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USING PERCENTILE SCHEDULES TO INCREASE EYE CONTACT IN CHILDREN WITH FRAGILE X SYNDROME

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Aversion to eye contact is a common behavior of individuals diagnosed with Fragile X syndrome (FXS); however, no studies to date have attempted to increase eye-contact duration in these individuals. In this study, we employed a percentile reinforcement schedule with and without overcorrection to shape eye-contact duration of 6 boys with FXS. Results showed that although aversion to eye contact is often thought to be unamenable to change in FXS, it can be shaped in some individuals using percentile schedules either alone or in combination with overcorrection.

DESCRIPTORS: eye contact, Fragile X syndrome, overcorrection, percentile schedules, shaping

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Studies have shown that children who have been diagnosed with particular genetic syndromes often engage in highly specific forms of aberrant social behavior (Oliver, Demetriades, & Hall, 2002; Reiss & Dant, 2003). These behavioral phenotypes have been considered to be important examples for investigations of the interplay between genes and environment (i.e., behavioral neurogenetics research; Kennedy, Caruso, & Thompson, 2001).

Children with Fragile X syndrome (FXS), the most common known form of inherited developmental disability, often show prominent aversion to eye contact (Cohen, Vietze, Sudhalter, Jenkins, & Brown, 1991; Hall, DeBernardis, & Reiss, 2006). For example, in the study by Hall et al., boys with FXS showed this aversion 80% of the time during a 5-min social interaction with an unfamiliar person, despite repeated prompts for eye contact.

To our knowledge, no studies have specifically attempted to improve eye contact in children with FXS. One way to train successively longer durations of eye contact would be to employ a shaping procedure (e.g., differential reinforcement of successive approximations to a desired goal; Martin & Pear, 1992). Traditional shaping procedures, however, may be limited by inconsistent identification of criterion responses. To overcome this problem, Galbicka (1994) has advocated the use of a percentile reinforcement schedule, a mathematical rule that determines whether an observed response is a criterion response. Percentile schedules may allow more consistent identification of criteria for reinforcement during shaping.

To date, percentile schedules have been employed to shape smoking cessation (Lamb, Morral, Kirby, Iguchi, & Galbicka, 2004), computer game playing (Miller & Neuringer, 2000), and academic task engagement (Athens, Vollmer, & Pipkin, 2007), with successful outcomes in all cases. In the present study, we employed a percentile reinforcement schedule to allow more consistent shaping of eye-contact duration in children with FXS. Specifically, we wanted to examine to what extent duration of eye contact could be increased by employing percentile schedules in time-limited sessions (e.g., 1 to 2 hr) to show that the behavior was amenable to behavioral treatment. For those children who were initially noncompliant (i.e., did not look at the experimenter when prompted), we implemented an overcorrection procedure similar to that employed by Foxx (1977) to ensure that all children would make contact with the percentile schedule.

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METHOD

Participants and Setting

Participants were 6 boys, aged 8 to 17 years, who had been diagnosed with FXS. The developmental levels of the participants, as measured by the Vineland Adaptive Behavior Scales (Sparrow, Balla, & Cicchetti, 1984), ranged from 1 to 5 years. All children were recruited from the local area and had undergone previous genetic testing to confirm their diagnoses of FXS. All participants were able to understand simple instructions and could speak in short sentences using at least two words.

Sessions were conducted in a room containing a large desk and several chairs. The participant sat in a chair located against the back wall of the room, and the experimenter sat in a chair directly opposite the participant, with knees almost touching the participant. An observer (the second author), who was trained in observational procedures to greater than 80% interobserver agreement, sat 1 m away and to the right of the experimenter. Preferred items were identified using the protocol described by Fisher et al. (1992).

Response Measurement and Interobserver Agreement

Eye contact was defined as the child orienting his head toward the experimenter so that the participant's eyes looked directly at the experimenter's eyes. *Behavior during overcorrection* was defined as the child or experimenter moving the child's head in one of three directions—up, down, or straight ahead—and maintaining each position for 15 s.

The percentile schedule was implemented on a laptop computer. (The program was written in Visual Basic, runs under Windows, and is available from the corresponding author.) On each trial, when the experimenter delivered the verbal prompt, participant eye contact was recorded on the computer by the observer. The observer pressed a specific key to indicate the onset and again to indicate the offset of participant eye contact. Successive durations of eye contact were then used by the computer to rank response durations ordinally and to indicate a criterion for reinforcement. The computer then determined whether a reinforcer should be delivered. Behavior during overcorrection was recorded using a stopwatch.

In six of the 12 sessions, interobserver agreement data for duration of eye contact and duration of behavior during overcorrection were collected. For each observer, the number of seconds of eye contact or minutes of behavior during overcorrection was summed over blocks of five trials. Total agreement was calculated by dividing the smaller number by the higher number and converting this ratio to a percentage. The mean level of agreement across participants was 91% (range, 84% to 96%) for eye-contact duration and 100% for overcorrection duration.

Experimental Design and Procedure

An ABAB design was used to evaluate the effects of percentile schedules on eye-contact duration. The experimenter conducted two sessions approximately 1 hr in length on separate days with each participant. During each session, each participant was exposed to two conditions. In the baseline condition, on each trial the experimenter and participant sat facing each other while the experimenter held an edible item (e.g., Skittles) or play material (e.g., Lego) close to one eye and gave the verbal prompt "Look at me for as long as possible, please." If the participant made eye contact within 5 s, the observer recorded the duration of eye contact on the computer. Once eye contact had been recorded, the computer simultaneously determined whether the experimenter should deliver reinforcement with a random probability of .5. If a reinforcer was scheduled, the computer sounded a beep, and this was a cue for the experimenter to deliver the edible item or play material. Both experimenter and observer then said "Good job, good eye contact." If there was no eye contact, no reinforcement was delivered, and the experimenter waited for 10 s before initiating the next trial. This condition was conducted for 20 trials and allowed the current level of eye contact and the effects of intermittent reinforcement of eye contact to be assessed, independent of the duration of the response.

In the percentile schedule condition, successively longer durations of eye contact were required before the experimenter delivered reinforcement. As in the baseline condition, on each trial, the experimenter and participant sat facing each other and the experimenter delivered the verbal and nonverbal prompts described above. If the participant made eye contact with the experimenter within 5 s, the observer recorded the duration of eye contact on the computer. To determine whether the response should be reinforced, the computer program operated a percentile reinforcement schedule (see Galbicka, 1994). The percentile schedule requires two parameters to be prespecified: the probability of reinforcing a criterion response (w), and the number of prior observations (m) to be included in the calculation. The percentile schedule equation, $k = (m + 1)(1 - w)$, specifies the kth rank that must be exceeded before the current response becomes a criterion response. In this study, we set $w = .5$ and $m = 5$. Using the equation above, $k = 3$. This means that the value of the current response would be considered a criterion response only if it exceeded three of the previous five response values. The criterion response would then have a 50% chance of being reinforced. The starting criterion for the percentile schedule was any duration of eye contact with the experimenter. If the participant did not engage in eye contact within 5 s of the prompts (as occurred for Ben, Jay, and Eric), the experimenter said, "You did not look at me," in a stern voice and proceeded to implement the overcorrection procedure (i.e., functional movement training) for 60 s (Foxx, 1977). During overcorrection, the participant was required to move his head in one of three directions—up, down, or straight ahead—and to maintain each posture for 15 s at a time. The experimenter prompted the participant at the beginning of each 15-s period by saying either "head down," "head forward," or "head up." No prompts for eye contact were delivered. If the child did not move his head in the required direction or did not maintain each posture, the experimenter stood beside the child and gently guided the child's head with his hands. Once four postures had been maintained, overcorrection was completed, and the experimenter then waited 10 s before initiating the next trial. In total, the percentile schedule condition was conducted for a maximum of 80 trials or until 1 hr had passed, whichever came first.

RESULTS AND DISCUSSION

Figure 1 shows that for both Bob and Sal, eye-contact duration was relatively low during baseline but increased steadily in duration in each of the percentile schedule phases. For Bob, eye contact increased from a mean of 2 s at baseline to a minimum of 4 s in the last five trials of the second percentile-schedule phase. For Sal, eye contact increased from a mean of 2 s in the first baseline condition to 6 s in the first percentile-schedule phase and from a mean of 4 s in the second baseline phase to 12 s in the second phase in which the percentile schedule was implemented. However, the data for Jesse indicated that only a marginal increase in eye-contact duration occurred during the first percentile-schedule phase, and that eye contact did not improve in the second percentile-schedule phase.

For Ben, Jay, and Eric (Figure 2), levels of eye contact were zero on some trials during the percentile schedule condition, which necessitated the use of the overcorrection procedure. All 3 children received overcorrection during the first 30 trials of the percentile schedule condition, but once compliance to the eye-contact prompt was established, this contingency was no longer

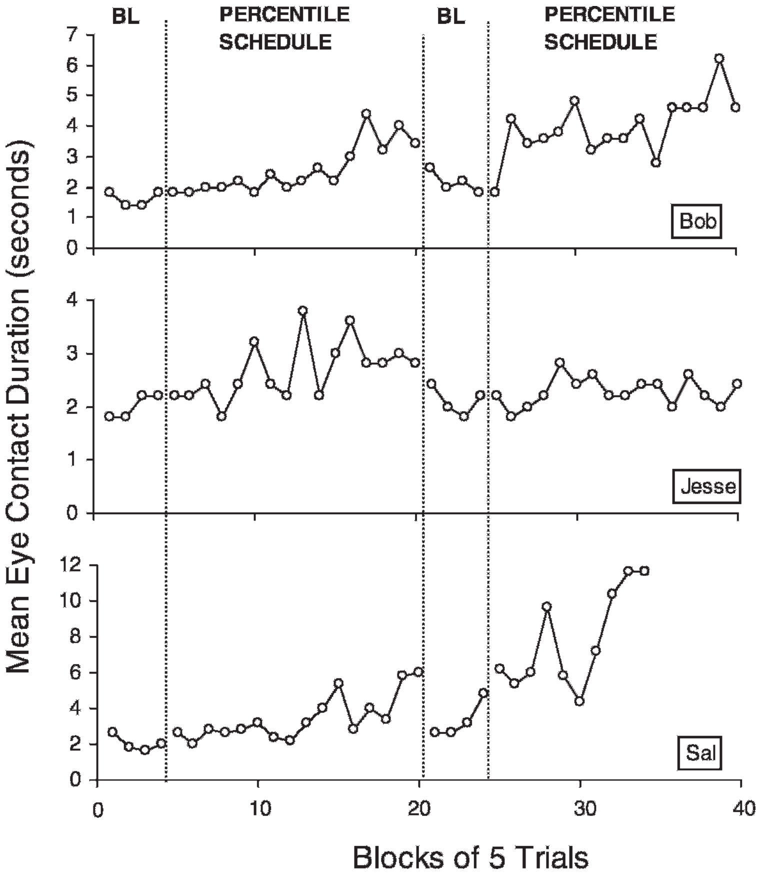

Figure 1. Eye-contact duration (in seconds) for Bob, Jesse, and Sal at baseline and in the percentile schedule condition. Data points represent five-trial means.

required. For Jay, eye contact increased from a mean of 0.5 s at baseline to a minimum of 2 s in the last five trials of each percentile schedule phase. For Eric, eye contact increased from a mean of 1 s at baseline to a minimum of 3 s in the last five trials of the second percentile-schedule phase. For Ben, eye contact did not appear to improve above baseline in the first percentile-schedule phase. However, eye contact increased from a mean of 0.5 s at baseline to a minimum of 3 s in the last five trials of the second phase in which the percentile schedule was implemented.

Previous investigators have considered aversion to eye contact in FXS to be a prominent feature of the syndrome that may be difficult to remediate. The data from the current investigation indicate that eye-contact duration can be improved in some children with FXS (Bob, Sal, Jay, and Eric), at least in the short term. Future studies should be conducted to determine whether parents or teachers could implement these training sessions in school or at home, perhaps leading to longer term improvements in eye contact. Although Galbicka (1994) suggested ways in which percentile schedules could be implemented in naturalistic settings using pencil-and-paper techniques, it seems likely that efficient implementation of percentile schedules would, at the very minimum, require a computer program running on a handheld computer, which may not be available to all consumers.

For 3 of the participants, the presence of the overcorrection procedure in the percentile sched-

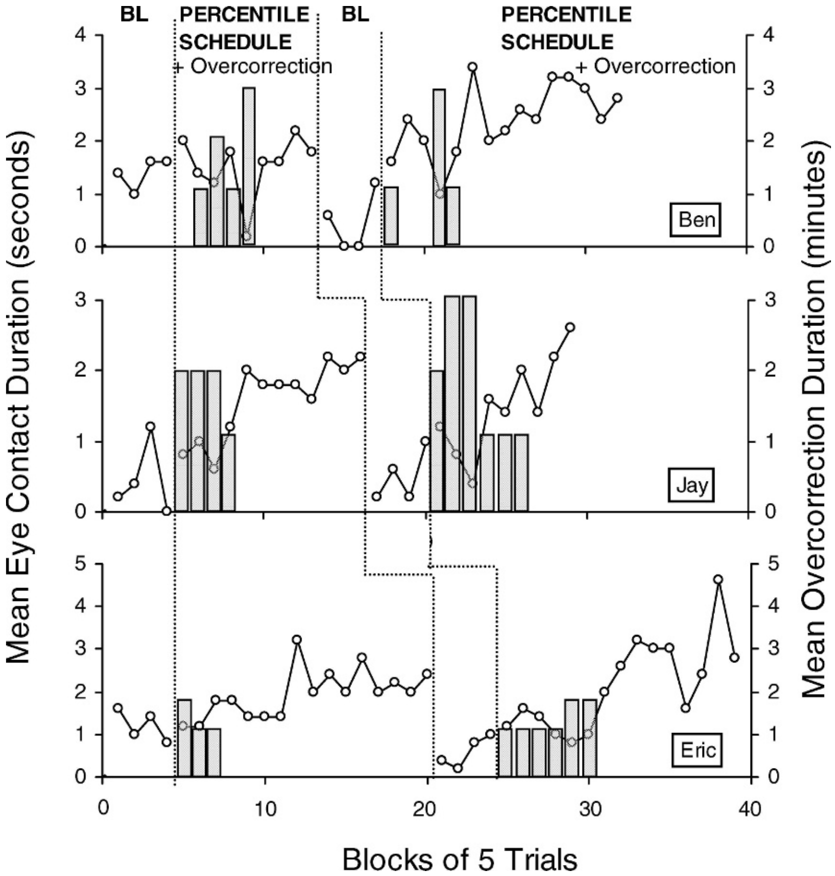

Figure 2. Results for Ben, Jay, and Eric at baseline and in the percentile schedule plus overcorrection. Open circles indicate eye-contact duration (in seconds) plotted along the left *y* axis. Bars indicate duration of the overcorrection consequence (in minutes) plotted along the right *y* axis. Data points represent five-trial means.

ule condition precludes an unbiased assessment that the changes observed were due to the percentile schedules. It is possible that the overcorrection procedure would have been effective independent of the percentile schedule; some studies have shown that the effect of punishment may not reverse when it is withdrawn (e.g., Piazza, Hanley, & Fisher, 1996). The data from the current investigation also are limited in that levels of eye contact were increasing in baseline for several of the participants prior to the initiation of the percentile schedule, the baseline condition was implemented substantially less often than the percentile schedule, and the improvements in eye contact were gradual in the percentile schedule condition.

FXS is the most common known form of inherited developmental disability and is caused by a mutation to the FMR1 gene located on the X chromosome. However, it is unclear how the FMR1 mutation places an individual with FXS at risk for eye-contact aversion. It is possible that the mutation alters the relative reinforcing property of escape from social stimulation in these children and that aversion to eye contact may allow the child to escape social stimulation. Once established, it seems likely that environmental contingencies may further shape and maintain this behavior. To date, no functional analysis of aversion to eye contact in FXS has been conducted in which escape as a consequence has been manipulated systematically. It is therefore possible that such aversion may serve other functions.

REFERENCES

Athens, E. S., Vollmer, T. R., & Pipkin, C. C. (2007). Shaping academic engagement with percentile schedules. *Journal of Applied Behavior Analysis*, *40*, 475–488.

Cohen, I. L., Vietze, P. M., Sudhalter, V., Jenkins, E. C., & Brown, W. T. (1991). Effects of age and communication level on eye contact in fragile X males and non-fragile X autistic males. *American Journal of Medical Genetics*, *38*, 498–502.

Fisher, W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J. C., & Slevin, I. (1992). A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. *Journal of Applied Behavior Analysis*, *25*, 491–498.

Foxx, R. M. (1977). Attention training: The use of overcorrection avoidance to increase the eye contact of autistic and retarded children. *Journal of Applied Behavior Analysis*, *10*, 489–499.

Galbicka, G. (1994). Shaping in the 21st century: Moving percentile schedules into applied settings. *Journal of Applied Behavior Analysis*, *27*, 739–760.

Hall, S., DeBernardis, M., & Reiss, A. (2006). Social escape behaviors in children with fragile X syndrome. *Journal of Autism and Developmental Disorders*, *36*, 935–947.

Kennedy, C. H., Caruso, M., & Thompson, T. (2001). Experimental analyses of gene–brain–behavior relations: Some notes on their application. *Journal of Applied Behavior Analysis*, *34*, 539–549.

Lamb, R. J., Morral, A. R., Kirby, K. C., Iguchi, M. Y., & Galbicka, G. (2004). Shaping smoking cessation using percentile schedules. *Drug and Alcohol Dependence*, *76*, 247–259.

Martin, G., & Pear, J. (1992). *Behavior modification: What it is and how to do it* (4th ed.). Englewood Cliffs, NJ: Prentice Hall.

Miller, N., & Neuringer, A. (2000). Reinforcing variability in adolescents with autism. *Journal of Applied Behavior Analysis*, *33*, 151–165.

Oliver, C., Demetriades, L., & Hall, S. (2002). Effects of environmental events on smiling and laughing behavior in Angelman syndrome. *American Journal on Mental Retardation*, *107*, 194–200.

Piazza, C. C., Hanley, G. P., & Fisher, W. W. (1996). Functional analysis and treatment of cigarette pica. *Journal of Applied Behavior Analysis*, *29*, 437–449.

Reiss, A. L., & Dant, C. C. (2003). The behavioral neurogenetics of fragile X syndrome: Analyzing gene-brain-behavior relationships in child developmental psychopathologies. *Development and Psychopathology*, *15*, 927–968.

Sparrow, S. S., Balla, D. A., & Cicchetti, D. V. (1984). *The Vineland adaptive behavior scales*. Circle Pines, MN: American Guidance Service, Inc.

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