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BEHAVIORAL VISION TRAINING FOR MYOPIA: STIMULUS SPECIFICITY OF TRAINING EFFECTS

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The present study assessed transfer of visual training effects for myopia using two different training stimuli and a single subject A-B-C-A design. A male student volunteer, with lens prescription of −3.0 D (left) and −2.0 D (right), served as the subject. During baseline (10 sessions), visual acuity was assessed by two behavioral acuity tests. One test consisted of 50 line drawings of common objects as testing stimuli and the other test had 50 Chinese characters. A procedure including stimulus fading and reinforcement (positive verbal feedback) was used to train the subject to identify either pictorial stimuli or Chinese characters presented from a distance. Training was effective in improving performance on both behavioral acuity tests during the training phases and follow-up but the change was more pronounced on the specific stimuli being used for training. Refractive errors assessed on a weekly basis showed no change in the physiology of both eyes. These results suggest that effects of visual training only partially transferred to untrained stimuli.

DESCRIPTORS: myopia, vision training, refraction, stimulus specificity, Chinese characters

Recent evidence suggests that behavioral intervention may be useful in modifying visual behavior (Collins, 1981). With respect to myopia, an operant training package developed by Esptein, Collins, Hannay, and Looney (1978) seems most effective in modifying visual acuity. This type of program usually involves a combination of stimulus fading and reinforcement (positive verbal feedback) procedures. In a training session, letter stimuli are first presented at the farthest distance at which they can just be identified without squinting. The distance is increased by a short interval every time performance meets a predetermined criterion (e.g., 10 consecutive correct discriminations). Every correct response receives positive verbal feedback; any incorrect response is ignored. The majority of studies evaluating this program consistently report positive results, with training myopes demonstrating better acuity when tested with letter stimuli from a distance (Blount, Baer, & Collins, 1984; Collins, Epstein, & Hannay, 1979, 1981; Collins, Ricci, & Burkett, 1981; Epstein, Greenwald, Hennon, & Hiedorn, 1981; Gil & Collins, 1983).

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To establish the clinical utility of the Epstein et al. (1978) training procedure, however, researchers must be able to demonstrate that acuity change achieved with the training stimuli can be generalized or transferred to other stimuli of varying nature and size. Recently, Gil and Collins (1983) conducted an experiment that provided evidence of transfer. They used a video computer game as the training medium while acuity performances were assessed by three different measures, including the Snellen Letter Chart, a Behavioral Acuity Test (BAT), and a performance test on the computer game. Gil and Collins (1983) found transfer with one of the two untrained stimuli. Compared to controls, training subjects displayed significant improvements on the BAT. However, these results may not be conclusive because significant differences were not found on the other two dependent measures. Most interestingly, performance did not improve on the very computer game that had been used for training.

Doubts concerning transfer of visual acuity training have been raised by Matson, Helsel, and LaGrow (1983) who also used similar procedures to train myopic persons. In this study, students were required to identify the orientation of the letter E; acuity performance was assessed on both the Snellen Illiterate E and Snellen Letter Charts. Performance on the trained stimuli (Snellen E) was found to have improved significantly whereas that on the untrained stimuli (Snellen Letters) was not. In other words, an equivalent change across trained and untrained stimuli did not occur. Matson et al. (1983) concluded that these results were best described in terms of improved visual efficiency on the trained stimuli.

More recently, Leung, Lai, Hsu, and Ho (1987) further investigated the transfer of training in myopia using a single subject methodology: a multiple baseline across subject design. Six bilingual Chinese students were recruited and divided into three pairs, each of which was exposed to a different baseline. During the treatment phase, subjects with myopia of various severity were trained to identify 50 Chinese characters presented from a distance using stimulus fading and positive verbal feedback. The dependent measures included a Chinese BAT and an English BAT. Training was effective in improving performances on both tests during treatment and follow-up but the change was more pronounced on the Chinese BAT. These results were consistent with Matson et al. (1983) in showing that transfer of training may well be stimulus specific.

Both Matson et al. (1983) and Leung et al. (1987) tested transfer of training with the training stimuli and an untrained stimulus and found better performance on the former. Such a discrepancy, however, might have been due to one stimulus class being more difficult than the other for visual discrimination. For example, in the Leung et al. (1987) study, the Chinese characters may have been more familiar to the Chinese students than the English alphabets and therefore easier to identify. Given that this was the case, one would expect to see better performance on the Chinese BAT, which also happened to be used as the training stimuli.

One possible approach for better assessing the transfer of training is to include every testing stimulus in training at various times. If transfer is complete or non-stimulus specific, then the relative performance on these tests should not be affected by the type of stimulus being used for training. The present experiment adopted this approach with two testing stimuli, each of which also served as the training stimulus at a different phase of intervention. Apart from the study of Gil and Collins (1983), training stimuli in previous studies were always selected from a writing system such as English or Chinese. In the present study, pictorial stimuli consisting of line drawings of common objects were also included.

METHOD

Subject

Two criteria guided the selection of the subject: (a) the absence of eye disorders other than myopia, and (b) normal-sighted parents. The screening interview and eye examination were conducted by a qualified ophthalmologist. A male psychology student (age 21) was selected from a group of five volunteers who answered a recruitment poster displayed on the departmental notice board. The subject had a lens prescription of −3.0 Diopter (D) for the left eye and −2.0 D for the right eye, and objective refractions assessed by retinoscopy revealed slight discrepancies (i.e., −3.25 D and −2.25 D for left and right eyes, respectively).

Setting and Apparatus

Training and acuity assessments were conducted in a well-illuminated and air-conditioned room. The subject's chair was placed against the back wall. In front of the chair, a brown masking tape, marked in 1-cm intervals, was attached to the vinyl floor. This provided the ruler for measuring training and testing distances.

One hundred stimulus cards consisting of simple Chinese characters (five to seven strokes), commonly found in local Chinese newspapers, were prepared. A character was 13 mm wide and 14 mm high with an even stroke width of 2 mm and was centered on a white card (17 cm by 27 cm) by phototypesetting. Based on the study by Leung et al. (1987), students with 20/20 vision could just identify each of these characters when viewed from a distance of 610 cm. From this set of stimulus cards, 50 were randomly chosen for training purposes and the remaining 50 cards were used for the Behavioral Acuity Test (BAT).

Another set of 100 pictorial cards contained stimuli chosen from the 260 line drawings standardized by Snodgrass and Vanderwont (1980). Those with familarity ratings equal to or above 7/10 (when presented to a class of Introductory Psychology students) were chosen. Each line drawing was copied and enlarged to a size which, when centered on a white card, could be just identified by 15 students with 20/20 vision when viewed from 610 cm. A line drawing was identified if the student gave the most common name of the object. For example, the correct answer for the drawing of a dog should be "dog," but other names such as "poodle," "collie," and "four-legged animal" were considered incorrect. Students were given some naming demonstrations and practice until they understood the task. Because the objects chosen were highly familiar objects, students had no problem in supplying the acceptable name. Like the Chinese stimulus cards, 50 pictorial cards were randomly selected for training and the remaining for the pictorial BAT.

All training and testing stimuli cards were presented on a movable wooden stand whose height was adjustable to lie level with subject's line of sight. Training and testing distances were indicated by a pointer marked on the foot of the stand directly below the stimulus card.

Dependent Measures

Refractive error. Objective refractions of both eyes were assessed by retinoscopy (see Giddings & Lanyon, 1974). The retinoscope for measuring visual acuity was accurate to the nearest 0.25 D.

The Chinese BAT. A BAT provided a behavioral estimate of visual acuity during each session of the experiment. Basically, this test was modeled after that used by Epstein et al. (1978) except for the number of testing distances involved. To improve the discriminability of the measure, we divided 610 cm into six, instead of four, equal portions. For the Chinese BAT, 10 stimuli cards of Chinese characters, randomly selected from the 50 testing cards, were presented at distances of 102 cm, 203 cm, 305 cm, 407 cm, 508 cm, and 610 cm. During baseline, all distances were used for testing. Once training began, test distances were confined to those at which the subject failed to complete identification of 10 testing stimuli. The order of test distances and stimulus presentations were randomly determined at each session. No feedback was given to the subject concerning his performance. The behavioral acuity score was the percentage of characters correctly identified over all distances.

The pictorial BAT. This behavioral measure was similar to the Chinese BAT in both testing and scoring procedures. In this case, 50 drawings of common objects, not selected for training, served as the testing stimuli. As in the standardization exercise described above, the subject was given instruction and practice in naming the line drawings on the stimulus cards.

Design and Procedure

The study had four consecutive phases in an A-B-C-A design: Baseline Training with Pictorial Stimuli, Training with Chinese Characters, and Follow-up. Daily sessions were conducted 6 days a week. Each session lasted for about 1 hr.

During all phases of the experiment, refractive errors for both eyes were assessed weekly by an ophthalmologist. A daily session was preceded by a 15-min relaxation period. Upon arrival, the subject took off his glasses and relaxed his eyes. During this period, he was told not to engage in any close work (e.g., reading and writing) that might strain his eyes.

Baseline. In a baseline session, behavioral visual acuity was assessed by both the Chinese BAT and the pictorial BAT. The order of these tests alternated daily. This phase lasted for 10 sessions.

Training with Pictorial Stimuli. In a daily session, testing always preceded training. The BATs were administered first as in baseline followed by vision training using stimulus fading and positive verbal reinforcement (Epstein et al., 1978). Because baseline data revealed a slightly superior performance on Chinese BAT over pictorial BAT, training using pictorial stimuli was introduced in this phase. The initial training distance was determined by adding 5 cm to the farthest distance at which the subject correctly identified three randomly selected

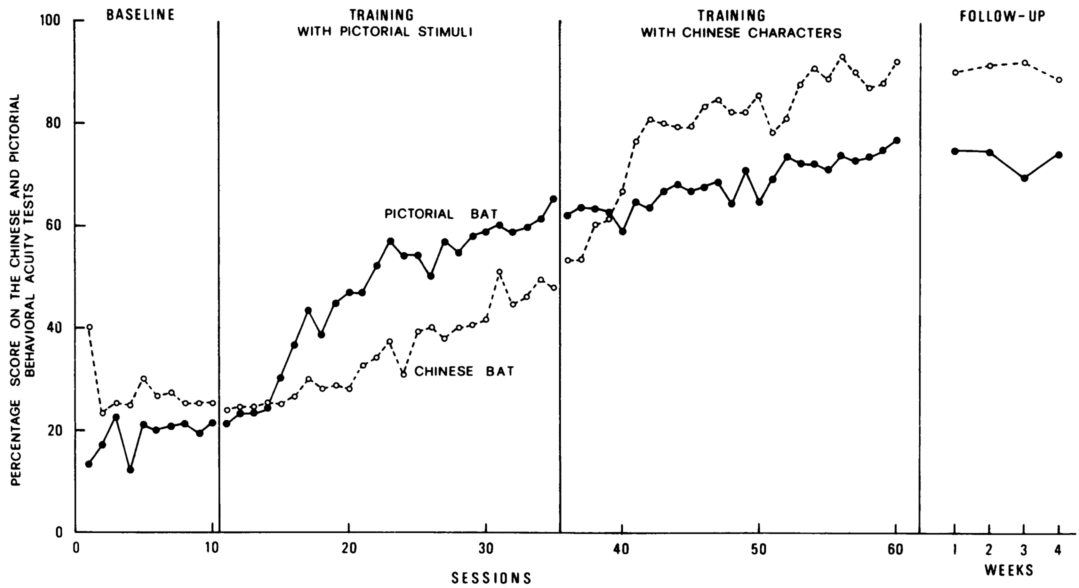

Figure 1. Percentage acuity scores over sessions for both the pictorial BAT and the Chinese BAT during baseline, training with pictorial stimuli, training with Chinese characters, and follow-up.

stimuli. To maintain an optimal level of motivation, the initial distance for training did not follow from the maximum distance reached in the previous session but was freshly determined in each session (Collins, Ricci, & Burkett, 1981). Training began by presenting the training stimuli at that distance for identification. Correct responses received positive verbal feedback (e.g., "good," "excellent," or "you are doing well") from the experimenter; incorrect responses received no feedback. Upon 10 consecutive correct discriminations, the distance was increased by 10 cm. If this criterion could not be satisfied following 50 presentations, then the distance was reduced by half of the increment; the minimum increment allowed was 2.5 cm (10 cm/5 cm/2.5 cm). A training session usually consisted of 100 stimulus presentations but could be reduced if the subject reported fatigue on a particular day. This phase lasted for 25 sessions.

Training with Chinese Characters. In this phase, the procedure was similar to that in the previous training condition, except that Chinese characters served as the training stimuli instead of line drawings. This phase also lasted for 25 sessions.

Follow-up. The Chinese BAT and pictorial BAT were administered weekly over a period of 4 weeks after the completion of the two training phases. At the final follow-up session, the subject was interviewed concerning his eyesight and his impression of the training program as a whole.

RESULTS

The initial distance at the first training session was 117 cm and the final distance at the last training session was 578 cm. Hence the increment amounted to 461 cm. Despite improvements observed on behavioral measures, refractive errors evaluated on a weekly basis revealed no change in either eye.

Acuity data in terms of percentage scores on the two BATs for the baseline, training, and follow-up phases are presented in Figure 1. Baseline performances for both BATs became stabilized following 10 sessions of testing. Throughout baseline, the score for the Chinese BAT (M = 27.1%) was always higher than that for the pictorial BAT (M = 18.9%) indicating a slight discrepancy in the two measures.

During training with pictorial stimuli, treatment effects were clearly demonstrated by an increase in pictorial BAT scores over sessions. However, substantial improvement on the pictorial BAT was not evident until the fifth session of training. A steady rate of increase was observed from the eighth session onward. With respect to the Chinese BAT, performance also improved with training but at a relatively slower rate. Consequently, the discrepancy between the two measures observed during baseline was reversed as the score for the pictorial BAT (M = 47.1%) became higher than that of the Chinese BAT (M = 35.0%) and this trend was maintained throughout this phase. The reversal can be clearly seen from the cross-over of the two lines shown in Figure 1.

During training with Chinese characters, training stimuli had different effects on BAT performance. The rate of increase on the Chinese BAT became more rapid than that in the previous phase with a slight fluctuation evident at the early stage of this phase. In contrast, the improvement on the pictorial BAT scores slowed down with respect to the performance during training with pictorial stimuli. This alternation in rates is indicated by the second crossover of the two lines shown in Figure 1. In this phase, the mean Chinese BAT and pictorial BAT scores were 79.5% and 68.1%, respectively. By the end of training with Chinese characters, the BAT score did not reach the normal acuity level of 100%.

The follow-up data indicated that the improvement achieved during the last treatment phase was maintained at the end of 4 weeks.

DISCUSSION

The major objective of the present study was to evaluate the transfer of training effects for improving acuity in myopes using a program first developed by Epstein et al. (1978). By using a single-subject methodology of A-B-C-A design and including all the testing stimuli in training, we were able to rectify the measurement problem encountered in previous research (Gil & Collins, 1983; Leung et al., 1987; Matson et al., 1983).

In accord with previous studies, the present results further demonstrated that vision constitutes another class of behavior modifiable by behavioral techniques. Given the stable performance in both baseline and follow-up, observed improvements in visual acuity can be attributed to the training procedure of stimulus fading and positive verbal feedback. Improvements were maintained during the 4-week follow-up.

However, the treatment effect appeared to be stimulus specific. That is, the degree of improvement depends on the type of stimuli used for training. When pictorial stimuli were used, performance on the pictorial BAT was better than that on the Chinese BAT. On the other hand, when Chinese characters were used instead, the trend was reversed. This finding of partial transfer of training effect was consistent with that observed by Leung et al. (1987). They showed that visual training effects acquired with one writing system (Chinese) might not achieve a complete transfer across another writing system (English).

We tend to agree with Matson et al. (1983) that the Epstein et al. (1978) procedure may be useful in raising visual efficiency but may not affect the accommodation mechanism of the myopic eyes. Perhaps behavioral training improves the ability to discriminate specific blurred stimuli rather than improving vision regardless of the stimuli being viewed. This is supported by the physiological data collected throughout the course of the present study; no change in refractive errors of either eye was found. But the finding of partial transfer of training effect is puzzling. If behavioral improvement was purely stimulus specific, then change should be observed only with the trained stimuli and not with the untrained stimuli. It seems reasonable to assume that training helps to improve the general sensitivity of the myopic eyes for discriminating distant objects but the best effect is achieved only with the type of stimuli being trained. According to the follow-up interview, the subject was able to identify distant objects better than before without glasses but his eyes became tired very easily. But when glasses were worn, acuity gained from training was negligible.

In conclusion, the present study replicated the findings of Leung et al. (1987) and Matson et al. (1983) by demonstrating the limited transfer of behavioral training effects on visual acuity with two different stimuli. The fact that these effects were more or less stimulus specific casts doubt on the general clinical utility of the training procedure for correcting the visual defect of myopia. However, this does not necessarily refute the possible applications (e.g., Collins et al., 1979) of the Epstein et al. (1978) procedure in modifying visual behavior, but highlights the importance of identifying the appropriate target for intervention.

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