Behavioral Interventions
Behav. Intervent. **26**: 1–22 (2011)
Published online 27 September 2010 in Wiley Online Library
(wileyonlinelibrary.com) **DOI**: 10.1002/bin.315

USING STIMULUS CONTROL PROCEDURES TO TEACH INDOOR ROCK CLIMBING TO CHILDREN WITH AUTISM

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The present study evaluated an intervention package for teaching route following to two children with autism at an indoor rock-climbing gym. The intervention consisted of multiple within-stimulus fading procedures in combination with errorless learning procedures, positive reinforcement, an error correction procedure, and conditional discrimination training technologies. The results demonstrated that both participants learned to climb at least 10 ft/3 m on specified routes. Furthermore, both participants learned to climb an entire 22-ft/6.7-m wall for at least one of three different routes without any errors in a regular rock-climbing gym setting. The acquisition of this skill provides children with autism with an additional option for leisure participation with others. Copyright © 2010 John Wiley & Sons, Ltd.

It is well documented that individuals with autism do not typically engage in appropriate play and leisure activities (American Psychiatric Association, 1994; Bauminger, Shulman, & Agam, 2003; Orsmond, Krauss, & Seltzer, 2004). Although children and adolescents with autism often have an abundance of free time, they may not have the skills necessary to use this time productively (Wehman, 1983). Teaching individuals with autism to engage in appropriate leisure activities may have many beneficial results, including increases in on-task behavior (MacDuff, Krantz, & McClannahan, 1993), social interaction (e.g., Betz, Higbee, & Reagon, 2008; Charlop-Christy, Le, & Freeman, 2000; Ward & Ayuvazo, 2006; Warger, 1984), independence (Jerome, Frantino, & Sturmey, 2007; Kurt & Tekin-Iftar, 2008), and integration into the larger community (Fennick & Royle, 2003). Physically engaging forms of recreation can be particularly beneficial leisure activities for individuals with autism by decreasing the high risks of obesity, heart disease, type II diabetes, hypertension, and stroke as well as potentially decreasing rates of stereotypic behavior (Allison, Basile, & MacDonald, 1991; Bachman & Sluyter, 1988;

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Baumeister & MacLean, 1984; Ho, Eaves, & Peabody, 1997; Jansma & Combs, 1987; Kern, Koegel, Dyer, Blew, & Fenton, 1982; McGimsey & Favell, 1988; Powers, Thibadeau, & Rose, 1992; Rosenthal-Malek & Mitchell, 1997; Watters & Watters, 1980).

Despite these benefits, few procedures for teaching exercise activities to individuals with developmental disabilities, including autism, have been empirically evaluated (e.g., Fennick & Royle, 2003; Lagomarcino, Reid, & Ivancic, 1984; Luyben, Funk, Morgan, Clark, & Delulio, 1986; O'Conner & Cuvo, 1989; Pitetti, Rendoff, Grover, & Beets, 2007; Rapp, Vollmer, & Hovanetz, 2005; Todd & Reid, 2006; Ward & Ayuvazo, 2006; Weber & Thorpe, 1992). Only one known study, Luyben et al. (1986), employed stimulus fading of materials as a component of an intervention package to teach recreational skills to individuals with disabilities. In addition, no studies to date have evaluated stimulus fading in the teaching of leisure skills to children with autism. Though few studies have evaluated within-stimulus fading techniques in teaching skills to children with autism, children with other disabilities as well as typically developing children have benefited from within-stimulus fading procedures (e.g., De Graaff, Verhoeven, Bosman, & Hasselman, 2007; Gollin & Savory, 1968; Moore & Goldiamond, 1964; Schilmoeller, Schilmoeller, Etzel, & LeBlanc, 1979; Sidman & Stoddard, 1967).

Within-stimulus fading techniques may be most easily implemented and faded to teach recreation skills when a relevant stimulus can be readily made more salient and a portion of the stimulus is already imbedded in the activity. Indoor rock-climbing is a sport that can easily accommodate within-stimulus fading procedures and has increasingly become a popular recreational activity. In recent years, indoor rock-climbing has become a conventional sport for children, adolescents, and adults (Lee, 2007; Regenald, 2009; Siderelis & Attarian, 2004). In New Jersey alone there are at least 13 rock climbing gyms that are open to the general public (Indoor Climbing.Com, 1998–2008). In all of these facilities, children's birthday parties are advertised and team-building events are often held. In the New Jersey Rock Gym, in addition to having a competitive climbing team for children, youth classes are held tri-weekly (New Jersey Rock Gym, 2006–2008). Such activities offer opportunities for a structured leisure activity to a diverse group of individuals.

One unique aspect of rock climbing is that anyone of almost any age, physical ability, and intellectual ability can participate at varying levels concurrently with others of different levels. Additionally, social connections may be established by the nature of the belayer–climber relationship. Furthermore, rock-climbing facilitates both fine and gross motor development as well as cardiovascular exertion (Jasmin, Couture, McKinley, Reid, Fombonne, & Gisel, 2009; Rodio, Fattorini, Rosponi, Marchetti, & Quattrini, 2008). Rock climbing may additionally be a suitable leisure activity for individuals with autism because each climb ends with completion of a task. Task completion can be a potential natural reinforcer for

DOI: 10.1002/bin

some individuals, particularly for those who have a strong history of reinforcement for task completion which is typically emphasized in discrete-trial based learning programs. Another aspect of climbing that may be appealing to individuals with autism is that the rules are simple and concrete. There are three main rules of indoor rock climbing: climb up, follow the designated routes, and let go of holds at the end to be let down. In most established rock climbing gyms around the world, separate routes are each distinguished by specific colored tape. Every hold on a single route has a piece of tape of a certain color extending a few inches from its base. Each route is arranged by professional route setters and/or experienced rock climbers and is rated at different levels of difficulty. This allows climbers to climb routes at their experience level and to incrementally challenge themselves. Though it is possible to climb a wall in a rock gym disregarding the arranged routes, it is not typically practiced. Furthermore, following the outlined routes encourages the use of proper technique and facilitates greater physical exertion. There are often a few routes juxtaposed with one other, all distinguished by their unique tape color. When a person climbs a route, each hold serves as a discriminative stimulus for the behavior of reaching up and grasping. The colored tape serves as a conditional stimulus for the same behavior. In other words, if a climber is following a specific route, he or she will reach and grasp a hold upon seeing one, but only if a specific color tape is attached. Any other color tape serves as an S^{Δ} for that behavior. So, if a climber is climbing a pink taped route, he or she will likely avoid grasping any other color taped hold.

The purpose of the current study was to evaluate the use of an intervention package for teaching indoor rock climbing to children with autism consisting of multiple within-stimulus fading procedures, errorless learning procedures, positive reinforcement, error correction, and conditional discrimination training technologies based on the recommendations of Green (2001).

METHOD

Participants and Setting

The participants were two children diagnosed with autism according to the *DSM-IV* (American Psychiatric Association, 1994) via independent evaluation prior to the study. At the onset of the study Alice was 11 years, 4 months old and Genie was 6 years, 6 months old. Participants were selected based on parental interest, ability to receptively identify colors, and the ability to climb up 12 ft/3.66 m of a rock wall using any color-taped hold. Both participants attended private ABA-based programs for children with autism and other pervasive developmental disorders. In addition, neither

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participant had regularly participated in any type of intensive physically engaging activities.

Sessions were conducted at the New Jersey Rock Gym in Fairfield, NJ. The main gym area was 3048 m^2 with a ceiling height of 9.1 m. Teaching sessions were conducted in a small room to the side of the main gym that was 6.1 m $\times$ 7.6 m with a ceiling height of 7.6 m. Within the gym, wood structures had previously been built to simulate the varying inclines and declines that may appear on an outdoor cliff. The baseline wall stood at a 90° angle to the floor and both the teaching and generalization walls stood with a slight incline. The entire floor was lined with 5.1-cm thick Tiffen© closed cell foam with a carpeted top.

Materials

Equipment

The most accessible type of indoor climbing is called top-roping. Top-roping involves a climber as well as an individual called a "belayer." The belayer controls a safety device that enables progressive removal of the slack in the rope generated by the ascending climber. The belayer, who remains stationary at the base of the climb, feeds and withdraws slack expectantly and is responsible for securing the rope when the climber rests or falls as well as for releasing the rope to let the climber down. The climber is attached to the other end of the rope and climbs up the wall using the artificial holds that are in place. In the current study, the hand and foot holds used were removable polyurethane molds of various shapes and colors which could be attached to the walls in different configurations. The ropes used were 50-m dynamic beal single ropes which looped around a steal beam attached to the ceiling. Air traffic controllers (ATCs) were attached to each rope. These are belay devices that are secured to the belayer's harness and are used to catch and release the rope tied to the climber's harness. The harnesses worn were Petzl Gym waist with double backing capability.

Taped Frames

In Phases I–VI of the experiment, as described in detail in the procedures section below, each hold intended to serve as an S^D for grabbing was surrounded by a taped frame. The base of each frame was a cardboard cutout with a square hole in the middle so that, when placed on the climbing wall, it framed the hold. The surface area of each frame was covered in red, yellow, or blue tape. Each frame also had a 2.54-cm wide strip of oak tag, which varied in length from 7.6 cm to 0.3 m and extended from the bottom to simulate tape lengths found on typical rock gym routes. A piece of colored tape was placed over the strip of cardboard. The thick frames consisted of four 7.6-cm

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Figure 1. Photograph of the wall in Phase II with thick taped frames.

wide sides, a base length ranging from 23 cm to 0.3 m, and a height ranging from 23 cm to 0.3 m (see Figure 1). The thin frames consisted of four 2.3-cm wide sides and a base length ranging from 15.3 to 20.3 cm and a height ranging from 15.3 to 20.3 cm. A set of T-shaped frames, comprised of a one 2.3-cm wide strip perpendicular to another 2.3-cm wide strip each with varying lengths of 15.3 to 20.3 cm, were designed for Phase VII. Phase VIII used 2.3-cm strips of tape covering strips of cardboard of lengths ranging from 15.3 to 20.3 cm. Each frame was secured to the wall with adhesive Poster Putty®.

Hold Covers

In Phases I–V, hold covers were used to conceal the holds that were not on route. Wooden embroider hoops with diameters of 20.3, 15.2, and 10.2 cm were used to secure cotton sheet cut-outs over the holds. Adhesive Poster Putty® was adhered to the edges of the hoop to secure the covers to wall.

Bracelets

In Phases I–VIII, 7.6-cm wide bracelets were used in an alternative procedure described in the Procedures section. There was a pair of bracelets for each color (red, blue, and yellow). The bracelets were made of two 25.5-cm long strips of colored tape (the same type of tape as used for the tape frames) adhered to one another. Three Velcro® dots, 1.59 cm in diameter, were placed side by side from one of the ends of the top surfaces. One dot of the reverse Velcro® was adhered to the other side of the strips at the opposite end.

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Route Map

About 7.6-cm long strips of black tape were mounted horizontally along the left and right edges of both the baseline and treatment walls each separated by a vertical 1 ft/30.5 cm. Photographs were taken of the baseline and treatment wall with each hold uncovered and the black tap present. On the photographic printouts, horizontal lines connected the images of the black tape on the left and right sides of the wall. Each line represented the feet/meters from 1 ft/0.3 m to 10 ft/3 m above the starting position.

Dependent Variables and Data Collection

The dependent variable was the number of meters correctly climbed per route trial without an error. One route trial was defined as the sequence of climbing moves from the start hold to the last hold grabbed correctly. Correct climbing was defined as grasping a specified color taped hold in the absence of grabbing other holds with no more than a 10-s inter-response time between grabbing one hold and grabbing another correct hold. An error was scored when the participant grabbed a hold taped with another color or when the participant's response time between grabbing two holds was longer than 10 s. A route trial was considered completely correct when the participant climbed the entire 10 ft/3.0 m (12 ft/3.66 m including the bottom 2 ft/0.61 m) with 0 errors. The number of feet/meters climbed correctly was recorded as determined by referencing video footage of the sessions and the route map described above. Sessions were approximately 45 min each and were conducted three times per week. The number of route trials ranged from 5 to 15 per session. When the participants made fewer errors, the sessions generally consisted of fewer route trials because each individual successful climb was longer and more time consuming than climbs that were quickly ended in an error. In addition, five consecutive correct climbs resulted in a 15- to 20-min route change which limited the amount of time available for climbing in a single session. All sessions were videotaped for subsequent data collection.

Pre-experimental Procedures

Preference Assessment

Prior to the study, an open-ended brief interview was conducted with the parents of the participants to identify eight preferred edible items to be used as putative reinforcers. Before each route trial, the experimenter conducted a multiple stimulus preference assessment by presenting all of the eight items to the participant in a bin and instructing the participant to "pick one."

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Establishment of the Motivational System

Prior to the study, an auditory stimulus was systematically paired with edibles to establish the sound as a potential conditioned reinforcer. This allowed the experimenter to putatively reinforce route following at a distance and without interrupting the participant during climbing. The experimenter sat across from the participant. In one hand, the experimenter held a steel cup with a plastic castanet placed inside and in the other hand she held the participant's preferred edible reward. The experimenter presented the participant with one mastered direction (e.g., ''touch head''). Immediately after the participant responded correctly, the experimenter tapped the castanet inside the cup and dropped an edible reward within 2 s of the sound. Initially, the cup with the edibles was delivered to the participant on an FR1 schedule. This sequence occurred three times. Next, an FR5 schedule was used three times, followed by an FR10 schedule. Finally, an FR21 schedule was used because there were at most 21 holds on a given route.

Assessment of the Motivational System

Following this pairing procedure, an assessment was conducted to evaluate the participant's response to the sound of the castanet and edibles dropping into a cup without visual access to the putative reinforcers. The experimenter placed a foam board in front of the castanet, cup, and edibles to block the participant's view of the materials. The experimenter presented the participant with mastered directions (e.g., ''touch head,'' ''stomp your feet,'' ''stand up''). When the participant responded correctly, the experimenter tapped the castanet and dropped a snack into a cup. After 21 responses the participant received the cup with edibles. This procedure was repeated two more times. Baseline began when a participant met the criterion of 90% correct across three sessions. Both participants reached criterion during their first three sessions.

Procedure for Designing Climbing Routes

Each route began with a preliminary 21 holds. In total, there were 63 holds on the wall across three routes (21 for each colored route), and each hold had a pocket deep enough for children to fit at least ½ the length of their fingers. The pattern of holds across routes was also varied during teaching to program for generalization to different route arrangements that simulate typical routes in a rock gym. Within each route, the holds were spaced approximately 15.2 cm horizontally and vertically from one another. A colored frame was placed on each hold on route, while other colored strips of tape and/or hold covers were placed around holds off-route as predetermined

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by the experimenter. The midlines of each route were separated by approximately 0.9 m. Each route was set at a 5.2–5.4 USA Climbing level as determined by an experienced climber.

Experimental Design and Procedures

A non-concurrent multiple baseline design across participants with reversal probes was used to evaluate the effects of the intervention.

General Procedures

To facilitate appropriate control of responding by relevant stimuli, procedures based on the recommendations of Green (2001) were used. First, there were three comparison stimuli (three colored taped routes) presented within the same visual field for each session with only one sample stimulus, ‘‘climb (one of the three designated colors).’’ Second, each sample was presented equally often in treatment in an unsystematic order. Third, the number of consecutive times that a sample stimulus was presented was limited. Fourth, the participant was required to emit an observing response by verbally repeating the instruction. Finally, comparison stimuli were not rearranged in view of the participants. Rather, the tape and holds were placed on the wall when the participants were not present. The position in which the routes on the wall were arranged (i.e., left, middle, right) varied as predetermined by the experimenter in a quasi-random fashion. This was facilitated by leaving the holds on the wall and moving the tape frames. Because the position of the holds on the wall was randomly predetermined, the position of holds varied for each colored route.

Prior to the start of each experiment, each of the parents was asked to take a class and be certified as a belayer through the NJ Rock Gym. This allowed them to be able to assist their child in preparing for the climb. At the start of a session, the participant put on her harness and her parent tied the other end of the rope into his or her own harness. In addition, the instructor tied a second loose rope into the harness of the participant. When the climber's harness was tied into the rope, a safety check was conducted and the participant was manually prompted to stand 0.3 m away from the wall within 0.5 m horizontally from the start hold in the designated route. When the experimenter said, ‘‘climb (one of three designated colors),’’ the participant was required to repeat the phrase as an observing response. No verbal prompting was used in any phase as it has been suggested that verbal prompts may be difficult to fade (MacDuff et al., 1993). However, because it is common for climbers to receive verbal praise when they are succeeding, verbal praise was regularly provided. Each time the participant's hand reached a correct hold, non-specific verbal praise (e.g., ‘‘great,’’ ‘‘you got it,’’ ‘‘fantastic’’) was given. In addition, at the same moment, the castanet

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was tapped and the predetermined reward was dropped into a cup held by the instructor. When the participant reached the last hold, the instructor said, "Great job. You climbed (the color of the route that was climbed)." The instructor then said, "OK, come down" to prompt the participants to bear their weight on the rope so that the belayer could lead the rope through the ATC to allow the participant to descend. When the participant reached the floor, she received the cup containing the preferred reward. After the participant ate her snacks, the instructor prepared her to climb another route. After every 3 climbs, there was a 5-min resting period before climbing another route.

During a session, if the participant reached for and grabbed a hold that had a piece of tape at the base of the hold of a color other than the color verbally designated by the instructor at the start of the trial, a hold with no tape at all, or a hold concealed by a hold cover, the instructor said, "Stop. That is not (designated color)," lightly tugged on the second rope to prevent further climbing, and followed with, "come down." The instructor then provided enough slack in the rope for the participant to be lowered. When the climber returned to the floor, the rewards that were dropped into a cup were poured back into their original container. A second attempt was then made to complete the climb. If another error was made, the error correction procedure was implemented followed by a third climbing attempt. If a third error was made, the participant was given a 5-min break. After the break, the participant was given three more opportunities to climb successfully. If there was still no success, another 5-min break was given. After this break, a procedure using colored bracelets was implemented (br).

The experimenter placed a bracelet, the same color of the route, on the participant's left and right wrists. After the participant's and the instructor's harnesses had been reconnected to the rope, the instructor guided the participant to stand 0.3 m from the wall within 0.5 m horizontally of the start hold of the designated route. The instructor then pointed to the tape on the route frames and vocally labeled the color. Next, the instructor pointed to the bracelets on the participant's wrists and vocally repeated the color. If the participant again reached for and grabbed a hold that was taped with a different color other than the one designated, or she did not contact the next hold within 10 s of the previous hold, the error correction as described above was implemented. This error correction procedure was conducted for up to 3 consecutive trials (see Phase IA). Once the participant climbed the route successfully, the bracelets were removed and the route was climbed without the bracelets. This procedure took place for each route. The participant continued to climb each colored route until she had successfully climbed five consecutive routes correctly, which helped ensure mastery was reached for each color.

In each phase, five successful routes climbed consecutively signaled completion of the phase and baseline probes were conducted. This was done to eliminate any

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unnecessary teaching procedures. Baseline probes took place on the same routes that had been arranged for baseline. When the three baseline routes were climbed successfully, generalization probes were conducted. Generalization probes took place in the large gym on a 5.1- to 5.4-level route.

Baseline

A red route, a blue route, and a yellow route were arranged on the baseline wall, fully integrated with one another (i.e., all three routes overlapped with one another so that the participant could potentially physically contact both the designated S^D*s* and S^Δ*s* simultaneously when asked to climb one designated route) (see Figure 2) and set at a 5.1–5.4 climbing level. Each route was identified with only a piece of colored taped extending below each hold. In this phase, the participants put on their harnesses and were tied into one end of the rope. Once safety checks were completed, the belayer said "climb (one of the three designated colors)." Neither verbal praise nor

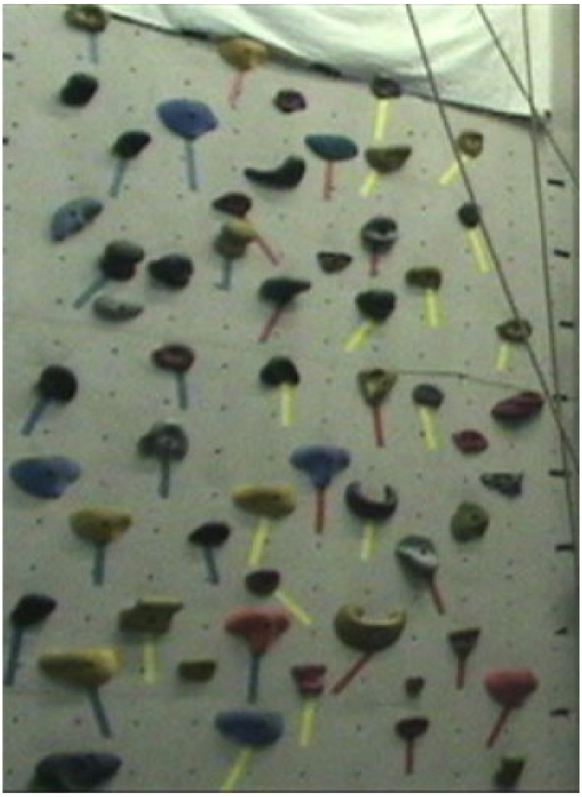

Figure 2. Photograph of the wall in baseline with fully integrated routes.

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edible rewards were provided for correct climbing. However, when the participant grabbed a hold that did not have the designated color of tape below the hold, or the latency of responding was greater than 10 s, the instructor lightly tugged on the rope attached to the harness and said ‘‘come down’’ not followed by ‘‘that is not’’ (one of the three designated colors). This was done to avoid practicing errors as well as to prevent reinforcement of undesired responses, if the act of climbing itself was automatically reinforcing. The order of routes climbed was chosen in a quasi-random fashion and was the same for both participants.

Phase I

In this phase, the midlines of three routes (red, blue, yellow) were arranged approximately 0.9 m apart from one another, a distance that would make it very difficult for the participants to reach holds of another route when climbing a designated route. A thick tape frame of the specified route color surrounded each exposed hold on each of the three routes. For example, on the red route, all of the holds had a red frame cutout surrounding each hold. The holds themselves were of varying colors as they typically are in rock gyms. Surrounding the exposed holds on each route were hold covers masking other holds beneath each separated by approximately 7.6 cm to 15.2 cm from the next.

Phase IA

This phase was added as a back-up phase for the participant that emitted continuous errors in Phase I. When the number of feet climbed per route trial failed to increase from Phase I following within three climbing trials, the bracelets were removed and this phase was instituted. In this phase the surface area of the holds on route were covered in masking tape. Masking tape was used because it successfully hid the color of the holds while maintaining the integrity of their pockets. This was intended to decrease the saliency of the color of the holds and increase the saliency of the color of the tape around the holds. When a participant successfully completed Phase IA, she was reintroduced to Phase I.

Phase II

In this phase, three extra holds were placed in each route. The arrangements of the order of routes on the wall varied in this phase as predetermined by the experimenter. This was done by maintaining the position of the holds on the wall and changing the placement of the tape frames from one set of holds to another set of holds. In addition, some of the newly uncovered holds had frames placed around them to serve as $S^D s$ so

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that the same holds did not serve as $S^{D}s$ for every phase. The $S^{\Delta}s$ had only a strip of tape extending from the base of the hold just as most holds look in a typical rock gym. The strips of tape at the base of the $S^{\Delta}s$ were different colors than the color of the tape frames around the holds that served as $S^{D}s$.

Phases III–V

The same procedures were followed as in the previous phases. However, in Phases III–IV, three hold covers were removed from each route during each phase. By the end of Phase IV, nine hold covers had been removed from each route. In Phase V, three frames were removed from each route leaving 12 holds off-route exposed. Once again, in each of these phases, the thick frames were moved around so that some of the holds that were previously serving as $S^{D}s$ now served as $S^{\Delta}s$ and *vice versa*. The same error correction procedure as in Phase II occurred in each of these phases.

Phases VI, VII, VIII, and IX

The same procedures were administered as in Phases I through V with the following exceptions. Although the frames were moved around in a similar manner as in the previous phase, different tape frames were used in each phase to facilitate successful stimulus fading. In Phase VI the thin four-sided frames surrounded each hold on the route. In Phase VII, the T-frames were mounted underneath the designated holds. In Phase VIII the tape-covered cardboard strip was placed below each hold on the designated route. Finally, in Phase IX, colored tape was mounted directly onto the wall extending from the base of the holds.

Baseline Probes

After each phase was completed successfully, a probe was conducted under baseline conditions (i.e., reversal probes). Three baseline data points were collected over one session.

Generalization and Follow-Up Probes

Probes were conducted in the large gym after three consecutive successful climbs in a baseline probe following 3 weeks of no climbing. In addition to the routes being located in a different setting and arranged in a different manner, a novel color tape was used, a greater number and variety of people were present, and the noise level was audibly higher than in the training room. Unlike the baseline and teaching stimuli, which were red, blue, and yellow, the generalization routes were red, blue, and green.

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Furthermore, the height of the climb was extended to the full length of the wall (22 ft/ 6.7 m). As in baseline, neither verbal praise nor edibles were provided for correct climbing. However, in generalization, there was no extra rope attached to the harness, and when the participant grabbed a hold that did not have the designated color of tape below the hold, or the latency of responding was greater than 10 s, the experimenter did not instruct the participant to stop and come down.

Inter-observer Agreement (IOA)

Primary and secondary data on the number of feet climbed per route trial were collected by independent observers via video recording of sessions and reference to the route map. IOA was calculated by dividing the lower score by the higher score and multiplying the resulting quotient by 100%. IOA was assessed during 63% of randomly selected sessions for Alice and during 70% of randomly selected sessions for Genie. For both participants, IOA was 100% during all sessions in baseline and treatment.

Procedural Integrity

Procedural integrity was measured during 43% of randomly selected sessions for Alice and 35% of randomly selected sessions for Genie across all phases. Two independent observers recorded the correct or incorrect use of verbal and tangible rewards, verbal instruction, placement and rotation order of tape frames, and error correction. Procedural integrity was summarized as the percentage of components correctly implemented per session. IOA was recorded for the procedural integrity measures in the same manner as described above. Alice's treatment integrity scores were 100% during baseline with a mean of 98% (range, 80–100%) during treatment. Genie's treatment integrity score during baseline was 100% with a mean of 99% (range, 71–100%) during treatment. IOA on treatment integrity data was collected during 35% of treatment integrity sessions for both participants. IOA was 100% in baseline with a mean of 99% in treatment for Alice (range, 98–100%). IOA was 100% in baseline with a mean of 98% in treatment for Genie (range, 88–100%).

Social Validity

Social validity of the procedures was assessed by asking 10 gym staff members to read descriptions of the procedures for Phases I–IX in non-scientific language and then rate the difficulty of implementation for each phase. In addition, a survey was sent to 10 parents of children with autism, asking them to rate their level of interest in activities such as indoor rock climbing. A social validity measure was also used to

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determine whether or not the participants were rated as distinguishable from their peers while climbing. To assess this, ten undergraduate students from a local college were selected to watch three videos of each participant as well as three peers of similar ages, climbing the same routes. The college students, who were blind to the study, rated their impressions of various aspects of the behaviors of the individual participants and of their typically developing peers.

RESULTS

Figure 3 depicts the number of feet climbed across phases for both participants. As seen in the top panel, in baseline Alice's climbing ranged from 0 ft/0 m to 5 ft/1.5 m

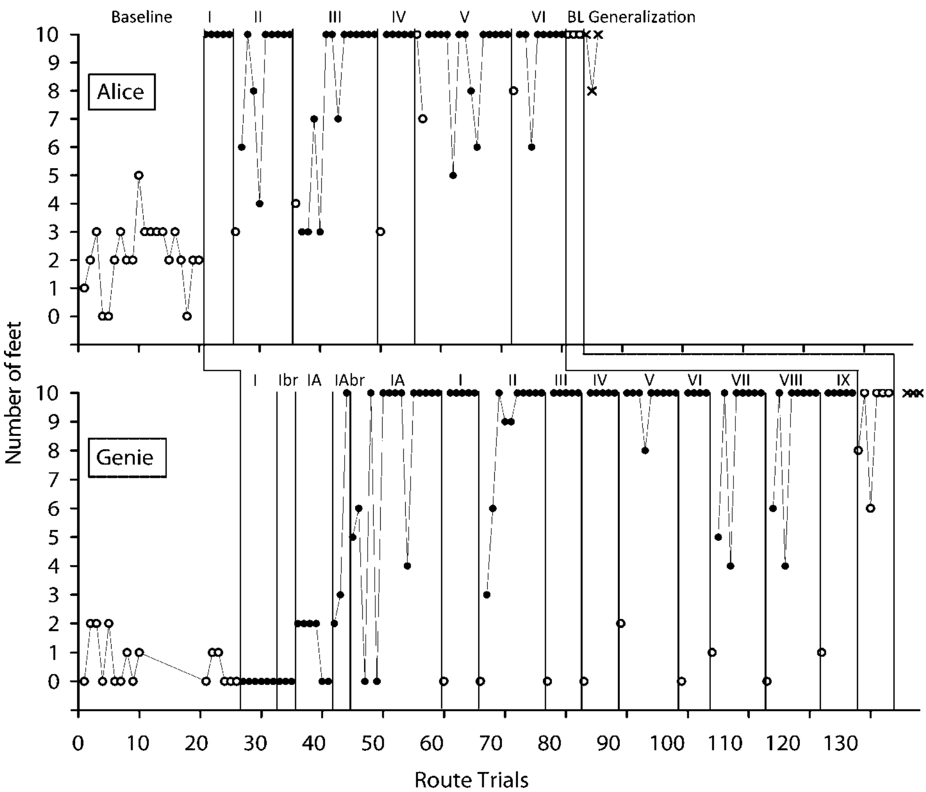

Figure 3. Graph of number of feet climbed per route trial across training phases. Above, the open circles represent baseline data and reversal probes, the closed circles indicate treatment data, and the x's represent generalization data.

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($M = 2.4$ ft/0.7 m). In Phase I, Alice climbed 10 ft/3 m without any errors for the entire session, reaching criterion after five trials. In Phase II, Alice's climbing ranged from 4 ft/1.2 m to 10 ft/3 m ($M = 8.9$ ft/2.7 m), and after initial variability, the phase was completed in nine trials. Phase III began with an upward trend, with climbing ranging from 4 ft/1.2 m to 10 ft/3 m, stabilizing at 10 ft/3 m, and reaching criterion in 13 trials ($M = 8.2$ ft/2.5 m). In Phase IV, Alice climbed consistently 10 ft/3 m without making any errors and reached criterion after five trials. In Phase V, Alice climbed 10 ft/3 m without errors for four consecutive trials. After climbing with some variability in the middle of the phase with the distance ranging from 5 ft/1.5 m to 10 ft/3 m, Alice's climbing stabilized. She completed Phase V in 14 trials ranging 5 ft/1.5 m to 10 ft/3 m ($M = 9.2$ ft/2.8 m). Alice completed Phase VI in eight trials with only the third trial below 10 ft/3 m at 6 ft/1.8 m ($M = 9.5$ ft/2.9 m).

During the return to baseline probes after each phase, Alice's climbing gradually increased in each subsequent probe, with a slight decrease after Phase III. Following mastery of Phase VI, Alice climbed 10 ft/3 m without error during each baseline probe consecutively. In the generalization/follow-up phase, Alice climbed two of the generalization routes above criterion. That is, she climbed 10 ft/3 m as in previous sessions and continued climbing up to 20 ft/6.1 m on the red route and 22 ft/6.7 m on the green route. Alice climbed below criterion level on the blue route at 6 ft/1.8 m. The entire intervention was completed in 10 days across 54 trials (excluding baseline probes).

As seen in the bottom panel, during baseline Genie's climbing ranged from 0 ft/0 m to 2 ft/0.61 m ($M = 0.69$ ft/0.21 m). In Phase I, Genie climbed 0 ft/0 m consistently for six trials. When the bracelet procedure was implemented, Genie again climbed 0 ft/0 m for six trials. The alternative procedure, Phase IA (i.e., climbing with all holds on route covered with tape) was then instituted and climbing levels were maintained at 0 ft/0 m. When the bracelet procedure was implemented for Phase I, Genie consecutively climbed 2 ft/0.6 m, 3 ft/0.9 m, and 10 ft/3 m. In Phase IA post-bracelet intervention, Genie climbed a range of 0 ft/0 m to 10 ft/3 m ($M = 7.6$ ft/2.3 m) and reached criterion in 15 trials. In the following portion of Phase I, Genie climbed 10 ft/3 m without errors for all five trials. In Phase II, criterion was reached on the tenth trial with a range of 3 ft/0.9 m to 10 ft/3 m during this phase ($M = 8.6$ ft/2.6 m). During both Phases III and IV, Genie met criterion after the fifth trial with no errors during any trials. In Phase V, Genie completed the phase in nine trials with only one trial below 10 ft/3 m at 8 ft/2.4 m ($M = 9.7$ ft/2.9 m). Genie completed Phase VI in five trials without errors. In both Phases VII and VIII, climbing began with variability and stabilized quickly to 10 ft reaching criterion in eight trials. The range of Phase VII was 4 ft/1.2 m to 10 ft/3 m ($M = 8.6$ ft/2.6 m) and the range of Phase VIII was 4 ft/1.2 m to 10 ft/3 m ($M = 9$ ft/2.7 m). Phase IX was successfully completed in five trials without errors.

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During the return to baseline probes after each phase, Genie's climbing remained at 0 ft until Phase IV was implemented. Between Phases IV and VIII, Genie's performance increased slightly with little variability between 0 ft/0 m and 2 ft/0.6 m. After completing Phase IX, Genie's performance increased substantially and remained between 6 ft/1.8 m to 10 ft/3 m for the first three trials and ended with the following three trials at 10 ft/3 m. Genie climbed 22 ft/6.7 m without any errors for all three routes in the generalization/follow-up phase. Treatment was completed in 15 days comprising 88 trials (excluding baseline probes).

The gym staff questionnaires, parent surveys, and video comparison forms indicated high levels of social validity. The mean response of the gym staff questionnaires was 2.4 (range, 2–4), suggesting that the procedure was regarded as easily implemented by gym staff members. The results of the parent surveys demonstrated a high interest in having their child with autism engage in activities that have similar properties to rock-climbing. Eight of the ten parents indicated that they were "very interested" in having their child learn to rock-climb. Only two of the parents specified that they were "maybe interested" in having their children learn to rock-climb. For the video comparison survey, a mean response of 4.2 (strongly disagree to strongly agree that the participants' behaviors were indistinguishable from their peers' behaviors) (range, 4–5) was obtained for Alice and 3.5 (undecided to agree) (range, 1–5) for Genie.

DISCUSSION

The current study evaluated a multi-component intervention package designed to teach indoor rock climbing to children with autism. Both participants successfully learned to follow and climb routes in an indoor rock gym. These findings add to the limited research on the application of within-stimulus fading procedures to teaching discrimination skills to individuals with autism (e.g., Schreibman, 1975; Schreibman & Charlop, 1981; Sherman & Webster, 1974). This study also adds to the literature on teaching leisure skills to children with autism, including those skills that are physically engaging (Pitetti et al., 2007; Rapp et al., 2005; Ward & Ayuvazo, 2006).

The conditional discrimination training techniques based on Green (2001) likely facilitated appropriate discrimination and generalization in the current study. The use of three comparison stimuli, quasi-randomized rotation of sample stimuli and comparison stimuli, the limitation of consecutive identical colors climbed, the emission of an observing response, and the arrangement of stimuli out of view of the participants all possibly contributed to the participants grabbing only the intended holds on route. Although in this study each phase was not taught without error, a greater number of climbs were completed successfully than those that ended in error.

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For Alice, 77% of the climbs were completed successfully without any error. For Genie, 67% of the climbs were free of error. While Green (2001) suggested that initial errors may lead to further errors and emotional responding may interfere with skill acquisition, it appears in this study that the error correction procedure may have helped to increase skill acquisition. With the exception of Genie's first two phases of the treatment, the participants required no more than three error corrections to complete a route. Furthermore, with each attempt, the latter almost always had fewer errors than the previous attempt. Although implementing other intermediate stimulus fading phases may have resulted in fewer errors, the amount of time that the extra phases would have required may have actually extended the duration of intervention.

Although both participants learned to follow a specified color route within a relatively short period of time, Alice acquired the skill faster than Genie. There are a number of possible reasons for this. One reason is that Alice was 11 years, 4 months old and Genie was 6 years, 6 months old. This age discrepancy may have contributed to Alice having had a greater chance of exposure to similar types of tasks that require attending to one salient stimulus and not to another. Alice may have also had more extensive generalization training which could have accounted for her generalizing the skills to the baseline wall in an earlier phase than Genie had. Furthermore, since height and strength are typically correlated with age, Alice was significantly taller and seemingly stronger than Genie. Her height and strength may have resulted in a greater ease of reaching holds.

Alice's faster acquisition may also be attributed to her position in baseline. Both participants were exposed to an extended baseline to ensure that they would not learn the skill from the repeated consequence of "that's not____ (one of three designated colors)" and the tug of the rope. Since Alice's baseline data were initially unstable and then assumed an upward trend, her baseline phase was extended further. Although Genie's baseline data were trending downward, to establish a functional relationship, Genie could not advance to treatment until Alice's data were stable. Anecdotally, during her baseline, Genie grabbed mostly holds that were of the designated color. For example, if the instruction "climb red" was provided, Genie often grabbed a hold that was red regardless of the color of the tape below it. It is possible that the absence of reinforcement for the appropriate responses in baseline briefly helped maintain unwanted stimulus control. Additionally, it was noted that toward the end of baseline and in the beginning of Phase I, Genie's responding slowed down altogether. For instance, when the request to climb a route was given, Genie often did not grab any holds. This lack of responding may be attributed to non-reinforcement of climbing behavior leading to extinction of the behavior. For the sake of Genie's skill acquisition, it may have been beneficial to shorten the baseline phase. In effect, though Alice's baseline was extended to establish experimental control, it may have weakened demonstration of a functional relationship since Genie's responding

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remained at baseline levels well after intervention was initially implemented. Since most of the baseline probes for the two participants indicated responding at or near baseline levels throughout intervention, a moderate level of experimental control was demonstrated. Though return to baseline prior to generalization probes demonstrated acquisition of the skill, it did not help to support experimental control. Furthermore, though two participants successfully learned to follow routes in an indoor rock gym, implementation of the procedure with a third or fourth participant would have increased levels of experimental control.

Though generalization was eventually achieved for Genie, in the early phases of treatment it appeared that Genie was over-selective in reaching for holds. Initially, in Phase I, Genie made few responses in the presence of the taped frames. It was not until Phase IA was implemented and the holds were covered that Genie began reaching for holds surrounded by taped frames. Although Phase IA was significant in Genie's skill acquisition, it would have likely been a more errorless learning process had Phase IA been implemented before Phase I. Covering the holds from the start may have decreased the saliency of the color of the holds and strengthened the saliency of the tape from the very beginning eliminating future errors. Another modification that could have been made to increase the saliency of the tape and to reduce initial errors is to put the same colored frames around all of the holds on a designated section of the wall instead of covering a portion of them in Phase I. This would eliminate any possibility of error as long as the participant did not walk to another part of the wall where a different colored route was arranged and responded with 10 s of the request. This would also visually create very distinct differences between the three colored routes. In each progressive phase, frames could have been removed from specified holds in order to fade in $S^{\Delta}s$ instead of exposing new holds.

Another consideration of the current study is that the intervention was implemented as a package. The independent variable consisted of within-stimulus fading procedures in combination with errorless learning, positive reinforcement, conditional discrimination training techniques, and error correction. Since all elements of intervention were simultaneously implemented, it is not clear whether or not they were all necessary to achieve the desired results. However, an anecdotal observation may indicate the within-stimulus fading component as an integral component of the package. It was noted that as the participants acquired the skill of reaching for the correct holds with their hands, they selectively put their feet on the holds of that route as well. Although climbers typically adhere to a specified route with their hands and feet, this study exclusively focused on teaching the participants to reach for the correct holds with their hands. The procedure only entailed providing verbal praise and tangible reinforcement for correct hand-reaching responses and not for foot-stepping responses. This indicates that direct reinforcement of correct responses may have not been the dominant variable responsible for success. The only element

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present in the teaching trials that may have prompted stepping on specific holds is the salient tape frames around the holds. However, it is also possible, given the similar topographies of reaching with one's hands and stepping with one's feet, that reaching for specific holds generalized to stepping on specific holds. Furthermore, it is possible that the participants stepped only onto holds on-route, particularly in the first phase, due to the inaccessibility of any other holds. Since a part of the criterion for reinforcement was a brief inter-reach time (less than 10 s), it is possible that stepping was inadvertently reinforced.

Future research may focus on other benefits of indoor rock climbing for children with autism. For example, it was anecdotally noted that both of the participants engaged in a high degree of vocal stereotypy at rest. However, when climbing, stereotypy decreased to almost none.

In addition, generalization probes were fairly successful for both participants. The ability to generalize route following to different colors, settings (e.g., sounds, people, rooms), routes, and schedules of reinforcement would be helpful in facilitating a transition to a group setting with typically developing peers. Other research may focus on an integrative approach to climbing and its effects on peer modeling and socialization. Furthermore, though the participants appeared to enjoy the activity, indicated by persistent smiles and laughter emitted from both participants before and after climbing trials as well as reported independent requests to go climbing, empirical data were not collected on the participants' preferences for climbing as an activity. Future researchers may consider conducting preference assessments of climbing in an array of other functional activities.

In conclusion, within-stimulus fading procedures in combination with errorless learning, positive reinforcement, and conditional discrimination training techniques appear to be an appropriate technique in teaching children with autism to follow designated routes in an indoor rock gym. Results indicate that the intervention package successfully produced the desired change in the dependent variable. These results are the first to indicate a within-stimulus fading procedure as being a viable option for teaching leisure skills to children with autism. Additionally, these outcomes add to the paucity of general research based on within-stimulus fading for individuals with autism (Schreibman, 1975; Schreibman & Charlop, 1981; Sherman & Webster, 1974). These data may be useful in other domains such as self-help skills (e.g., dressing, shoe tying, bathing) and independent living skills (e.g., schedule-following, map-following). In addition, the results of this study support the use of a number of Green's (2001) recommendations on conditional discrimination training. Although such techniques should be used with caution as there is little additional published research available to support them, these conceptually sound techniques may have broader application to teaching conditional discrimination skills to children with autism. Future research may focus on using the recommended techniques to

DOI: 10.1002/bin

teach conditional discrimination skills (e.g., object identification, people identification, direction following, sign following) to learners with strong histories of faulty stimulus control.

ACKNOWLEDGEMENTS

This study is based on a thesis submitted by the first author, under the supervision of the second author, to the Department of Psychology at Caldwell College for the Master's degree in Applied Behavior Analysis. We thank the participants and their families, the managers and staff members of the NJ Rock Gym, the Garden Academy parents, students, and staff members, and the students and staff members of Caldwell College, for their many generous contributions to our study.

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DOI: 10.1002/bin