RESEARCH ARTICLE

Chaining Functional Basketball Sequences (with Embedded Conditional Discriminations) in an Adolescent with Autism

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Published online: 28 April 2016
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Abstract Individuals with developmental disabilities successfully participate in fewer recreation activities, including sports activities, than their typically developing peers. Although a functional basketball-playing repertoire might increase social opportunities and physical health for these individuals, no research has outlined a behavior-analytic strategy for teaching this sport. In our study, we taught a 13-year-old male diagnosed with autism to play basketball. During phase 1, we employed discrete-trial training to establish proficiency with nine fundamental basketball skills (i.e., recruiting attention, passing, dribbling, etc.). During phase 2, we used a forward chaining procedure to teach-specific sequences of these component skills that are appropriate for playing offense and defense and for participating in a full-court basketball drill. The participant learned all pre-requisite skills and response chains came under the control of contextually appropriate discriminative stimuli.

Keywords Basketball · Autism · Discrete-trial instruction · Chaining · Multiple probe

The World Health Organization defines recreation as involvement in formal and informal activities such as play, sports, relaxation, and music (2002). Previous research has connected participation in recreational activities with increases in quality of life, improvements in social relationships with peers and family, and decreases in problem behavior (Lo, Burk, & Anderson, 2014; Potvin, Prelock, & Snider, 2008; Potvin,

Snider, Prelock, Kehayia, & Wood-Dauphinne, 2013; Sowa & Meulenbroek, 2012). Furthermore, participation in sports-related recreation may have direct health benefits such as decreased risk of obesity-related illness (U.S. Department of Health & Human Services [USDHHS], 2008). In fact, recent guidelines suggest children and adolescents should spend 60 min per day engaging in moderate-to-vigorous physical activity (USDHHS, 2008) and several high-profile national programs have recently developed campaigns focusing on increasing physical activity through game and sports play (e.g., *Let's Move* [www.letsmove.org], *NFL Play 60* [www.nflrush.com/play60]).

Notwithstanding, children with disabilities participate in fewer recreational activities (Lee, Harrington, & Louie, 2008; Orsmond, Krauss, & Seltzer, 2004; Potvin et al., 2008; Solish, Perry, & Minnes, 2010; Wagner et al., 2002) and are at greater risk for engaging in insufficient physical activity than their typically developing peers (Carroll et al., 2014; Mangarud, Bjerkeset, Lydersen, & Indredavik, 2014; Memari, Ghaheri, Ziaee, Kordi, Hafizi, & Moshayedi, 2013; Pan, 2008, 2014). One potential reason for this may be related to social impairments and/or the presence of problem behavior commonly contacted in developmentally disabled populations such as those diagnosed with autism-spectrum disorder (ASD; Obrusnikova & Dillon, 2011; Potvin et al., 2013). Despite these challenges, current federal recommendations support the provision of additional skill-acquisition supports for these individuals (USDHHS, 2012).

Unfortunately, research on behaviorally-based recreational interventions is limited (although see Giangreco, 1983; Lagomarcino, Reid, Ivancic, & Faw, 1984; Schleien, Certo, & Muccino, 1984 for notable exceptions) and few specifically target sports-related physical activity. Whereas a growing body of research shows that behavior analytic procedures can be used to increase desired sports-related behaviors for individuals

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without disabilities (cf. Harrison & Pyles, 2013; Kladopoulos & McComas, 2001; Quinn, Miltenberger, & Fogel, 2015; Stokes, Luiselli, Reed, & Fleming, 2010), relatively fewer studies have focused on teaching sports-related recreation behaviors to individuals with disabilities. Furthermore, many of these studies focused on increasing physical activity through solitary activities such as swimming or participating in treadmill programs, often in relation to a goal of decreasing problematic behavior (e.g., stereotypy, off-task behaviors; see Celiberti, Bobo, Kelly, Harris, & Handleman, 1997; Nicholson, Kehle, Bray, & Van Heest, 2011; Rogers, Hemmeter, & Wolery, 2010). Thus, although common behavior-analytic approaches to addressing skill deficits (e.g., discrete trial training, response chaining, shaping, etc.) are likely a powerful tool for increasing sports-related recreational behavior in individuals with developmental disabilities, the evidence-base for this endeavor is underwhelming.

For example, basketball is the most commonly played team sport by both girls and boys from age 9 years through adolescence (Sports and Fitness Industry Association, 2013). Despite its popularity, only one published study has focused on improving ball play for individuals with disabilities. Specifically, Lo and colleagues (2014) examined the effects of a progressive video prompting procedure on the basketball free throw accuracy of students diagnosed with moderate intellectual disabilities. Although this study highlights the potential of a behavior-analytic approach to basketball-related instruction, it is limited because it focused only on one of many skills needed to engage in a functional game of basketball and researchers did not provide instruction for when and how this skill might be used during an actual game. Thus, the purpose of this study was to expand the research base on behavior-analytic approaches to sports-related recreational activity. Specifically, we demonstrated the utility of a chaining procedure with embedded conditional discriminations for establishing a functional game-playing repertoire in an adolescent diagnosed with ASD.

Method

Participant

Marcel, a 13-year-old male diagnosed with ASD and an attention deficit disorder, attended a public middle school in an urban school district in the southeast region of the USA. He received special education services in a self-contained setting but was included with typically developing peers for lunch and related arts. Outcomes of the NECC-Core Skills Assessment (New England Center for Children, 2015; Dickson, MacDonald, Mansfield, Guilhardi, Johnson, & Ahearn, 2014) demonstrated Marcel's proficiency with foundational skills in the domains of communication (i.e., request

items, indicate and name pictures and objects, indicate body parts, respond to name, respond to greetings, respond to stop, and follow directions in groups), social skills (i.e., delayed object imitation, gross motor imitation, social distance, follow a point, and wait for items), and discrimination (i.e., attending, session behavior, simple discriminations, matching pictures to objects, and objects to pictures). However, Marcel was less proficient at requesting attention, requesting assistance, accepting and rejecting items, waiting in groups, and following schedules.

Marcel was referred to a university-based behavior clinic for the treatment of stereotypy (e.g., object flapping), property destruction (e.g., throwing objects at walls), and self-injurious behavior (e.g., nail biting and hair pulling). Additionally, Marcel's family reported that his limited interests made it challenging to connect with him and communicated a desire for Marcel to engage in activities valued by the family. Marcel's father and 16-year-old brother frequently played basketball. When approached about participating in this study, both reported that they would like to help teach Marcel how to play the game.

Setting

All phases of this study were conducted during the final hour of 3-h biweekly appointments during the final month of Marcel's participation in the behavior clinic and were preceded by a 10-min walk from said behavior clinic to a university recreation center. The study took place in a university recreation center with three basketball courts, each measuring 22.6×12.8 m. The court used in this study was equipped with two basketball hoops and two benches. Confederate "basketball players" included four graduate students in a special education and applied behavior analysis training program, their supervisors (a board-certified behavior analyst [BCBA] and a doctoral-level BCBA), Marcel's father, and his brother.

Response Definitions and Measurement

We hypothesized that Marcel could successfully participate in a game of basketball if he independently emitted three response chains incorporating conditional discriminations at contextually appropriate times. Specifically, we determined that a functional half-court offensive sequence (offense), half-court defensive sequence (defense), and full-court offensive sequence (drill) would be sufficient to allow Marcel to access the game of basketball.

After conducting a task analysis of each chain, we determined that mastery of nine prerequisite skills (i.e., pass, get open, recruit attention and catch ball, dribble, shoot, cover opponent [without ball], run with opponent, cover opponent [with ball], and rebound) would be necessary prior to initiating a forward chaining instructional procedure to teach these chains.

Table 1 Descriptions of player positions and pre-teaching sequences during component-skills instruction (phase 1)

Skill	S ^D	Player positions and pre-teaching	Correct response
Pass	“Pass”	<p><i>Player positions:</i> A¹ and the therapist stood at cone 1. A², B¹, and B² stood at cones 2, 3, and 5 (specific locations rotated across trials).</p> <p><i>Pre-teaching:</i> Prior to initiating a block of trials the therapist said, “you pass the ball like this” and passed the ball to A² when A² stood at cones 2, 3, and then 5.</p>	A ¹ threw ball within arm’s reach of A ²
Get open	“Get open”	<p><i>Player positions:</i> A¹ and the therapist stood at cone 1. B¹ stood with his back to the basket approximately 1 m in front of A¹. A² and B² stood together at cone 3 (or 5).</p> <p><i>Pre-teaching:</i> The therapist said, “they (pointing to A² & B²) are standing over there. That space (point to cone 3 or 5) is open. In order to get open, you need to run toward the basket, run away from others, and then turn to face your teammate.” Next, the therapist said, “this is how you get open,” jogged from cone 1 to cone 2 (while B¹ back-pedaled in a straight line until crossing the free throw line), stopped, and then jogged from cone 2 to cone 3 (or 5). B¹ did not follow the therapist (or A¹) during the 2 to 3 (or 2 to 5) transition. Finally, the therapist turned to face A² (who transitioned with B² from cone 5 [or 3] to cone 1 while A¹ transitioned from cone 2 to cone 3 [or 5]).</p>	A ¹ jogged from cone 1 to cone 2, away from A ² & B ² to cone 3 (or 5), and turned to face A ² .
Recruit attention and catch ball	“Say you’re open”	<p><i>Player positions:</i> A¹ and the therapist stood at cone 3 (or 5). A² and B² stood at cone 1. B² stood at cone 2. A² continuously dribbled in place and looked away from A¹. A² did not turn toward A¹ until he/she heard “I’m open” and did not throw the ball until A¹ made eye contact with him/her and showed him/her both of his hands.</p> <p><i>Pre-teaching:</i> The therapist said, “in order to get the ball you need to face your teammate, show him/her the palms of both of your hands, and say, ‘I’m open!’ You have to say it loud enough so that he/she can hear you. When he/she throws the ball, you should try to catch it. The therapist then faced A², showed the palms of both his/her hands, said, “I’m open,” and caught the ball (after it was thrown).</p>	A ¹ made eye contact with A ² , showed palms of hands, said, “I’m open” loud enough for A ² to hear, and attempted to catch the ball.
Dribble	“Dribble toward the basket”	<p><i>Player positions:</i> A¹ and the therapist stood at cone 3 or 5. A² and B² stood at cone 1. B¹ stood at cone 2. The therapist then handed the ball to A¹. As soon as A¹ touched the ball B¹ ran from cone 2 to cone 3 (or 5) and stood with his/her hands up approximately 1 m in front of A¹ and between A¹ and the basket. As A¹ moved forward, B¹ back-pedaled in order to maintain the distance between them.</p> <p><i>Pre-teaching:</i> The therapist said, “to dribble, you need to walk to that cone (points to cone 4 [or 6]) while dribbling the ball like this” (dribbles the ball from cone 3 to 4 [or 5 to 6]).</p>	A ¹ maintained control of ball while bouncing it and walking (or jogging) from cone 3 to 4 (or 5 to 6). Perpetual bouncing was required but “double dribbles” were not penalized.
Shoot	“Shoot”	<p><i>Player positions:</i> Marcel and a therapist stood at cone 4 or 6.</p> <p><i>Pre-teaching:</i> The therapist said, “in order to shoot the ball, you need to place your hands like this, jump, and then push the ball toward the basket” (while shooting the ball).</p>	A ¹ threw ball in general direction of basket at, or near, height of rim.
Cover opponent (without ball)	“Cover him/her”	<p><i>Player positions:</i> B¹ stood at cone 3 (or 5). A¹ and the therapist stood between cone 3 (or 5) and cone 1. A² and B² stood at cone 1 (with B² holding the ball and facing the basket).</p> <p><i>Pre-teaching:</i> The therapist said, “in order to cover your opponent, you need to get between him/her and the basket and put your hands between</p>	A ¹ positioned himself between B ¹ and basket and placed one or both hands in passing lane.

Table 1 (continued)

Skill	S ^D	Player positions and pre-teaching	Correct response
Run with opponent	"Follow him/her"	him/her and the ball (i.e., in the passing lane) like this." The therapist then ran to the appropriate cone and modeled the appropriate action. <i>Player positions:</i> A ¹ and B ¹ stood at cone 3 (or 5). Following the S ^D , B ¹ ran from cone 3 to 5 (or 5 to 3). <i>Pre-teaching:</i> The therapist said, "in order to follow your opponent you need stay close to him/her and stay in between him/her and the basket like this." Then B ¹ ran from cone 3 to 5 (or 5 to 3) and the therapist modeled the appropriate action.	A ¹ stayed within 3 feet of B ¹ and between B ¹ and basket at all times.
Cover opponent (with ball)	"Cover the ball"	<i>Player positions:</i> A ¹ and B ¹ stood at cone 3 (or 5). A ² and B ² stood at cone 1 (B ² held the ball and faced the basket). Immediately before initiating each trial, B ² passed the ball to B ¹ , who caught the ball and then rotated the ball in a large (i.e., below waste and over head) clockwise and then counterclockwise circle. <i>Pre-teaching:</i> Prior to initiating a block of trials, B ² passed the ball to B ¹ . The therapist then said, "in order to cover the ball, you need to stand between him/her and the basket and keep your hands in front of the ball like this." B ¹ then rotated the ball in a large (i.e., below waste and over head) clockwise and then counterclockwise circle. The therapist simultaneously modeled a hand motion that mirrored this movement.	A ¹ stayed between B ¹ and basket and A ¹ hand movement mirrored B ¹ ball movement during both ball rotations.
Rebound	"Rebound"	<i>Player positions:</i> A ¹ and B ¹ stood at cone 4 (or 6). <i>Pre-teaching:</i> The therapist said, "in order to rebound the ball you have to look up, find the ball, and then run to the spot that you think it is going." Then, B ¹ took a shot (intentionally missing) so that the therapist could model rebounding.	A ¹ retrieved ball after B ¹ shot ("catching" encouraged but not required).

A = Marcel, B = Marcel's opponent, AA = Marcel's teammate, BB = opponent of Marcel's teammate. All player-position descriptions reference the top panel of Fig. 1

Correct responses for each prerequisite skill are defined in Table 1 and correct sequences of responses are outlined in Table 2. During *offense*, we attempted to bring the sequence *pass*, *get open*, *recruit attention* and *catch ball*, *dribble*, and *shoot* under the control of the vocal verbal discriminative stimulus (S^D), "take the ball out." During *defense*, we attempted to bring the sequence *cover opponent (without ball)*, *run with opponent*, *cover opponent (with ball)*, *run with opponent*, and *rebound* under the control of the vocal verbal S^D "cover him (or her)." During *drill*, we attempted to bring the response combination "*pass*, *get open*, and *recruit attention and catch ball*" (emitted three consecutive times), and *shoot*, under the vocal verbal response "do the drill."

Trained observers used traditional pen and paper scoring sheets to code the outcomes of each opportunity to respond throughout all phases of the study. Observers scored *independent correct*, if Marcel independently emitted a correct response following the presentation of a relevant S^D. Observers scored *prompted correct* if Marcel was prompted

to emit a correct response following the presentation of a relevant S^D and they scored an *error* if Marcel responded incorrectly, or if he did not respond at all. During phase 1, we presented trials in blocks of five or nine and reported the number of independent correct responses as a percentage of opportunities across blocks of trials. During phase 2, we coded responding during each step of a response chain and reported the number of independent correct steps as a percentage of total steps.

Procedural Fidelity

During a subset of instructional trials, observers scored therapist fidelity to programmed procedures using "yes/no/not applicable (NA)" checklists. Checklists consisted of abbreviated approximations of the following questions: (1) Was the correct number of "players" present and in position prior to the start of the trial? (2) Were the correct materials present and in position prior to the start of the trial? (3) Was the S^D presented at the

Table 2 Sequence of responses chained during phase 2

Chain	S ^D	Sequence
Offense	<i>“Take the ball out”</i>	Step 1. Pass i. B ¹ faces A ¹ at cone 1 and B ² faces A ² at cone 3 (or 5) Step 2. Get open Step 3. Recruit attention and catch ball Step 4. Dribble Step 5. Shoot
Defense	<i>“Cover your man”</i>	Step 1. Cover opponent (without ball) Step 2. Run with opponent Step 3. Cover opponent (with ball) Step 4. Run with opponent i. B ¹ dribbles from cone 5 to 6 (or from 3 to 4) Step 5. Rebound
Drill	<i>“Do the drill”</i>	Step 1. Pass i. A ¹ passes to A ² from cone 1 to cone 2 (or 4) ii. A ² catches pass and transitions from cone 2 (or 4) to slight right (or left) of cone 3 Step 2. Get open i. A ¹ transitions from cone 1 to 3 and then away from A ² to cone 4 (or 2). Step 3. Recruit attention and catch ball i. A ² passes to A ¹ ii. A ² transitions from cone 3 to 7 (or 5) Step 4. Pass i. A ¹ passes to A ² from cone 4 to 7 (or 2 to 5) Step 5. Get open i. A ¹ transitions away from A ² , from cone 4 to 6 to 5 (or 2 to 6 to 7) Step 6. Recruit attention and catch ball i. A ² passes to A ¹ ii. A ² transition from cone 7 to 9 (or 5 to 8) Step 7. Pass i. A ¹ passes to A ² from cone 7 to 8 (or 5 to 9) Step 8. Get open i. A ¹ transitions away from A ² , from cone 5 to 8 (or from 7 to 9) Step 9. Recruit attention and catch ball i. A ² passes to A ¹ and stays in current position Step 10. Shoot i. A ¹ shoots from cone 8 (or 9)

“Offense” and “Defense” were trained using the cone positions shown in the top panel of Fig. 1. Except when specifically noted, player positions during these sequences were identical to positions during component-skills instruction (described in Table 1). “Drill” was trained using the cone positions shown in the bottom panel of Fig. 1. Although physical movements during “drill” were identical to those described in Table 1, player positions differed and are specified in this table

correct time? (4) Was the correct level of prompting used? (5) Was the correct action reinforced? (6) Were error-correction procedures applied as programmed?

We calculated fidelity scores by dividing “yes” by the sum of “yes” and “no,” and multiplying by 100. Mean fidelity to phase 1 procedures was 93.1 % (range 66.7–100 %) and was evaluated during 30.8 % of trials. Mean fidelity to phase 2 procedures was 98.7 % (range 71.4–100 %) and was evaluated during 50.2 % of trials.

Reliability

A second trained observer independently collected data on all dependent variables for each skill evaluated in this

experiment. We calculated interobserver agreement (IOA) with a point-by-point method, dividing the number of agreements between observers by the number of agreements plus disagreements and multiplying by 100. During phase 1, mean IOA was 95.8 % (range 80–100 %) across 100 % of trials. During phase 2, mean IOA was 95.9 % (range 60–100 %) across 100 % of trials. A second trained observer also independently collected data on therapist fidelity to programed procedures. We calculated IOA of fidelity evaluations using the same method described above. During phase 1, mean IOA of fidelity was 98.7 % (range 83.3–100 %) across 37.5 % of fidelity evaluations. During phase 2, mean IOA of fidelity was 99.1 % (range 75–100 %) across 25.4 % of fidelity evaluations.

Procedure

The purpose of phase 1 was to ensure mastery of all prerequisite skills prior to advancing to phase 2. The purpose of phase 2 was to chain subsets of these skills for offense, defense, and drill and to bring each chain under contextually appropriate discriminative control.

Therapists utilized small cones to mark the court during training sessions (see Fig. 1). One basketball measuring 74.9 cm in diameter was used in all sessions. Throughout the study, all active players wore one of four reversible jerseys with one black side and one white side. Upon arrival, Marcel chose to wear either a white or black jersey, and the remaining jerseys were assigned to three additional players. Marcel and his teammate wore matching jerseys whereas the two other players (i.e., opponents) wore jerseys of the opposite color. In order to ensure that Marcel attended to jersey color when discriminating the roles of others on the court, all players alternated roles so that no single person consistently played the role of Marcel's teammate or opponent. A therapist in charge of providing contingency reviews and prompts did not wear a jersey.

For skills that called for Marcel, or other players, to be on a specific side of the court (i.e., left of the basket or right of the basket), we counterbalanced their position across trials during

both phases of the study so that Marcel would get experience performing the required task (or discrimination) on both sides of the court. For example, if we required Marcel to move to cone 3 (top panel of Fig. 1) during one trial of a specific skill then we required him to move to cone 5 during the next trial for the same skill.

Prior to initiating this study, we conducted a multiple stimulus without replacement (MSWO; DeLeon & Iwata, 1996) preference assessment to identify high-preferred tangible items. Marcel's highest preferred item was an iPad®. During phase 1, we placed a token on a token board (visually accessible to Marcel at all times) every time Marcel completed a block of trials. When we filled Marcel's token board with five tokens, he immediately gained 5-min of uninterrupted access to his iPad. During phase 2, we only used the token board when the magnitude of Marcel's responding was considerably low (e.g., when he walked instead of jogging or running).

Phase 1 Therapists set up cones using the arrangement shown in the top panel of Fig. 1. We provided instruction for one skill at a time and did not address a new skill until Marcel demonstrated mastery of the current target. With one exception, performance of each skill was evaluated in a discrete-trial format in which we presented relevant vocal verbal S^Ds (e.g., “shoot”) in blocks of five. However, when evaluating “pass,” we presented trials in blocks of nine so that we could rotate the position of Marcel's teammate and defenders and still allow for each player to stand at each assigned cone three times within any given block of trials.

Baseline We collected baseline data to establish Marcel's current level of performance of all prerequisite skills. During baseline, a therapist delivered the relevant vocal verbal S^D and gave Marcel approximately 5 s to respond. Correct responses produced cheers from everyone in attendance (i.e., graduate students described above, their supervisor, and Marcel's family). Errors produced no programed consequences. Two consecutive errors or three total errors within any block of trials, immediately ended that block of trials. When this occurred, we scored all un-presented trials as errors.

We ended baseline blocks early in order to avoid providing Marcel with numerous opportunities to practice a skill incorrectly. When we did this, we scored un-presented trials as errors so as to not artificially inflate his proficiency scores. This conservative measure of Marcel's performance allowed us to ensure that he received additional instructional support for any un-mastered pre-requisite skill prior to working on the complex chaining procedures presented during phase 2.

We considered a skill “mastered” if Marcel's responses to S^Ds were coded as *independent correct* for a minimum of 80 % of opportunities across two consecutive blocks of trials. We provided discrete-trial training for all un-mastered skills.

Fig. 1 Cone positions during instruction. Squares show approximate location of each cone on basketball court. Top panel shows cone positions during phase 1 and during *Offense* and *Defense* chains during phase 2. Bottom panel shows cone positions during the *Drill* chain in phase 2

Discrete-trial training We anticipated that Marcel would master pre-requisite skills relatively quickly and wanted to provide him with opportunities to demonstrate this mastery as early in our instructional sequence as possible. Thus, we used a least-to-most prompting procedure during phase 1 instruction. Prior to each block of trials, the therapist delivered a pre-correction script to ensure that Marcel could correctly identify which players were his opponents and teammate (i.e., “What color is your jersey? Point to your teammate. Point to your opponents.”). Next, the therapist provided verbal instruction on how to perform the targeted skill while simultaneously modeling the necessary steps (see “pre-teaching” for each skill in Table 1). Finally, the therapist initiated each trial in the block by delivering the relevant vocal verbal S^D. Inter-trial intervals were approximately 5–10 s. Correct responses produced cheers from everyone in attendance.

The prompting sequence consisted of four “levels” (i.e., level 1—no prompt; level 2—model with verbal prompts [e.g., “run to that cone,” “look at your teammate,” etc.]; level 3—graduated guidance [Wolery & Gast, 1984] with verbal prompts; and level 4—continuous physical guidance with verbal prompts). Progression through these levels occurred across blocks of trials. The therapist started the first block of trials at level 1. That is, following pre-block instructions and model, the therapist did not provide additional pre-response prompts during any trial in the block. An error during any block of trials produced the least intrusive prompt necessary to occasion correct responding. If Marcel made two consecutive (or three total) errors during a trial block, then the therapist started the next block at a more intrusive level (e.g., increase from level 1 to level 2). If Marcel completed a block of trials with at least 80 % of responses coded as *independent correct* and/or *prompted correct*, the therapist started the next block of trials at a less intrusive level (e.g., decrease from level 2 to level 1). Otherwise, the therapist started the next block of trials at the current level. If Marcel completed two consecutive blocks of trials with 80 % of responses coded as *independent correct*, we considered the skill mastered. When time allowed, we conducted maintenance probes of select mastered-skills. Response requirements for each prerequisite skill are described in Table 1.

Phase 2 We used a multiple probe design (Horner & Baer, 1978) to demonstrate the effect of a forward chaining instructional sequence on Marcel’s performance of the targeted response chains (see Table 2). Prior to implementing the chaining procedure, we conducted baseline probes to determine whether mastery of the prerequisite skills taught during phase 1 was sufficient to establish mastery of the more complex chains (without additional instruction). During baseline, we conducted five probes of all chains (we determined the order in which to conduct probes [e.g., drill, offense, and defense] using a random number generator). Additionally,

we periodically conducted probes of all chains to establish Marcel’s current proficiency with each and to determine whether additional chaining was necessary. If Marcel independently completed all steps of a chain across three consecutive probes (regardless of the step he was currently working on), we considered that chain mastered and began training the next response chain. Completion of a chain produced cheers from everyone in attendance. Procedures for probe and forward chaining trials are described below. Similar to phase 1, we initiated a pre-correction script prior to beginning every chaining trial to ensure that Marcel had correctly identified which players were his opponents and teammate.

Probe We used the “single-opportunity method” (Cooper, Heron, & Heward, 2007) for assessing Marcel’s mastery of targeted chains. Specifically, at the onset of each trial, we guided Marcel to the “start position” of the relevant response chain (e.g., offense) and delivered the S^D that we hoped would control each chain by the end of the study (i.e., “take the ball out” for offense, “cover him/her” for defense, and “do the drill” for drill). If Marcel emitted an *independent correct* response when it was scheduled to occur (e.g., Marcel “got open” after “passing”), confederate players engaged in all relevant responses (e.g., Marcel’s teammate caught his pass) and/or transitioned to prescribed locations (e.g., Marcel’s opponent backpedaled from position 1 [top panel of Fig. 1] to position 2 and stayed at position 2 when Marcel transitioned from position 1 to 2 to 3 while Marcel’s teammate and the teammate’s defender simultaneously transitioned from position 5 to 1) in order to provide Marcel with an opportunity to independently complete the next prescribed step in the chain (e.g., “recruit attention and catch ball”). However, if Marcel made an error or did not emit the correct response within 5–10 s of when the opportunity presented itself, we ended the probe. To increase the probability that Marcel could be successful in generalization settings, we conducted all probes of all chains in the absence of cones.

Forward chaining These trials were similar to probes with important exceptions. First, we started all sessions with cones positioned at the locations shown in the top panel of Fig. 1 (offense and defense) or the bottom panel of Fig. 1 (drill). Second, we implemented a forward chaining procedure. Because we anticipated that Marcel would require more support to master these complex response chains than he did to master each chain’s component skills, we used a 5-s constant time delay procedure (Wolery et al., 1992). That is, therapists immediately delivered the most intrusive prompt from phase 1 (i.e., continuous physical guidance with verbal prompts) during the first trial of any given training step (as well as immediately following any error emitted at any time). If Marcel demonstrated *prompted correct responding* for two consecutive trials, therapists delayed their prompt by 5 s during

subsequent trials. If Marcel made two consecutive errors, therapists returned to the immediate prompt during subsequent trials. Therapists advanced to a new training step when Marcel demonstrated *independent correct* responding at the current training step for two consecutive trials.

If Marcel made an error during a previously-mastered step (e.g., step 2 when training step 5), therapists immediately prompted that step and then allowed Marcel to complete the remainder of the chain as programmed. If Marcel made two consecutive errors at a previously mastered step, that step became the new training step during subsequent trials and instruction at that step began with an immediate prompt. To increase the probability of learning via practice effects, therapists prompted (i.e., continuous physical guidance with verbal prompts) all untrained steps of targeted chains (Spooner, Spooner, & Ulicny, 1986).

Adapted forward chaining This condition was identical to forward chaining (as described above) except that therapists removed cones that corresponded to the training step (as well as all previously mastered steps). Thus, no cones were present when Marcel was trained to complete step 5.

Maintenance

We periodically conducted probes of mastered chains to evaluate the maintenance of chaining effects. Maintenance procedures were identical to those described in the “probe” section.

Social Validity

We used two questionnaires with Likert-type rating scales to evaluate the social validity of our intervention (see Table 3 for specific questions). The first was a “satisfaction” survey that we administered to Marcel’s family immediately following this study. The second was a “functionality” survey administered to groups of adults who we observed playing games of “pick up” basketball. Researchers visited basketball courts specifically available for use to individuals who were not members of formally organized basketball teams (i.e., the university recreating center and two community centers). Adults observed playing basketball who agreed to complete this study were included in the evaluation. After describing relevant chains, researchers asked respondents to rate the utility of each sequence during a typical game of “pick up” basketball.

Results

The results of phase 1 are shown in Fig. 2. Marcel demonstrated mastery of *pass*, *dribble*, and *shoot* during baseline. Conversely, Marcel received discrete-trial training prior to demonstrating mastery for *get open*, *recruit attention* and

catch ball, *cover opponent (without ball)*, *run with opponent*, *cover opponent (with ball)*, and *rebound*.

The results of phase 2 are shown in Fig. 3. During baseline probes, Marcel consistently passed the ball to his teammate (i.e., the first step of each offensive chain) in response to relevant vocal verbal S^Ds during *offense* and *drill* trials. Conversely, Marcel never performed any prescribed steps during *defense* trials. Following forward chaining, Marcel demonstrated mastery of all steps across all targeted chains and this mastery generalized to no-cones probes for *defense* and *drill*. However, generalization to no-cones probes did not occur for the offense chain until we implemented the adapted forward chaining condition. Due to time constraints, we were unable to evaluate maintenance of *drill*. However, both *offense* and *defense* maintained following initial demonstrations of mastery.

The results of our social-validity surveys are seen in Table 3 and show that Marcel’s family reported perfect satisfaction scores. To obtain data for our “functionality” survey, we visited the basketball courts of the university recreation center and two community centers on two separate occasions (once in the morning and once at night). We consented 15 adults across two of those sites (we did not observe anybody playing basketball at one of the community centers during either visit). All respondents were male and mean reported age was 24 years (range 18–46 years); however, three respondents failed to report their age. Additionally, one respondent chose to only evaluate the offensive sequence (omitting responses to *defense* and *drill*). Notwithstanding, survey results suggest that our sequences could be useful in a game of “pick up” basketball.

Discussion

Previous research regarding instruction of basketball skills for individuals with disabilities has focused on establishing mastery of component skills (i.e., Lo et al., 2014). However, functional play in team sports such as basketball is more complex than simple demonstrations of mastery of these skills. During game play, context changes frequently (e.g., teammates move, ball possession changes, etc.) and players are required to continuously discriminate when and how specific responses should be chained together (e.g., only “cover your man” when playing defense, indicate that “you’re open” when you’re away from your defender and your team has the ball, etc.).

In an attempt to address this reality, we first identified three chains of responding that we determined could be functional multiple times during a single game of basketball. Then, we identified three relevant verbal S^Ds (i.e., phrases commonly heard during actual games) that a teammate could use to rapidly occasion these chains (until appropriate control could be transferred to naturally occurring non-verbal S^Ds). Finally, we

Table 3 Results of satisfaction and functionality surveys

Questions from satisfaction survey	Parent rating 1: strongly disagree 5: strongly agree
My son benefited from this experience	5
I benefited from this experience	5
I am satisfied with the service that was provided	5
I would recommend this service to others in need of behavioral support	5
Questions from Functionality Survey	Mean score (range) 1: strongly disagree 5: strongly agree
Offense (15 of 15 responders)	
This sequence could be useful to someone playing a game of “pick up” basketball	4.1 (range 2–5)
I am likely to see this sequence <i>at least</i> once during a typical game of “pick up” basketball	4.7 (range 4–5)
I am likely to see this sequence <i>more than</i> once during a typical game of “pick up” basketball	4 (range 1–5)
Defense (14 of 15 responders)	
This sequence could be useful to someone playing a game of “pick up” basketball	4.6 (range 1–5)
I am likely to see this sequence <i>at least</i> once during a typical game of “pick up” basketball	4.7 (range 4–5)
I am likely to see this sequence <i>more than</i> once during a typical game of “pick up” basketball	4.8 (range 4–5)
Drill (14 of 15 responders)	
This sequence represents a reasonable chain of responses to a “full-court press”	3.8 (range 3–5)
This is a useful drill	3.6 (range 2–5)

1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree

used forward chaining to bring these chains under the control of the above-mentioned S^Ds. Furthermore, during Marcel's final appointment (after he demonstrated mastery of the final response chain [*drill*]), Marcel, his family, and therapists played an impromptu “game” of basketball; alternating between offense and defense chains multiple times without anyone emitting the vocal verbal S^Ds which controlled

responding during this study. That is, control of responding transferred from verbal instructions (e.g., “cover him/her”) to naturally occurring contextual cues produced directly by the game itself (e.g., other team has the ball and opponent is “open”).

From a clinical standpoint, this type of programming could be an efficient way to effectively address multiple areas of concern

Fig. 2 Results of phase 1. Data in all graphs depict percentage of independent correct responding across blocks of trials. The top row shows skills Marcel mastered during baseline. The bottom two rows show skills for which discrete-trial training was employed prior to establishing mastery

Fig. 3 Results of phase 2. Data in all graphs depict percentage of steps independently and correctly completed across each trial. Open data points show responding in the presence of cones. Closed data points show responding in the absence of cones

simultaneously. Specifically, bringing functional chains of complex sports-related behavior under contextually appropriate discriminative control has the potential to improve social opportunities, physical activity, and recreational outcomes in populations (e.g., adolescents with autism) for whom deficits in these areas are commonly observed. Generally speaking, it would have been interesting to evaluate whether Marcel became more likely to recruit attention in non-athletic settings following this intervention, whether he was more likely to be active on a day-to-day basis and/or whether he had lost any weight.

Prompting through untrained steps during forward chaining procedures, and periodically probing for mastery of the entire response chain, represents another approach to efficient programming highlighted by this study. For example, forward chaining procedures that end instruction after subjects perform

the targeted training step may eliminate opportunities for learning that could occur as a result of practice effects (Spooner et al., 1986). Furthermore, forward chaining procedures impose artificial performance ceilings which can result in participants remaining in intervention for longer than is necessary. Thus, it can prudent to periodically probe for mastery of the entire response chain; especially when participants are prompted to complete all untrained responses in the chain (as was the case in the current study). For example, when chaining the defensive sequence, we briefly interrupted instruction to probe for mastery of the entire chain (which he demonstrated at that time). As a result of this probe, we were able to terminate the chaining procedure earlier than we had initially anticipated.

Although Marcel learned to emit all targeted responses relatively quickly, it is interesting to note that the skill that

required the most trials to mastery during phase 1 was the step that called for the most nuanced social interaction (i.e., “recruit attention and catch ball”). In order to demonstrate mastery of this skill, Marcel needed to orient toward his teammate, make eye contact with him/her, gesture, speak loud enough to be heard, and then catch a pass. Future researchers may wish to investigate whether, or the degree to which, proficiency with common social interactions such as eye contact and mands for attention (both ubiquitous in team sports) influence proficient gameplay by individuals diagnosed with ASD.

Also of interest is that we incorporated family members into our programming. We did this in an attempt to increase the probability of post-study maintenance and generalization of these sports-related skills (as suggested by Miltenberger & Charlop, 2014). We reasoned that *because* Marcel’s family valued basketball and played the game often, the probability of them providing Marcel with continued opportunities to play basketball and contact reinforcement following the study would be high. Furthermore, including Marcel’s family exposed them to instructional strategies to which Marcel was particularly responsive. It was our hope that this exposure would be useful for his family as they attempted to refine Marcel’s post-study gameplay (however, due to practical constraints, we did not formally assess the extent to which this occurred).

A few limitations of our study should be noted. First, we did not establish experimental control over skill mastery during phase 1. Additionally, during baseline of phase 1, we discontinued blocks of trials in which Marcel made two consecutive errors or three total errors in order to decrease the number of incorrect responses Marcel might emit in the presence of programed S^D s (prior to instruction). For these reasons, we cannot verify that DTT was responsible for target-skill mastery during phase 1. However, the purpose of phase 1 was strictly utilitarian and it was not our intention to focus on mastery of component skills during this study. Rather, we conducted phase 1 to ensure that Marcel was capable of performing all steps of the more complex response chains targeted during phase 2.

A second limitation of our study was that experimental control during phase 2 may have been compromised. Although the original chaining procedure increased the percentage of steps mastered across all response chains, mastery of *offense* did not generalize to no-cones probes until slight modifications to the procedure were made (i.e., cones were systematically removed). Even though this modification was minimal, it represents a slight deviation from the programming used during the second and third tiers of the intervention and, thus, statements about the effectiveness of the intervention should be tempered accordingly.

A third limitation of our study is that we did not conduct generalization probes. This fact certainly limits our ability to speak to the generality of treatment effects. However, we did

not probe for generalization because we conducted this study on a publicly available basketball court and incorporated Marcel’s family into all phases of intervention. Thus, by the end of this study, Marcel had already demonstrated mastery of all targeted chains with the people most likely to play a game of basketball with him, in the most relevant setting available to us at the time. However, we cannot say with certainty that Marcel would have played basketball on a different court or with other people.

A final limitation of our study is that we based response chains on personal experiences playing games of “pick up” basketball and did not seek expert guidance from professional players or coaches prior to designing our instructional sequences. However, results from our “functionality” survey indicate that the highlighted sequences could be useful during an actual game. Regardless, it may have been helpful to collect video of Marcel performing the targeted chains and showing said videos to professionals (or recreational players) and then asking them to evaluate Marcel’s proficiency when performing each chain (variations in speed, latency from S^D , etc. would likely predict the degree to which Marcel would contact success during an actual game of basketball). It would also have been informative to evaluate how Marcel’s preference for the game changed across time, whether he became a more effective player after the intervention (e.g., did he score more points?) and the degree to which our intervention influenced long-term social outcomes for Marcel and his family.

Despite the limitations, this study highlights a promising strategy for increasing sports-related play in a population for whom sustained exercise- and recreation-related behavior is not common. Although we designed sequences most likely to be effective during recreational gameplay, it is possible that a similar instructional procedure could establish proficiency with sequences more appropriate for formal competition (e.g., plays designed by coaches). This possibility represents one potentially fruitful area of future research.

Author Note We thank Calvin Diggs and the Vanderbilt Recreation and Wellness Center for providing the space and resources needed to conduct this study. We thank Katelyn B. Paradis for assisting in its implementation and the New England Center for Children for providing access to their Autism Curriculum Encyclopedia®; which facilitated the study’s conceptualization.

Compliance with Ethical Standards All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of Interest The authors declare that they have no conflict of interest.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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