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Teaching Discrimination of Adult Gaze Direction to Children with Autism

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Abstract

Three young children diagnosed with autism did not reliably locate objects in the environment on the basis of an adult's gaze shifts. A training program designed to teach gaze following used the activation of remote controlled mechanical toys as both prompts and consequences. Over several training sessions, toy activation was progressively delayed following the adult's gaze-shift cues. All of the children eventually came to anticipate the toy activation and locate the target object on the basis of the adult's gaze-shift cue alone. Discrimination of another person's gaze direction is discussed in relation to joint attention deficits in children with autism.

Keywords

Joint attention; gaze shift; gaze following; autism; children

Joint attention refers to behavior that functions to coordinate attention between interactive social partners with respect to objects or events, or to share an awareness of the objects or events (Dawson et al., 2002; Mundy, Sigman, Ungerer, & Sherman, 1986). Early developing joint attention behavior includes shifting gaze between an object or event in the environment and a familiar person and combining gaze shifting with gestures to an object or event. Nonverbal joint attention begins to emerge between 9 and 12 months in typically developing children (Bakeman & Adamson, 1984). More advanced levels of joint attention include vocalizations and contact or distal gestures, and these response topographies vary with the developmental level of the child. Younger children may use only eye contact; older children

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tend to use a combination of gestures that may include eye contact, pointing, reaching, or showing an object to a person (Siebert, Hogan, & Mundy, 1984).

Researchers have documented deficits in joint attention in children with autism (Carpenter, Pennington, & Rogers, 2002; Mundy, Sigman, & Kasari, 1994; reviewed in Jones & Carr, 2004). Children with autism may fail to orient to speech sounds or social stimuli (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998), and fail to look where others point (Leekam, Hunnisett, & Moore, 1998). Related problems in autism have been reported in declarative pointing and showing (Baron-Cohen, 1989) and referential looking (Charman, Swettenham, Baron-Cohen, Cox, Baird, & Drew, 1997). For example, Charman et al. found that all children with autism looked at a mechanical toy when it was activated but did not exhibit gaze switches between the toy and an adult who was present (also see Kasari, Sigman, Mundy, & Yirmiya, 1990; MacDonald et al., 2006; Mundy et al., 1986; Whalen & Schreibman, 2003).

Recently, Dube, MacDonald, Mansfield, Holcomb, and Ahearn (2004) presented an analysis of the reinforcement contingencies that may be involved in the typically developing child's gaze shift in joint attention initiation. This analysis proposed that interesting objects or events offer opportunities for social interaction and shared experiences, but only if the adult is aware of and attending to the object or event. If so, then one important consequence for the child's gaze shift from an object to an adult is a visual indication that the adult is aware of the object; for example, the adult's eyes are open and oriented toward it. In order for this consequence to be effective, the child must be able to determine where the adult is looking from the visual information available in the adult's head and eye orientation relative to the interesting objects or events. One could test for the child's ability to make such a discrimination by testing gaze-following behavior: If the adult looks at an object in the environment, can the child locate that object after observing the adult's gaze direction? Previous research has shown that children with autism have deficits in this type of discrimination (Dawson et al., 1998; Whalen & Schreibman, 2003).

For example, Leekam, Lopez, and Moore (2000, Experiment 1) compared responses to an adult's gaze-shift cues in preschool children diagnosed with autism and children with other types of developmental delay. The procedure was adapted from one originally used to test typically developing infants (Corkum & Moore, 1998). Target objects were two identical mechanical toys that could be either (a) hidden within a box, or (b) displayed and activated with flickering lights by remote control. The targets were placed on the left and right sides of the adult, so that the adult's shift from eye contact with the child to the target involved a 90-degree head turn. Only 20% of the children with autism followed gaze-shift cues when the target object was a plain box, compared to 65% for children with other types of developmental delays. An additional 40% of the children with autism, however, learned to follow the gaze-shift cue within 24 trials when it predicted toy appearance and activation.

One approach to remediation for gaze-following deficits was reported in Whalen and Schreibman (2003). A training program used a graded set of tasks and prompting procedures to teach five 4-year-old children with autism to follow an adult's gaze-shift cue. The training objects were toys, used both as targets for adult cues and as reinforcers for the children's responses (they could play with the toy if they correctly followed the adult's cue). Participants progressed through six instructional steps in which the child engaged with a training object after (a) contact cues (e.g., placing the child's hand on the object), (b) distal pointing and auditory cues, (c) distal pointing cues alone, (d) making eye contact with the experimenter in response to an auditory cue (no object engagement on this step), (e) engaged with a training object after eye contact plus a point cue, and finally (f) engaged with the object after eye contact plus a gaze cue. As summarized in text in Whalen and Schreibman, completion of this training required 270 to 390 trials (5 trials per session, 3 sessions per day).

The present report will present three quantitative case studies to illustrate a method, based on the toy-activation findings of Leekam et al. (2000), for establishing and verifying discrimination of adult gaze direction in preschool children with autism. The Leekam et al. procedure was modified and extended by including: a larger number of toys and target locations, a progressively increasing delay between the adult gaze-shift cue and toy activation during initial training, the introduction of trials with no toy activation (i.e., static target objects) during the last stage of training, and pre- and post-training evaluations with non-mechanical toys.

Method

Participants

Participants were three young boys enrolled in an intensive early intervention program for children diagnosed with ASD: Paul (chronological age 4.1 yr., Mullen Scales of Early Learning Developmental Quotient 58, Autism Diagnostic Observation Schedule 14), Mark (CA 6.25 yr., DQ 57, ADOS 11), and Jim (4.75 yr., DQ 29, ADOS 15). The Mullen Scales (Mullen, 1995) and ADOS (Lord, Rutter, DiLavore, & Risi, 2001) were administered by qualified assessment specialists not otherwise involved in the research. Higher ADOS scores indicate more observed characteristics consistent with autism. All children were tested with ADOS Module 1; suggested diagnostic cut-off scores are autism 12, autism spectrum disorder 7. Participants were selected for this study on the basis of initial evaluations showing that an adult's gaze shift did not reliably control the child's direction of gaze.

Setting and Materials

Experimental sessions took place in a small, quiet room containing two tables, chairs, three stools, and a toy shelf. There was a screened partition approximately 3 m in front of the child and a video camera behind the partition recorded sessions through a small opening in the partition. Materials included 24 different toys that were used as *target objects*: 16 of these toys were mechanical toys that could be activated remotely by pressing a footswitch. Toys could be placed in four locations around the room prior to sessions: behind, to the left, to the right, and in front of the child. The toys were placed on top of a stool or on a table so that they were near the child's eye level. Toys were placed in shallow plastic containers so that mechanical toys would not move from their locations when activated. The specific toys used for sessions varied unpredictably, with the restrictions that a toy was never used in successive sessions and never in the same location on two successive appearances.

General Procedures

Experimental sessions were approximately 4 to 7 minutes in duration and usually conducted 3 days per week. Sessions began with the opportunity for a brief play time in which the child was allowed to play with a toy selected from the shelf or brought from the classroom. After 3 minutes of play, the experimenter directed the child to put the toy away and sit at the table. After several sessions, this introductory play time was omitted if the child went directly to the table and sat down upon entering the room. The experimenter and child sat diagonally across one corner of the table, with the experimenter to the child's right. After all non-experimental toys were put away and the child was seated, the experimenter conducted a brief reinforcer preference test. She presented small pieces of three different preferred edibles on a napkin and instructed the child to "pick a treat." The item selected was presented as a reinforcer during the subsequent session.

Because the experimenter was required to maintain visual fixations on target objects during gaze-shift trials, a second experimenter was present during sessions. The second experimenter sat behind the partition with a stopwatch and observed through a small opening in the partition.

The second experimenter provided audible vocal cues to the first experimenter to signal correct responses or trial time limits.

Evaluation Sessions

Evaluation sessions consisted of 32 trials alternating irregularly among the three trial types described below. Prior to each session, a different non-mechanical toy was placed in each of the four target locations. As each trial began, the experimenter established eye contact via least-to-most prompting (modeling, calling the child's name, holding an edible before the experimenter's eyes, and manually guiding the child's head).

Maintenance trials were included in sessions to break up runs of successive gaze-shift trials and to provide opportunities for the child to earn edible reinforcers. Maintenance trials included familiar instructions (e.g., clap your hands) and gross-motor imitation tasks. Correct responses were followed by verbal praise and a small piece of the edible chosen at the beginning of the session. Following any incorrect responses, the experimenter remained silent and refrained from eye contact for several seconds before going on to the next trial.

Gaze Shift Evaluation trials—After at least 1 s of eye contact, the experimenter turned her head and eyes toward one of the target objects. The target object location for each trial was listed on a prepared data sheet, and the order of target locations within sessions varied unpredictably. A *correct response* was defined as the child's gaze shift from the experimenter directly to the target within 5 s of the experimenter's gaze shift. Following a correct response, the experimenter made a comment to the child about the toy (e.g., "That's a funny clown.") and then went on to the next trial. Thus, in Evaluation sessions, correctly following an adult's gaze shift produced only social consequences. If the child did not respond correctly, the experimenter remained silent and refrained from eye contact for several seconds, and then went on to the next trial. The child's responses were recorded as correct or incorrect on the data sheet.

Gaze Shift + Look Evaluation trials were identical to the Gaze Shift trials, except that the experimenter said "Look" immediately before shifting her gaze to the target object.

Training Sessions

Delayed Cue training—The Delayed Cue training trial procedure was the same as that for the Gaze Shift Evaluation trials, with the following modifications: (a) Target objects were placed in three locations: in front, behind, and to one side of the child. (b) Nine Delayed Cue trials, three trials per location, were interspersed among nine Maintenance trials, described above. (c) In the first session, if the child responded correctly within 2 s of the experimenter's gaze-shift cue, the toy at the target location was activated for 5 s and the experimenter made a comment about the toy. This was recorded as a correct response with *no prompt*. (d) If the child did not respond within 2 s, the toy at the target location was activated for 5 s. If the child responded correctly while the toy was activated, the experimenter made a comment about the toy and recorded a correct *prompted* response. (e) Over subsequent sessions, toy activation was progressively delayed within the trial to encourage a transfer of stimulus control from toy activation onset to the experimenter's gaze-shift cue. Following one session with a total of at least eight correct responses (no-prompt plus prompted), the delay between gaze-shift cue and toy activation increased in the following sessions to 3 s, then 4 s, and finally to 5 s. The criterion to complete Delayed Cue training was least 17 correct responses (total no-prompt plus prompted) in two consecutive sessions (i.e., no more than one error) with a 5-s delay.

Contingent Activation training—With the Contingent Activation procedure, the consequence for a correct response within 5 s of the experimenter's gaze-shift cue was the

same as on Delayed Cue trials: The target toy was immediately activated for 5 s and the experimenter made a comment about it. If, however, the child did not respond correctly within 5 s of the gaze-shift cue, the toy was not activated, the trial ended, and an incorrect response was recorded. The criterion to complete Contingent Activation training was at least 17 correct responses in two consecutive sessions. If this criterion were met, the child received an Evaluation session followed by one more Contingent Activation session. If a child did not meet the 17/18 criterion within a limit of 10 Contingent Activation sessions, Delayed Cue training was repeated.

Intermittent Activation sessions were initiated after a child had completed successive Evaluation and Contingent Activation sessions with high accuracy on both (at least 7/8 and 8/9 correct, respectively). Intermittent Activation training was designed to strengthen gaze-following behavior in the absence of toy activation. In the first Intermittent Activation session, the target toy was scheduled to be activated on only six of the nine gaze-shift trials. The experimenter continued to provide a comment after every correct response. Following one session with at least eight correct responses, the number of trials with toy activation scheduled varied unsystematically across sessions, either six, three, or zero trials. Occasionally, a child was given three response-independent activation trials before an Intermittent Activation session. During these extra trials, the target toy was activated 2 s after the gaze-shift cue, regardless of the child's behavior. After the response-independent activation trials, the Intermittent Activation session was conducted as usual.

Inter-Observer Agreement and Procedural Integrity

A trained observer independently scored the participants' responses on gaze shift trials for 37% of sessions, including at least two sessions for each participant with each procedure. Inter-observer agreement (IOA) was calculated by dividing the number of trials with response agreement by the total number of trials. Mean IOA was 98% (range 89% to 100%). The experimenter's procedural integrity (PI) for gaze shift trials was evaluated by an independent observer for 19% of the sessions, including at least one session for each participant with each procedure. PI was calculated by dividing the number of trials in which both (a) the experimenter cued the correct location (according to the prepared data sheet) and (b) the correct consequence was presented, by the total number of trials. Mean PI was 99% correct, with a range of 96% to 100%.

Results

Maintenance trials

As expected, accuracy was high for all participants on Maintenance trials during evaluation and training sessions.

Initial Evaluation sessions

The left portions of the plots in Figure 1 show the results of the initial Evaluation sessions. All three subjects were correct on fewer than half of the Gaze trials in which only a visual gaze-shift cue was given. Performance was equivalent or slightly better on Gaze + Look trials when the verbal cue "Look" accompanied the gaze-shift cue, but the additional verbal cue had only a small effect.

Training and additional Evaluation sessions

Paul completed Delayed Cue training in 7 sessions and met the 17/18 accuracy criterion after 3 Contingent Activation sessions. In his second set of Evaluation sessions he was 6/8 and 7/8 correct on Gaze trials in the first and second sessions, respectively. Gaze-following accuracy

remained high during Intermittent Activation sessions, and in his last session he was 100% correct with no toy activation on any trial.

Results with Mark were similar to those with Paul. He completed Delayed Cue training in 5 sessions and met the Contingent Activation accuracy criterion in 2 sessions with no errors. He was correct on 7/8 Gaze trials in his second Evaluation session and 8/8 in the final Contingent Activation session. Accuracy remained very high when Intermittent Activation was introduced. In his third and fourth Intermittent Activation sessions he was 100% correct with toy activation on 3 trials per session. At this point training was interrupted for 10 weeks because of a scheduling problem.

After the 10-week break, Mark was given an Evaluation session and he was correct on 5/8 Gaze trials. He continued to make errors (3 or fewer) when Intermittent Activation sessions were resumed, and he was given 3 response-independent activation trials before Intermittent Activation Sessions 21–23. Accuracy was high in Session 23 and the pre-session response-independent activation trials were discontinued. In his final 5 sessions, toy activation occurred on 3 or 0 trials per session (average 1.8 trials/session) and he never made more than one error per session (42/45 correct).

Jim completed Delayed Cue training in 8 sessions. After 10 sessions of Contingent Activation training, however, he was still making 2 or 3 errors per session and so Delayed Cue training was repeated. After 8 Delayed Cue sessions, his accuracy was 8/9 correct on unprompted trials (i.e., correct responses before toy activation) for two consecutive sessions. Accuracy was high during the subsequent Contingent Activation and Evaluation sessions (one or zero errors per session). When Intermittent Activation training began, Jim's accuracy fell to 5/9 correct in the second session. Response-independent toy activation trials were programmed before each of the subsequent sessions. Although Jim's accuracy scores continued to fluctuate more than the other participants during Intermittent Activation training, he completed the last 3 sessions with a total of 24/27 correct responses and toy activations on an average of 3 trials per session.

Discussion

Discriminative control by gaze-shift cues in children with autism increased was established with exposure to the Delayed Cue training procedure with remote controlled toys. During Delayed Cue training, the experimenter's gaze shift was a perfect predictor of subsequent toy activation. The increase in unprompted correct responding across Delayed Cue training sessions indicates a transfer of stimulus control from the toy activation cue to the experimenter's gaze-shift cue as the time delay between the gaze shift and toy activation increased. Training progressed fairly rapidly with Paul and Mark (DQ 58 and 57, respectively), but Jim, the more developmentally limited participant (DQ 29), did not meet the initial accuracy criterion until his second exposure to the Delayed Cue procedure.

The present study included no direct comparison of the Delayed Cue training method with any other methods, but we note that it appears to compare favorably in one respect with the more conventional prompting strategy of Whalen and Schreibman (2003). Training was successful with all participants in both studies. Training in Whalen and Schreibman required a total of 270 to 390 trials, and this is comparable to the 252 training trials for participant Jim to meet the initial learning criterion for the Contingent Activation condition in the present study (28 sessions, 9 trials per session). Two participants in the present study, however, required substantially fewer training trials to meet this initial learning criterion, 63 for Mark and 90 for Paul. Although numerous differences between the two studies allow only speculation, these results at least raise the question of whether training with the within-stimulus prompt of toy activation in the present study might be more efficient than training with extra-stimulus

prompts as in Whalen and Schreibman (e.g., pointing to target objects; Schreibman, Charlop, & Koegel, 1982; reviewed in Lancioni, & Smeets, 1986). Investigation of this possibility will require a formal comparison of training methods.

Another positive feature of the results was the maintenance of correct responding at fairly high levels during the Intermittent Activation condition. It seems reasonable to assume that gaze-following in non-programmed environments may produce reinforcers on an intermittent basis (i.e., adults may not always be looking at something interesting to the child). The results from Intermittent Activation conditions indicate that the trained behavior persisted under conditions that may approximate the reinforcement contingencies of uncontrolled environments.

Limitations of the present study include a relatively restricted setting and time course. Further study will be needed to determine the extent to which gaze-following trained with toy-activation consequences (a) will generalize to novel settings and adults, non-toy target items, and visually complex non-laboratory settings; and (b) will persist with intermittent social reinforcement over longer periods of time.

One possible reaction to this approach concerns the contrived reinforcement contingencies for the child's behavior in the Contingent Activation condition. That is, were we teaching the child that he or she could activate a toy just by looking at it? In response to this concern, we note that toy activation occurred only if the child followed the adult's gaze-shift cue. Thus, it seems more accurate to say we were teaching the child that sometimes adults can predict the occurrence of interesting events, and this seems true in many situations for young children.

Finally, we point out that the child's gaze-following behavior in training sessions need not constitute joint attention responding. On the one hand, gaze-following was always followed by an upbeat verbal comment from the adult about the toy; to the extent that the function of the behavior was to produce this shared social interaction regarding the toy, the behavior could be classified as joint attention responding. On the other hand, on training trials and some of the trials in most Intermittent Activation sessions, gaze-following was also followed by toy activation; to the extent that function of the behavior was limited to producing this non-social sensory reinforcement, then the behavior would not be appropriately classified as joint attention responding. Although this distinction is theoretically interesting and important, the function of the child's behavior seems independent of the procedure's value for measuring the child's ability to detect target locations on the basis of the adult's gaze-shift cues. We have argued that the ability to make such discriminations is a likely prerequisite for gaze shifts in joint attention initiation and coordination (Dube et al., 2004). The present results demonstrate the feasibility of the Delayed Cue toy-activation method as a means to accomplish relevant discrimination training.

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Figure 1.

Number of correct gaze-shift responses per session during evaluation sessions (left vertical axis) and training sessions (right vertical axis). For Delayed Cue training sessions, white and black points show correct responses that occurred before (no prompt) or after (prompted) toy activation. Correct responses on Maintenance trials are not shown.