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7. Stimuli were presented three times at 20-second intervals in the following order: (i) 100-db (A scale) noise bursts; (ii) intense light flashes (370 footcandles); (iii) high-pressure oxygen was emitted from a hose causing it to hiss and flail about; (iv) low-pressure oxygen was emitted producing a mild hiss; and (v) a mechanical, battery-operated ape approached the animal swinging its arms and producing a loud, mechanical noise.
8. The results and behavioral descriptions from the study of Hall *et al.* (*4*) suggest that these behaviors in cats are related to the augmenting-reducing phenomenon.
9. The use of Flaxedil presents two interrelated problems: the animal when conscious can perceive pain, and Flaxedil when used in high dosages for a prolonged time can produce a comatose state [R. Hodes, *Electroencephalogr. Clin. Neurophysiol.* **14**, 220 (1962)]. Therefore, Flaxedil was continuously infused (intravenously) at the lowest rate and concentration necessary to produce paralysis and was discontinued whenever the animal failed to desynchronize to natural stimuli. Periodically all wounds were treated with local anesthetics, the eyes and tongue were moistened, and the animal was rotated and its legs flexed. The EEG, electrocardiogram, expired CO_2, and body temperature were continuously monitored and maintained within normal limits.
10. Concentric stimulation electrodes were formed from an insulated wire extending 0.5 mm from within a 24-gauge tube. The final 0.25 mm of the tip and 0.5 mm of the barrel were stripped of their insulation. Reticular coordinates were anterior 2.0, lateral 2.5, and horizontal −1 to −2.5. This region was shown to be most effective for producing long-lasting EEG desynchronization [M. Bonvallet and A. Newman-Taylor, *Electroencephalogr. Clin. Neurophysiol.* **22**, 54 (1967)].
11. Reticular stimulation consisted of 0.5-second trains of 0.1-msec pulses delivered at a rate of 150 pulses per second. Each train terminated 25 msec prior to presentation of the visual stimulus, with 30 trains given at each intensity. Three averages each consisting of five EP's for both OT and OR stimulation were collected during each intensity of MRF stimulation. In addition, the five potentials recorded immediately preceding each MRF stimulation run were averaged and served as baseline data.
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13. One footcandle is equivalent to 10.76 lumen/m².
14. A three-factor analysis of variance for unequal number of subjects per group indicated that the main effects for groups (augmenter-reducer) and ITI were not significant. Suprathreshold MRF stimulation significantly increased thalamic responsiveness for both groups, $F(5, 60) = 21.75$, $P < .001$.
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17. The groups differed significantly, $F(1, 10) = 5.34$, $P < .05$, as did the groups by RF stimulation interaction, $F(5, 50) = 3.05$, $P < .05$.
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22. Previous results indicated a negative correlation between EP augmenting and withdrawal (*4*). We defined withdrawal as the degree of movement away from the noxious stimuli. Augmenters reacted more to the stimuli than did the reducers and part of their initial reaction was a definite withdrawal. We have the impression that the reducers withdrew more to the back of their home cages when approached than did the augmenters. The discrepancy, therefore, may be in the definition of withdrawal.

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Imitation of Facial and Manual Gestures by Human Neonates

Abstract. *Infants between 12 and 21 days of age can imitate both facial and manual gestures; this behavior cannot be explained in terms of either conditioning or innate releasing mechanisms. Such imitation implies that human neonates can equate their own unseen behaviors with gestures they see others perform.*

Piaget and other students of developmental psychology consider the imitation of facial gestures to be a landmark achievement in infant development. Infants are thought to pass this milestone at approximately 8 to 12 months of age. Infants younger than this have been postulated to lack the perceptual-cognitive sophistication necessary to match a gesture they see with a gesture of their own which they cannot see (*1*). The experiments we report show that the infant's imitative competence has been underestimated. We find that 12- to 21-day-old infants can imitate both facial and manual gestures (Fig. 1). This result has implications for our conception of innate human abilities and for theories of social and cognitive development.

An experimental evaluation of the neonate's imitative competence raises several methodological difficulties. One consists of distinguishing true imitation from a global arousal response. For example, one can conclude nothing about imitation if an infant produces more tongue protrusions in response to a tongue protrusion demonstration than he does to

Fig. 1. Sample photographs from videotape recordings of 2- to 3-week-old infants imitating (a) tongue protrusion, (b) mouth opening, and (c) lip protrusion demonstrated by an adult experimenter.

the presentation of a neutral facial expression. It would be more parsimonious simply to conclude that a moving, human face is arousing for the infant and that increased oral activity is part of the infant's arousal response. A second issue involves controlling interactions between adult and infant that might shape the imitative response. We found that if parents were informed of the imitative tasks we planned to examine, they practiced these gestures with their infants before coming into the laboratory so that their baby "would do well on the test." In reviewing films of preliminary work, we also noticed that the examiner tended to alter the rhythm of his tongue protrusion as a function of the response of the infant. These kinds of interactions would expose findings of imitation to a variety of explanations, including the possibility that the infants were merely being conditioned to imitate tongue protrusion. A third issue concerns the scoring of the infant's responses. The movements tested were not generally produced in a discrete, unambiguous fashion, and not surprisingly, there were gross differences in the scoring as a function of whether or not the observer knew which gesture had been demonstrated to the infant.

In the experiments we now report, these three issues are addressed as follows. (i) Each infant's response to one gesture is compared to his response to another similar gesture demonstrated by the same adult, at the same distance from the infant, and at the same rate of movement. For instance, we test whether infants produce more tongue protrusions after an adult demonstrates tongue protrusion than after the same adult demonstrates mouth opening, and vice versa. If differential imitation occurs, it cannot be attributed to a mere arousal of oral activity by a dynamic, human face. (ii) Parents were not told that we were examining imitation until after the studies were completed; moreover, the experiments were designed to preclude the possibility that the experimenter might alter the rhythm of his demonstration as a function of the infant's response. (iii) The infant's reactions were videotaped and then scored by observers who were uninformed of the gesture shown to the infant they were scoring (*2*).

In experiment 1, the subjects were six infants ranging in age from 12 to 17 days ($\bar{X}$ = 14.3 days). Three were male and three female. Testing began with a 90-second period in which the experimenter presented an unreactive, "passive face" (lips closed, neutral facial expression) to the infant. Each infant was then shown the following four gestures in a different random order: lip protrusion, mouth opening, tongue protrusion, and sequential finger movement (opening and closing the hand by serially moving the fingers). Each gesture was demonstrated four times in a 15-second stimulus-presentation period. This period was immediately followed by a 20-second response period for which the experimenter stopped performing the gesture and resumed a passive face. In order to allow for the possibility that the infants might not watch the first stimulus presentation, the procedure allowed a maximum of three stimulus presentations and corresponding response periods for any one gesture. Half the cases required only one stimulus presentation. In those cases necessitating more than one stimulus presentation, the 20-second response period used in assessing imitation was the one following the final presentation of the gesture. A 70-second passive-face period separated the presentation of each new type of gesture from preceding ones.

The videotape recordings of the response periods were scored in a random order by undergraduate volunteers. Two groups of six coders were used. One group scored the infant's facial behavior; the other scored the manual responses. The face coders were informed that the infant in each videotaped segment was shown one of the following four gestures: lip protrusion, mouth opening, tongue protrusion, or passive face. They were instructed to order the four gestures by ranks from the one they thought it most likely the infant in each segment was imitating to the one they thought was least likely. No other training was given. The hand coders were treated identically, except that they were informed that the infant in each segment was presented with one of the following

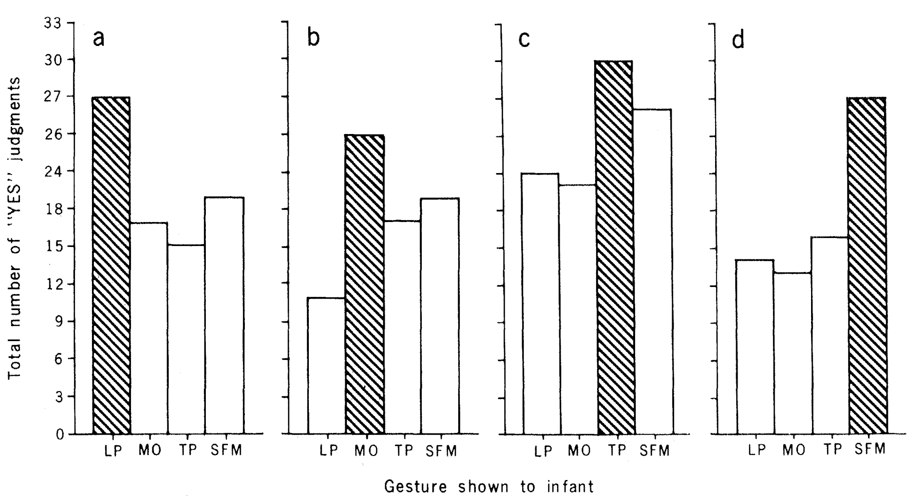

Fig. 2. Distribution of "yes" judgments as a function of the gesture shown to the infant during experiment 1. The maximum possible number of judgments for each bar was 36 (six infants and six judges). Shaded bars indicate the imitative reaction. (a) Number of judgments that infants responded with lip protrusion (*LP*) to each of the four gestures shown them, (b) mouth-opening (*MO*) judgments, (c) tongue-protrusion (*TP*) judgments, and (d) sequential-finger-movement (*SFM*) judgments.

Condition	Baseline exposure	Baseline period (150 seconds)	Experimental exposure 1	Response period 1 (150 seconds)	Experimental exposure 2	Response period 2 (150 seconds)
Experimenter	Passive face	Passive face	Gesture 1	Passive face	Gesture 2	Passive face
Infant	Pacifier	No pacifier	Pacifier	No pacifier	Pacifier	No pacifier

Fig. 3. Schematic illustration of the pacifier technique for assessing facial imitation in neonates in experiment 2. Half of the infants were exposed to the gestures in the order tongue protrusion, mouth opening; the other half were exposed to the gestures in the reverse order.

hand gestures: sequential finger movement, finger protrusion, hand opening, or passive hand.

For the purposes of analysis, the two highest ranks and the two lowest ranks were collapsed. This procedure yields dichotomous judgments of whether it was likely or unlikely (hereafter referred to as "yes" or "no") that the infants were imitating a particular gesture. The distribution of "yes" judgments for each infant gesture peaked when the corresponding gesture was demonstrated by the experimenter (Fig. 2). In all four instances, Cochran Q tests (*3*) reveal that the judged behavior of the infants varies significantly as a function of the gestures they are shown [lip protrusion, $P < .01$ (Fig. 2a); mouth opening, $P < .02$ (Fig. 2b); tongue protrusion, $P < .05$ (Fig. 2c); and sequential finger movement, $P < .001$ (Fig. 2d)]. That this variation is attributable to imitation is supported by the fact that none of these effects is significant when the judgments corresponding to the imitative reaction (shaded columns in Fig. 2) are excluded from the analyses.

Experiment 1 avoided a prolonged stimulus-presentation period during which the experimenter might alter the timing of his gesturing as a function of the infant's responses. However, in adopting a fixed stimulus-presentation period as brief as 15 seconds, it was sometimes necessary to repeat the presentation to ensure that the infants actually saw the gesture they were to imitate. This procedure then opened the possibility that the experimenter might unwittingly have been prefiltering the data by readministering the stimulus presentations until the random behavior of the infant coincided with the behavior demonstrated. A second study was therefore designed which is not open to this potential objection.

The subjects in experiment 2 were 12 infants ranging in age from 16 to 21 days ($\bar{X} = 19.3$). Six were male and six female. They were shown both a mouth-opening and a tongue-protrusion gesture in a repeated-measures design, counterbalanced for order of presentation. The experimental procedure is illustrated in Fig. 3. Testing began with the insertion of a pacifier into the infant's mouth. Infants were allowed to suck on it for 30 seconds while the experimenter presented a passive face. The pacifier was then removed, and a 150-second baseline period was timed. After the baseline period, the pacifier was reinserted into the infant's mouth, and the first gesture was demonstrated until the experimenter

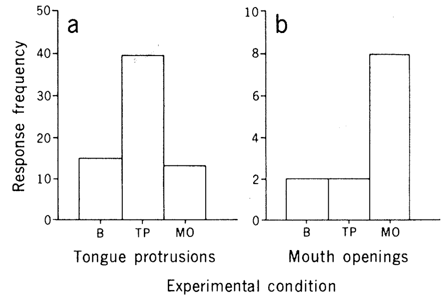

Fig. 4. Total frequency of (a) tongue-protrusion and (b) mouth-opening responses for three conditions in experiment 2. Abbreviations: *B*, baseline period; *TP*, tongue-protrusion response period; and *MO*, mouth-opening response period.

judged that the infant had watched it for 15 seconds. The experimenter then stopped gesturing, resumed a passive face, and only then removed the pacifier. A 150-second response period, during which the experimenter maintained his passive face, was clocked. Immediately thereafter the pacificer was reinserted, and the second gesture was presented in an identical manner (*4*).

Infants did not tend to open their mouths and let the pacifier drop out during the mouth-opening demonstration; nor did they push out the pacifier with their tongues during the tongue-protrusion demonstration. On the contrary, they sucked actively with the pacifier remaining firmly within their mouths during the stimulus-presentation period. Thus, the pacifier technique (i) safeguards against the experimenter's altering his gesturing as a function of the imitative responses of the infant and (ii) permits the experimenter to demonstrate the gesture until the infant has seen it, while ensuring that the experimenter's assessment of this point is uncontaminated by any knowledge of the infant's imitative response.

The 36 videotaped segments (12 infants for 3 periods each) were scored in a random order by an undergraduate assistant who was uninformed of the structure of the experiment. The frequencies of tongue protrusions and mouth openings were tallied for each videotaped segment (*5*). The results demonstrate that neonates imitate both tongue protrusion and mouth opening (Fig. 4). As assessed by Wilcoxon matched-pairs signed-ranks tests (*3*), significantly more tongue-protrusion responses occurred after that gesture had been presented than during the baseline period ($P < .005$) or after the mouth-opening gesture ($P < .005$). Similarly, there were significantly more mouth-opening responses after that gesture had been demonstrated than during the baseline period ($P < .05$) or after the tongue-protrusion gesture ($P < .05$). It is noteworthy that under the present experimental conditions, the infants had to delay their imitation until after the gesture to be imitated had vanished from the perceptual field.

At least three different mechanisms could potentially underlie the imitation we report.

1) It could be argued that the imitation is based on reinforcement administered by either the experimenter or the parents. In order to prevent the experimenter from shaping the infant's imitative responding, the procedure directed that he maintain an unreactive, neutral face during the response period. The experimenter's face was videotaped throughout both experiments in order to evaluate whether this procedure was followed. The videotaped segments were shown to observers whose task it was to score any reinforcements that the experimenter administered. No smiles or vocalizations were noted in any trial. Indeed, the only changes from the passive face occurred in three trials in experiment 1, when the experimenter was judged to "blink extremely rapidly." Considering only experiment 2, then, the experimental procedure does not appear to have been violated, and therefore, differential shaping of the mouth-opening and tongue-protrusion responses during the successive 150-second response periods is an unlikely source of the effects obtained. Since none of the parents were informed about the nature of the study, special practice on imitative tasks at home in preparation for the experiment was avoided. Further, informal questioning revealed that no parent was aware of ever having seen babies imitating in the first 21 days of life; indeed, most were astonished at the idea. Thus, a history of parental reinforcement seems an improbable basis for imitation at this very early age.

2) This early imitation might be based on an innate releasing mechanism such as that described by Lorenz and Tinbergen (*6*). This view would hold that tongue protrusion, mouth opening, lip protrusion, and sequential finger movement are each fixed-action patterns and that each is released by the corresponding adult gesture (sign stimulus). The overall organization of the infant's imitative response, particularly its lack of stereotypy, does not favor this interpretation. In addition, the fact that infants imitate not one, but four different gestures, renders this approach unwieldy.

3) The hypothesis we favor is that this imitation is based on the neonate's capacity to represent visually and proprioceptively perceived information in a form common to both modalities. The infant could thus compare the sensory information from his own unseen motor behavior to a "supramodal" representation of the visually perceived gesture and construct the match required (*7*). In brief, we hypothesize that the imitative responses observed are not innately organized and "released," but are accomplished through an active matching process and mediated by an abstract representational system. Our recent observations of facial imitation in six newborns—one only 60 minutes old—suggest to us that the ability to use intermodal equivalences is an innate ability of humans. If this is so, we must revise our current conceptions of infancy, which hold that such a capacity is the product of many months of postnatal development. The ability to act on the basis of an abstract representation of a perceptually absent stimulus becomes the starting point for psychological development in infancy and not its culmination.

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2. In addition, the following procedural details were held constant for both experiments. All infants were full term (40 ± 2 weeks gestation), of normal birth weight (3400 ± 900 g), and born through an uncomplicated vaginal delivery with a minimum of maternal medication (for example, no general anesthesia). The infants were tested when awake and alert, and they were supported in a semiupright posture by a well-padded infant seat. All the gestures were silently demonstrated 35 cm from the infant's eyes. They were presented against a white cotton backdrop and illuminated by a 20-watt spotlight placed directly above and behind the infant's head. The experimental room was kept as free as possible from auditory distraction and was maintained in subdued, indirect lighting.
3. S. Siegel, *Nonparametric Statistics* (McGraw-Hill, New York, 1956).
4. There was no significant difference ($P > .05$) between the duration of the presentation of the tongue protrusion ($\bar{X}$ = 67.6 seconds) and mouth opening ($\bar{X}$ = 74.8 seconds) gestures. Preliminary work revealed that infants continued to make sucking movements for about 3 seconds after a pacifier was removed. Therefore, in all cases, a 3-second interval was timed after the pacifier was removed and before the beginning of the 150-second baseline or response period. The infant's oral activity during this interval was not included in the analyses.
5. A tongue protrusion was scored only when the tongue was thrust clearly beyond the lips. A mouth opening was tallied only when the infant fully opened his mouth. Intraobserver agreement (number of agreements divided by the total number of agreements plus disagreements) was high for both tongue protrusion (93 percent) and mouth opening (92 percent).
6. K. Lorenz and N. Tinbergen, *Z. Tierpsychol.* **2**, 1 (1938); N. Tinbergen, *A Study of Instinct* (Oxford Univ. Press, New York, 1951).
7. "Supramodal" is used, following T. Bower [*Development in Infancy* (Freeman, San Francisco, 1974)], to denote that the representation is not particular to one sensory modality alone.
8. A preliminary version of parts of experiment 1 was presented at the Biennial Meeting of the Society for Research in Child Development Denver, Colo., 10 to 13 April 1975. Portions of this research were reported in A.N.M.'s thesis [Oxford University (1976)]. Supported by NSF grant GS42926, the Social Science Research Council, the Washington Association for Retarded Citizens, and the Child Development and Mental Retardation Center of the University of Washington (grant HD02274). This research has greatly benefited from the encouragement and advice provided by Drs. J. S. Bruner and G. P. Sackett. We thank Drs. D. Holm, S. Landesman-Dwyer, O. Maratos, D. Gentner, and P. Kuhl for helpful suggestions. We are especially indebted to M. DurkanJones for her long and careful work on this project. We also thank W. Barclay, D. Blasius, J. Churcher, D. Clark, A. Gopnik, V. Hanson, R. Hart, M. McCarry, G. Mitchell, and V. Papaioannou. We acknowledge the cooperation of University Hospital of the University of Washington.
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Transplantable Pancreatic Carcinoma of the Rat

Abstract. *Pancreatic carcinoma, which developed in a male Fischer 344 rat fed 0.1 percent nafenopin for 20 months, is being successfully transplanted into weanling rats. The tumor cells contain variable numbers of zymogen granules, and the endoplasmic reticulum and the Golgi apparatus appear prominent. This transplantable tumor, which displays substantial amylase and lipase activity, should serve as a useful model system for immuno- and chemotherapeutic experiments, as well as for the study of synthesis, storage, and release of zymogen proteins in neoplastic cells.*

Epidemiological studies indicate an unequivocal increase in the incidence of pancreatic carcinoma in several countries during the past three decades (*1, 2*). In the United States, pancreatic carcinoma ranks as the fourth most common cause of death by cancer, exceeded only by cancer of the lung, large bowel, and breast (*2*). Difficulty in early diagnosis, as well as lack of adequate knowledge of its biological behavior, appear to be major factors contributing to the poor prognosis of pancreatic carcinoma in humans (*3*). Since several studies suggest that pancreatic cancer in man may be etiologically related to exogenous chemicals and thus preventable (*4*), attempts are being made to develop suitable animal models of this cancer (*5*) which could serve as an effective system for various experimental manipulations aimed at preventing or altering the natural progression of the disease. Here we describe a transplantable pancreatic carcinoma of the rat which is capable of producing amylase and lipase.

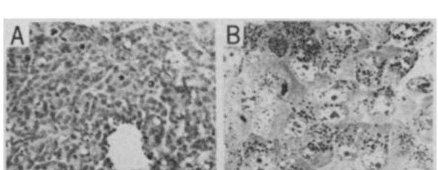

Fig. 1. (A) Histological appearance of the original pancreatic carcinoma from a male Fischer 344 rat treated with nafenopin for 20 months. Acinar differentiation is evident, and numerous mitoses are present. (Hematoxylin and eosin; ×80.) (B) Subcutaneous transplant of pancreatic carcinoma (second generation), fixed in 2.5 percent glutaraldehyde in 0.1*M* cacodylate buffer, *p*H 7.4, for 30 minutes and then in 1 percent OsO_4. This section (0.5 μm thick) of plastic-embedded tissue shows numerous secretory granules in the cytoplasm of tumor cells. (Toluidine blue; ×450.)

The primary tumor developed in the pancreas of a male Fischer 344 rat that was fed nafenopin (2-methyl-2-[*p*-(1, 2, 3, 4-tetrahydro-1-naphthyl)phenoxy]propionic acid; Su-13437), at a dietary concentration of 0.1 percent for 20 months. Nafenopin is a potent hepatic peroxisome proliferator (*6*) and, as reported elsewhere (*7*), the majority of rats fed this compound develop liver tumors. The primary pancreatic tumor was highly vascular, measured 6 cm in diameter, and contained several cystic spaces filled with straw-colored fluid. Metastases were present in the liver. Histologically, the tumor was a well-to-poorly differentiated pancreatic acinar carcinoma originating from exocrine tissue (Fig. 1A). On electron microscopic examination, the primary pancreatic carcinoma cells revealed large nuclei with prominent nucleoli; the cytoplasm displayed abundant rough endoplasmic reticulum and prominent Golgi apparatus. Numerous zymogen granules were also seen in the tumor cells. Portions of this primary tumor were minced and diluted in sterile normal saline for inoculation into the peritoneal cavity at laparotomy,