MAINTAINING CONDITIONING IN YOUNG CHILDREN WITH VARIED SCHEDULES OF REINFORCEMENT

by

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ABSTRACT

Twenty-four young children were conditioned to localize to a complex visual reinforcer upon the presentation of a broadband noise. Once conditioning was established, the sound stimulus was presented with either 0%, 50%, or 100% visual reinforcement. Conditioning was maintained more effectively for both the 50% and 100% reinforcement conditions than when no reinforcement was provided. No differences were found between the 50% and 100% conditions. The results appear to support the use of either continuous or intermittent reinforcement in testing the hearing of young children.

Conditioned orientation reflex audiometry (COR) was developed by Suzuki and Ogiba (1961). The infant was conditioned to localize to a tone presented in a sound-field by pairing the presentation of the tone with the activation of an illuminated toy. Once conditioning had been established, an attempt was made to determine sound-field thresholds by observing the infant for this localization response to tones presented in the absence of the illuminated toy. Although the infant might localize initially following the presentation of each tone, Suzuki, Ogiba, and Takei (1972) argued that the responsive behavior would extinguish rapidly unless the illuminated toy was activated following each correct response. They suggested that the activation of the illuminated toy served to reinforce the infant's localization behavior, and recommended that each response be reinforced visually.

Visual reinforcement is typically administered on a continuous basis in behavioral audiometry (Lloyd, 1966). Yet, it has not been proven that this schedule of reinforcement is the most effective at maintaining conditioning. In fact, there is evidence that the visual reinforcer may diminish in its effectiveness after repeated trials. Moore, Thompson, and Thompson (1975) noted that infant responsivity to a suprathreshold complex noise declined over the final stimuli under conditions of simple visual reinforcement administered on a continuous schedule. In the same study, they demonstrated that the type of visual reinforcer affected the level of infant responsivity, with a complex visual reinforcer providing a significantly greater number of localization responses than a simple visual reinforcer.

We questioned whether alternate schedules of reinforcement might also produce significant changes in auditory responsivity. For example, Holland and Skinner (1961) reported that a conditioned response can be made very resistant to extinction when an intermittent schedule of reinforcement is used. The purpose of the present study was to investigate the maintenance of the conditioned localization response in infants under three conditions of complex visual reinforcement.

METHOD

The subjects were 24 infants ranging from 12 to 24 months of age. Information obtained from each child's physician reported normal physical development. A review of the medical records of all subjects gave no history of middle ear problems within 3 months prior to testing, and every infant demonstrated a sound-field speech detection threshold of 20 dB HL (re ANSI, 1969) or better. Impedance audiometry and/or otoscopic examination revealed that all children had at least one normal functioning middle ear on the date of the experiment.

The infants were divided into three groups of eight each. The median age for all groups was 17.5 months. Each group was studied under one of three conditions of reinforcement: continuous visual reinforcement (CVR), intermittent visual reinforcement on a 50% schedule (IVR), or no visual reinforcement (NVR).

All testing was conducted in a two-room, single-walled IAC sound-attenuated suite. A Maico, MA-24 clinical audiometer was used to present broadband noise through a single loudspeaker at a constant sound pressure level of 70 dB. Calibration of the stimulus was checked periodically during the study (Quest 215 sound level meter and OB-45 octave band filter).

The infant was seated on the lap of one of the parents. The loudspeaker was situated approximately one meter from the subject and at a 45 degree angle to the left of mid-line. A colorful, animated toy (dog in a rowboat) was situated atop the loudspeaker and slightly above each child's lateral plane of vision. Prior to the conditioning and stimulus trials, the parent of each infant was instructed not to speak to the child.

The examiner presented the signals and observed the subject's responses from an adjacent room. A second observer sat across from the parent and infant. This observer kept the infant's attention distracted from the loudspeaker by allowing the child to quietly play with toys. Communication between the examiner and observer was maintained via the audiometer talk-back system. The observer signaled the examiner with a "patient response" button if a response was observed during a conditioning or control trial. The stimulus, lasting 2 seconds, was presented only when the infant was relatively calm and distracted from the loudspeaker. The inter-stimulus interval was at least 10 seconds.

Each infant received three conditioning trials prior to the presentation of the test stimuli. During these trials, the auditory stimulus and visual reinforcer were presented simultaneously as described by Suzuki and Ogiba (1961). All infants responded appropriately to each conditioning trial by localizing to the loudspeaker and/or visual reinforcer. Once conditioning was established, the stimulus trials were initiated. Reinforcement was provided for 3 seconds when both the observer and examiner agreed that there was a response within 2 seconds following presentation of the auditory stimulus. The CVR group received reinforcement for every response, the IVR group for every other response, and the NVR group received no reinforcement once conditioning was established.

Following every third stimulus trial, there was a control trial lasting 4 seconds during which time no stimulus was presented. These trials were employed as checks on observer reliability. Any localization responses observed during those periods were recorded as false positive responses. As with the stimulus trials, agreement between the examiner and observer was required for a false positive response to be recorded. Observer agreement for all stimulus and control trials was high (98.5% and 95.8% respectively). The number of localization responses observed during the control trials was small (0.4%).

Data from 40 trials were evaluated for each child. Most children ceased responding at much

TABLE 1

The median (N = 8) number of responses and median percentage of responsivity for each reinforcement condition prior to and following the criterion point of response decrement. Ranges are also shown. The number of trials to the point of response decrement varied with each child. The post-decrement data are based on responses to 10 trials following the point of response decrement.

	Pre-Decrement		Post-Decrement		
Condition	**Responses**	**% Response**	**Responses**	**% Response**	
NVR	14.0	87.3	1.5	15.0	Median
	7–23	78–92	0–4	0–40	Range
IVR	20.0	90.1	5.0	50.0	Median
	8–31	80–93	3–7	30–70	Range
CVR	21.5	90.0	2.5	25.0	Median
	13–31	87–94	1–3	10–30	Range

lower numbers of presentations, while some infants were able to maintain minimal responsivity over as many as 50 presentations.

We wanted to specify a criterion point where the conditioned localization response began to show substantial decline. This would allow us to examine the effectiveness of the three reinforcement schedules in maintaining infant responsivity prior to and following the point where responsivity exhibited substantial decrement. Moore *et al.* (1975) observed that, during a series of 30 stimulus trials under conditions of complex visual reinforcement, the localization response in infants was maintained over eight of the final 10 trials (80%). Having no other guide, we accepted an 80% level of responsivity as the criterion level for our investigation. Once an infant's responsivity fell below 80%, the child was judged to exhibit decremental behavior to the reinforcing stimulus. Any child failing to localize to the auditory stimulus for three or more trials during any series of 10 consecutive trials fell below the criterion and thus demonstrated response decrement. The second trial to which no response was observed in that series of 10 consecutive trials was chosen as the criterion point, marking the beginning of decremental behavior. All trials presented after that point were counted as occurring post-response decrement. One infant in the NVR group failed to respond three times after only the first nine trials. All other children in the study allowed for at least 10 stimulus presentations before responsivity fell below 80%.

RESULTS

Figure 1 illustrates the overall response behavior across 40 trials and the median points of response decrement for the three groups. All infants in the CVR group responded to every stimulus for the initial 11 trials. Comparatively, all children in the NVR and IVR groups responded to all stimuli for only the first five and six presentations, respectively. Beyond these points, the response behavior for all groups steadily decreased over 40 trials.

Table 1 shows the medians and ranges for the number and percentage of responses prior to and following the point of response decrement. Inspection of Figure 1 and Table 1 reveals

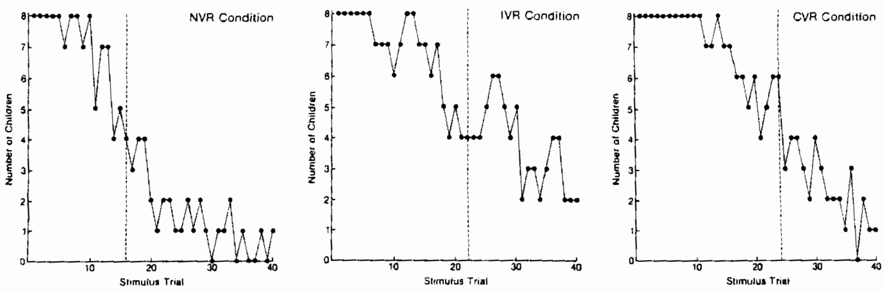

Figure 1. Number of children (N = 8) responding as a function of stimulus trial for NVR, IVR, and CVR conditions across 40 trials. The dashed line denotes the point of response decrement for each condition.

the effectiveness of this criterion level. Prior to response decrement, each reinforcement condition maintains a level of responsivity of approximately 90%. Once the point of response decrement is reached, however, responsivity falls consistently at or below 50% for all three reinforcement schedules. The median number of trials presented prior to the beginning of response decrement was less for the NVR group (16) than for either the IVR or CVR groups (22 and 23.5 trials, respectively).

The number of responses to response decrement varied considerably among individual infants, both within and between groups. Therefore, the Mann-Whitney U nonparametric statistic was used to compare the response behavior of the three groups. Not unexpectedly, the CVR condition maintained infant responsivity for a significantly greater number of trials prior to response decrement ($U(8) = 11$, $p < .05$) than did the NVR condition. This result is supportive of the finding of Moore *et al.* (1975) who noted that a complex visual reinforcer elicited significantly more responses than no visual reinforcement. The median difference in the number of trials between the IVR and CVR groups was small and statistically insignificant ($U(8) = 29$, $p = .40$). While not significant ($U(8) = 20$, $p = .12$), the median difference between the IVR and NVR conditions was six trials. Seven infants from the CVR group and six from the IVR group exceeded the median value for the infants in the NVR condition.

As noted earlier, the number of trials preceding the criterion point of response decrement varied for each individual. The point at which response decrement occurred fixed, in a sense, the number of stimulus trials which followed. Therefore, the infants exhibiting response decrement earliest received substantially more trials after response decrement than did the infants who did not show response decrement as quickly. Thus, only the 10 stimulus trials immediately following response decrement were used in the analysis of post-response decrement behavior.

Figure 1 shows that, in general, a greater number of infants in the IVR group remained responsive over all 10 trials following response decrement than either of the other two groups. Statistical analysis revealed that the IVR group exhibited a significantly greater number of responses than either the NVR ($U(8) = 7$, $p < .01$) or CVR ($U(8) = 6$, $p < .01$) groups. The CVR and NVR groups did not significantly differ from each other ($U(8) = 27$, $p = .32$).

It is interesting to note that while both the CVR and IVR conditions produced comparable response behaviors prior to response decrement, the IVR condition was more effective at maintaining responsivity for trials following the criterion point of response decrement. All infants in the IVR group showed post-response decrement levels of response which were higher than the median response levels for the NVR and CVR conditions. In contrast to this, none of the children from either the NVR or CVR groups exceeded the median level of the IVR group.

DISCUSSION

The use of a visual reinforcer to both condition and maintain conditioning to an auditory stimulus has proven to be an invaluable tool for the clinician interested in assessing the hearing of infants and young children. Since the introduction of the COR technique (Suzuki & Ogiba, 1961), a number of investigators have developed modifications such as PIWI (Haug, Baccaro, & Guilford, 1967) and VRA (Liden & Kankkunen, 1969). While these modifications are somewhat different from the original technique, they employ the same stimulus-response-reinforcement paradigm.

Suzuki *et al.* (1972) have maintained that visual reinforcement should follow every appropriate response to the stimulus. In the present study, however, no significant differences in response behavior were apparent between the continuous and intermittent visual reinforcement groups when localization behavior was measured prior to an arbitrarily defined point of response decrement. Indeed, responsivity following the point of response decrement was maintained highest by a 50% reinforcement schedule; whether this latter finding is clinically relevant cannot be answered without further study.

It would appear that strict adherence to a continuous visual reinforcement schedule in COR audiometry is not a requisite for maintaining conditioning in infants. This knowledge should prove reassuring to the clinician who may be uncertain as to whether a "questionable response" by an infant should receive reinforcement. If the "response" was actually due to random movement on the part of the infant, then reinforcement might only serve to confuse the child and increase the random behavior. On the other hand, if the child's responses were extremely weak at times, withholding reinforcement probably would not decrease the overall responsivity of the infant. Thus, when the clinician is uncertain of whether an infant has responded to a stimulus, the prudent decision would be to withhold reinforcement of the "response." In this way, the clinician would avoid the inadvertent rewarding of random behavior without detracting from the overall level of responsivity.

It was of interest that the criterion point of response decrement proved so accurate at denoting when infant responsivity began to rapidly decline. All infants maintained a high level of responsivity prior to response decrement. Even though intermittent visual reinforcement provided for significantly greater responsivity following the point of response decrement than either of the other reinforcement conditions, localization behavior was well below the 80% level established for this investigation. We conclude that it may be possible to determine when an infant is "turning-off" to the test situation. With such knowledge available, the alert clinician should be able to alter the test situation (as occurs in PIWI when puppets are changed frequently) to insure the maintenance of a high level of conditioning.

While the auditory stimulus used here was presented at a suprathreshold level, there is reason to assume (as do Moore *et al.*, 1975) that the conditioned response (localization) would be maintained at lower stimulus intensities. In a review of conditioned response generalization, Kimble (1961) reported that, once conditioned, an organism would exhibit the conditioned response to stimuli which were similar to the conditioning stimulus. It remains to be determined whether or not decreased levels of the suprathreshold stimulus employed in this investigation would constitute a "similar" stimulus.

It is our impression that further investigation in the area of conditioned audiometry should attempt to clearly define the effects of various reinforcement schedules on infant responsivity. There is also a need to determine other ways of delaying the onset of response decrement, so that maximal data can be obtained from each child.

ACKNOWLEDGEMENTS

The authors wish to thank Mary Carter and Anthony Guarage for their assistance in collecting the data. Also, we are grateful to the physicians and staff of the Oberlin Clinic, Inc. (Ohio) for their help in obtaining medical clearance for the subjects used in this study.

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REFERENCES

Haug, O., Baccaro, P., & Guilford, F. A pure-tone audiogram on the infant; the PIWI technique. *Archives of Otolaryngology*, 1967, *86*, 101–106.

Holland, J.G., & Skinner, B.F. *The Analysis Of Behavior: A Program for Self-Instruction*. New York: McGraw-Hill, 1961.

Kimble, G.A. *Hilgard and Marquis' Conditioning and Learning*. 2nd Edition. New York: Appleton-Century-Crofts, Inc., 1961.

Liden, G., & Kankkunen, A. Visual reinforcement audiometry. *Acta Otolaryngologica*, 1969, *67*, 281–292.

Lloyd, L. Behavioral audiometry viewed as an operant procedure. *Journal of Speech and Hearing Disorders*, 1966, *31*, 128–136.

Moore, J.M., Thompson, G., & Thompson, M. Auditory localization of infants as a function of reinforcement conditions. *Journal of Speech and Hearing Disorders*, 1975, *40*, 29–34.

Suzuki, T., & Ogiba, Y. Conditioned orientation reflex audiometry. *Archives of Otolaryngology*, 1961, *74*, 192–198.

Suzuki, T., Ogiba, Y., & Takei, T. Basic properties of conditioned orientation reflex audiometry. *Minerva Otorinolaringologica*, 1972, *22*, 181–186.