Intersensory Interaction in Newborns: Modification of Visual Preferences Following Exposure to Sound

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LEWKOWICZ, DAVID J., and TURKEWITZ, GERALD. *Intersensory Interaction in Newborns: Modification of Visual Preferences Following Exposure to Sound.* CHILD DEVELOPMENT, 1981, 52, 827-832. The present study investigated intersensory interaction between auditory and visual stimulation in newborn infants. Stimulation in 1 modality may influence the response to stimulation in a second modality by changing the infant's state of arousal. To test this possibility, newborns' visual preferences for light patches of different intensity were examined following auditory stimulation. Visual preferences in infants not previously exposed to sound described an inverted U, indicating a preference for the light of intermediate intensity. In contrast, infants who were first exposed to sound preferred the light of lowest intensity. The results indicate that newborns attend to quantitative variations in stimulation and that these variations reflect both the objective stimulus intensity and organismic factors.

Recently there has been a growing appreciation of the importance of intersensory functioning during infancy. This concern has been evidenced in studies of intersensory equivalence (Allen, Walker, Symonds, & Marcell 1977; Bryant, Jones, Claxton, & Perkins 1972; Gottfried, Rose, & Bridger 1977; Lewkowicz & Turkewitz, in press; Rose, Gottfried, & Bridger 1978; Ruff & Kohler 1978) and multimodal coordination (Lawson 1980; Lyons-Ruth 1977; Spelke 1976, 1979). However, these areas are only two aspects of intersensory functioning; included in the realm of inter-sensory interactions are also intersensory effects of a facilitative or inhibitive nature, and these have a long history of research in adults (see Ryan 1940). In contrast, there have been very few attempts to study the latter two types of interactions in infants (Hainline 1978; Horowitz 1974; Irwin 1930; Mendelson & Haith 1976). The current investigation therefore seeks to examine the effect of immediately preceding auditory stimulation on the visual preferences of newborn infants.

A number of studies indicate that visual preferences in early infancy are influenced by various quantitative aspects of stimulation such as brightness (Hershenson 1964), amount of contour (Berlyne 1958; Brennan, Ames, & Moore 1966; Greenberg & O'Donnell 1972; Karmel, Hoffmann, & Fegy 1974; Karmel & Maisel 1975; Maisel & Karmel 1978), size (Maisel & Karmel 1978; Ruff & Turkewitz 1975), number of elements (Hershenson, Munsinger, & Kessen 1965), and rate of change (Karmel, Lester, McCarvill, Brown, & Hoffmann 1977; Volkmann & Dobson 1976). In fact, it has been suggested (McGuire & Turkewitz 1979; Schneirla 1959, 1965) that early in development organisms respond primarily to the quantitative aspects of stimulation, while later they also respond to their qualitative aspects. A number of studies suggest that young infants in fact ignore qualitative attributes of stimulation in favor of quantitative ones. Thus, infants 10 weeks of age or younger ignore pattern differences and fixate the larger of a pair of stimuli (a bull's-eye vs. a striped pattern), while older infants fixate a bull's eye pattern more often than a striped pattern, regardless of size (Ruff & Turkewitz 1975). Similarly, younger infants' (5-6 weeks) looking is af-

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fected by stimulus size, but older infants' looking (8-10 weeks) is not (Maisel & Karmel 1978). In 10-15 week-old infants, finger extension and flexion is related to the size, distance, and brightness of a visual stimulus, but no such relationship exists in older (20-25 weeks) infants (McGuire & Turkewitz 1978).

In addition to the evidence suggesting responsiveness primarily to quantitative aspects of stimuli within a modality, other evidence suggests that young infants ignore such basic qualitative differences as the modality of input. Thus, 3-week-old infants respond to the degree of similarity between the intensity of a repeatedly presented light and that of a sound while ignoring differences due to the modality of presentation (Lewkowicz & Turkewitz 1980).

Thus, a considerable body of evidence indicates that young infants attend to the quantitative aspects of stimulation both within and across modalities. These quantitative variations are ones that, according to one view, do not uniquely determine responding but rather contribute to what has been termed the effective intensity of stimulation (McGuire & Turkewitz 1979; Schneirla 1959, 1965). The effective intensity of a stimulus is not only determined by objective intensity, as influenced by such stimulus attributes as contour density, size, brightness, and rate of change, but also by such characteristics of the organism as the state of arousal, state of adaptation of the receptors, and prior history. For example, a light of a particular brightness may be effectively intense to an infant who is dark adapted but effectively weak to an infant who is light adapted. In sum, the young organism's response is determined not only by characteristics of the stimulus but by those of the organism as well.

If young infants respond primarily to the total amount of stimulation, stimulus attributes such as contour density, size, brightness, and rate of change should be both interchangeable and additive in their effects on the infant. There is, in fact, some evidence that such is the case. Changing the brightness level of a series of stimuli varying in contour density shifts visual preferences (McCarvill & Karmel 1976) and combining different levels of brightness and size of a visual stimulus results in a behavioral effect greater than that produced by each variable alone (Ruff & Turkewitz 1979). Additivity across modalities apparently occurs as well; thus visual preferences in newborns are affected by concurrent auditory stimulation (Lawson & Turkewitz 1980).

While a mechanism based on additivity may be used to explain the effects of concurrent variations in intramodal or cross-modal stimulation, a somewhat different mechanism may operate when organismic factors act to modify the effective intensity of a stimulus. In the latter case, the state of arousal, for example, may alter the effective intensity of a stimulus by modulating the effect of an incoming signal. Thus, a visual stimulus of a given brightness may be effectively strong for an infant in an aroused state but effectively weak for an infant in a quiescent state. If so, then intersensory effects may be mediated indirectly by changes in arousal due to prior stimulation in one or another modality. Changes in the infant's state of arousal may indeed play a role in determining the effective intensity of a stimulus; thus the prandial status of the infant or swaddling affect visual preferences in prematurely born infants (Gardner & Turkewitz, Note 1). In this study we examined a specific instance of such indirect intersensory influences, namely, changes in the infant's visual preferences due to prior auditory stimulation.

Method

Subjects.-Thirty-two infants (18 males, 14 females) participated in this study; they were primarily of working-class black and Puerto Rican background and were born at the Bronx Municipal Hospital Center. The infants were tested when they were between 11 and 48 hours old (M= 34.9 hours); their birth weights ranged between 2,715 and 4,140 grams (M = 3,356 grams), and their 1-min and 5-min Apgar scores were not less than 8 and 9, respectively. No prenatal, perinatal, or postnatal complications were noted for any of the infants, and they were all delivered without any labor or delivery medications. Data from 16 additional infants were excluded from analyses due to sleepiness or crying.

Apparatus.-An apparatus modeled after Fantz and Nevis (1967) was used to study visual preferences. It consisted of a wooden chamber which was lined with gray felt. A wooden panel, covered with black cardboard, was mounted facing the infant between the side, top, and bottom panels of the chamber. This panel had two 15 x 15-cm openings placed an equal distance from the center which were covered with milk-white Plexiglas to provide a homogeneous field of white light. A 0.5-cm peephole placed in the center of the panel allowed the experimenter to observe the infant's visual fixations and to record them on a Rustrak event recorder.

The visual stimuli were produced by two 14-watt GE Deluxe Cool (F14T12, color temperature 4,200 K) white fluorescent lamps mounted inside a 50 x 18 x 23-cm box which was attached to the back of the stimulus panel. The intensity of each of the two stimuli was independently controlled by changing the current flowing through the bulbs. Broad-band white noise (50-10,000 hertz) was produced by a Grason Stadler (model 901B) noise generator and was presented through an 8-inch speaker (Realistic MC-500). The speaker was in the same plane as the visual stimuli at midline below the infant.

Procedure .-Testing took place in a quiet room where the ambient sound-pressure level was 60 db (linear scale, re 0.0002 dynes/cm^2). All infants were tested 95-60 min prior to their 09:30 feeding. The infant was swaddled, given a pacifier for the duration of the test, and placed in a semisitting position either in an assistant's lap or in an infant seat. The assistant was blind to the intensities of the lights. The infant's eyes were approximately 30 cm from the stimulus plane. Those infants who sat in the infant seat had their head maintained in the midline by a specially constructed support. The observer changed the intensity of the lights before every trial and was therefore not blind to the intensities presented to the infants.

The infants were presented with visual stimuli of three luminance levels: 8, 57, and 205 ftL as measured with a MacBeth illuminometer. The visual stimuli were paired with one another to form three pairs and were counterbalanced for side of presentation, resulting in a total of six stimulus pairs for each subject. The six pairs were presented according to a previously determined random sequence. The auditory stimulus was 78 db (linear scale, re 0.0002 dynes/cm^2) when measured at the infant's ears.

There were two groups of infants: a sound group and a no-sound group. The sound group was presented with 10 2-set bursts of white noise with an interburst interval of 8 sec. A pair of visual stimuli was then presented for 30 sec. To maintain the effect of the auditory stimulation, following the first pair of visual stimuli five bursts of white noise were presented, and the second pair of visual stimuli was then presented. This sequence, five auditory stimuli followed by a test of visual preference, was continued until all six pairs of test stimuli were presented. The interval between the last auditory stimulus of a series and the test stimuli was also 8 sec. For the no-sound group the procedure was identical except that no auditory stimuli were presented prior to the presentation of the visual stimuli. To keep the intervals between visual stimulus presentations equal in the two groups, the visual stimuli for the no-sound group were presented every 58 sec. For some infants it was necessary to interrupt the procedure in order to arouse them. There was no differential drop-out rate in the two groups.

The duration of the visual stimuli was controlled manually by an experimenter who responded to a signal from a timer. The duration of the auditory stimulus and interstimulus intervals were controlled by a Lafayette automatic timer.

Results

Because of the high intersubject variability in total amount of looking at each of the three stimuli, the data for each infant were normalized by a z score transformation. All analyses were based on these z scores. As may be seen in figure 1, the infants looked at the stimuli for unequal amounts of time, and looking was affected by whether or not the visual stimuli were preceded bv auditorv stimulation. A two-way repeated-measures ANOVA with intensity as a within-subiect factor and sound condition as a between-subject factor indicated a significant main effect of intensity, $F(2,60) = 4.66$, $p < .025$, and a significant intensity x sound condition interaction, $F(2,60) = 4.62$,

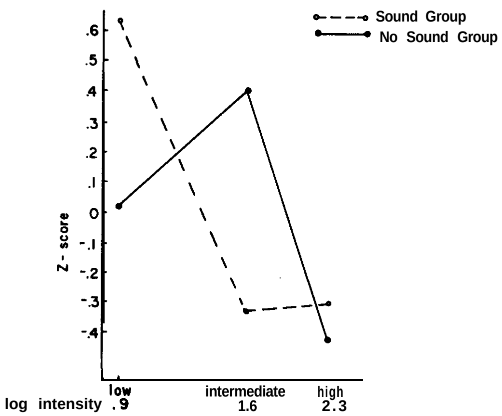

FIG. 1.-Visual preferences for lights of different intensities in the sound and no-sound conditions.

$p < .025$. There was no main effect of sound condition. The fact that there was no main effect of sound condition on looking indicates that sound had no overall facilitative or disruptive effect on visual behavior.

To identify the source of the intensity by sound condition interaction, an analysis of the simple main effects due to this interaction was performed. Looking time differed between infants exposed to the sound and those not exposed to it for both the dim light, $F(1,30) = 7.66$, $p < .01$, and the intermediate light, $F(1,30) = 9.30$, $p < .01$, but not for the bright light. The finding that looking to the different intensities of light is affected by exposure to sound provides support for the hypothesis under examination.

To further examine the effect of preceding auditory stimulation on visual preferences, the shape of the function relating looking and intensity was examined in each condition separately. The relationship between intensity and looking in the no-sound condition was best described as an inverted U (fig. 1), and a trend analysis weighted for unequal intervals (Keppel 1973) indicated that the data are best described by a quadratic trend, $F(1,15) = 4.96$, $p < .05$. Presentation of a sound prior to the presentation of the visual stimuli did in fact change the infant's visual preferences in that the shape of the function for the sound group (fig. 1) was best described by a significant linear trend (unequal intervals trend analysis; $F[1, 15] = 13.0$, $p < .01$).

To check for the possibility of order effects, a one-way repeated-measures ANOVA was performed for each group separately on the total duration of fixation as a function of trial. Separate ANOVAs were computed for each locus of stimulus presentation and for the two loci combined. No effects of trial were found on any of these analyses.

Discussion

The systematic relationship between light intensity and looking found in both groups of infants confirms prior findings that newborns are responsive to the intensity of visual stimulation (Hershenson 1964). The results of the present study further indicate that visual preferences in human newborns can be modified by immediately preceding exposure to sound. Infants presented with pairs of lights of three different intensities looked longest at the intermediate-intensity light. Exposure to white noise prior to the presentation of the visual stimuli resulted in a shift in visual preferences such that the low-intensity visual stimulus was now the most preferred. These results are similar to Lawson and Turkewitz's (1980) finding that sound presented concurrently with visual stimulation modified visual behavior. However, the present finding cannot reflect direct summation of the visual and auditory stimuli as they were not presented concurrently. The most likely mechanism mediating the shift in visual preferences observed here is a change in the infants' state of arousal.

The shift in visual preference may be understood in the context of Schneirla's approach/withdrawal theory (McGuire & Turkewitz 1979; Schneirla 1959, 1965). According to this theory, organisms exhibit approach behavior over a wide range of intensities. The relationship between responding and intensity is an inverted U. Thus, responding is low to weak sources of stimulation, increases to a maximum to intermediate intensities, and decreases to high intensities. The response of the no-sound group did in fact describe such an inverted U-shaped function. The peak of this function presumably reflects the optimal level of the visual stimulus for these infants. If the optimal level is determined by both the objective intensity of the stimulus and level of arousal then it should be possible to change the effective intensity of a given stimulus by changing the infant's level of arousal. Thus, changing an infant's level of arousal with sound stimulation should shift preferences in the manner observed in the sound group. Infants exposed to sound were presumably more aroused; therefore, all three visual stimuli were effectively more intense and preference shifted to an objectively less intense light.

The foregoing interpretation is consistent with the hypothesis under investigation; nevertheless, support for the hypothesis is indirect since there were no measures indicating changes in the infants' state of arousal following auditory stimulation. However, there is abundant evidence that exposure to white-noise stimulation results in both autonomic (Bartoshuk 1964; Steinschneider, Lipton, & Richmond 1966; Turkewitz, Moreau, Birch, & Davis 1971) and behavioral (Steinschneider et al. 1966) changes; both types of changes are presumed to reflect changes in arousal.

The data presented here are consistent with Lawson and Turkewitz's (1980) finding that auditory stimulation alters infants' visual behavior. Lawson and Turkewitz's data could, however, be interpreted as reflecting a disruption of preference rather than a shift in preference, since their infants showed no significant preference under conditions of auditory stimulation. This interpretation, however, cannot account for the data obtained here; infants in the sound group did show a significant visual preference albeit to a different intensity than infants in the no-sound group.

Finally, this study suggests that because the newborn infant pays attention to quantitative rather than qualitative attributes of stimulation, his sensory/perceptual world is rather primitive. Nonetheless, he is already capable of subtly modulating his intake of visual information in accord with his present condition. Also, these results suggest yet another form of intersensory interaction which differs from those which have previously been emphasized.

Reference Note

1. Gardner, J., & Turkewitz, G. The effect of arousal level on visual preferences in premature infants. Paper presented at the Eastern Psychological Association meeting, Hartford, Connecticut, 1980.

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