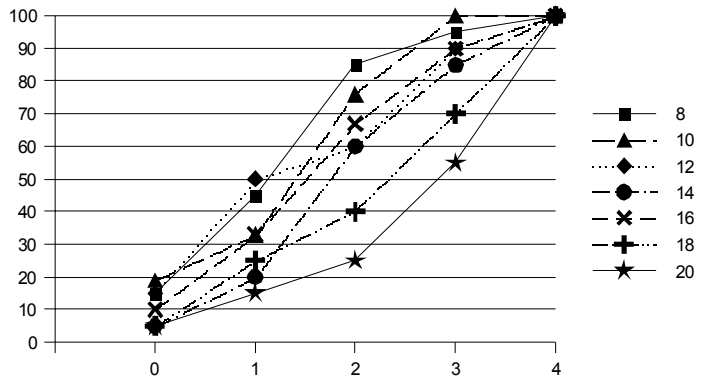

Fig.1. Cumulative percentages of infants at 7 age levels that matched from 0 to 4 behaviors, collapsing across behavioral categories. Each of the 4 behaviors was modeled by the infant's parent for 3 minutes. Compare the number of behaviors matched by at least 50% of infants at each age level.

Chi-square tests confirm that the distributions of infants aged 8 to 16 months do not differ, and that those at 18 and 20 months are also not significantly different. However, there are significant differences between the distributions at 14 and 18 months, and at 16 and 20 months. Thus, there appears to be a change in infants' ability or willingness to match their mothers' behaviors at around 18 months of age.

Which categories of behaviors do infants match first? As the data in Fig. 1 imply, there was considerable overlap across age groups in the numbers and kinds of behaviors matched by individual infants. Thus, rather than examine matches at each age level, I grouped infants across ages by the number of behaviors they matched, and then asked which categories of behavior were most likely to be matched by infants who matched only one behavior, by those who matched two, and by those who matched 3 behaviors. The results are illustrated in Fig. 2.

Infants who matched only one behavior overwhelmingly matched an action that made a sound and that they could see themselves do. Infants who matched 2 behaviors were still most likely to match in the Visible/Sound behavioral category. Their matching frequencies descended across the other 3 categories in the order predicted by the learning account. Finally, infants who matched 3 behaviors distributed their matching responses more equally over the 4 behavioral categories. Thus, emulation is prior to mimicry as infants begin to display behavioral matching. In addition, the data indicate that, as predicted by the learning account, infants initially and most readily match behaviors that produce sounds and that they can see themselves do. Only when matching is well-established are they likely to match behaviors that lack sound cues and that they cannot see themselves do.

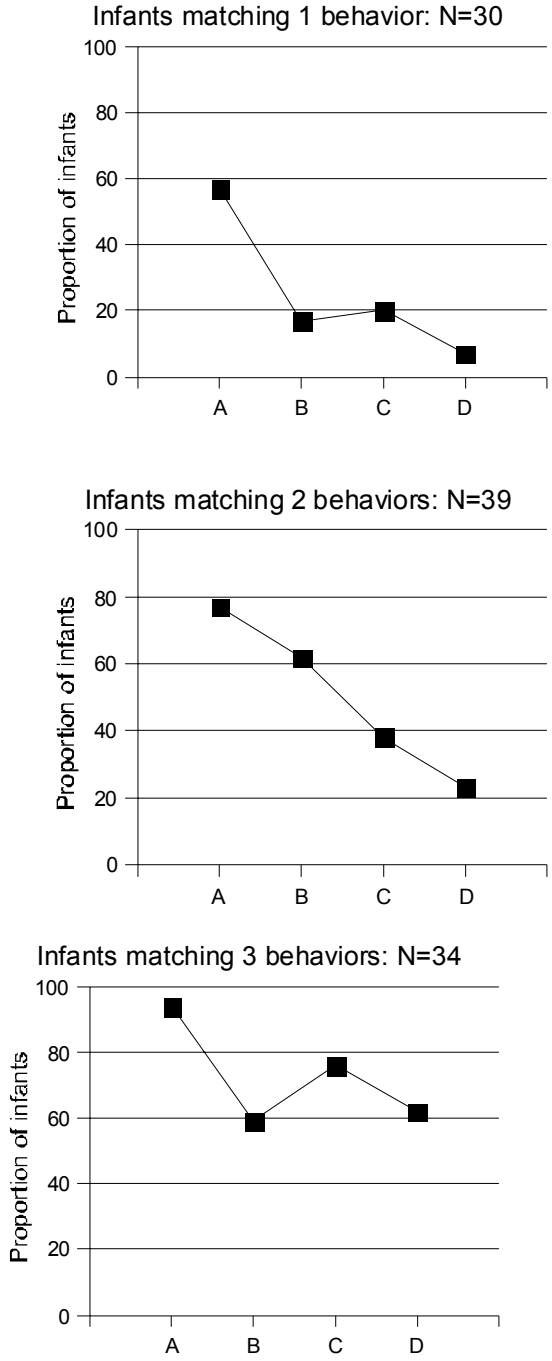

Figure 2. For all age groups (N=142), numbers of infants who matched 1, 2, or 3 behaviors, and the categories of behaviors they matched. Behavioral categories were: A) emulation with visual feedback; B) emulation with no visual feedback; C) mimicry with visual feedback; D) mimicry with no visual feedback. Fifteen additional infants matched no behaviors, and 18 infants matched all 4.

In summary, the developmental trend appears to be:

a) *emulation*, followed by…

b)*mimicry* that provides visual as well as proprioceptive feedback, followed by …

c) *mimicry* that provides proprioceptive feedback alone.

Three other findings are worth noting. First, as described by Piaget, younger infants who matched Category A behaviors did not produce accurate copies of the model's movements. For example, some infants tapped the table with their feet. These infants used the wrong muscle to make the wrong movement but nevertheless produced the right outcome.

Second, and again as described by Piaget, among infants matching movements that they could not see themselves perform, we observed an intermediate stage in which the infant moved some of the right muscles, but in the wrong way. For example, the infant in Fig. 3, who is watching his father perform tongue protrusions, has clearly found the region of the body where his father's movements are located, but has not found the right muscles to reproduce those movements.

Fig. 3. A 10-month-old infant responds to his father's repeated tongue protrusions with intense mouth opening.

Finally, Fig. 4 shows the proportions of infants at each age level who produced tongue protrusions while their parent was modeling that behavior. The relatively low proportions of infants that match tongue protrusions before 16 months of age provide additional evidence against the claim that infants can imitate a tongue protruding model from birth.

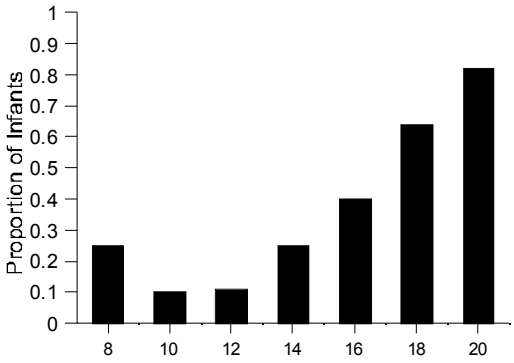

Fig. 4. Proportion of infants at each age level who produced tongue protrusions while their parent modeled tongue protrusions.

C. *Detection and production of behavioral matching in 8-month-old infants* [15].

This study addressed two different questions about imitation in 8-month-old infants. First, how much behavioral matching is produced by mothers and by infants during natural interactions between the two? Secondly, can infants at 8 months of age detect a difference between their mothers' imitative versus other contingent but non-matching responses to the infants' own behavior? The idea here is that there might be something about being imitated – for example, the repetition of the amodal properties of the behavior – that would draw the infant's attention to the match.

In the experiment, infants and their mothers participated in 3 types of interaction, each for a period of 3 minutes. All mother-infant pairs began with a Baseline period in which mothers were asked to interact with their infants naturally as though they were at home. In an Imitation condition – one of 2 conditions following the Baseline condition that were counterbalanced across infants – mothers were instructed to imitate all of their infants' behaviors, except their leg movements. In the remaining Contingent Responding condition, mothers were asked to respond to all of the same kinds of behavior with the drawn-out words "Yes" and "Good".

Mothers' and infants' mouth pursing and eye widening within the same 3 sec. periods during natural interactions in the Baseline period were counted to determine how much each partner matched the other's behavior. Infant matching occurred at a very low rate (M = 0.125/min, sd = 0.24) and was likely to have occurred by chance. However, mothers reproduced their infants' facial actions at a rate of about 1 instance per minute (M = 0.94, sd = 0.58).

The frequencies of infants' smiles produced during the Imitation and Contingent Responding conditions were examined for evidence that the infants discriminated between the two kinds of responses and preferred the imitative responses. As Fig. 5 shows, the infants produced more smiles during the Imitation condition.

This study provides a snapshot of behavioral matching at one age level. It shows that infants at 8 months do not spontaneously imitate their mothers' behaviors. However, mothers do imitate their infants, and when they do, infants appear to notice and enjoy something in the experience of being imitated that sets it apart from other contingent responding.

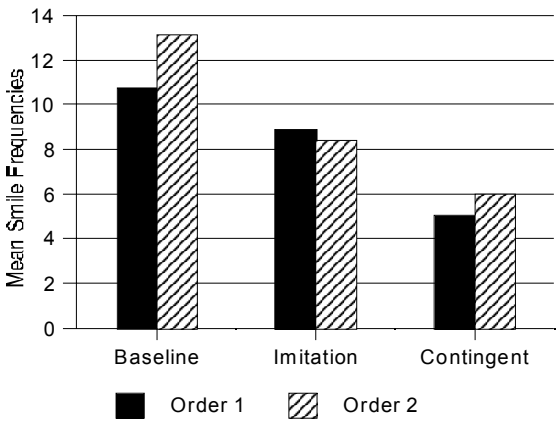

Fig. 5. Infants' mean smile frequencies during 3 min. periods of natural interaction with their mothers (Baseline), imitation of all of their actions by their mothers (Imitation) and stereotyped contingent responses to all of their actions by their mothers (Contingent).

III. Conclusions

There is good reason to doubt current claims that infants can imitate adult behaviors from birth, and that imitation is therefore an innate competency in humans. I have outlined an alternative account of the origins of imitation derived largely from Piaget's [4] description of behavioral matching across infancy, with the addition of associative learning as the primary mechanism driving change. This account strongly implies that imitation is not a specific competency but instead is a way of using knowledge acquired via domain general processes. By this account, any associative learning entity should be able to develop the ability to imitate. However, it is clear that many such entities, including many primates, do not display imitative behaviors [16]. This may be because the acquisition of imitative abilities depends on the acquisition of specific kinds of knowledge – for example, knowledge of the equivalencies between one's own body and movements and the bodies and movements of others – which in turn clearly depends on certain kinds of experience. In particular, the present learning account implies that a necessary condition for learning to imitate is having one's own behavior imitated, at high rates and over long periods of time. I suggest that, given massive experience of this sort, a wide range of organic and inorganic learning machines would acquire the ability to imitate.

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