Training and generalization of complex auditory-visual conditional discriminations in individuals with autism: New procedures using dynamic stimuli.

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Individuals with autism and other developmental disabilities often have difficulty learning auditory-visual conditional discriminations that are important for early communication and generalization may be restricted. Programs for teaching these individuals often involve the fading (gradual change) of stimuli in small steps across trials. Failure to establish desired discriminations occurs when the fading does not direct attention to the relevant critical aspects of the stimuli. The research described here illustrates new attention-shaping procedures for teaching complex auditory-visual discriminations and assessing generalization. The major purpose was to begin evaluation of the dual-modality transfer procedures with abstract stimulus sets that would rule out pre-experimental learning as an explanation of cross-modal (i.e., visual-to-auditory) transfer of stimulus control.

In one procedure, auditory samples (pairs of same and different tones) were added to visual stimuli (pairs of same and different forms that participants matched already) presented as samples and comparisons. Across-trial contrast fading then gradually ‘vanished’ the visual samples, in order to establish conditional control of comparison selections by the pairs of same and different tones. Generalization then was assessed using new frequencies of the tones.

Another procedure introduced a novel dynamic fading method. The visual cues that already controlled responding were erased actively within trials (like apparent movement) and cumulatively across trials. After fading, conditional control was demonstrated by the auditory samples only. Generalization was tested using tones with frequencies different from the training stimuli.

Method

Participants. Four teenagers and one 20-year old, each diagnosed with autism, (PPVT scores from 3-4 [years-months] to 10-11) participated. Each already performed identity matching with the visual forms to be used in training but did not match these stimuli to arbitrary auditory samples presented in a 24-trial pretest (results shown at left in data Figures).

Procedure. Apple McIntosh computers were used to present the visual and auditory stimuli, which will be described later. The sample area was centered on the computer screen: Comparison stimuli were presented at the corners. Selections of stimuli made via cursor location and mouse-click were recorded automatically. Reinforcers (edibles, and tokens exchanged for money and food) were individualized.

A. Contrast fading. The four visual stimuli were pairs of figures, two small and two large outlined squares, and one square of each size in both left/right orders. The auditory stimuli to which these visual stimuli were to be matched were pairs of tones, 250 hz and 1500 hz and their mixtures, respectively. Tones lasted 150ms and were separated by 500ms of silence.

Training. Initial training (Train 1 in Fig.1), was carried out with the same-size squares and repeating tones. The auditory and visual stimuli were presented together as complex samples for matching tasks in which the visual stimuli were comparisons and thus could be performed as identity matching tasks that were not disrupted by the presence of the visual stimuli. Next, the visual samples were gradually faded out across 44 trials leaving only the tones as samples. Twelve trials of the final auditory-visual matching performance (FP) then followed immediately. After this initial training, the mixtures were trained alone (Train 2). All four types of stimuli then were presented in unsystematic order for Train 3. Sessions that involved the final performance consisted of only 24 auditory-visual matching trials.

Generalization tests. Stimulus generalization was assessed in trials using new frequencies of tones as samples. These were 450 and 850 hz, 750 and 1150 hz, 150 and 550 hz, and 250 and 500 hz.

Results. The dual-modality transfer training with same-size squares occurred virtually without error for participant CAN (Figure 1, Train 1). However, four training sessions with the stimulus mixtures

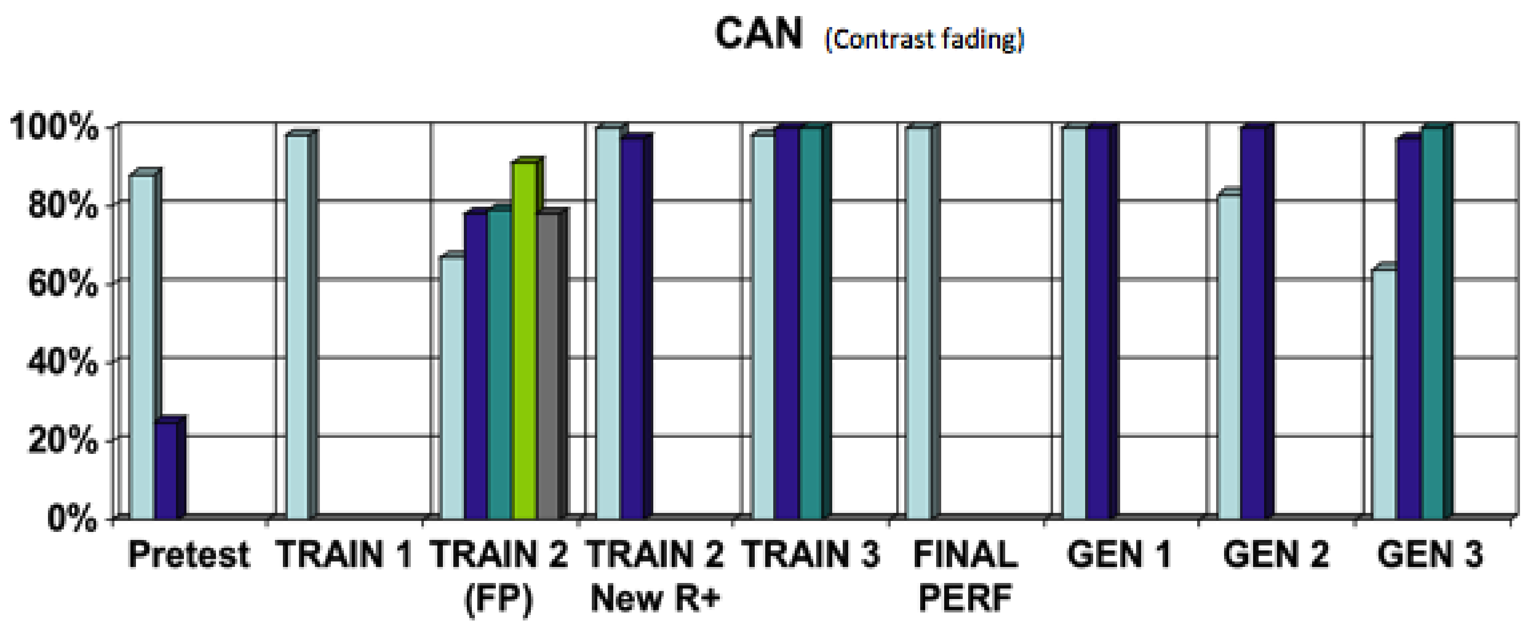


Figure 1. Performance accuracy of participant CAN. FP = final performance. New R+ = new reinforcer exchanges. Pretest sessions show visual identity (left bar) and auditory-visual matching (right bar). All other data show auditory-visual matching.

(Figure 1, Train 2) and a changed reinforcement procedure (New R+ that included several token exchanges during a session.) were repeated to produce virtually perfect performance. Performance generality was demonstrated with the new pairs of auditory stimuli.

Discussion. The contrast fading procedure successfully produced visual-to-auditory, cross-modality transfer of sample stimulus control with one set of stimuli. The relational performance established then occurred readily with different sets of stimuli. Auditory samples consisting of two identical tones controlled selections of identical visual stimuli, with larger squares being selected conditionally on presentations of higher frequency tones and smaller squares being selected on presentation of lower frequency tones. Further, when sample tones were mixed, the visual comparisons selected were the appropriate small-large and large–small mixtures.

B. Dynamic fading. This introduces a novel *dynamic fading* training method with different sets of stimuli in two studies.

Study 1. The visual comparison stimuli to be matched to samples (identical and auditory) during training were the pair of circles and the oblique black line shown at right in Figure 2. Sample stimuli were presented dynamically (as indicated by left to right order in Figure 2). The auditory training stimuli (T) were three tones of different frequencies that accompanied the visual stimuli.

As with the contrast fading, presentations of the visual stimuli allowed identity- matching performance that the participants already could do. Training 1 (Figure 3) then could show that such performance was not disrupted by simultaneous presentations of the auditory with the visual samples.

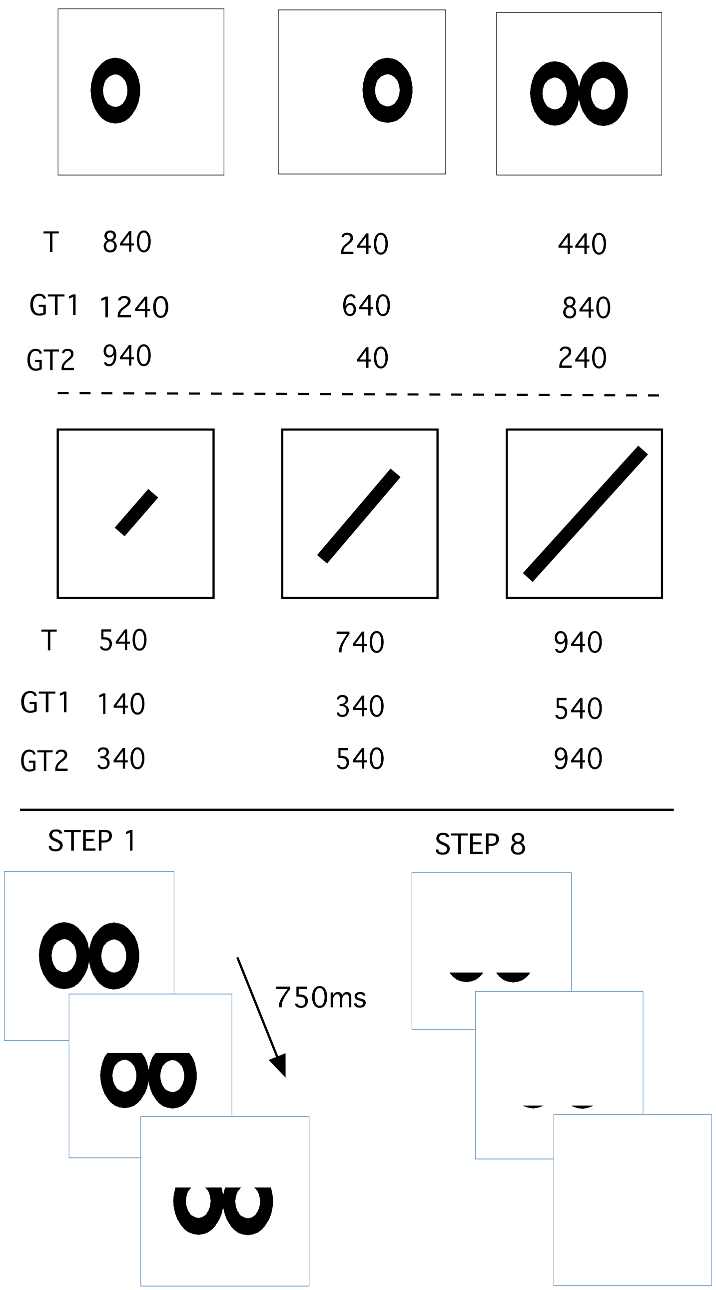
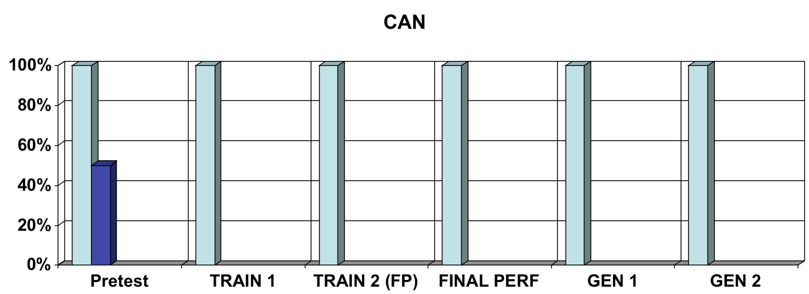


Figure 2. Training (T) and Generalization test (GT1, GT2) stimuli used in Study 1. Lower panel illustrates dynamic sample fading STEPS 1 and 8. See text.

The visual components then were removed gradually with dynamic fading, which erased these cues actively within trials (like apparent movement) and cumulatively across trials in 8 steps (Figure 2, bottom). After fading, conditional control by the auditory samples only was assessed in Final Performance (FP) trials. Generalization was tested using tones with frequencies differing from the training stimuli (See Figure 2, GT1 and GT2).

Results. For the two participants shown in the top row of Figure 3, few or no errors occurred when the auditory and visual stimuli were presented as compound samples (Train 1).



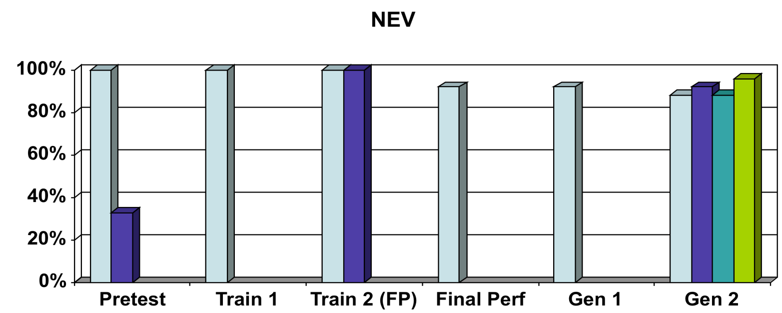
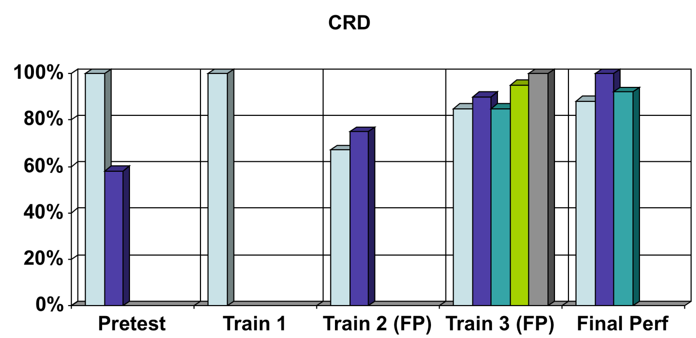


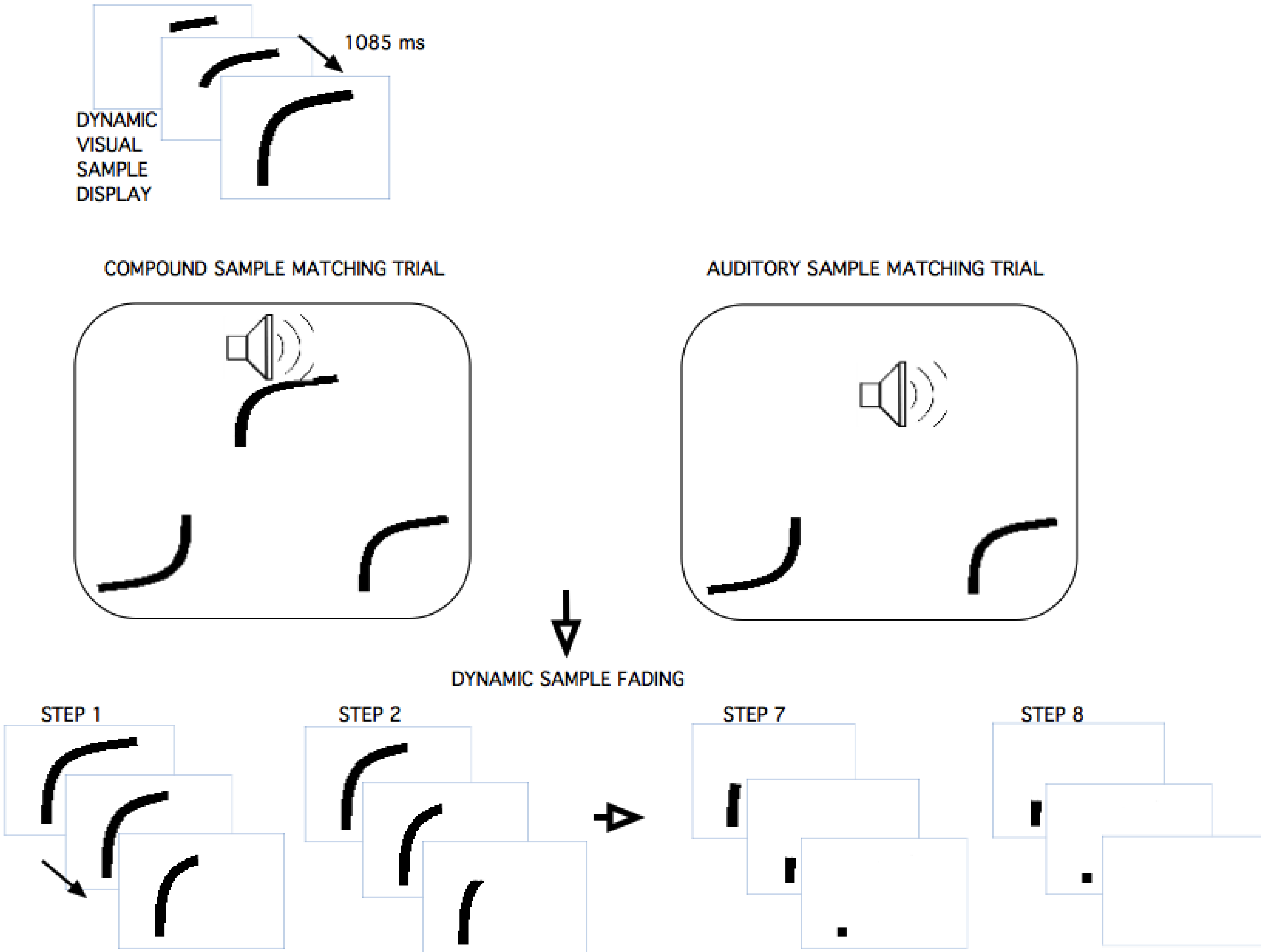
Figure 3. See text.



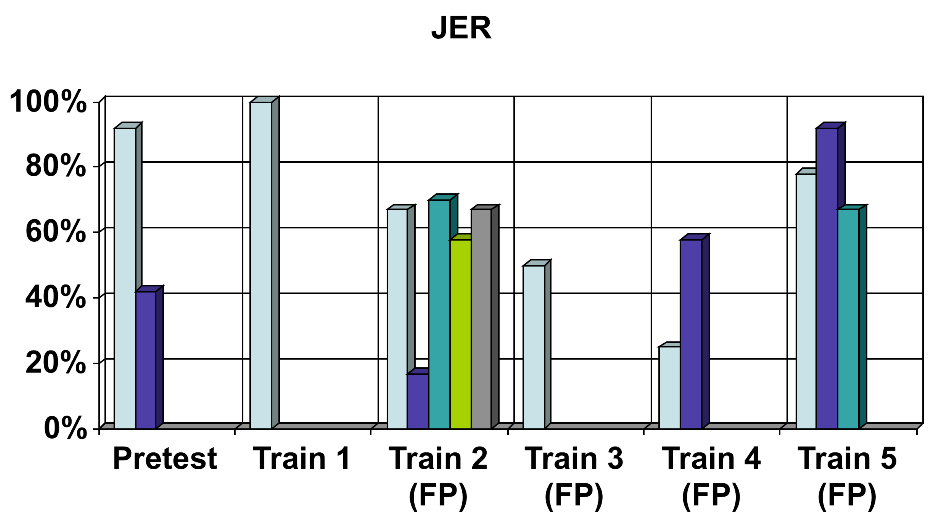
Performance on fading trials then was errorless (data not shown). Both participants then continued to perform with high accuracy on the final auditory- visual matching trials and demonstrated generalization when new auditory samples were presented.

The participant shown in the bottom panel, however, made errors initially on Final auditory-visual performance trials when fading ended (Train 2). Increasing the number of these trials presented for Train 3 resulted in improved performance across sessions. Generalization was not assessed with this participant.

Study 2. This study illustrates the use of dynamic fading with the letter-like stimuli shown below. The auditory stimuli were tones of 440 hz gradually bent up and bent down an octave, respectively, using sound-editing software. Visual components of a dynamic sample presentation are illustrated at top left.



Results. Initial results for one participant are shown here. As before, presenting the samples that were compounds of the auditory and visual stimuli (Train 1) did not disrupt performance based on visual identity matching. Then, accuracy in the first session with dynamic fading (Train 2) was perfect (not shown) but errors occurred during the final set of (12) auditory-visual trials in which the backup to compound sample trials was eliminated. Notably, the participant



spontaneously verbalized a correct sample-comparison relation during the auditory-visual trials. She said, “When the sound goes up, pick the one that goes up”.

Next, across 7 sessions, the dynamic fading trials were almost always correct but the same high level of performance was not maintained for the terminal trials. Some poor performances may have occurred because of extra-experimental factors that are matters for discussion (e.g., session 2 of Train 2). In other sessions, adding final performance trials (Train 3) and interpolating trials that provided the visual cues from the last step of dynamic fading (performed correctly during Train 4) had no positive effect. Finally (Train 5), based on the verbalization described above, prompts to name the stimuli “Up” and “Down” were given before the sessions began. Auditory-visual matching performance immediately improved.

The results of these studies showed highly successful visual to auditory transfer. Additional research should examine relationships between training and maintenance of performance after fading ends. The effect of previous learning and verbal behavior that a participant may bring to the complex learning situation also requires study.

General Discussion. The dual-modality transfer procedures studied effectively promoted cross-modality relational learning. The procedures thus establish a good foundation for applications with beginning communicators.

The visual sample stimuli provided the critical determinants of the (identical) comparison selections in initial trials of the auditory-visual training. The attention-shaping that then produces control by the auditory samples alone results from active removal of these visual stimuli by the dynamic fading. The within-trial aspect of the fading actually may emphasize and ensure control by the visual sample stimuli initially. The active, observable removal of these stimuli then may facilitate the shift to control by the auditory cues, which remain unchanged both within, and also across trials. This contrasts with typical fading procedures where the gradual changes in critical stimuli occur only across trials. Such procedures not only lack the directly observable removal and systematic change of stimuli that are, or become, irrelevant or redundant, these changes even may go undetected and result in failure to promote shift in stimulus control.

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