References and Notes

1. E. J. Russell and E. W. Russell, *Soil Conditions and Plant Growth* (Longmans, Green, London, ed. 8, 1950).
2. S. Caillère and S. Hénin, *Compt. rend.* **226**, 580 (1948); W. Feitknecht, *Helv. Chim. Acta.* **25**, 555 (1942); ——— and F. Held., *ibid.* **27**, 1495 (1944).
3. W. Feitknecht, *Helv. Chim. Acta.* **25**, 555 (1942).
4. K. W. Sykes, "Stability constants, part 11: inorganic ligands," *Spec. Publ. No. 7 Chem. Soc. London* (Metcalf and Cooper, London, 1957).
5. This report is contribution No. 49, Soil Research Institute, Canada Department of Agriculture.

4 December 1961

Method for Studying Exploratory Behavior in Infants

Abstract. An experimental crib has been designed for use in studying the effect of visual feedback upon the exploratory behavior of the human infant. It can be easily adapted to older children, to some animals, and to problems other than the development of exploratory behavior.

Exploratory behavior is clearly apparent in human infants by the time they are 3 months old (*1*). An apparatus designed for use in studying the beginnings of this behavior, especially in relation to feedback from the external environment, is also adaptable to the study of other kinds of early behavior, both human and animal. The apparatus holds the infant in a suitable position, permits measurement of certain behavior, and provides for sensory feedback from that behavior.

A specially designed crib is approximately 5 feet long, 3 feet wide, and 4 feet high. It stands on legs 2 feet 5 inches long. Interior surfaces are made of Acoustitex nonperforated sound-insulation boards, painted ivory. Six 6-watt bulbs are mounted at the top of the wall behind the infant. The sides of the crib are double sliding panels. Behind the infant is a double observation window, 28 inches long by 18 inches wide, glass on the outside and plastic on the inside. At the other end is a double glass window, 16 by 17 inches, set at an angle of 60°, through which images can be projected on a screen. The screen is frosted Plexiglas, 34 by 31 inches, also set at an angle of 60°. The crib is ventilated by a blower of capacity 60 ft^3/min (Fig. 1).

The infant faces the screen at a distance of 30 inches, supported in a commercially available canvas seat (*2*), on a modified frame adjustable at angles between 45° and 90°. A cloth strap holds the infant across the chest and abdomen, leaving its hands and feet

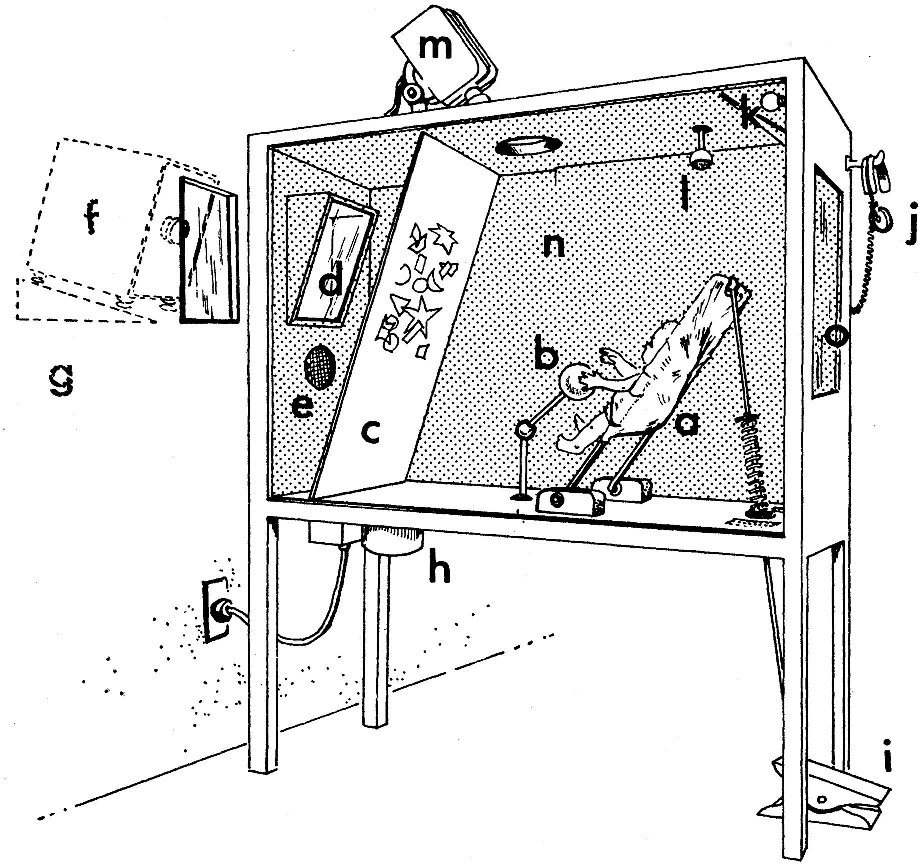

Fig. 1. Experimental crib: *a*, seat; *b*, manipulandum; *c*, screen; *d*, projection opening; *e*, sound source; *f*, projector; *g*, control room; *h*, ventilator; *i*, rocker; *j*, intercom; *k*, crib lights; *l*, microphone; *m*, television camera; *n*, doors of crib; *o*, window.

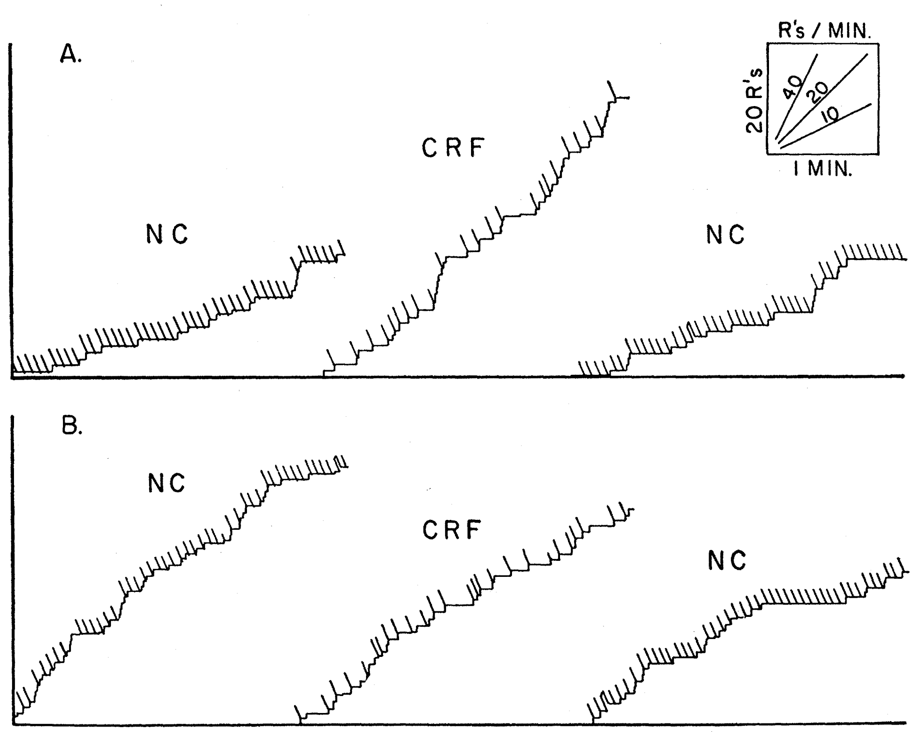

Fig. 2. Cumulative response curves for two infants, showing (*A*) performance sensitive to changes in experimental conditions and (*B*) performance not sensitive. Under the noncontingent (*NC*) condition the movie appeared for alternate 1½-second periods regardless of the infant's behavior, under the continuous reinforcement (*CFR*) condition the movie followed each of the infant's responses.

free. The seat can be rocked by the observer's pressing a pedal.

A hollow nonshiny stainless-steel sphere, 4 inches in diameter, mounted on an adjustable rod, is positioned so that only its near and visible surface can be touched by the infant. Touching the sphere activates a capacitance relay, the sensitivity of which is adjusted by a variable frequency oscillator. Control equipment in an adjacent room operates a cumulative recorder, counters, and stimulus-producing elements, namely, a continuous-movie projector (*3*) and a closed-loop tape system (*4*). Images are projected on the crib screen; auditory stimuli come from a speaker located directly behind the screen. Stimuli presented either way can be controlled by the infant's responses to the sphere, by a clock, or manually by the operator. The durations of the movie, the sound, and the experimental conditions are controlled by timers (*5*). A variable resistance-capitance relay is included to make the inter-response interval adjustable from 50 msec to 5 sec. As we have used the apparatus, responses which are spaced in accordance with a predetermined interval (typically, 0.2 second) appear on a cumulative recorder, while counters accumulate all responses spaced more than 17 msec apart.

The infant's behavior is monitored in the control room by closed-circuit television (*6*) and earphones. The television camera is mounted on the ceiling on the crib, while a microphone over the infant's head transmits his vocalizations both to the operator and to a tape recorder. An intercom system connects observer and operator. The infant's behavior can be photographed from the television screen.

Most 4- to 6-month-old infants will perform in the apparatus for at least 8 minutes without fussing, a period of time comparable to that used by other investigators studying conditioning in human infants (*7*). Some preliminary work with older children, 2 to 5 years of age, suggests that the experimental period for this group may be extended to 20 minutes or longer. If the infant fusses, the observer rocks him, but if the infant cries, he is removed at once.

Mothers assist in placing their infants in the crib and then go to the control room to observe their infants on the television screen.

The reinforcing effects of visual stimuli on exploratory behavior are currently under investigation. Sample performances are shown in the cumulative records of Fig. 2. In both cases, touching the sphere produced a motion picture of brightly colored geometric paper figures moving over a black velvet drum for 1.5 seconds.

A great variety of visual and auditory stimuli can be used, programmed as either reinforcing or discriminative. The projected images may be of things or people, known or strange, and such stimulus properties as complexity and novelty can be varied systematically. The effect of auditory reinforcement, alone or coupled with visual reinforcement, can be analyzed, while other manipulanda can be introduced to study response differentiation.

HARRIET L. RHEINGOLD
National Institute of Mental Health, Bethesda 14, Maryland
WALTER C. STANLEY
Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine
JOHN A. COOLEY
National Institute of Mental Health Bethesda 14, Maryland

References and Notes

1. A. Gesell and H. Thompson, *Infant Behavior* (McGraw-Hill, New York, 1934); J. Piaget, *The Origins of Intelligence in Children* (trans. by Margaret Cook). (International Universities Press, New York, 1952); H. L. Rheingold, "The effect of environmental stimulation upon social and exploratory behavior in the human infant," in *Determinants of Infant Behaviour*, B. Foss, Ed. (Methuen, London, 1961), pp. 143–171.
2. Welsh Company, St. Louis, Mo.
3. Cinesalesman, modified.
4. Mohawk Business Machines.
5. Time delay timers, series TDAF, Industrial Timer Corp.
6. Kin Tel.
7. H. Papoušek, *Cs. Pediatric* **15**, 981 (1960); M. W. Simmons and L. P. Lipsitt, *J. Exptl. Analysis Behavior* **4**, 233 (1961).

9 January 1962

On "Reflexive Selection"

Abstract. Some natural populations show an extremely high degree of polymorphism, especially in color and pattern, which may be interpreted as "protective variation." Two possible genetic models, one based on frequency-stat (like thermostat) and one based on higher selection value of heterozygotes, have been proposed to account for the phenomenon.

Moment (*1*) discusses the massive diversity in color and pattern in natural populations of certain species, as exemplified by that of brittlestar, *Ophiopholis aculeata*. Out of hundreds of individuals collected it is not possible to find two exactly alike. This is a very interesting but not uncommon phenomenon. In fact, I venture to say it would be a common phenomenon if every trait were as conspicuous as color or pattern.

Table 1. Distribution of the 3025 possible genotypes if $A_1, \ldots, A_{10}$ is for color and $B_1, \ldots, B_{10}$ is for pattern, each with frequency 1/10.

	10 Genotypes .01 $A_1A_1 \ldots$	45 Genotypes .02 $A_1A_2 \ldots$
.01 B_1B_1 • • •	100 Genotypes (total freq., .01)	450 Genotypes (total freq., .09)
.02 B_1B_2 • • •	450 Genotypes (total freq., .09)	2025 Genotypes (total freq., .81)

Moment observes: "Massive diversity of this kind is usually dismissed as the result of the free play of meaningless mutation in the absence of selection on the assumption that the colors and patterns have a selection value of approximately zero." In this connection I wish to add that since publication of the statement of E. B. Ford in 1953, evidence has begun to accumulate indicating that even the most unsuspected "neutral" genes of long standing (for example, the ABO locus in man) may have selective effects, although the precise nature of these effects remains obscure. The recent thinking of most geneticists is that diversity of such a magnitude is maintained by some kind of balanced or stabilizing selection scheme, rather than by the free play of mutation in the absence of selection. (The latter case would lead to biological chaos.) Hence, I agree with Moment that we should view the diversity in terms of selection.

As to the scheme of selection, Moment suggests: "In the case of massive variation the possibility presents itself that it is the variation as such which is adaptive, giving a measure of protection against predators. . . . The term *reflexive selection* suggests itself because it is the variation per se which is adaptive, and the freqeuncy of any one type is determined by a feedback relationship with all the other types." The suggestion is quite reasonable as far as it goes, but it seems to me that it does not go far enough. It does not say anything about the mode of inheritance of color and pattern, the system upon which selection operates. All I wish to do in this note is to add a few speculative remarks to complete the story and to stimulate experimental investigation on this subject.