COMMON AUDITORY-VISUAL SPACE PERCEPTION IN EARLY INFANCY

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by

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A Thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science

Department of Psychology
Memorial University of Newfoundland
April 1982

St. John's Newfoundland

ABSTRACT

Common auditory-visual space perception was studied in infants aged 10 to 52 weeks. A violation of the normal spacial relationship between a speaking person and his voice was presented and the infants' response to the incongruent presentation was measured in terms of affectivity, inattention, and heart rate. The youngest infants, age 10 to 23 weeks, reacted with heart rate acceleration to the incongruent presentation, indicating an expectancy that voice comes from a person.

ACKNOWLEDGMENTS

This work is the result of guidance, support, and encouragement from numerous people. Included among this group are:

Jack Strawbridge,
John Evans,
Graham Skanes,
Sam Revusky,
Norm Braveman,
Dara Heller,
the Rabinowitz family,
and my parents.

Special recognition must be given to my advisor and my friend, Mike Rabinowitz, whose uncompromising expectation of quality has taught me a great deal.

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Introduction

The infant's capacity to visually localize auditory stimuli has been demonstrated in several studies. Wertheimer (1961) reported that his daughter, less than 10 minutes after birth, responded with coordinated eye movements to the location of a toy clicker. Similarly, Piaget (1952) described a series of observations (obs. 44-49) in which his children visually located their calling father. The orientation response included head turning and eye movements. In a more structured design, utilizing head turning as the dependent measure, Leventhal and Lipsitt (1964) concluded that 1 to 4 day old infants can discriminate sound location. They also noted that this ability is attenuated with reduced sound reverberation.

Although some type of intermodal coordination is apparent from these studies, no information has been provided as to the cognitive process involved in this integration. Piaget interpreted from his observations that it is impossible to determine whether the visual orientating response was simple accommodation to the auditory stimulus or cognitive search for the informative stimulus. The former (passive association) is characterized as a response controlled by the environment. The infant responds to stimulation with the assimilatory schemata he has available to him. The visual orientating response is one of several assimilatory responses available at that age. In the latter condition (active association) the auditory stimulus is interpreted as a signal carrying relevant information about the source. (The speech signal is highly effective in this regard.) The visual response is interpreted as an active assimilatory response to the auditory information. Implicit in this notion is an expectancy that the perceived visual stimulus will be veridical with the auditory information. Only in this latter condition, when the expectancy can be detected, can the cognitive structure of common auditory-visual space be assumed.

In a more recent study involving 2 to 8 day-old infants, McGurk, Turner and Creighton (1977) failed to replicate the findings of Wertheimer (1961). The majority of their subjects failed to respond visually during the presentation of an auditory stimulus. Many of the infants who did respond, looked in the opposite direction of the auditory stimulus. McGurk et al. suggested that during the neonatal period auditory and visual modalities function as relatively independent perceptual systems.

Cohen (1974) systematically manipulated the congruity of auditory-visual stimuli to determine the infant's ability to use auditory and visual information in forming a concept of mother. This was a developmental study using five- and eight- month olds. For each trial the infant's mother and a female stranger were seated equidistant from the infant. Both held a small speaker at shoulder level. A trial period consisted of a 30 second recording of either the mother's or the stranger's voice played from one of the speakers. Speaker location and voice pattern were systematically arranged to produce two congruous conditions, i.e., mother's voice from mother's speaker and stranger's voice from stranger's speaker, and two incongruous conditions, mother's voice from stranger's speaker and stranger's voice from mother's speaker.

Each infant experienced the four trials (a series) twice. The dependent variable was the amount of distress exhibited in the incongruous condition in relation to the congruous condition. This was measured several ways. Four visual fixation measures were used: mean length of first fixation, number of fixations, duration of fixation, and direction of first fixation; and four overt measures: smiling, crying, fretting and vocalizing, and mouthing behaviours were used. The overt behavioural indices were idiosyncratic resulting in too few measures to be analyzed. The incongruous intermodal information did not noticeably influence the visual behaviour of the young subjects. Significant visual disturbances were detected, however, in the older subjects. The older girls had longer first fixations in the congruous condition, first series. Several of the older male and female subjects directed their fixation to the speaker during the congruent condition and away from the speaker during the incongruent condition. Neither measure was significant in the second trial series. Cohen postulated that the disruption of the visual behaviour in the incongruous condition reflected the level of perceptual-cognitive development in the eight-month old. Specifically, she believed that the lack of an encompassing distress measure indicated the fragility of auditory-visual association in the eight month old.

Using a similar design, Aronson and Rosenbloom (1971) attempted to demonstrate psychomotor coordination of auditory and visual space in early infancy. In their experiment, the infants were seated in an infant chair. Their mothers were located two feet away in an adjacent room. A large window separated the two. Situating the mother in the adjacent room allowed for selective location of her amplified speech in the infant's room. Congruent visual and auditory information was simulated by the balanced output of two speakers at either side of the infant's head. Incongruity was accomplished by adjusting the speaker balance so that one speaker was completely dominant. Dominance was counterbalanced left and right. Aronson and Rosenbloom utilized several overt behavioural measures as dependent variables. All but one, tongue protrusions, occurred too infrequently for analysis. The mean number of tongue protrusions during the incongruous condition was greater than during an equal interval prior to the incongruous condition. No effect of differential tongue protrusions was evident in a second study in which the audio balance adjustment was completed while the mothers were hidden from view. Aronson and Rosenbloom concluded from these studies that it was the discrepant audio and visual information and not simply the shift in speaker balance that produced distress in the infants as signaled by the number of tongue protrusions. They further concluded that infants as young as 30 days, the youngest age of the sample, perceive a common auditory-visual space.

McGurk and Lewis (1974) were critical of the Aronson and Rosenbloom study for several reasons. Along with methodological criticisms, they explained that the measure, tongue protrusions, has not been demonstrated to be a valid indicator of infant distress.

McGurk and Lewis attempted to replicate the Aronson and Rosenbloom study, adding several modifications. In their experiment, McGurk and Lewis used one, four and seven month old infants. Three audio speakers, instead of two, were situated in the infant's room. The two speakers remained at either side of the infant's head. The additional speaker was located on a panel in front of the infant. Only one speaker operated at a time. Voice location was not simulated by speaker balance; the congruous condition was maintained by the output of the front speaker. The sequence of presentation, criticized in the Aronson and Rosenbloom design, was controlled in the McGurk and Lewis study. Four 30 second presentations were given in succession. Voice location was congruent in Conditions 1 and 4. In Conditions 2 and 3, voice location was presented randomly left-right or right-left. McGurk and Lewis used several dependent measures. Crying and fretting, frowning, tongue protrusions, and vocalizations occurred infrequently and were not significant. At four months, smiling occurred to a greater extent during Condition 1 only. The number of head turns was different in the incongruous condition for the two older groups. The direction of the head turn was toward the sound source. McGurk and Lewis concluded that although the older infants responded to the sound location, the lack of an adequate distress index supported the notion that auditory and visual input are not coordinated by infants of these ages. They maintained that there was no evidence that the infant has an expectancy of face and voice occupying the same spatial location. The development of such a relationship, in their view, remains an open question.

Condry, Haltom and Neisser (1977) further examined common auditory-visual space perception in infants aged 6 to 8 weeks of age. The infant's mother stood directly in front of the infant and talked very softly to him. Her voice was amplified through one or both speakers situated at either side of the infant's head. Congruent auditory-visual information was simulated by balancing the speaker output. In the incongruent conditions speaker balance was adjusted so that one of the two speakers was completely dominant. The dependent measures were tongue protrusions, head orientation (left, right or center) and emotional state. No significant effect was obtained. Condry et al. noted, "... although several of the infants may have noticed the new location of their mothers' voices, none was distressed by the discrepancy between its auditory and its visual location." They added that the Aronson and Rosenbloom (1971) method makes two assumptions: that infants combine auditory and visual information and that they are distressed when there is a discrepancy between the two. Condry et al. concluded that their failure to replicate may only mean that the second of the two assumptions is incorrect.

In the present study, a further examination of the infant's capacity to integrate audio and visual information was completed. The presentation was a modification of those used by Aronson and Rosenbloom (1971) and McGurk and Lewis (1974). Instead of placing the communicator (the human who was apparently speaking to the infant) in a separate room, he was in the same room as the infant, miming the audio track.

The infant was presented with five different conditions: a)

Baseline: auditory and visual information congruent, communicator directly in front of the infant; b) Congruent-Movement: auditory and visual information congruent, communicator moving at one side of the infant; c) Congruent-Stationary: auditory and visual information congruent, communicator stationary at one side of the infant; d) Incongruent-Movement: auditory and visual information incongruent, communicator moving at one side of the infant; e) Incongruent-Stationary: auditory and visual information incongruent, communicator stationary at one side of the infant. At all times throughout the presentation the communicator attempted to maintain eye contact and "talk" to the infant.

In the movement conditions the communicator and the voice moved at the same rate, but not always in the same direction. In the Congruent-Movement condition, the sound moved in the same direction as the communicator. However, in the Incongruent-Movement condition, the sound moved in the opposite direction to the communicator. In the Baseline and Stationary conditions, the voice and the communicator remained at one location. In the Baseline and Congruent-Stationary conditions, voice and communicator were at the same location, while in the Incongruent-Stationary condition the voice and the communicator were on opposite sides of the infant.

In the congruent conditions, Congruent-Movement and Congruent-Stationary, an infant may perceive the presentation in one of several ways. He may: a) attend to one stimulus, auditory or visual, and ignore the other, b) attend to both simuli as discrete elements occupying a common location, or c) perceive the presentation as a stimulus complex. Only the third alternative represents common auditory-visual space perception. If the infant processes the information in one of the first two forms, then either the presentation fails to adequately simulate a natural speech act, or the infant has not yet learned the relationship between the auditory and visual stimuli. Presentation of an incongruent condition, IncongruentMovement or Incongruent-Stationary, to an infant who does not understand the auditory-visual relationship should not violate any expectation about those stimuli. Alternatively, if the infant is exhibiting common auditory-visual space perception, then the incongruent conditions are improbable events and a violation of the expectation of congruity of the two stimuli.

The infant's reaction to incongruent events will depend upon his/her interpretation of the situations. The infant who has not developed an expectancy of the relationship between voice and speaker should not perceive the Incongruent-Movement and Incongruent-Stationary conditions as incongruent events. Thus there should be little change in his attention to the presentation and in his affective state. These infants should visually track stimulus movement in both movement conditions. In the incongruent conditions the child may attend to the visual stimulus, the auditory stimulus, or both stimuli. These infants should remain attentive for the duration of the presentation, showing little emotional response to any condition.

The infants who have developed an expectancy of the relationship between voice and speaker should differentially react to the incongruent nature of the Incongruent-Movement and Incongruent-Stationary conditions. Generally, it has been predicted that the infant will react with distress to this presentation [Aronson and Rosenbloom (1971), McGurk and Lewis (1974), and Condry et al. (1977)]. However, these studies failed to acknowledge that the child can react with interest to these incongruent events. A child will be distressed with the incongruent information when he is frustrated that his expectancy is wrong or when he is unable to accommodate the new discrepant information. It is predicted that these children will react with a neutral to negative affective state and with a corresponding reduction of attention to the presentation. However, children who can accommodate the new information either by reformulating their expectancy or by perceiving the presentation as a trick will be very interested in the discrepant information. These children should react with a neutral to positive affective state and with increased attention to the presentation.

In this study changes in heart rate were examined in addition to the overt behavioural measures. Changes in heart rate have been used as an index of discrimination in several studies, e.g., Kagan, Henker, Hen-Tov, Levine, and Lewis (1966), and Moffitt (1971). Cardiac deceleration has been associated with sensory intake and attentiveness to the environment, whereas cardiac acceleration has been associated with a defensive reaction to the environment (Campos, Emde, Gaensbauer, and Henderson, 1975). It appears that even in very young infants, cardiac decelerations occur to events which violate expectations (Clifton, 1974). It is predicted that heart rate responses will indicate whether the congruent and incongruent conditions are discriminated and whether the response to the incongruent condition is one of attention to or avoidance of the improbable event. Heart rate deceleration will be associated with an attentive reaction to the incongruent conditions and heart rate acceleration will be associated with a defensive response to the incongruent condition.

Method

Subjects. Infants were located by parental response to an advertisement placed in the local paper. All infants were Caucasian, living in or around the city of St. John's. Only healthy, full term babies were used.

A total of 54 infants were brought to the laboratory. Of these 6 were not included because of fussing and crying during the initial pre-presentation adaptation period. Data are reported on 48 subjects, 24 male and 24 female. The subjects of each sex were divided into three age groups, youngest, 10 to 20 weeks (mean age 15.5 weeks) for males and 10 to 23 weeks (mean age 16.75 weeks) for females; middle, 19 to 40 weeks (mean age 31.63 weeks) for males and 20 to 37 weeks (mean age 29.5 weeks) for females; and oldest, 38 to 52 weeks (mean age 43.25) for males and 32 to 51 weeks (mean age 44 weeks) for females. Overlaps in the male ranges were caused by the assignment of one 19 week old to the middle age group and one 38 week old to the oldest age group. Overlaps in the female age ranges were caused by the assignment of one 20 week old to the middle age group and one 32 week old to the oldest age group. These overlaps occurred because the subjects were randomly assigned to a treatment group when they arrived at the laboratory. Placement of these children in their respective groups allowed for the complete counterbalancing of sex, age, and presentation sequence.

Apparatus. Two rooms (3 x 2.7 x 5.5m and 3 x 2 x 4m) separated by a two way mirror were used. The larger acoustically tiled room was used as the presentation setting. A 2.7 m high semicircular curtain (1.2 m radius) divided this room. The curtain was used as a backdrop (Figure 1). Behind the curtain were six J.I.L. speakers (model 608) regularly spaced around the curtain arc (Figure 2). The speakers were placed at the height of the communicator's face, approximately 1.5 m above the floor. The portion of curtain 1.5 to 1.7 m above the floor was constructed of grey acoustic cloth. This allowed unimpeded sound passage. The remainder of the curtain was made of heavy black paper.

Two Shibaden FP 100 television cameras were situated behind the curtain to record the visual attention and facial expression of the infants. A microphone was placed near the subject to record vocalizations. The audio and visual responses of the infants were recorded on a video tape recorder. The presentation side of the curtain was illuminated by a 100 watt light overhead and by the light of a 600 watt quartz lamp bounced off the ceiling from behind the curtain.

An observer and the remaining apparatus were located in the smaller room. The audio component of the presentation was recorded and played on a Roberts 771X tape recorder at a comfortable listening level. The audio output was fed into a speaker control module linked with the speakers. The module consisted of an L-pad and six speaker balance controls. This system allowed for a constant level of audio output with any speaker combination. A speaker could be activated or silenced without the characteristic "pop" associated with speaker onset. The observer used the module to control the audio movement in the presentation. Audio movement was created by the adjustment of speaker balance between each successive pair of speakers.

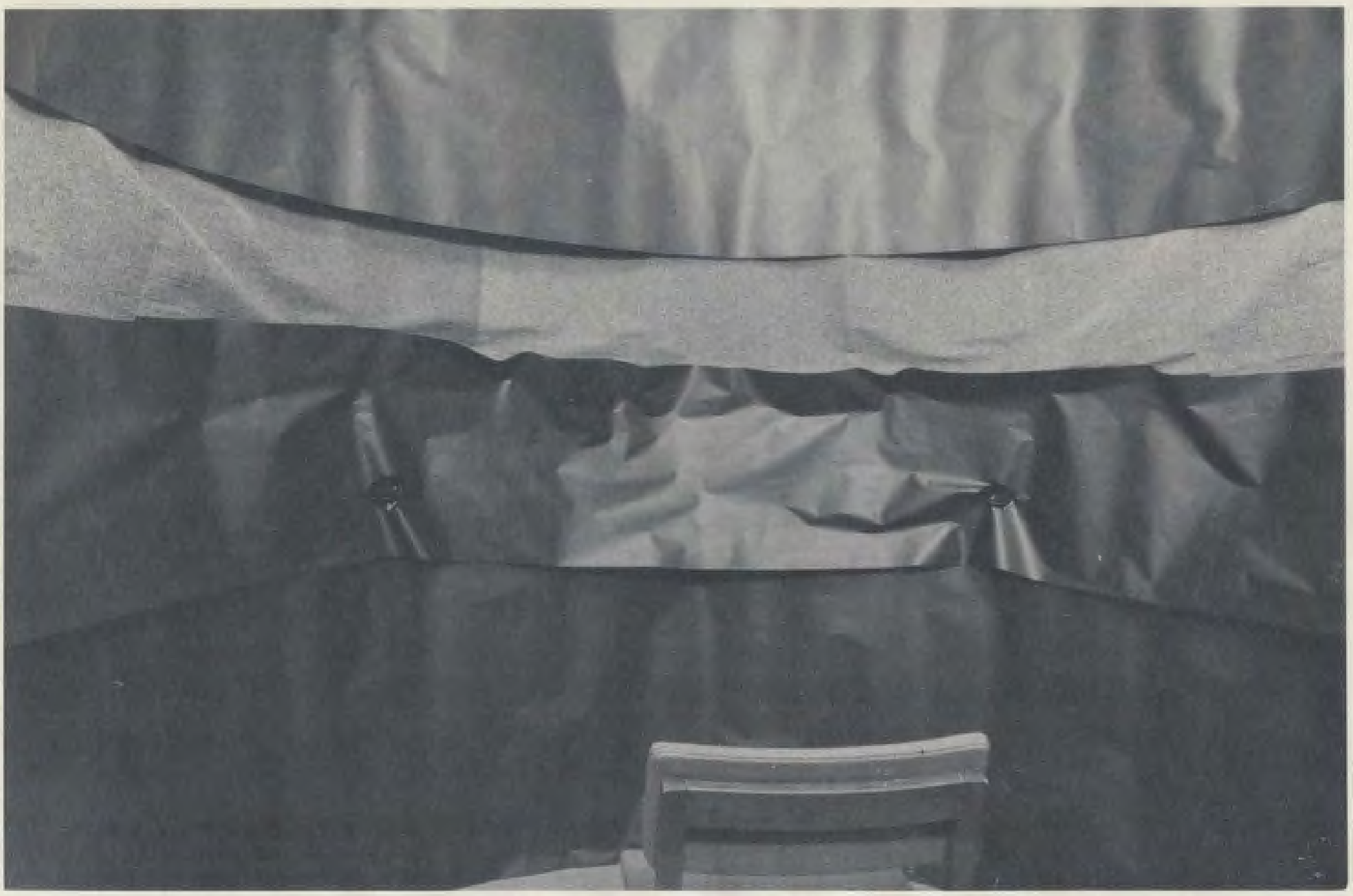

Figure 1. Photograph of the presentation side of the black backdrop.

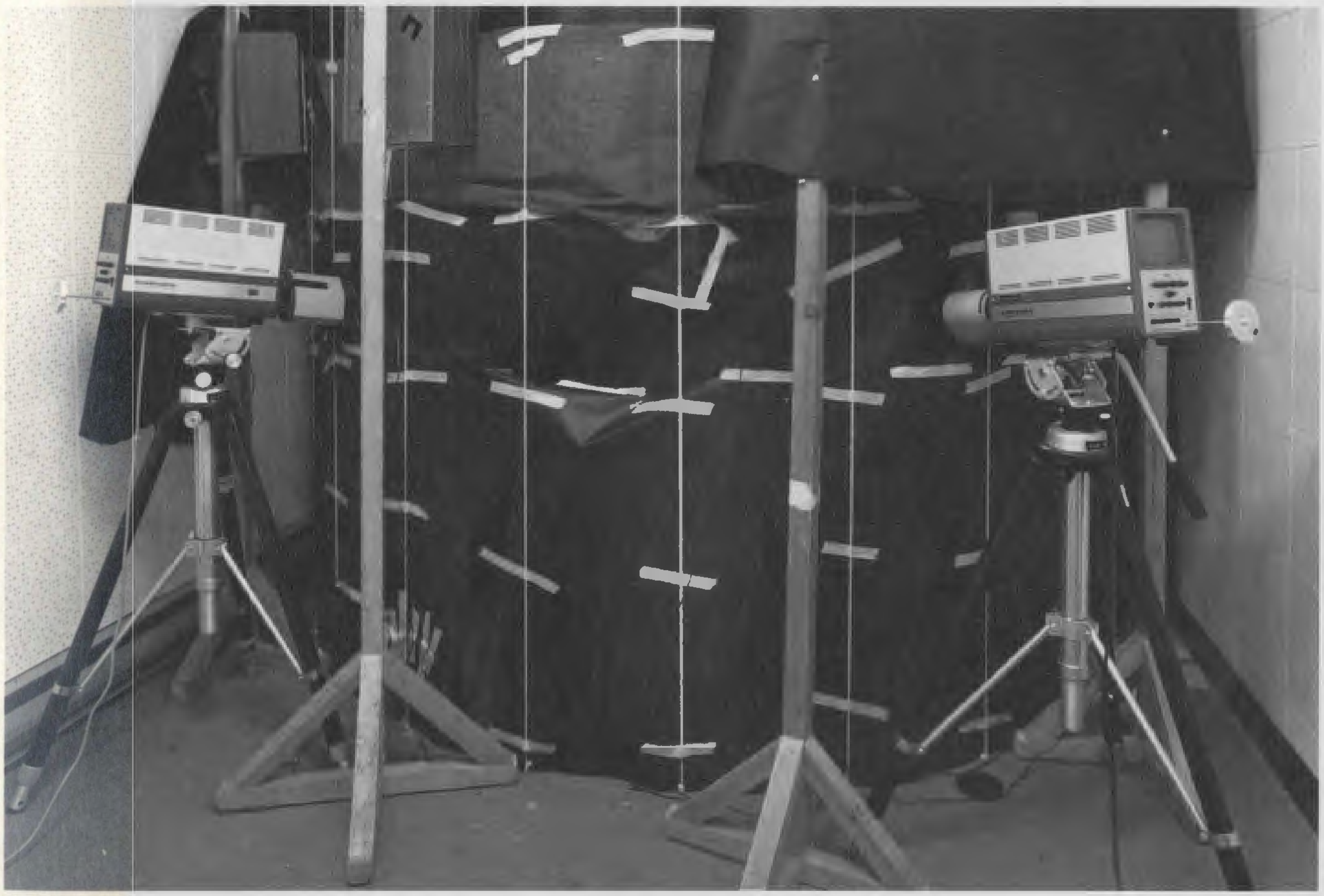

Figure 2. Photograph of the equipment side of the black backdrop.

The camera output fed into a Panasonic miniwiper (model WJ 530). This unit allowed two camera (split screen) viewing on one monitor. This output along with the audio response of the infant was recorded on a video tape recorder.

Heart rate was measured on a Beckman Dynograph (model 411) with a type 481b preamp and a type 9857 coupler at a paper speed of 15cm per sec. Three 5mm skin electrodes in conjunction with Spectra 360 redux were used for recording.

Procedure. The procedure was explained when the infant and the parent were brought into the presentation room. The parent was then seated on a chair situated at the center point of the speaker arc. The infant sat in the lap of the parent. In all cases the parent was the infant's natural mother. The electrodes were fixed to the infant's chest. The ground electrode was placed approximately one inch above the navel, while the two active electrodes were placed approximately 2.5cm above each nipple. This electrode placement had been suggested by Moffitt (1971). An adaptation period followed the electrode placement. The experimenter left the room and the heart rate measure was checked. The mother and child were left in the presentation room until the infant quieted. The communicator entered the room and began the presentation as soon as the infant quieted. If the infant did not quiet in five minutes, he/she was removed from the study.

The presentation began with the Baseline condition. In this condition, the communicator stood directly in front of the child (point A, Figure 3) approximately one meter away. The location of the voice

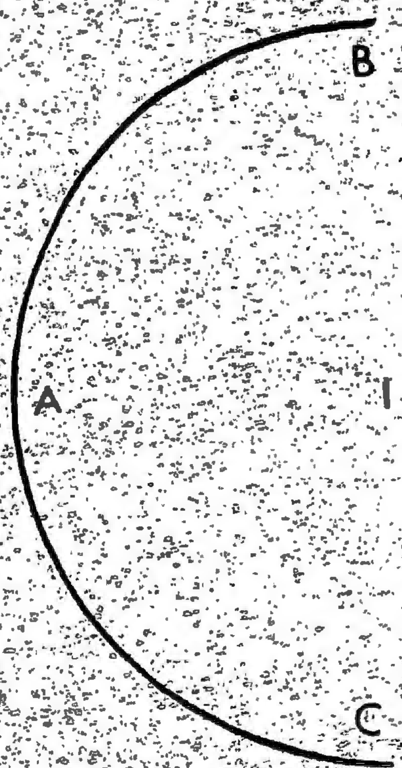

Figure 3. Diagram of the experimental setting. The infant (I) sat on mother's lap facing the dark semicircular curtain. The communicator began the presentation at point A, and then moved to point B or C during the experimental presentation.

was congruent with the position of the communicator. After 20 seconds of Baseline, the communicator started to move around the curtain arc. This initiated one of the two movement conditions. Half of the infants were presented with the Congruent-Movement condition and half the Incongruent-Movement condition. The communicator adopted a walking pace of 1/4 of the arc per 5 seconds. Thus, movement around the arc from point A to point B or C required 10 seconds. In the Congruent-Movement condition, the direction and rate of movement of the voice was the same as the communicator. In the Incongruent-Movement condition only the rate of voice movement was the same. The direction of voice movement was opposite. When the communicator reached the end of the speaker arc, either point B or C, he stopped and the 20 sec stationary period began. In the Congruent-Stationary condition, both voice and communicator were located at the side of the infant at point B or point C. In the Incongruent-Stationary condition, the voice and the communicator were located on opposite sides of the infant. After 20 seconds, a second movement condition was presented. The communicator and the sound moved back to point A together in the Congruent-Movement condition. However, the communicator and the sound moved from opposite sides of the infant back to point A in the Incongruent-Movement condition. The rate of movement for the communicator and the sound was 1/4 arc per 5 seconds. Once the voice and the communicator reached point A, the Baseline condition was presented a second time. Following the second presentation of the Baseline, infants already presented with the Congruent-Movement condition were presented the Incongruent-Movement condition and vice versa. The direction of the communicator's movement remained the same as in the previous movement condition. The communicator followed the same pattern: movement for 10 seconds, stationary at the side of the infant for 20 seconds and then movement back to point A in 10 seconds. The presentation ended when the communicator returned to point A for the second time. The total presentation time was 120 seconds (Table 1).

Table 1

Experimental Design

Order: Congruent-Incongruent

First Phase (60 seconds)

Baseline	Congruent-Movement	Congruent-Stationary	Congruent-Movement
(20 sec.)	(10 sec.)	(20 sec.)	(10 sec.)

Second Phase (60 seconds)

Baseline	Incongruent-Movement	Incongruent-Stationary	Incongruent-Movement
(20 sec.)	(10 sec.)	(20 sec.)	(10 sec.)

Order: Incongruent-Congruent

First Phase (60 seconds)

Baseline	Incongruent-Movement	Incongruent-Stationary	Incongruent-Movement
(20 sec.)	(10 sec.)	(20 sec.)	(10 sec.)

Second Phase (60 seconds)

Baseline	Congruent-Movement	Congruent-Stationary	Congruent-Movement
(20 sec.)	(10sec.)	(20 sec.)	(10 sec.)

Total Presentation Time = 120 seconds

Dependent Measures

Affectivity. On a separate occasion, the two observers rated the emotional response of the infants from the videotape. The evaluations were made according to a modified version of the Ricciuti Scale of Affectivity (Appendix B) which was reported in Grellong (1973). The ratings were made of 10 second blocks. In 92% of the cases, both observers assigned a neutral score to the rating block. The ratings of the observers differed on only 12 occasions (1% of the total number of blocks). In each case, the ratings of the two observers differed by only one of a possible nine points. In the 12 instances where the observers differed, the rating closest to neutral was accepted.

Heart Rate. Mean heart rate was calculated by measuring the interbeat intervals between the R spikes of each beat and averaging across five second intervals. The interbeat interval was divided into 60 seconds to determine the average beats per minute. Any interbeat intervals occurring at the termination point of a 5 second block were discarded.

Visual Inattention. Measurements of visual inattention to the presentation were made by two independent observers who were unaware of the experimental conditions. The observers were instructed to measure the amount of time the infants were visually inattentive to the presentation. Visual Inattention was defined as eyes looking down at the floor or back to their mother or eyes closed. These measurements were made from the videotapes of the infants recorded during the experimental presentation. Measurements were made in 10 second blocks.

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The correlation between the measurements of the two observers was .92 (Pearson Product Moment Correlation). When the measurements of the two observers differed, the mean of the two measurements was used in the analysis.

Results

__Affectivity__. Only 21 of the 48 subjects obtained an affectivity rating other than neutral during any part of the experimental presentation. Eighteen subjects received at least one positive rating and six received at least one negative rating. Three subjects demonstrated both positive and negative affectivity. The highest positive rating was +1 and the lowest negative rating was -4. Only two subjects, a 16 week old male and a 32 week old female, obtained a -4 rating. The young male received a -4 rating during the second 10 seconds of the first baseline period and two other times during the presentation. The older female received -4 ratings throughout the movement conditions. The Incongruent-Movement condition was the first movement condition presented to her. Of the 21 subjects who obtained an affectivity score other than 0, 11 were from the youngest age groups, 5 were from the middle age groups and 5 were from the oldest age groups. An analysis of this distribution revealed no significant effect of age, Chi Square(2)=3.43, $p>.05$.

__Heart Rate__. Due to experimenter error the data for five subjects were incomplete. For two subjects, a 16 week old male and a 40 week old male, the heart rates for the last 10 seconds of the presentation (10 seconds of movement) were lost. For one subject, a 45 week old male, the final 20 seconds (10 seconds of stationary and 10 seconds of movement) were lost. For one subject, a 35 week old female, the final 40 seconds (20 seconds of stationary and 20 seconds of movement) were lost, and for one subject, a 40 week old male, the final

50 seconds (10 seconds of baseline, 20 seconds of stationary and 20 seconds of movement) were lost. All missing data were lost during the second minute (second phase) of the presentation. The data for the first phase of the presentation were complete.

Prior to both the congruent and incongruent presentations a 20 second baseline heart rate was recorded. The heart rates for the final 10 seconds of each of the two baselines served as covariates for an analysis of covariance. In this analysis, the congruent and incongruent data were adjusted according to the values of the preceding baseline heart rates. Thus, the variance associated with the treatment effects was reduced by using the baseline scores as a covariate. The Order of presentation (Congruent-Incongruent and Incongruent-Congruent), Sex and Age (youngest, middle, and oldest) were between-subjects variables. Congruent-Incongruent, Movement-Stationary, and Period (first 10 seconds and second ten seconds of experimental condition) were within-subject variables. The appropriate cell means were substituted for the missing second phase data.

The analysis of covariance was an appropriate statistical technique, as a significant amount of between-subjects and within-subjects variability was associated with the covariates, $F(1,36)>100$, $p<.001$ and $F(1,36)=21.27$, $p<.001$, respectively. A large number of significant contrast effects, including several uninterpretable higher order interactions were obtained. These effects included: the six way interaction, Order X Sex X Age X Congruent X Movement X Period, $F(2,36)=3.94$, $p<.05$), an Order X Sex X Age X Congruent X Movement interaction, $F(2,36)=4.91$, $p<.05$, an Order X Age X Congruent X Movement interaction, $F(2,36)=5.00$, $p<.05$, an Age X Congruent X Movement X Period interaction, $F(1,36)=4.37$, $p<.05$, an Order X Sex X Period interaction, $F(1,36)=4.75$, $p<.05$, a Sex X Congruent X Period interaction, $F(1,36)=7.05$, $p<.05$); a Sex X Congruent X Movement interaction, $F(1,36)=8.84$, $p<.01$, a Sex X Age X Movement interaction, $F(2,36)=3.87$, $p<.05$, an Order X Age interaction, $F(2,36)=4.58$, $p<.05$, a Congruent X Movement interaction, $F(1,36)=4.97$, $p<.05$, and the main effects of Order, $F(1,36)=4.70$, $p<.05$, Sex $F(1,36)=6.07$, $p<.05$, and Period, $F(1,36)=12.97$, $p<.001$.

Since the order of presentation interacted with all other variables, the heart rate date were analysed separately for each phase of the experiment. Each subject experienced both Congruent and Incongruent treatments, presented in one minute phases. The order of these presentations was counterbalanced, i.e, half of the subjects were presented with the Congruent treatment in the first phase of the experiment and the Incongruent treatment in the second phase. The remaining subjects were presented with the opposite order. When separate analyses were conducted on each phase, the heart rates of the subjects presented with the incongruous conditions were compared with the heart rates of the subjects presented with the congruous conditions. Thus, for these analyses, Congruent-Incongruent was a between-subjects variable.

The first and second test phases were analysed by a 2(Congruent) X 2(Sex) X 3(Age) X 2(Movement) X 2(Period) analysis of covariance. In both cases the covariates were associated with a significant reduction of the variance, Fs(1,36)>100, $p<.001$. The first test phase analysis revealed a significant Sex X Age X Movement interaction (means presented in Table 2) $F(2,36)=8.94$, $p<.001$, and a significant Congruent X Sex X Movement interaction (Table 3), $F(1,36)=10.44$, $p<.005$. Neither effect was particularly interesting except for the fact that the Congruent factor was present in an interaction. However, the significant Congruent X Age interaction (Table 4), $F(2,36)=5.37$, $p<.01$, is important. A further analysis of the Age interaction revealed a significantly lower heart rate in the youngest subject groups during the congruent presentation than during the incongruent presentation, $F(1,36)=11.48$, $p<.005$. The heart rate means during the congruous and incongruous condition were not significantly different in the middle and the oldest age groups, Fs(1,36)<1.

The analysis of the second test presentation data revealed the following significant effects: a Congruent X Age X Movement X Period interaction, $F(2,36)=3.29$, $p<.05$, a Sex X Age X Movement X Period interaction, $F(2,36)=4.76$, $p<.05$, an Age X Movement X Period interaction, $F(2,36)=4.08$, $p<.05$, a Congruent X Sex X Period interaction, $F(1,36)=11.22$, $p<.005$, a Sex X Period interaction, $F(1,36)=4.48$, $p<.05$, a Congruent X Movement interaction, $F(1,36)=4.96$, $p<.05$, and the main effects of Congruent, $F(1,36)=4.16$, $p<.05$, Sex, $F(1,36)=8.07$, $p<.01$ and Period, $F(1,36)=12.93$, $p<.001$. Most of the effects were overshadowed by the large higher order interactions. The

Table 2

Adjusted Heart Rate Means for the Sex X Age X Movement Interaction Obtained in the First Test Phase Analysis

Sex & Age Group	Experimental Presentation Movement	Stationary	Collapsed
Male Youngest	132	133	133
Male Middle	136	135	136
Male Oldest	134	136	135
Collapsed	134	135	134
Female Youngest	140	137	139
Female Middle	135	139	137
Female Oldest	135	135	135
Collapsed	137	137	137
Overall Means	135	136	136

Table 3

Adjusted Heart Rate Means for the Congruent X Sex X Movement Interaction Obtained in the First Test Phase Analysis

	Experimental Presentation		
Congruent & Sex	Movement	Stationary	Collapsed
Congruent, Male	134	133	134
Congruent, Female	135	137	136
Collapsed	135	135	135
Incongruent, Male	135	137	136
Incongruent, Female	138	135	137
Collapsed	137	136	136
Overall Means	136	136	136

Table 4

Adjusted Heart Rate Means for the Congruent X Age Interaction Obtained in the First Test Phase Analysis

	Experimental Presentation		
Age Level	Congruent	Incongruent	Collapsed
Youngest	131	140	136
Middle	138	135	137
Oldest	136	135	136
Collapsed	135	137	136

Table 5

Adjusted Heart Rate Means for the Congruent X Sex X Period Interaction Obtained in the Second Test Phase Analysis

	Experimental Presentation		
Congruent & Sex	Period 1	Period 2	Collapsed
Congruent, Male	136	135	136
Congruent, Female	139	145	142
Collapsed	138	140	139
Incongruent, Male	134	137	136
Incongruent, Female	136	137	137
Collapsed	135	137	136
Overall Means	136	139	137

Congruent X Sex X Period interaction (Table 5) which was not secondary to any higher order interactions was not particularly interesting. However, the presence of the Congruent main effect and several Congruent interactions indicated that the Congruent and Incongruent treatments elicited differential reactions from the infants.

<u>Inattention</u>. Due to experimenter error the data for two subjects were incomplete. The last 10 seconds (10 seconds movement) were lost for a 16 week old male and the last 30 seconds (20 seconds stationary, 10 seconds movement) were lost for a 43 week old male. No data were lost from the first test phase.

A 2(Order) X 2 (Sex) X 3(Age) X 2(Congruent) X 2(Movement) X 2(Period) analysis of covariance was performed on the inattention data. As in the Heart Rate analysis the 10 seconds of baseline prior to the two experimental treatments were analysed as covariates. However, the covariates were only associated with a significant reduction of the between-subjects variance, $F(1,36)=15.04$, $p<.001$. The Sex X Age X Movement interaction (Table 6), $F(2,36)=5.84$, $p<.01$ and the main effects of Period $F(1,36)=6.19$, $p<.05$, and Movement, $F(1,36)=7.37$, $p<.05$ were significant. Although a Sex X Age X Movement interaction was also found in the first test presentation analysis of the heart rate data, it is not particularly interesting. The main effect of Period reflects that the subjects attended more to the first than to the second 10 second period (mean inattention; Period 1 = 1.9 sec, Period 2 = 2.5 sec). The main effect of movement was overshadowed by the higher order Sex X Age X Movement interaction.

Table 6

Adjusted Mean Inattention (Seconds) for the Sex X Age X Movement Interaction Obtained in the Inattention Analysis

	Experimental Presentation		
Sex & Age Group	Movement	Stationary	Collapsed
Male, Youngest	1.4	1.6	1.5
Male, Middle	1.4	1.8	1.6
Male, Oldest	1.6	3.7	2.7
Collapsed	1.5	2.4	1.9
Female, Youngest	2.0	1.8	1.9
Female, Middle	2.3	4.1	3.2
Female, Oldest	2.6	2.1	2.4
Collapsed	2.3	2.7	2.5
Overall Means	1.9	2.6	2.2

<u>Heart Rate and Inattention Z-Score Analysis</u>. Graham and Clifton (1966) suggested that heart rate deceleration is a component of an orienting response, a system for facilitating reception and integration of stimuli, whereas heart rate acceleration is a component of defensiveness, a system for avoiding stimuli. Thus, an infant's heart rate should decrease during periods of attention and increase during periods of inattention. In this study the most important finding was the Congruent X Age interaction obtained in the first test phase heart rate analysis. An examination of the inattention data revealed a similar pattern of results in the first test phase. Thus, the heart rate and inattention scores were analysed to determine if the relationship between the two measures was consistent with the Graham and Clifton hypothesis. The first step in the analysis was to calculate difference scores. The difference scores were derived by subtracting the baseline value from each treatment value across each test phase. For the inattention data a negative difference score was indicative of greater attention to the presentation during the treatment than during the baseline. Similarly, a negative heart rate difference score indicated cardiac deceleration i.e., a slower heart rate during the treatment condition as compared to the baseline. The heart rate and inattention difference scores were then converted to Z-Scores so that a comparison of the two measures could be made. The Z-Scores were analysed by a 2(Order) X 2(Sex) X 3(Age) X 2(Dependent Measure) X 2(Congruent) X 2(Movement) X 2(Period) analysis of variance. A large number of significant effects including several uninterpretable higher

order interactions were obtained. These included: an Order X Sex X Dependent Measure X Congruent X Period interaction, $F(1,36)=7.42$, $p<.01$, an Order X Sex X Age X Dependent Measures X Congruent X Movement interaction, $F(2,36)=4.85$, $p<.05$, an Order X Sex X Age X Congruent X Movement interaction, $F(2,36)=3.78$, $p<.05$, a Sex X Dependent Measures X Congruent X Period interaction, $F(1,36)= 7.86$, $p<.01$, an Order X Age X Period interaction, $F(1,36)=5.19$, $p<.05$, an Order X Age X Congruent interaction, $F(2,36)=3.40$, $p<.05$, a Sex X Age X Movement interaction, $F(2,36)=4.76$, $p<.05$, a Sex X Congruent interaction, $F(1,36)=7.98$, $p<.01$, a Sex X Dependent Measures interaction, $F(1,36)=7.78$, $p<.01$, and main effects of Movement, $F(1,36)=5.33$, $p<.05$ and Period, $F(1,36)=11.66$, $p<.005$.

As was the case with the heart rate overall analysis, the order of presentation interacted with all other variables. Therefore the Z-Scores were analysed separately for each phase of the experiment. The data were analysed by a 2(Congruent) X 2(Sex) X 3(Age) X 2(Movement) X 2(Period) analysis of variance with Congruent-Incongruent a between-subjects variable. The first test phase analysis revealed the following significant effects: a Congruent X Sex X Dependent Measure X Movement X Period interaction, $F(1,36)=5.42$, $p<.05$, a Sex X Age X Movement interaction, $F(2,36)=7.64$, $p<.005$, a Congruent X Period interaction, $F(1,36)=4.91$, $p<.05$, a Congruent X Age interaction, $F(2,36)=5.69$, $p<.01$, and the main effects of Congruent, $F(1,36)=4.22$, $p<.05$ and Period, $F(1,36)=4.59$, $p<.05$. All effects except the Sex X Age X Movement and the Congruent X Age interactions are lower order to the 5-way interaction.

The Sex X Age X Movement interaction (Table 7) is interesting because it had been obtained in both the first phase heart rate analysis and the inattention overall analysis. However, this interaction is not particularly relevant to the question of common auditory-visual space perception and thus was not pursued. The Congruent X Age interaction (Table 8) is important because it indicates that the infants discriminated the congruent and incongruent presentations. A further analysis of the interaction revealed that the youngest age group obtained a significantly lower Z-Score during the congruent presentation than during the incongruent presentation, $F(1,36)=14.26$, $p<.001$. The Z-Score obtained during the congruent and incongruent presentation were not significantly different for the middle and the oldest age groups, $Fs(1,36)<1$. The youngest subject heart rate (Table 9) and inattention (Table 10) difference scores show cardiac deceleration and increased attention during the congruent presentation which is consistent with the Graham and Clifton (1966) hypothesis. However, the cardiac acceleration associated with the incongruent presentation was not accompanied by a decrease in attention.

The analysis of the second test revealed several significant effects. These included: a Congruent X Sex X Age X Dependent Measure X Movement interaction, $F(2,36)=7.48$, $p<.005$, a Congruent X Age X Dependent Measure X Period interaction, $F(1,36)=4.98$, $p<.05$, a Sex X Dependent Measure X Period interaction, $F(1,36)=4.82$, $p<.05$, a Congruent X Sex X Period interaction, $F(1,36)=6.04$, $p<.05$, an Age X Dependent Measure X Period interaction, $F(2,36)=6.52$, $p<.005$, a Sex X Dependent

Table 7

Mean Z-Scores for the Sex X Age X Movement Interaction

Obtained from the First Test Phase Analysis of Variance

	Experimental Presentation		
Sex & Age Level	Movement	Stationary	Collapsed
Male, Youngest	-.06	-.53	-.30
Male, Middle	.01	.11	.06
Male, Oldest	.53	.12	.33
Collapsed	.16	-.10	.03
Female, Youngest	-.46	.29	-.09
Female, Middle	.24	.10	.17
Female, Oldest	-.16	.08	-.04
Collapsed	-.13	.16	.01
Overall Means	.02	.03	.02

Table 8

Mean Z-Scores for the Congruent X Age Interaction

Obtained from the First Test Phase Analysis of Variance

	Experimental Presentation		
Age Level	Congruent	Incongruent	Collapsed
Youngest	-.76	.38	-.19
Middle	.02	.21	.12
Oldest	.27	.01	.14
Collapsed	-.16	.20	.02

Table 9

Mean Heart Rate Difference Scores (Beats Per Minute)

for the Congruent X Age Interaction

Obtained in the First Test Phase Z-Score Analysis

	Experimental Presentation		
Age Level	Congruent	Incongruent	Collapsed
Youngest	-6.9	3.5	-1.7
Middle	0.9	-0.8	0.1
Oldest	-0.1	0.0	0.0
Collapsed	-2.0	0.9	-0.5

Table 10

Mean Inattention Difference Scores (Seconds)

for the Congruent X Age Interaction

Obtained in the First Test Phase Z-Score Analysis

	Experimental Presentation		
	Congruent	Incongruent	Collapsed
Youngest	-3.0	-0.1	-1.5
Middle	-1.3	0.7	-0.3
Oldest	0.8	-1.0	-0.1
Collapsed	-1.2	-0.1	-0.6

Measure, $\underline{F}(1,36)=5.31$, $\underline{p}<.05$ and a Period main effect, $\underline{F}(1,36)=11.24$, $\underline{p}<.005$. The significant higher order interactions make these findings difficult to interpret.

Discussion

The results of the Affectivity measure are consistent with the results obtained by McGurk and Lewis (1974) and Condry et. al. (1977). No significant treatment effects were found. Generally, little emotional response was detected. The responses that were detected were idiosyncratic. Only six of the forty-eight subjects showed any negative emotion during the presentation.

Although few overt emotional responses were detected, the youngest subjects showed a differential response to the experimental conditions. Cardiac deceleration and a increase in attention occured during the congruent presentation, while cardiac acceleration occured during the incongruent presentation. According to the Graham and Clifton (1966) model, the youngest subjects appear to have oriented to the congruent presentation and reacted with defensiveness to the incongruent presentation.

Kagan et. al. (1966) and McCall and Kagan (1967) have suggested that cardiac change is an important index of the ability of infants to assimilate events. In the present study, the youngest subjects appear to assimilate the congruent events which are consistent with daily experiences. However, they do not appear to assimilate the incongruent events which are inconsistent with daily experience. Thus, the youngest subjects demonstrated not only common auditory-space perception, but also an expectation that voice comes from the "talking" person.

It is not clear why the middle and oldest subjects did not differentially respond to the congruent and incongruent presentation. It was anticipated that at some developmental level the incongruent presentation would elicit a greater orienting response than the congruent presentation. However, the middle and oldest subjects showed little orienting behaviour (as compared to baseline) to either condition. A possible explanation is that both groups failed to be tricked by the situation, that is they failed to make the association between the voice and communicator during the baseline condition. If the association were not made then the congruent and incongruent presentations would be similar from the subject's perspective. Since the behaviours of interest require that an initial association between face and voice be made, the most effective methods of fostering this association should be examined in future research.

The recording of multiple response measures, including cardiac activity, in the study of infant perception and cognition is recommended. In the present study, heart rate change was a more sensitive measure of infant behaviour than were fixation or emotional responding. One should also attempt to keep the babies as alert as possible in order to maximize information processing. In this study, one half of the experimental presentation involved movement. Although the infants' response to movement was not uniform (significant Sex X Age X Movement interactions were obtained from the heart rate, inattention and Z-Score analyses), the movement manipulation appeared effective in maintaining the subjects' attention.

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Appendix A

Communicator's Dialog

Hello baby, welcome to Memorial University. Who knows, someday you might be attending school here. You might as well get used to it while you can. I am very happy that you were able to bring your mother or father along with you. I hope you both will (20 seconds, end of first baseline) have a good time. How are you, baby? Are you happy? That's good. We're doing a little experiment. (30 seconds, end of first movement) You are a big part of it. Yes, you are. My name is Jim Heller. I am a graduate student here. Are you interested in that? Not yet I suppose, we will have to wait a little while. I am interested in babies your age. (50 seconds, end of first stationary) They can to a lot of wonderful things. Do you think you can? I hope so. I'm sure you will have fun. (60 seconds, end of second movement) Do you like being in an experiment? Good. If you don't mind, I would like to tell you a story. Would you like to hear it? It is about three bears. Once upon a time there were three bears. They were big (80 seconds, end of second baseline) and brown. They lived in the middle of the woods away from people. They really didn't get along with people that well. (90 seconds, end of third movement) One day when they had very little to do, the Papa bear suggested that they go for a walk. Do you like walks? I sure do. The Papa bear called the Mama and the baby and off they went. Isn't (110 seconds, end of second stationary) that nice? Well, as soom as they were gone, a little girl walked up to their door. She was a little bigger than you are (120 seconds, end of fourth movement and end of presentation).

Appendix B

Scales for Rating Affectivity

+4 Strong Positive: Broad or moderate smiling accompanied by positive vocalization.

+3 Moderate Positive: Broad smiling without vocalizations, or positive vocalizations and visual orientation without broad smiling.

+2 Weak Positive: Moderate smiling with visual orientation and without positive vocalizations.

+1 Minimal Positive: Moderate smile or positive vocalization with other positive cues.

0 Neutral: No clear negative or positive facial or vocal cues.

-1 Minimal Negative: Pre-cry facial expression or whimper vocalization with no other negative cues.

-2 Weak Negative: Distressed facial expression or fussy vocalization with no other negative cues.

-3 Moderate Negative: Distressed facial expression with some whimpering.

-4 <u>Strong Negative</u>: Crying with or without other negative cues, or weak crying with clear visual or postural withdrawl.