shown in Table 1. It can be seen in the table that responses by the infants matching the model were more likely than some responses but not more likely than other responses. For instance, when sequential finger movement was modeled, the incidence of sequential finger movement responses (27) was clearly higher than the incidence of finger protrusion responses (8), but it was virtually the same as the incidence of tongue protrusions (26) and hand opening (24) responses. Whether one concludes that the infants did or did not imitate would then depend on an arbitrary selection of a comparison base. It can thus be concluded that when the data are properly analyzed, little evidence remains that neonates can imitate specific movements.

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References and Notes
2. I am grateful to Dr. A. N. Meltzoff for providing part of the information in Table 1. The helpful comments of E. Anisfeld and A. C. Goldstein are gratefully acknowledged.

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In their report on the imitation of facial and manual gestures by human neonates, Meltzoff and Moore (1) hypothesized an active cognitive process involving cognitive representation and motor matching. Methodological problems, including the selection of target neonatal behaviors, the scoring and definitions of "imitative" behavior plus a current absence of convergent evidence for the cognitive sophistication of newborns, allow the questioning of this conclusion.

In experiment 1, four discrete but not unrelated behaviors were modeled: lip protrusion, mouth opening, tongue protrusion, and sequential finger movement. These behaviors all participate in early feeding and clinging reflex systems. Six judges (for whom no rater reliability was presented) scored videotapes of neonatal reactions to each modeled behavior, ranking the four possible behaviors according to the likelihood that they had occurred. For analysis, the top two ranked behaviors were each scored "yes" and the bottom two "no." This is problematic for a number of reasons. First, a "yes" judgment for imitation could occur when the actual imitative act was not the one a judge thought had occurred but rather the one thought to be second most likely. No information was given regarding the degree of "error" in judgments of imitation (judgments that the behavior matching the model was second most likely to have occurred). Moreover, collapsing these ranks set the chance or guessing probability that a given behavior would be scored as imitative equal to .50. Even through statistical analyses revealed significant differences between the frequency of "yes" judgments for the behavior matching the modeled one and that for the other behaviors, there is no indication that the frequency of "yes" judgments for the matching behavior significantly exceeded the guessing probability. A final problem of this scoring system is that it blurred the distinction between the behavior categories: If different oral behaviors (for example, lip pursing and tongue protrusion) were often confused so that raters ranked them 1 or 2 with equal frequency (both of which would produce a "yes" categorization), arguments that a broad spectrum of distinct behaviors had been imitated would not be tenable. Such reasoning is important to support any conclusion that neonatal matching behavior was guided by a general cognitive process.

Further problems relate to the single nonoral behavior included in experiment 1, sequential finger movements. This specific label implies that manual actions commonly labeled differently, such as grasping, were not appropriately descriptive of the act. It is important for this to be the case, since one ground for rejection of a releasing-mechanism interpretation would be that the behavior in question is not one that has already been shown to occur in reflex fashion or to participate in fixed-action patterns. Lacking is a discriminant analysis of the degree to which typical infant grasping behavior was identified by the raters as an example of "imitation" or whether the unique serial ordering of finger movements was present. This sort of discriminant validity seems unlikely to be achieved when rater variability was such that the two top and bottom probability rankings for possible responses had to be combined. Experiment 2 is less methodologically flawed than experiment 1, but it adds little to the conclusion that complex representation processes are involved in early matching behavior. Only two behaviors were studied (tongue protrusion and mouth opening), both were oral, and thus were drawn from a repertoire of socially elicited neonatal feeding responses.

Although the several theoretical explanations proposed by Meltzoff and Moore for the apparent matching behavior of infants are still viable, their conclusion that complex cognitive processes guided imitative responding was premature in the face of methodological limitations and a general absence, at the moment, of evidence indicating that neonates are capable of the requisite representational processes. At least as sensible is a conclusion that the neonatal behaviors studied were relatively fixed-action patterns that are isomorphic in form to the visual stimuli eliciting or releasing them.

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References
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Meltzoff and Moore (1) have recently reported that infants between 12 and 21 days of age imitate tongue protrusion, lip protrusion, mouth opening, and sequential finger movements in response to an adult's performance of similar acts. Our research was stimulated by the prior work of Maratos (2, 3), who found that 1-month-old infants produced matching behavior in response to seeing an adult exhibit tongue protrusion. However, both Maratos and Meltzoff and Moore failed to include controls that would test an alternative interpretation—namely, that these responses could also be released by inanimate stimuli and did not represent selective imitation of the model. Our study explored this alternative hypothesis.

Twenty-four white full-term infants (14 boys and 10 girls) were seen at 6 weeks of age. A series of five stimulus events were presented in a counterbalanced order. The first, tongue protru-
sion, was an adult sticking out her tongue in front of the infant, holding that position for 3 seconds, and then withdrawing the tongue. The hand movement consisted of the experimenter’s opening and closing her raised right hand above the infant’s hand. The inanimate stimulus events were a white ball with indentations resembling a golf ball (diameter, 4.5 cm) and a closed black felt-tip pen (length, 14.7 cm), which were moved toward the infant’s mouth, held in position for 3 seconds, and withdrawn. These two events served as control stimuli for tongue protrusion. The fifth stimulus, an orange plastic ring (diameter, 8.8 cm) attached to a string, was dangled near one of the infant’s hands and raised and lowered. This event served as the control stimulus for the hand movement. Each stimulus event was performed four times for a total of approximately 20 seconds and followed by a 10-second interval. Each sequence of four presentations was repeated three times with a longer interval of 15 seconds between the different stimuli. The stimuli were arranged to alternate between the mouth and hand regions so that carry-over effects would be minimized.

The infants were tested when they were in a state of alert inactivity (4). Infants were fed before the testing session in order to avoid excessive tongue protrusion that could be attributed to hunger. The infant was then seated in an infant seat with a small pillow at the top for extra support for the head. The session was videotaped with the camera directed at the infant. The experimenter stood 30 cm away and at a 45° angle to the right of the infant. The camera was situated at a 45° angle to the left of the infant at a distance of 1.6 m; it attracted very little attention from any of the infants. A very small light over the infant seat was operated by a foot pedal. The light was too dim to catch the infant’s attention and served to signal change of stimulus on the videotape without indicating which stimulus was being shown. Although the experimenter was not visible on the videotape, the ball, pen, and ring were observed in a few instances (5).

Testing began with a 2-minute adaptation period in which the experimenter stood in front of the infant and spoke only to the extent necessary to prevent the infant from becoming alarmed. The experimenter did not smile. Infants were then shown the preset series of test items.

The responses were coded from the videotapes on an event recorder (Esteline Angus). Tongue protrusion was coded whenever the infant’s tongue was visible on the screen. The principal variable reported here is any tongue protrusion lasting 0.5 second or longer on the record (6). Hand opening and closing was coded whenever the infant opened and closed at least three fingers of either hand. There were no discernible differences in the form of tongue protrusions or hand movements coded as responses to the five stimulus events. The mean correlations for interobserver reliability were .87 for frequency of tongue protrusions and .89 for frequency of hand opening and closing. A two-way repeated-measures analysis of variance was performed on each measure with sex as a between-subjects factor and stimulus as a within-subject factor. All analyses were performed on the rate of response per minute for each of the two measures.

7 The results support the hypothesis that the infants’ tongue protrusion is a released response and not a selective imitation of the adult’s act. The five stimulus events elicited differential rates of tongue protrusion [F(4, 88) = 7.63, P < .001] (Table 1). Although girls exhibited more tongue protrusions than boys to all stimuli [F(1, 22) = 9.02, P < .01], the pattern of the responses was the same for both sexes [stimulus-by-sex interaction, F(4, 88) < 1]. The effects of each of the five stimuli were compared according to the Newman-Keuls procedure (7). The pen was as effective a releaser of tongue protrusions as the tongue model, and there was no significant difference between tongue and ball. Tongue protrusion was not a result of general arousal, however, for the tongue model was significantly more effective at eliciting tongue protrusions than the hand (P < .01) and ring (P < .01). The pen also elicited significantly more tongue protrusions than the hand (P = .05) and ring (P < .01). However, the ball was not significantly more effective than the hand (P > .10).

In a second analysis we examined which stimulus elicited the greatest rate of tongue protrusions for each subject. Given that the tongue was one of three stimuli directed to the mouth, the null hypothesis would predict that 33 percent of the infants would respond maximally to the tongue. While the tongue was the best elicitor for 12 of 24 subjects, the pen and ball elicited the greatest number of tongue protrusions for 11 subjects [test of the goodness of fit, χ²(1) = 3.00, not significant (N.S.)]. Thus, the tongue was not a significantly more effective incentive than the pen and ball.

Hand opening and closing showed no selective response to any of the stimuli [F(4, 88) = 1.08, N.S.] and no sex difference [F(1, 22) = 1.90, N.S.], which suggests that hand movement may reflect general arousal at 6 weeks. Several infants rarely moved their hands at this early age. In a later session with the same infants at 14 weeks (8), the rate of hand opening and closing was greater than at 6 weeks [t(23) = 2.92, P < .01], and the infants responded differentially to the five stimuli [F(4, 88) = 3.36, P < .05]. However, hand and ring were equally effective in eliciting hand opening and closing (Table 2). This response was not the result of general arousal at 14 weeks since the pooled means for hand and ring were significantly greater than the pooled means for the tongue, ball, and pen [F(1, 22) = 8.24, P < .01]. There was no sex difference [F(1, 22) < 1].

The results of this study suggest the need to qualify the interpretation of prior research. Although matching behavior occurs at 6 weeks in response to seeing an adult display tongue protrusion, other inanimate stimuli are equally capable of eliciting the same response. A moving pen was as effective an incentive as a tongue model in releasing tongue protrusions. A ball was somewhat less effec-
tive; the shape of the stimulus may be important. Similarly, although matching behavior occurred to hand movement at 14 weeks, an inanimate stimulus elicited this response as effectively. Since these two behaviors can be released by events other than the ones modeled by an adult, there was no evidence to support the hypothesis that 1- to 2-month-old infants can selectively imitate a model.

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References and Notes

2. O. Maratos, thesis, University of Geneva (1973). Others reporting matching behavior in early infancy include K. Mazzu (Enfance 10, 135 (1957)) and J. Gardner and H. Gardner (Child Dev. 41, 31 (1970)). In addition, Smillie and Coppotelli (3) found that 6-week-old infants exhibit matching behavior in response to watching tongue protrusion and mouth opening modeled for them.
4. P. Wolff, Psychol. Issues 5, 1 (1966). All subjects were seen between 8 and 10 a.m. in most instances they were brought to the laboratory while asleep and induced to wake up.
5. The initial expectation of S.W.J., who scored the tapes, was that the matching behavior represented selective imitation. Hence if any bias was introduced by the occasional appearance of the inanimate stimulus on the screen, it should have worked against the results in this report. Additionally, the coder was never able to determine which of the modeled behaviors was being displayed.
6. Rate of tongue protrusions lasting less than 0.5 second to the tongue, ball, pen, and hand were virtually identical, suggesting that this measure taps the level of arousal and is neither a released nor an imitative response. Both Meltzoff and Moore's second study (1) and Smillie and Coppotelli's study (3) were based on a measure similar to the one used here; for example, Meltzoff and Moore scored tongue protrusions only when the tongue was thrust clearly beyond the lips.
8. The research reported here was part of a larger longitudinal study. Tongue protrusion responses after 6.5 weeks were not presented here because they were affected by an experimental manipulation. Hand movement was not affected by the experimental intervention.
9. This research is part of S.W.J.'s thesis [Harvard University (1977)]. Supported by grants from the National Institute of Child Health and Human Development (HD 10094) (to J. K.) and the Department of Psychology and Social Relations (in part for the infants' participation; D. Smillie for her suggestions; J. Jacobson, P. deVilliers, P. Coppotelli for their assistance.

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We will show that the criticisms of Anisfeld (1) and Masters (2) cannot be sustained and the results reported by Jacobson and Kagan (3) provide no support for the hypothesis that neonatal imitative reactions are mediated by releasing mechanisms.

Anisfeld had expressed concern that in experiment 2 (4), "the scorer could have drawn on differences in the length of time the gestures were demonstrated in scoring for imitation." In fact, however, the scorer observed videotaped segments of the baseline and response periods, and these electronically timed periods were all precisely the same length (150 seconds). There were thus no time differences for the scorer to draw on.

Both Anisfeld and Masters suggested an alternative approach to analyzing the data from experiment 1. Although phrased differently, both arguments are mistaken for essentially the same reason. Anisfeld suggested that we should assess imitation of tongue protrusion, for example, by testing whether the number of tongue protrusion judgments exceeds those for the other categories of infant behavior. Similarly, Masters suggested that we test the number of tongue protrusion judgments against a .50 chance probability, since four infant behaviors were judged simultaneously and the top two judgments were collapsed to a ‘‘yes’’ and the bottom two to a ‘‘no.’’ We cannot agree with either suggestion because each ignores both baseline and arousal differences among the various infant behaviors. For example, it is likely that the baseline level of tongue exceeding other oral behaviors and that tongue differentially increases relative to other behaviors when the infant is aroused by watching a human face. Thus, one cannot assume, as Anisfeld and Masters do, that the different categories of infant behavior are equiprobable during baseline and arousal conditions. Without this assumption, it becomes arbitrary to compare the frequencies of different infant behaviors directly to one another or to a .50 probability of occurrence.

> The problem posed by different baseline and arousal frequencies is solved by analyzing the distribution of each measure separately across the different gestures demonstrated to the infant. For example, one should test the distribution of tongue protrusion scores across the mouth opening, lip protrusion, and sequen-5136-tal finger movement demonstrations. With this method, whatever the initial likelihood of a particular infant behavior, there is evidence for imitation if the frequency of this behavior varies as a function of the gestures demonstrated to the infant and it is greatest when this behavior is the one demonstrated. Such analyses were performed for our original report, and the results support the conclusion that the infants were imitating.

Masters questioned our finding of manual imitation in experiment 1 and suggested that judges sometimes may have mistaken a reflexive grasping response for sequential finger movements, thus leading to a false conclusion that sequential finger movement was imitated. This suggestion relies on two assumptions. The first is that the sight of a moving adult human hand elicits reflexive grasping in the human neonate. To our knowledge, this idea has not been previously advanced by any observer of infant behavior; tactile and proprioceptive stimulation are considered the elicitors of reflexive grasping in the neonate (5).

The second assumption is that the judges could not discriminate a grasping response from sequential finger movement. But if the sequential finger movement demonstration had elicited grasping, then infant hand opening and closing (a major component of grasping) should also have been judged to peak for this demonstration. The frequency of hand opening and closing, however, was stable across the various gestures shown to the infants and did not peak for the sequential finger movement demonstration (table 1 in (1)).

Masters was concerned that, in experiment 2, the tongue protrusion and mouth opening gestures were components of "feeding responses" and therefore might be elicited by the sight of a social stimulus. Neonatal sucking, however, does not entail the full tongue extensions or wide-open mouths specified in our operational definitions of these scoring categories. In addition, the same experiment-er sat in front of the infant for both the tongue protrusion and mouth opening demonstrations. Consequently, if global feeding responses were elicited by a social stimulus, there would be the same "feeding responses" in both instances. In fact, there were significantly more tongue protrusion responses to the tongue gesture than to the mouth opening gesture; conversely, there were more mouth opening responses to the mouth opening gesture than to the tongue pro-
Interpreting "imitative" responses in early infancy

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