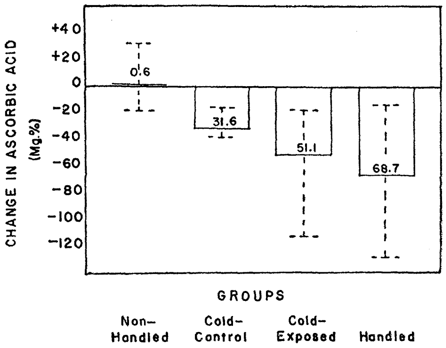

Fig. 1. Comparison of adrenal ascorbic acid depletion in the early treatment groups. Bars represent mean depletion, dashed lines indicate range among litters within each group, and mean values are on the bars. Mg %, milligrams per 100 grams.

metabolic, or physiological changes concomitant with handling, would be needed to verify these speculations. Because of the technical difficulties of obtaining such measurements, the following experiment was designed as an initial test of the hypothesis that the effects of handling are due to lowered skin or body temperature.

Thirteen Holtzman Sprague-Dawley litters, totaling 118 pups, were assigned by litter to one of four treatment groups. Animals in group H ($N=30$) were handled daily for 2 minutes. Animals in group NH ($N=31$) were not handled. Animals in group CE ($N=31$) were exposed daily to low temperature. Animals in group CC ($N=26$) were treated exactly like those in group CE, but were not exposed to cold. Pups in group CE were exposed to cold by placing the nest cage, containing mother and litter, in a refrigerator at 7° to 10°C. Cages housing pups in group CC were placed in a nonfunctioning refrigerator maintained at room temperature (23°C). Groups CE and CC remained in their refrigerators for 12 minutes, the approximate time that group H litters were out of their cages during the handling procedure. Cages were transported gently to minimize disturbance. All treatments began on the day following birth and continued for 6 days, thus encompassing the first week, the critical period for handling.

Depletion of adrenal ascorbic acid in response to cold stress was selected to evaluate the effectiveness of treatments because it yields clear-cut differences between handled and nonhandled animals at an early age, and because it permitted us to replicate some of Levine's excellent work (*2*). At 12 days, the earliest age for significant depletion by cold stress (*8*), half the pups in each litter were killed by cervical-spinal separation. Adrenals were removed, weighed, and analyzed for ascorbic acid content. The remaining pups were placed in small, metal containers inside a refrigerator for a 90-minute cold stress at 5°C preceding removal of adrenals and assay for ascorbic acid. The assay method and data treatment have been described elsewhere (*6, 8*).

The results are graphed in Fig. 1. Mean depletions of ascorbic acid, expressed in milligrams per hundred grams, were determined by subtracting the mean value for the stressed animals from that of the nonstressed animals within each treatment group. A Mann-Whitney U test (*9*) of the differences between stressed and nonstressed animals in each group demonstrated significant reductions in adrenal ascorbic acid at the .01 and .05 levels for the stressed animals in groups H and CE, respectively. There were no significant differences in ascorbic acid levels between stressed and nonstressed animals in the NH or the CC groups.

These results indicate that the essential aspect of the handling procedure is a drop in environmental temperature accompanying removal from the nest. Subjecting the pups to low temperature on days 2 through 7, although they were somewhat insulated in the nest by the mother, produced the same effect as handling (which exposed pups to room temperature for the same amount of time). The small, nonsignificant depletion in adrenal ascorbic acid in group CC we attribute to the mother's leaving the nest briefly when the cage was moved. When the mother leaves, the pups are dispersed and exposed to room temperature until they are returned to the nest by the mother. It seems likely that significant depletion at 14 days for Levine's cage-moved group resulted not from moving the cage, but from exposing the pups for 2 minutes during the mother's absence. Perhaps this exposure, longer than in our CC group, produced the significant change. On the other hand, Levine's animals were assayed at 14 days and are not entirely comparable with our CC animals, assayed at 12 days.

We have demonstrated that exposing the young pup to cold, mitigated somewhat by the nest and the mother, produced essentially the same effect as handling. Kalberer (*10*) has subsequently reported that cold treatment in early infancy produced a significant weight gain similar to that found in rats that have been handled in infancy. It remains to be demonstrated that handling does, in fact, affect skin or body temperature in infant rats, and that such a change has the same effects on later behavior as handling. Neurologic, physiological, and biochemical mechanisms for such temperature-produced effects also await further investigation (*11*).

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Magnitude Estimation of the Brightness of Brief Foveal Stimuli

Abstract. Eighteen observers judged the apparent brightness of light flashes that varied in both duration and luminance. The median numerical estimations (made relative to a standard flash) confirmed three principles: the reciprocity between luminance and duration (Bloch's law), the enhancement of brightness at about 50 milliseconds (Broca-Sulzer effect), and the power-law relation between brightness and energy (Stevens's law).

Detection of a brief flash of light is a function of its energy. Threshold studies of Bloch's law have shown that luminous power is integrated over time up to around 100 msec (*1*). Summation ceases beyond this "critical duration," and the threshold is then defined solely in terms of luminance.

Analogous studies at suprathreshold levels have defined similar luminance-duration reciprocity relations in the mediation of brightness, plus a curious overshooting effect in the growth of brightness with duration (*2*). This overshooting, the well-known phenomenon of Broca and Sulzer, is seen at moderately high luminances, and consists in the fact that brightness grows with duration up to around 50 msec and then diminishes as the stimulus is prolonged to about 200 msec.

Typically, these experiments have employed null methods—procedures in which adjacent targets are adjusted in luminance to yield brightness matches. With flashes of unequal duration, such experiments necessarily involve asynchronous stimulation of neighboring retinal areas—a condition which may generate metacontrast suppressions (*3*). Haploscopic presentation of the standard and test stimuli (*4*) may still be contaminated, since Kolers and Rosner (*5*) have recently demonstrated the existence of interocular (or "dichoptic") metacontrast.

Attempts to verify the Broca-Sulzer effect by simple reaction-time tests fail (*6*) because minimal reaction time to moderately intense stimuli is evoked by extremely brief flashes—those with durations of less than 500 μsec (*7*).

Although psychophysical scaling procedures are much less precise than the null methods (*8*), it seemed worthwhile to apply the former to the problem of the growth of brightness with duration. The method of direct magnitude estimation (*9*) was essayed despite the fact that this procedure commonly provides the observer with a rather long look (2 to 3 seconds) at the stimulus to be judged. In a further departure from the usual estimation procedures, two stimulus dimensions (luminance and duration) were varied in the same experiment.

Stimulus flashes were generated by transilluminating a ground glass plate with light from a glow modulator tube. The target was formed by masking off all of the glass except for the circular area directly behind a 1-cm aperture in the masking plate. This 1-cm target, viewed binocularly from a distance of 1 m, subtended a visual angle of 35 minutes.

Eighteen undergraduate students served as observers in the brightness-estimation experiment. All but two had previously served in a similar study of loudness scaling, and all were first tested in a preliminary study with 200-msec flashes.

Nine luminances were explored, covering the range between 350 and 0.035 mlam in steps of 0.5 log units. Twelve stimulus durations were used: 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, and 2000 msec. Seventeen of the low-level, short-duration stimuli were not used. The remaining 91 stimuli were each presented once to all subjects. This required three daily test sessions for each subject. Each session began with 5 minutes of dark adaptation, followed by several presentations of the standard stimulus (3.5 mlam, 200 msec) whose brightness was called "10." This standard was presented after every five trials and, in addition, whenever the subject asked to see it. A different random order of stimuli was used for each subject. Subjects presented the stimuli to themselves; each subject worked at his own pace.

Median brightness estimates are given in Fig. 1. Although the curves relating brightness to duration and luminance are irregular—especially for the weakest stimuli—it is clear that subjects can make brightness estimates in the face of differences in flash duration. As a result, brightness is seen to grow with duration up to around 100 msec, beyond which it does not change significantly. At higher luminance levels (beginning at 3.5 mlam), the overshooting effect of Broca and Sulzer is seen; brightness is maximal in the neighborhood of 50 msec. The extent of the overshoot can be estimated, and it corresponds to approximately half a log unit of luminance—a value which agrees very well with the measurements given by null methods (*4*).

Finally, the experiment provides some checks on the reciprocity law. If we consider those data points at 20 msec and less (before the Broca-Sulzer peaks occur), we have 15 equal-energy pairs of stimuli (for example, 35 mlam at 2 msec and 3.5 mlam at 20 msec). Two such equal-energy stimuli should be judged equally bright. The mean brightness of the 15 briefer stimuli (0.5, 1, and 2 msec) was 8.8. The mean brightness of the 15 longer flashes (5, 10, and 20 msec) with equal energy was 9.3. Within the region of temporal integration, stimuli having equal energies are given virtually equivalent brightness estimates.

Within this reciprocity region, brightness should be proportional to the cube root of stimulus duration (*10*). The mean brightness of the four stimuli presented at 0.5 msec was 7.8. At 1, 2, 5, 10, and 20 msec, the mean estimates

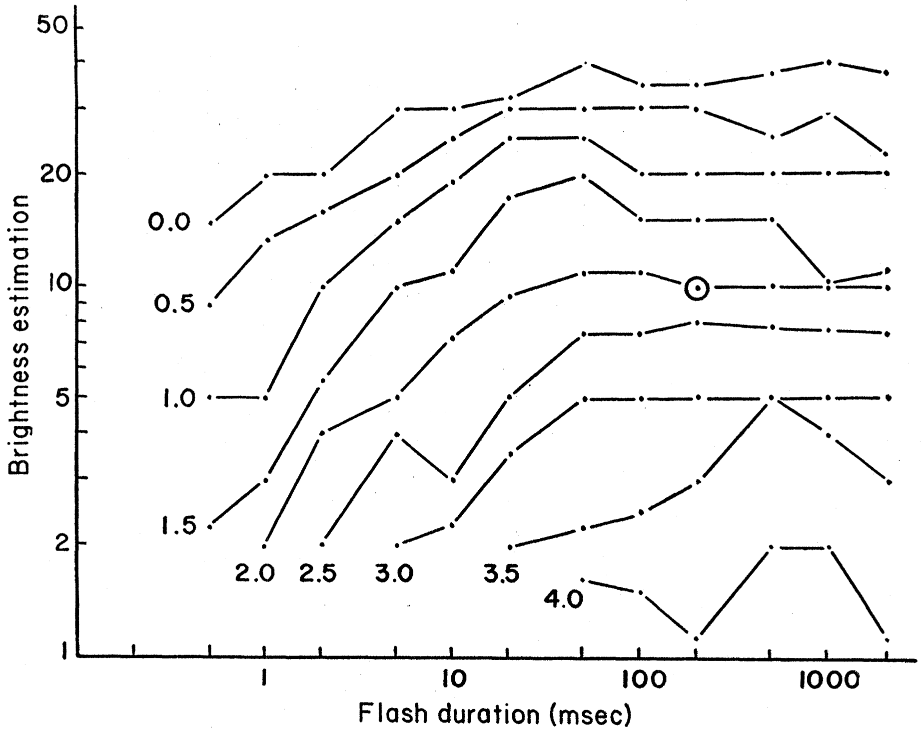

Fig. 1. Brightness estimation as a function of stimulus duration. The parameter is flash luminance in log units *below* 350 mlam. The circled point designates the standard stimulus.

were 10.4, 12.9, 18.8, 21.3, and 26.3, respectively. The fit of these values to Stevens's power law is excellent. The method of magnitude estimation thus seems capable of operating on brief stimuli varying in both luminance and duration (*11*).

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Prenatal Influence on Behavior of Offspring of Crowded Mice

Abstract. Pregnant albino mice were subjected to stress by crowding. When the litters encountered unfamiliar stimuli, they were less active, they were slower to respond, and they defecated less than control mice. These differences persisted at 30 and 100 days of age, whether the mice were raised by a crowded or by an uncrowded mother, and in spite of starvation. One explanation may be that aberrant endocrine activity in the crowded, pregnant female impairs the development of fetal response systems.

Everyone has heard the old wives' tale that guarantees a musically talented child to pregnant mothers who listen to Beethoven. Some recent findings are in harmony with this view, suggesting that prenatal environment may in fact influence postnatal behavior. Thompson (*1*), for example, found that rats which fear an electric shock deliver anxious pups. Their offspring need more time to leave a cage spontaneously, cover less ground when they do, and after starvation take longer to discover food than animals from normal mothers. In the experiments reported here, comparable results were found when pregnant mice were crowded.

Even when living space is varied from 1 to 42 square feet, Christian and others (*2*) have found similar increases in the adrenal weights of mice as population rises. Christian also noted significant differences in the reproductive activity of both sexes when he compared crowded groups of 20 with uncrowded groups of two. With Christian's procedure used as a guide, 15 female albino mice were crowded in a wooden cage, 6 by 12 by 5½ inches. Uncrowded control mice lived five to a cage of the same dimensions.

With parturition imminent, a pregnant mouse was segregated to deliver and raise her litter alone. To control for postnatal influences due to weaning, some crowded mothers were translocated so that they could nurse a litter born to an uncrowded female. Likewise control mothers were exchanged. A female and her litter were kept as units in uncrowded cages from birth until the time of testing. Food and water were supplied freely.

Behavior was investigated by recording the time which elapsed before a single mouse left its cage spontaneously. A wire mesh ramp in the cage allowed free access to a table. Response latency was measured from the time the wire ramp was installed until the moment the animal stepped from the ramp by putting all four feet on the table. Thus, the first mouse to leave the ramp was called the fastest mouse. Every litter had its own fastest mouse, second-fastest mouse, third-fastest, and so on, for which response times were separately recorded. The intention was to eliminate biases produced by any hierarchies of dominance or leadership, or both.

Latency was recorded with respect to five independent variables: (i) litter born to crowded or uncrowded (control) mother; (ii) age of 30 days versus 100 days; (iii) 1½ days of starvation before first latency test; (iv) 1½ days of starvation before second latency test; and (v) reciprocal translocation, where litters born to crowded or uncrowded mothers were raised by uncrowded or crowded mothers, respectively.

For all variables, test and control groups came from different litters. But control mice used with the first variable also served as the controls for the fourth; test groups for these variables were used in a similar manner. Thus, 15 of 75 litters (or 94 out of 479 mice) were examined with more than one variable.

Behavior was also examined by noting defecation in a previously unexperienced environment. This was measured for 100-day-old mice and for animals whose mothers were translocated. Each mouse was lifted by the tail from its cage and placed on a clean, black table. After 5 and 10 minutes, the number of pellets dropped by the litter was observed.

The results of the latency tests are summarized in Tables 1 and 2. In Table 3, the defecation results are listed.

Litters from crowded mothers were less active and slower to respond to unfamiliar stimuli than control groups born to uncrowded mothers. These differences were found whether the mice were raised by a crowded or by an uncrowded mother, at 30 days and at 100 days of age, and in spite of starvation. If the stimuli were familiar, however, hunger overrode other disturbances and few significant differences were found in the responses of starved animals.

At age 100 days, litters from crowded mothers defecated less than controls when placed in an unfamiliar environment. This also occurred at age 30 days in litters born to crowded mothers but raised by uncrowded females. A tendency for increased inhibition as a result of translocation and disturbance is evident, as in the latency tests, but the tendency is slighter and not statistically important.

Realistically, we expect that behavior is liable to both prenatal and postnatal effects, and some of these experiments may not separate the two. For example, at age 100 days, we may wonder why the difference in response latency fails to persist and why a significant variation in total activity makes its first appearance. Also, inadvertent differences in handling or social experience may have occurred. The fact that total activity dropped sharply when a litter was not raised by its own mother points even more clearly to strong postnatal modifications of response.

However, nursing and other postnatal modifications will not abolish behavior traits acquired *in utero*. Mice born to crowded mothers, but raised by uncrowded nurses, differ very little except in the amount of response from mice born to and reared by their own crowded mothers. Those that respond at all are just as slow in their sponta-