reading begins and an immediate cessation of this activity when reading stops.

Treatment of subvocalization is done in the following manner. The subject is asked if he is aware that he subvocalizes or reads aloud to himself. A brief discussion is held with the subject, informing him of his response tendencies while reading. The feedback technique is then introduced. The subject is told that he will be able to hear the activity of his vocal muscles as he reads, and that this will help him to eliminate the problem. The manner in which signals emanating from the vocal muscles are detected is explained to him. The subject is then given earphones to wear, and is asked to remain relaxed. Feedback is introduced by channeling the output of the oscillograph amplifier to an audio-amplifier, and then to earphones. When the subject is relaxed, the audio-circuit is opened and the subject is asked to swallow. The swallow results in an immediate burst of static in the earphones. The subject is then requested to experiment with the sound to satisfy himself that he can control it (stop it and start it) by such actions as talking, swallowing, turning his head, clenching his jaw muscles, and so forth. The subject is allowed to continue experimenting with the feedback, and with its control, until he states that is is able to control its presence or absence. The subject then begins reading while attempting to keep the EMG feedback to a minimum, that is, to maintain silence in the earphones.

A total of 50 college students from a reading improvement class were tested; it was found that 17 subvocalized. All subjects who subvocalized were treated in the manner described above. Originally, it was planned to administer the feedback treatment over several sessions to determine the number of feedback treatments necessary to establish normal reading patterns. This was found to be unnecessary. The feedback treatment was remarkably effective (Fig. 1). In all cases one session of the feedback was sufficient to produce complete cessation of subvocalization.

Most of the subjects showed a reduction of speech muscle activity to resting levels within a 5-minute period. At the end of the 30-minute experimental session in which feedback was given, all subjects were able to read with speech muscle activity at the same level as during relaxation. The level of speech muscle activity was monitored at the end of 1 month, and again after 3 months. During these tests, the subject read for 30 minutes; no feedback was used. None of the subjects gave any evidence of subvocalization in either of these tests.

In many ways, this is a surprising phenomenon. One does not expect the extinction of a habit—especially a habit which presumably had existed during the entire time the subject had been reading—to occur so quickly and easily. However, if the overlearned response of subvocalization is placed in conflict with a second, even more strongly overlearned response, extinction should be quite rapid. Such a second response is the ability to make a fine motor adjustment of the speech musculature on the basis of auditory cues. Exactly this response is involved under conditions of feedback of laryngeal EMG activity. The subject is required to make fine motor adjustments on the basis of auditory cues. Attempts to reduce the speech muscle activity by instructions alone were not successful. The subjects were not aware of their subvocal activity even when told they were subvocalizing, and were unable to reduce it without the feedback.

This ability to make fine motor adjustments of restricted muscle groups has been reported by Basmajian (*2*) who found that subjects can control the contractions of single motor units on the basis of auditory and visual cues. His subjects also achieved stable control of the muscles within 15 to 30 minutes. He reports, however, that the aural feedback in all subjects is more useful than visual display on a cathode ray tube monitor; the visual display served a subsidiary purpose (*2*).

The motor-auditory feedback loop as a cue produced by response might well be of considerable importance. Such phenomena as the marked disruption of speech under conditions of delayed auditory feedback provide ample evidence for the importance of this cue to normal speech. Consequently, the evocation of this overlearned response-produced cue may result in the rapid extinction of subvocalization under the conditions of auditory feedback.

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31 October 1966

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Monkeys Reared in Isolation with Pictures as Visual Input: Evidence for an Innate Releasing Mechanism

Abstract. *Monkeys reared in isolation from birth to 9 months received varied visual input solely from colored slides of monkeys in various activities and from nonmonkey pictures. Exploration, play, vocalization, and disturbance occurred most frequently with pictures of monkeys threatening and pictures of infants. From 2.5 to 4 months threat pictures yielded a high frequency of disturbance. Lever-touching to turn threat pictures on was very low during this period. Pictures of infants and of threat thus appear to have prepotent general activating properties, while pictures of threat appear to release a developmentally determined, inborn fear response.*

Research on a wide variety of animals has shown that early experiences can be important determinants of later social and nonsocial behavior (*1*). Some of these experiences apparently must occur during a limited developmental period if the animal is to exhibit behavior patterns normal for its species. One important, but relatively neglected, area of study in primate behavior involves determination of the developmental importance of different types of sensory input early in life. The experiment reported here is part of a study examining the effects of visual social and nonsocial stimulation presented to monkeys otherwise reared in total social isolation. The present study asks if totally naive infant monkeys will show differential behaviors toward specific types of visual stimulation, and whether such differential behaviors mature at specific periods during the monkey's development.

Four male and four female rhesus monkeys (*Macaca mulatta*) were reared in individual wire cages (61 by 71 by 71 cm) from birth to 9 months. Three walls, the ceiling, and the area below the wire floor of each cage were covered by Masonite or aluminum panels blocking all visual access to the world outside of the cage. The rear wall of each cage was a rear projection screen, which also blocked visual access to the outside. The screen had a ground surface, preventing a mirror effect on the inner surface. Thus, reflections of the monkey's own image on the screen were minimized, although slight shadows did appear when the screen was brightly illuminated by the projector. A nonmovable brass lever, 0.6 cm in diameter, projected 7.6 cm into the cage at the bottom right corner of the screen. During rearing, the subjects never saw another monkey, and saw no humans after a hand-feeding period during the first 5 to 9 days of life. Sounds were not controlled, so the monkeys did hear other animals and humans.

On day 14, two types of visual stimulus presentations were begun, as follows.

Experimenter-controlled slides. In this procedure pictures of monkeys engaged in different activities and nonmonkey control pictures were projected on the screen. Each individual picture was available for 2 minutes. Six monkey and two control pictures, randomly selected from a large pool, were projected in a daily test session. In these tests the subject had no direct control over the onset or duration of the picture.

Animal-controlled slides. In this procedure the subject could expose itself to pictures by touching the brass lever, which operated an electronic contact relay circuit. Lever-touching opened a shutter located in front of a Kodak Carousel slide projector, and also operated a printing counter that recorded the touching behavior. The standard schedule of six randomly selected monkey and two control pictures was used in each test session. Each picture was potentially available for 5 minutes and 15 seconds. During the first 15 seconds the shutter automatically opened, exposing the subject to the picture that would be available for the next 5 minutes. During the next 5 minutes each lever touch turned the picture on for 15 seconds. If the subject continued to touch the lever, the picture still went off at the end of 15 seconds, and did not come on again until contact was broken and then the lever was touched again.

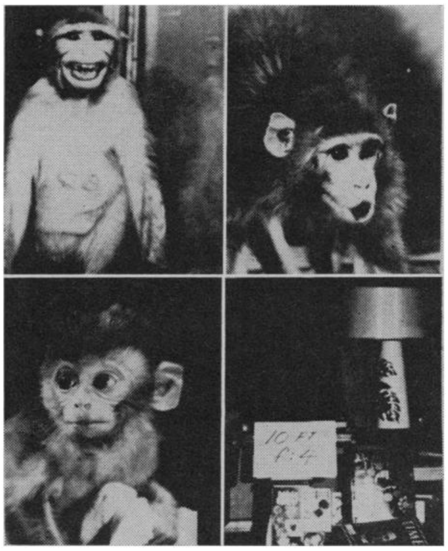


Fig. 1. Examples of picture stimuli from the ten categories. The four categories selected for illustration here are (top left) threat, (top right) fear, (bottom left) infant, and (bottom right) control. The actual pictures were in natural color.

Up to the fourth month of life all subjects received a minimum of two experimenter- and two animal-controlled tests each week. At 4 months, four subjects received motion picture stimuli, but these monkeys were still exposed to at least one trial of experimenter-controlled slides each week. The motion picture data parallel the data for slides, and will not be treated here.

The 2- by 2-inch (5- by 5-cm) colored slides used as stimuli were grouped into ten categories (four of which are illustrated in Fig. 1). They include pictures of (i) threatening, (ii) playing, (iii) fearful, (iv) withdrawing, (v) exploring, and (vi) sexing monkeys, as well as pictures of (vii) infants, (viii) mother and infant together, and (ix) monkeys doing "nothing." Labels were applied, and stimuli were included for study, only when the pictures received a unanimous title by a panel of eight experienced monkey testers. The final category, (x) control pictures, included a living room, a red sunset, an outdoor scene with trees, a pretty adult female human, and various geometric patterns. Each of the ten categories had at least four different examples. Only one randomly chosen slide from each category was used in any individual test session. Complete randomness was restricted such that no single slide appeared more than once in a 7-day period. The monkey pictures were projected with an approximately life-size image.

In animal-controlled tests, the basic data were the number of lever touches producing shutter openings out of the 20 possible shutter openings in each 5-minute stimulus period. In experimenter-controlled tests data were collected on a checklist by an observer looking through a nonreflecting one-way viewing screen in one wall of the cage. These checklist data were frequencies per 2-minute stimulus period of (i) vocalization, (ii) disturbance behaviors including rocking, huddling, self-clasping, fear, and withdrawal, (iii) playing with the picture, (iv) visual and manual exploration of the picture, and (v) climbing on the walls of the cage. Sex, threat, and aggressive behaviors were also scored, but sexual responses never occurred, and only three threatening or aggressive responses were observed during the 9 months of testing.

Evidence for behavioral differentiation of the ten types of stimuli during experimenter-controlled tests is shown in Table 1. These results can be summarized as follows. First, threat and infant pictures produced the greatest frequency of response on all measures of behavior. All differences between these two types of pictures and the other pictures taken individually were significant beyond the .01 level. Second, there was more vocalization and disturbance with threat than with in-

Table 1. Overall responsiveness to pictures. Mean frequency of the five behavioral measures for all 2-minute periods, during the 9 months of testing.

Stimulus picture	Behaviors				
	Vocalization	Disturbance	Play	Exploration	Activity (climbing)
Threat	0.61	0.83	0.46	5.0	1.7
Infant	.48	.37	.54	4.8	1.8
Withdraw	.27	.20	.17	2.4	0.8
Fear	.27	.15	.26	2.3	.9
Play	.27	.21	.21	2.7	.8
Explore	.22	.19	.19	2.2	.8
Sex	.17	.24	.18	2.2	.8
Mother-infant	.29	.25	.19	2.5	.7
Nothing	.22	.21	.31	2.7	.9
Control	.14	.12	.16	2.6	.7

fant pictures (both $p < .02$). Third, there were no significant differences between the remaining seven monkey pictures (fear, withdrawal, explore, sex, mother-infant, and nothing) on any measure (all $p > .10$). Tests of overall differences between any of these seven monkey pictures *for each month* during rearing also failed to reveal significant variation (all $p > .05$), indicating that these seven pictures were responded to similarly throughout rearing. Fourth, the control pictures had significantly lower frequencies than these remaining seven monkey pictures pooled together on the vocalization, disturbance, and play measures (all $p < .04$), but no significant differences appeared on exploration and climbing activity (both $p > .10$).

The development of responding during experimenter-controlled tests is summarized in Fig. 2. In these data the seven monkey pictures that did not differ significantly from one another in overall frequency of eliciting responses are pooled together to form an "other-monkey" category. Disturbance behavior occurred at a uniformly low level throughout the 9-month period for all pictures except threat. Beginning at 2 to 2.5 months, and peaking at 2.5 to 3 months, disturbance behavior consisting primarily of fear, withdrawal, rocking, and huddling occurred at high levels whenever pictures of monkeys threatening appeared on the screen. At 3.5 months this apparently innate fear response to threat stimuli declined. The vocalization measure, a response that reflects disturbance but may also reflect contentment, showed a course of development similar to disturbance, except that vocalizations were relatively high with infant pictures. After the first month of life, pictures of threat and of infants received more exploration and play than did other-monkey or control pictures. Interestingly, the first stimulus pictures to receive a relatively high degree of play were threat, which were played with even during periods when disturbance responses to threat pictures were high. Climbing responses (Fig. 3), taken as an index of general activity, exhibited a large increase after the first month. Climbing was most frequent in response to threat and infant pictures from this time until the end of testing. Also illustrated in Figs. 2 and 3 is the finding that all measures for all stimuli generally leveled off at about 6 months and remained constant thereafter.

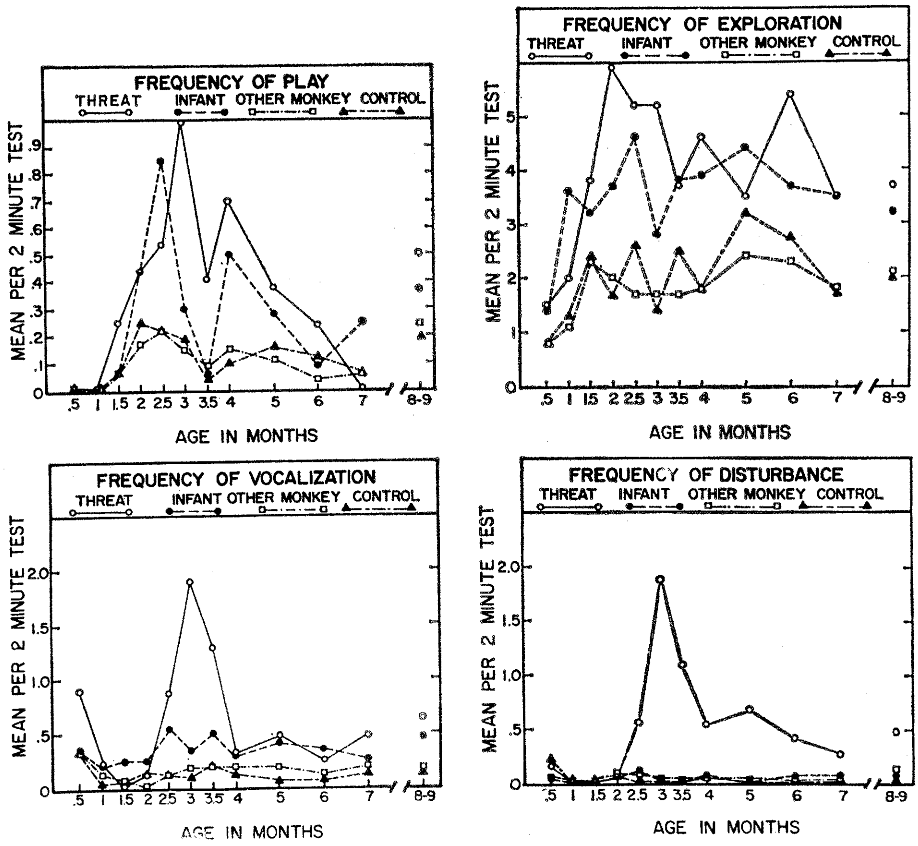
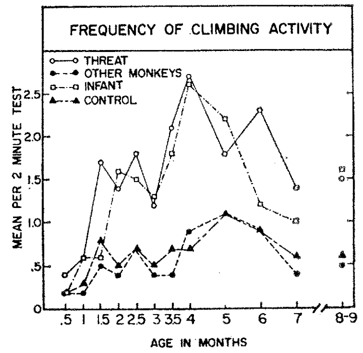


Fig. 2. Reactions to experimenter-controlled slides: the development of play, exploration, vocalization, and disturbance behaviors in response to pictures of threatening monkeys, infants, all other monkey pictures pooled, and control pictures.

Figure 4 presents the data for animal-controlled pictures for all stimuli through the first 6 months of life. Lever-touching was equal for all pictures during month 1. During months 2 and 3 the subjects began exposing themselves more to pictures containing monkeys than to control pictures. About month 3, when the subjects were beginning to show disturbance to threat pictures in experimenter-controlled tests, lever-touching for threat declined markedly. However, responding for infant and other-monkey pictures continued to increase. During month 4 responding to threat pictures was depressed below the control-picture level, but lever-touching for threat did increase again during months 5 and 6. Lever-touching was generally higher for pictures of infants than for other-monkey pictures from month 2 until the end of testing. Although lever-touching may have been influenced by



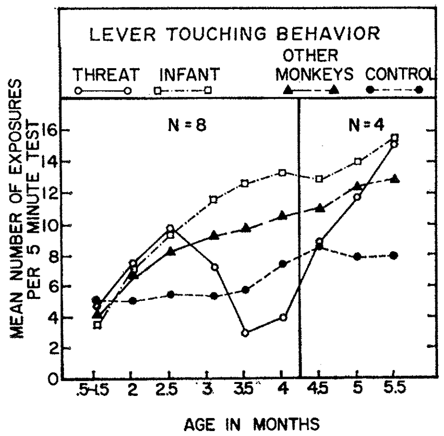


Fig. 3 (left). The development of climbing behavior during stimulation, taken as an index of general activity level. Fig. 4 (right). Frequency of self-exposures to threat, infant, other monkey, and control pictures for the first 6 months of animal-controlled tests.

differential general activity with the various stimuli, it is unlikely that the decrease in response for threat pictures was the result of such a factor. As shown in Fig. 3, climbing activity was similar for both threat and infant pictures from months 2 to 5, yet infant pictures elicited a high level of lever-touching while touching for threat pictures declined markedly.

In general, the shapes of the curves in Figs. 2–4 were characteristic of the behavior of individual subjects. The individual curves tended to follow the major inflections shown in the averaged data, although there were discrepancies of up to 1 month in the exact age at which a given monkey might show a large increase or decrease in a given behavior. The most important case concerns disturbance behavior in response to threat pictures. Two monkeys showed a large increase in disturbance at 2 months of age, four animals showed increases at 2.5 months, and the remaining two subjects showed increased disturbance at 3 months. Kendall's Coefficient of Concordance was calculated to measure the degree of consistency in disturbance with threat pictures between subjects over age blocks. This measure revealed a very high degree of association between subjects ($W = .808$; $p < .001$), indicating that individual animals behaved in a very similar manner toward the threat pictures.

These data lead to several important conclusions. First, at least two kinds of socially meaningful visual stimuli, pictures of monkeys threatening and pictures of infants, appear to have unlearned, prepotent, activating properties for socially naive infant monkeys. From the second month of life these stimuli produced generally higher levels of all behaviors in all subjects. Second, the visual stimulation involved in threat behavior appears to function as an "innate releasing stimulus" for fearful behavior. This innate mechanism appears maturational in nature. Thus, at 60 to 80 days threat pictures release disturbance behavior, although they fail to do so before this age. These fear responses waned about 110 days after birth. This could be due to habituation, occurring because no consequences follow the fear behavior released by threat pictures—consequences that would certainly appear in a situation with a real threatening monkey.

One important implication of these results concerns the ontogeny of responses to complex social communication in primates. These data suggest that at least certain aspects of such communication may lie in innate recognition mechanisms, rather than in acquisition through social learning processes during interactions with other animals. Although the maintenance of responses to socially communicated stimuli may well depend on learning and some type of reinforcement process, the initial evocation of such complex responses may have an inherited, species-specific structure. Thus, these data suggest that innate releasing mechanisms such as those identified by ethologists (*2*) for insect and avian species may also exist in some of the more complex behaviors present in the response systems of primates.

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3. Supported by grant MH-4528 from the National Institute of Mental Health. Portions of these data were reported at the 10th Interamerican Congress of Psychology, Lima, Peru, April 1966. I thank C. Pratt and L. Link for assistance with this research.

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Calcium and Bromide Contents of Natural Waters

Anderson, Graf, and Jones [*Science* **153**, 1637 (1966)] fitted a straight line to their log-log scatter plot of the Ca^{++} and Br^{-} contents of a group of natural waters. The equation of this line was given as

$$\log Ca^{++} \, [g/10^6 \text{ g (solution)}] = 1.263 + 1.406 \log Br \, [g/10^6 \text{g (solution)}]$$

The coefficient 1.406 is not correct for the line as drawn in their figure; a value of 1.05 (1.046, perhaps) seems more likely. Indeed, for the given data a line of unit slope would fit just as well.

The authors' emphasis on their particular line is presumably based on the coincidence that a line tightly fitting their Michigan data in the high-salinity range also gives a fairly good fit of the part of their Dead Sea data that fall in the low-concentration range. But this must be a coincidence unless the authors propose a single original source other than sea water, which falls well above that line.

It would be more instructive to draw a line of unit slope through their sea-water point, indicating compositions available by evaporation or dilution of sea water. The fact that almost all the data fall on the calcium-rich side of such a line, but less than a decade removed from it, is much firmer evidence of both a common sea-water origin and the proposed calcium-enrichment processes.

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Mangelsdorf is correct in suspecting that our proofreading was faulty: the constant in the equation should be 1.046, not 1.406. We also agree that drawing an additional line in the diagram (Fig. 1), at unit slope through the sea-water point, is a useful device; but one must remember that this new line, as defined by Mangelsdorf, is fictive, because precipitation of $CaSO_4$, $CaSO_4 \cdot 2H_2O$, and $CaCO_3$ prevents one from increasing the Ca concentration of sea water very much by simple evaporation.

The common source of $Ca{+}{+}$ and $Br-$ suggested for the Dead Sea and Michigan Basin chloride brines that plot on the line of Fig. 1 is sea water modified to a comparable extent by ultrafiltration, dolomitization, and fresh-water infiltration in the two areas. Sets of subsurface samples from other areas, with different hydrodynamic histories, would not be expected to fall on the line. The line, therefore, does involve a coincidence between two geographical regions; it is of significance not for its position but for its slope, which was interpreted in terms of the processes mentioned above, rather than of simple dilution or concentration, because of the particular chemical composition of the samples. It is quite possible that subsurface calcium chloride waters exist that have undergone dilution by fresh water subsequent to the other processes.

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