Journal of Applied Behavior Analysis

JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2019, **9999,** 1–15 NUMBER 9999 ()

# Comparison of two TAGteach error-correction procedures to teach beginner yoga poses to adults

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Teaching with acoustical guidance involves auditory feedback (e.g., a click sound when a desired behavior occurs) as part of a multicomponent intervention known as TAGteach. TAGteach has been found to improve performance in sport, dance, surgical technique, and walking. We compared the efficacy and efficiency of the standard TAGteach error-correction procedure and a modified TAGteach error-correction procedure to teach 4 novice adult yoga practitioners beginner yoga poses. Both error-correction procedures were effective for all participants; however, the relative efficiency of these error-correction procedures was unclear. Results are discussed in terms of limitations and considerations for future research.

*Key words:* behavioral coaching, error-correction, sport performance, teaching with acoustical guidance, yoga

The practice of yoga is an ancient discipline dating back to approximately 2500 B.C. (Tran, Holly, Lashbrook, & Amsterdam, 2001). Recently, yoga has been used as a therapeutic tool for the treatment of a variety of physical disorders and diseases such as rheumatoid arthritis (Badsha, Chhabra, Leibman, Mofti, & Kong, 2009), type 2 diabetes (Innes & Selfe, 2015), chronic back pain (Groessl, Weingart, Johnson, & Baxi, 2012), symptoms associated with cancer (Buffart et al., 2012), and the side effects of pregnancy (Bonura, 2014). In addition to these physical benefits, yoga has been found to produce immediate and prolonged mental health benefits such as the alleviation of depression and anxiety, and an overall sense of well-being (de Manincor et al., 2016; de Manincor, Bensoussan, Smith, Fahey, & Bourchier, 2015).

Despite its demonstrated physical and mental health benefits, there are risks associated with practicing yoga (Atkinson & Permuth-Levine, 2009; Birdee, Ayala, & Wallston, 2017; Chong, Tsunaka, Tsang, Chan, & Cheung, 2011; Cowen & Adams, 2005; Ross & Thomas, 2010). Yoga-related injuries may result in prolonged pain, discomfort, suffering, missed work, and financial loss (Russel, Gushue, Richmond, & McFaull, 2016). The exact causes of yoga-related injuries have not yet been empirically evaluated; however, one factor that may contribute to the risk of injury to practitioners is *how* yoga is taught. Therefore, it seems prudent to evaluate teaching procedures that promote safe yoga practices.

One such approach is the use of an auditory stimulus to give feedback during teaching (Quinn, Miltenberger, James, & Abreu, 2017). Behavioral coaching methods using auditory feedback have been found to improve safety (Harrison & Pyles, 2013) and performance within a variety of sports and fitness activities, including football (Harrison & Pyles, 2013;

This research was completed as part of the first author's master's thesis at Brock University under the supervision of the second author. We thank Joan Orr and Anne Wormald from TAGteach International for their contributions. We also thank Adam Carter, Laura Tardi, and Mahfuz Hassan for their assistance. This research was supported by a grant from the Council for Research in Social Sciences at Brock University.

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doi: 10.1002/jaba.550

Stokes, Luiselli, Reed, & Fleming, 2010), golf (Fogel, Weil, & Burris, 2010), and dance (Quinn, Miltenberger, & Fogel, 2015; Quinn et al., 2017). Teaching with auditory feedback, which is often referred to as teaching with acoustical guidance (TAG; e.g., Harrison & Pyles, 2013; Stokes et al., 2010), may also be used in intervention packages such as TAGteach (Fogel et al., 2010; Quinn et al., 2015). TAGteach uses an auditory stimulus to "provide immediate feedback and reinforcement in close temporal proximity to the occurrence of behavior" (Fogel et al., 2010, p. 26). TAGteach International, the company that coined the term TAGteach, trains teachers and coaches, called *TAGteachers*, to provide immediate feedback using a device called a *tagger*, which might also function as a conditioned reinforcer. The tagger emits an auditory stimulus called a *tag* (TAGteach International, 2004). To teach a skill, the TAGteacher first identifies the component steps involved in the composite skill and converts these steps into *tag points.* A tag point is a phrase that is five words or less and is used to help the student identify the target skill (e.g., "right toes forward"). TAGteachers then teach the tag points in a sequence. When the student performs the tag point correctly, the TAGteacher delivers a tag. A tag signals to the student that he or she performed the skill correctly and the absence of a tag signals that he or she performed the skill incorrectly, must reassess his or her performance, and perform the skill correctly three times before progressing to the next tag point in the sequence. Although TAGteach does not explicitly refer to this latter component of their intervention package as an error-correction procedure, we have conceptualized it as such in this study. A similar TAGteach strategy is the *three-try rule*, which TAGteachers use when a student performs a tag point incorrectly three times in a row. If this occurs, a TAGteacher returns to a *point of success*, or the last tag point the student performed correctly, and further breaks down the incorrectly performed tag point into smaller component parts. TAGteach International acknowledges that requiring correct performance of incorrect tag points three times was arbitrarily determined and requires empirical validation to ensure that it is the most effective and efficient teaching strategy (A. Wormald, personal communication, September 19, 2016).

TAGteach has been shown to improve performance across multiple skills when combined with other intervention strategies. The effectiveness of this intervention package has been evaluated when teaching a variety of physical skills such as golf (Fogel et al., 2010), jazz dance movements (Quinn et al., 2015; Quinn et al., 2017), appropriate walking gait in children with ASD (Persicke, Jackson, & Adams, 2014), and surgical skills (Levy, Pryor, & McKeon, 2016). However, there are several noteworthy limitations to these studies. First, the individual components of TAGteach (i.e., specific tag point phrasing, using personalized tag points, employing the three-try rule) have not been empirically validated. Second, only two of the five studies evaluating TAGteach assessed skill maintenance (Fogel et al., 2010; Quinn et al., 2017). Third, only three of the five studies included social validity measures (Fogel et al., 2010; Quinn et al., 2015; Quinn et al., 2017). Fourth, two studies included a single participant, which limits conclusions about the generality of the results (Fogel et al., 2010; Persicke et al., 2014). Finally, although three of five studies evaluated the efficacy of TAGteach alone (Levy et al., 2016; Quinn et al., 2015, Quinn et al., 2017), additional studies are needed to support the use of TAGteach alone.

The primary purposes of this study were to evaluate the error-correction component of the TAGteach intervention package, and to compare the efficacy and efficiency of two error-correction procedures (i.e., standard TAGteach, TAGteach with reduced practice) to teach

beginner yoga poses to novice adult yoga practitioners. The secondary purposes of this study were to compare participants' relative preference for each error-correction procedure and to compare the ratings of a certified yoga teacher, who was blind to condition, of participants' experience, errors, fluidity, and safety on all poses pre- and post-TAGteach training.

## METHOD

### *Participants, Setting, and Materials*

Four adults participated in this study: Edward (34 years), Madeleine (32 years), Makayla (39 years), and Nadine (35 years). We considered all participants novice yoga practitioners because each performed less than 50% of at least three beginner yoga poses correctly and reported that they had participated in three or fewer yoga classes prior to this study: Edward (three classes), Madeleine (no classes), Makayla (one class), and Nadine (no classes). The participants reported no physical injuries and did not practice yoga outside of research sessions for the duration of the study.

Each visit was no more than 1 hr in duration. All sessions were conducted by an experimenter who held certifications as a yoga instructor and TAGteacher (i.e., 200-hr yoga teacher certification, TAGteach Level 1 certification from TAGteach International). All sessions were conducted in a room (at least 3 m x 5 m) in participants' homes 1 to 3 days per week. We counterbalanced the order in which we conducted conditions across participants. Materials varied according to the experimental phase, but typically included two digital video cameras mounted on tripods (one with a forward-facing view and one with a side-facing view), a clipboard with paper data sheets, a pencil, a standard-sized yoga mat (60 cm x 182 cm), color photographs of the selected yoga poses, and a tagger.

### *Beginner Yoga Poses*

*Task analyses.* We selected five common, beginner-level yoga poses for this study. These poses included: (a) chair pose, (b) extended side angle pose, (c) half pigeon pose, (d) warrior III pose, and (e) downward dog pose. Prior to the study, the experimenter consulted with an external certified yoga teacher, hereafter referred to as the certified yoga teacher, to develop and approve a task analysis (TA) for each of these five beginner yoga poses. Definitions of the component steps for each yoga pose can be obtained from the first author.

*Logical analysis.* The experimenter conducted a logical analysis of each TA to ensure that the difficulty of each yoga pose was equal in terms of the number of steps required to perform the yoga pose and the mean time required to perform each yoga pose (Wolery, Gast, & Hammond, 2010) when performed by an experienced yoga practitioner. In addition, the certified yoga teacher rated the difficulty level of each yoga pose (Wolery et al., 2010) as either beginner, intermediate, or advanced. Each yoga pose consisted of 17 TA steps. Mean completion time for each yoga pose was calculated by measuring the amount of time it took an experienced yoga practitioner to perform each yoga pose five times. We then took the sum of each pose's duration times and divided by five. Mean completion times for each pose ranged between 5 s and 6 s. Each yoga pose was rated as a beginner yoga pose by the certified yoga teacher. Taken together, these results suggest that all five yoga poses were relatively equal in difficulty.

### *Experimental Design*

We used an adapted alternating treatments design (Sindelar, Rosenberg, & Wilson, 1985) in which we alternated standard TAGteach, TAGteach with reduced practice, and control conditions. The inclusion of a control condition allows us to demonstrate that change in

performance in the experimental condition is a function of the independent variable(s) and not a confounding variable if: (a) responding in the control condition remains within the same range observed in the baseline phase and (b) an increase in responding occurs in at least one test condition relative to responding in the control condition (Wolery et al., 2010). We assigned yoga poses to each condition such that no more than two yoga poses were assigned to the same condition across participants. In addition, we counterbalanced the order in which we conducted conditions across participants.

*Response Measurement, Interobserver Agreement, and Procedural Integrity*

The experimenter recorded the frequency of the dependent variables using paper and pencil. The experimenter scored an *independent tag point* when participants correctly performed the skill outlined in the TA. The experimenter scored an *error* when participants incorrectly performed the skill outlined in the TA. Efficiency was examined using measures of total session duration, mean session duration, and the number of teaching sessions required to meet the acquisition criterion.

Two independent observers collected data on all dependent measures during 35% of sessions for all participants. We compared observers' records on a trial-by-trial basis. We calculated interobserver agreement by dividing the number of agreements by the total number of TA steps and converting the ratio to a percentage. We defined an agreement as both observers recording the same response (i.e., an independent tag point or an error) for each step of the TA. We defined a disagreement as each observer recording a different response (i.e., one observer scored a response as an independent tag point while the other observer scored the same response as an error). Mean interobserver agreement for independent tag points was 100% for Edward, 93% (range, 75% to 100%) for Madeleine, 96% (range, 83% to 100%) for Makayla, and 96% (range, 86% to 100%) for Nadine. Mean interobserver agreement for errors was 98% (range, 91% to 100%) for Edward, 100% for Madeleine, 100% for Makayla, and 96% (range, 67% to 100%) for Nadine.

At least one observer collected procedural integrity data for 33% of sessions for all participants to ensure that the procedures described in each experimental condition were implemented as designed and reported. We calculated procedural integrity by dividing the number of steps performed correctly by the total number of steps and converting the ratio into a percentage. Observers scored the *correct provision of the tag point phrase* when the experimenter provided a verbal response specifying the correct TA step to be performed by the participant (e.g., "The tag point is fingers wide"). The tag point phrase consisted of a predetermined phrase developed by the experimenter when writing the TA or was a personalized tag point developed by the participant prior to the start of the TAGteach session. Observers scored the *correct feedback on independent tag points* when the experimenter provided a tag within 3 s after the participant performed the tag point correctly. Observers scored the *correct feedback on errors* when the experimenter withheld a tag and verbal feedback following an error.

*Correct progression to subsequent tag points* in the TA changed depending on the condition. During the standard TAGteach condition, correct progression consisted of the experimenter initiating the next tag point following three consecutive independent tag points. During the TAGteach with reduced practice condition, correct progression consisted of the experimenter delivering the next tag point following one independent tag point before initiating teaching on the following tag point. Observers scored *correct termination of the session* when the experimenter ended the session (a) upon participant request, (b) after the correct error-

correction procedures had been implemented for all target tag points, (c) termination criteria had been met for any target tag point, or (d) when 15 min had elapsed. The mean procedural integrity for all participants was 100% for correct provision of the tag point phrase, 99% (range, 86% to 100%) for correct feedback on independent tag points, 100% for correct feedback on errors, 98% (range, 72% to 100%) for correct progression to subsequent tag points, and 94% (range, 0% to 100%) for correct termination of session.

A delegate from TAGteach International collected IOA on these procedural integrity measures during 33% of sessions in which procedural integrity was calculated for each condition within the error-correction comparison phase. We calculated trial-by-trial IOA by dividing the number of agreements by the total number of procedural steps and converting the ratio to a percentage. We defined an agreement as both observers recording the same experimenter response for each step of the TA. We defined a disagreement as each observer recording a different response. For all participants, mean interobserver agreement of the procedural integrity measures was 97% (range, 86% to 100%) for correct provision of the tag point phrase, 97% (range, 86% to 100%) for correct feedback on independent tag points, 100% for correct feedback on errors, 100% for correct progression to subsequent tag points, and 100% for correct termination of the session.

### *Procedure*

*Assessment sessions.* We conducted assessment sessions to evaluate the participant's current level of performance of the three target yoga poses. We assessed one beginner yoga pose in each assessment session. Each assessment session lasted up to 5 min and we conducted two to three assessment sessions per visit. During baseline, we only conducted assessment sessions. During the error-correction comparison phase, we conducted both assessment and TAGteach sessions (described below). We did not conduct more than one assessment and TAGteach session for each yoga pose per visit.

During all assessment sessions, regardless of phase, the experimenter showed the participant a photo of the target yoga pose, performed a live model of the yoga pose, and asked the participant to perform the yoga pose independently. The experimenter discontinued the live model before the participant performed the yoga pose. The experimenter did not provide praise or corrective feedback to the participant. Once the participant had performed the yoga pose, the experimenter said, "Thank you" to indicate that he or she may exit the yoga pose. We only graphed and analyzed data collected during assessment sessions because these data depict each participant's independent (i.e., unprompted) performance on each TA and allowed us to detect changes in responding as a function of the two error-correction procedures.

*TAGteach sessions.* We only conducted TAGteach sessions if a participant did not perform 100% of the TA steps for a yoga pose correctly during an assessment session. Before TAGteach sessions, the experimenter reviewed the tag points the participant performed correctly and incorrectly during the previous assessment session. During each TAGteach session, the experimenter only taught those tag points that the participant performed incorrectly during the previous assessment session. The experimenter asked the participant to create a personalized tag point for each tag point performed incorrectly during the assessment session. If the participant chose not to create a personalized tag point, the experimenter provided him or her with a pre-determined tag point. We taught one yoga pose in each TAGteach session. We continued each TAGteach session until the participant performed all tag points in the TA correctly or until 15 min lapsed (Quinn et al., 2015). No TAGteach session in either error-

correction condition reached this 15-min termination criterion. To assess the relative efficiency of each error-correction procedure, we collected data on four measures: number of TAGteach sessions, total duration of TAGteach sessions, average duration of TAGteach sessions, and the total percentage of errors.

*Experimental phases.* Prior to the start of this study, we sent our procedures to a delegate of TAGteach International who verified that our procedures were identical to those used by TAGteach International, except for differences in the error-correction procedure we used in the TAGteach with reduced practice condition.

*Baseline.* During the baseline phase, we conducted assessment sessions until performance of the target yoga poses was stable.

*Error-correction comparison.* Three conditions were alternated during this phase: (a) standard TAGteach error-correction (practicing a tag point three times), (b) TAGteach with reduced practice (practicing a tag point once), and (c) a control condition that was identical to baseline. The acquisition criterion was independent performance on 100% of the TA steps for a yoga pose across three consecutive assessment sessions (Wolery et al., 2010).

We used the point of success strategy once throughout the experiment for one participant, Edward. Edward erred on the tag point "toes forward" during chair pose three times during a TAGteach session. The experimenter returned to the last previously successful tag point ("feet hip-distance apart"), tagged Edward's correct performance of this tag point three consecutive times, then terminated the session. Before conducting the next session for chair pose, the experimenter further task analyzed the "toes forward" tag point into smaller, more teachable movements (i.e., right toes forward, left toes forward, both toes forward).

*Standard TAGteach condition.* At the beginning of a TAGteach session, the experimenter introduced TAGteach by showing the participant the tagger and saying, "This is a tagger. Today I'm going to ask you to show me your [target yoga pose]. To help you learn how to do [target yoga pose] correctly, I broke it down into several small steps, which are called tag points. You already do several of these tag points well such as [the experimenter listed the tag points that the participant performs correctly], so I'm only going to focus on the tag points that you can improve upon. When you are showing me [target yoga pose], I will be paying close attention to how you perform the following tag points [the experimenter listed and modeled each tag point that the participant did not perform correctly during the assessment session]. When you perform each tag point correctly, you will hear this sound [the experimenter pressed the tagger to make a click sound]. If you do not perform the tag point correctly, you will not hear this sound and you can try again. During this session, I will ask you to practice each tag point *three times in a row* before moving on to the next tag point. Do you have any questions?"

Because each yoga pose consists of many individual steps that must be completed in sequence, each yoga pose is considered a behavioral chain. As such, in order to complete a later step in the chain, the participant was first required to complete all earlier steps in the chain. Therefore, at the start of the TAGteach session, the experimenter asked the participant to begin performing the target yoga pose then specified the first target tag point on which the participant erred during the preceding assessment session. For example, "Show me the downward dog pose. The tag point is straight arms." Although *straight arms* is the sixth tag point (or sixth step in the behavioral chain), the participant first needed to complete the first five tag points (or the first five steps in the behavioral chain). If the participant performed the tag point correctly, the experimenter delivered a tag (i.e., click sound). The participant had to perform the tag point correctly on three consecutive attempts before progressing to the next tag point. This process continued until

the participant performed all tag points correctly or 15 min elapsed, whichever occurred first. If the participant performed the tag point incorrectly, the experimenter did not provide a tag or verbal feedback, and the participant tried again until he or she performed the tag point correctly three times in a row. The experimenter provided a tag for each independent tag point during the error-correction procedure.

*TAGteach with reduced practice condition.* This condition was identical to the standard TAGteach condition, apart from the error-correction procedure. That is, the experimenter introduced the tagger and the tag point the same way she did during the standard TAGteach condition. However, the experimenter informed the participant that, "If you do not perform the tag point correctly, you will not hear this sound and you can try again. During this session, I will ask you to practice each tag point *once* before moving on to the next tag point. Do you have any questions?"

*Control condition.* This condition was identical to baseline. These sessions were conducted after every sixth assessment session during the error-correction comparison phase.

### *Social Validity*

We assessed social validity in two ways. First, participants were asked to complete a questionnaire that consisted of two sections; four closed-ended questions and four questions answered on a 6-point rating scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). The purpose of the four closed-ended questions was to determine (a) what each participant liked and disliked about each condition, (b) the participant's overall preference for each error-correction procedure, and (c) the participant's perceived helpfulness of each error-correction procedure on improving performance of the selected yoga poses. The questions rated on a 6-point scale were used to assess the participant's perception of the two error-correction procedures along the following dimensions: (a) improvement of overall yoga skills, (b) helpfulness when learning more-complex yoga poses, (c) improved confidence with the target yoga poses, and (d) preference for which TAGteach procedure if taught yoga in the future using TAGteach.

The second social validity assessment involved asking the certified yoga teacher to rate video clips of each yoga pose; one video from baseline and one video after the participant met the acquisition criterion in the error-correction comparison phase. The certified yoga teacher was sent a rating scale and participant videos via email, watched all videos in a random order, and was blinded to the phase and condition of the study (i.e., the experimenter did not inform the certified yoga teacher if the video clip was taken before or after treatment). We asked the certified yoga teacher to rate each participant's experience with a yoga pose, the number of mistakes made during a yoga pose, fluidity when performing the yoga pose, and safety when performing the yoga pose.

## RESULTS

### *Treatment Evaluation*

Figure 1 depicts the results of the treatment comparison for Edward (top), Madeline (second), Makayla (third), and Nadine (fourth).

*Edward.* During baseline, we observed low to moderate levels of responding across each beginner yoga pose ($M$ = 31%; range, 29% to 41%). In the comparison phase, both error-correction procedures produced an immediate increase in the percentage of independent tag points, with a higher initial increase in the standard TAGteach condition. Responding during the control condition remained within baseline levels. Edward met the acquisition criterion in 10 assessment sessions in both error-correction conditions, indicating that both procedures were efficacious in promoting independent performance.

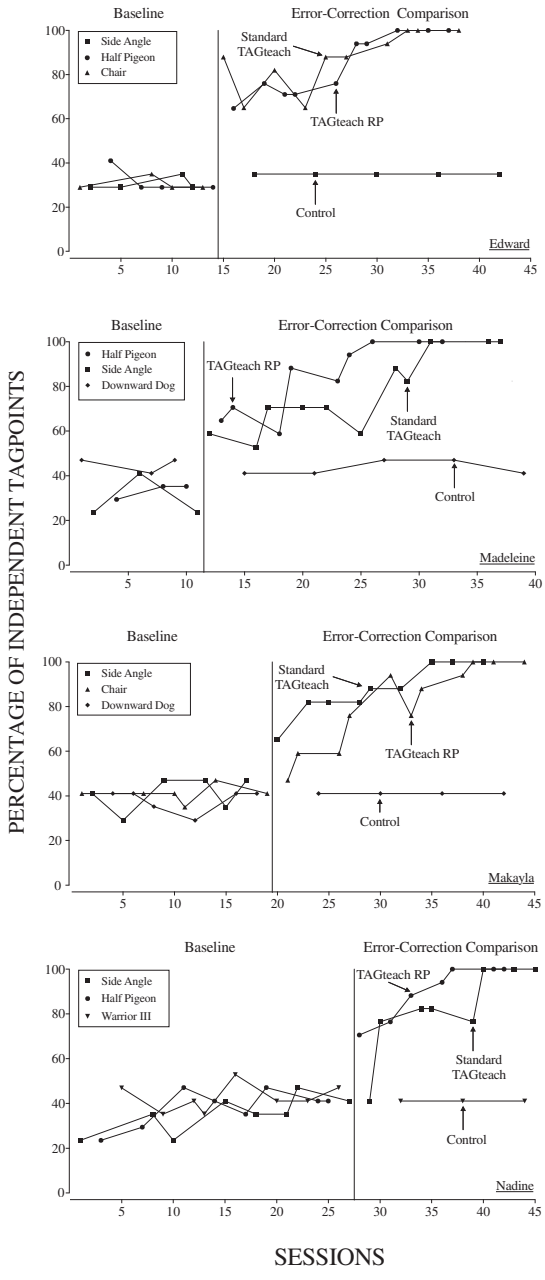


Figure 1. Percentage of independent tag points during baseline, error-correction comparison of standard TAGteach, TAGteach with reduced practice (TAGteach RP), and control conditions.

*Madeleine.* During baseline, we observed low to moderate levels of responding across each beginner yoga pose ($M$ = 36%; range, 24% to 47%). In the comparison phase, both error-correction procedures produced an increase in the percentage of independent tag points, with a slightly higher initial increase in the standard TAGteach condition. Responding during the control condition remained within baseline levels. Madeleine met the acquisition criterion in nine assessment sessions in the standard TAGteach condition and 11 assessment sessions in the TAGteach with reduced practice condition, indicating that both error-correction procedures were efficacious in promoting independent performance of these yoga poses.

*Makayla.* During baseline, we observed moderate levels of responding across each beginner yoga pose ($M$ = 40%; range, 29% to 47%). In the comparison phase, we observed an immediate increase in the percentage of independent tag points in the standard TAGteach condition only. After the third TAGteach with reduced practice assessment session, responding steadily increased across TAGteach conditions while responding during the control condition remained within baseline levels. Makayla met the acquisition criterion in nine assessment sessions in the standard TAGteach condition and 11 assessment sessions in the TAGteach with reduced practice condition, indicating that both error-correction procedures were efficacious.

*Nadine.* During baseline, we observed low to moderate levels of responding across each beginner yoga pose ($M$ = 39%; range, 24% to 53%). In the comparison phase, we observed an immediate increase in the percentage of independent tag points in the TAGteach with reduced practice condition only. After the second standard TAGteach assessment session, responding steadily increased while responding during the control condition remained within baseline levels. Nadine reached the acquisition criterion in eight assessment sessions in the standard TAGteach condition and seven assessment sessions in the TAGteach with reduced practice condition, suggesting that both error-correction procedures were efficacious.

Table 1 depicts efficiency data for all participants. Due to the inconsistent efficiency data within and across participants, we were unable to conclude which, if either, error-correction procedure was more efficient using visual inspection alone. Therefore, we combined the efficiency data for all participants to determine if, on average, one error-correction procedure was more efficient than the other. We defined the two error-correction procedures as roughly equal based on a difference of (a) one or fewer sessions, (b) 1 min or less, and (c) 5% or smaller difference between error-correction procedures. We found both error-correction procedures to be roughly equally efficient for three of the four efficiency measures: (a) number of TAGteach sessions, (b) total duration, and (c) average duration of TAGteach sessions. On average, we observed 0.75 fewer standard TAGteach sessions were required to meet the acquisition criterion. There was only a 33.5-s difference in the total duration and only a 13.7-s difference in the average duration of TAGteach sessions across participants. We found that standard TAGteach was more efficient than TAGteach with reduced practice with respect to the total percentage of errors obtained in each error-correction procedure. On average, the standard TAGteach condition produced 19% fewer errors than the TAGteach with reduced practice condition.

### *Social Validity*

Table 2 depicts the results of the participant questionnaire. In general, participants reported liking both standard TAGteach and TAGteach with reduced practice. Edward and Madeleine preferred standard TAGteach and Makayla and Nadine preferred TAGteach with reduced practice. Edward reported that standard TAGteach helped him improve more than TAGteach with reduced practice, whereas Madeleine, Makayla, and Nadine reported that both error-correction procedures helped them improve their performance equally.

Figure 2 depicts the results of the certified yoga teacher ratings. On average, the certified yoga teacher rated yoga poses performed in baseline 0.72 points lower than yoga poses

Table 1
Summary of Efficiency Data

| | | TAGteach sessions | | | |
|---|---|---|---|---|---|
| Participant | Condition | No. sessions | Total duration | Avg. duration (range) | % Errors |
| Edward | Standard TAGteach | 8 | 6:44 | 0:58 (0:17-1:36) | 8% |
| | TAGteach RP | 8 | 5:24 | 0:46 (0:05-1:30) | 35% |
| Madeleine | Standard TAGteach | 7 | 8:06 | 1:21 (0:08-4:48) | 8% |
| | TAGteach RP | 9 | 10:53 | 1:22 (0:19-2:19) | 36% |
| Makayla | Standard TAGteach | 7 | 7:13 | 1:12 (0:22-2:59) | 4% |
| | TAGteach RP | 9 | 4:55 | 0:37 (0:06-1:28) | 18% |
| Nadine | Standard TAGteach | 6 | 3:56 | 0:47 (0:27-1:36) | 12% |
| | TAGteach RP | 5 | 2:33 | 0:38 (0:30-0:57) | 20% |

*Note.* TAGteach RP = TAGteach with reduced practice. All times are listed as (min:s).

Table 2
Social Validity Outcomes

| Category | Questions | Participant | | | |
|---|---|---|---|---|---|
| | | Edward | Madeleine | Makayla | Nadine |
| Closed-ended Questions | Did you like participating in practices where standard TAGteach was used? | Yes | Yes | Yes | Yes |
| | Did you like participating in practices where TAGteach RP was used? | Yes | Yes | Yes | Yes |
| | Did you prefer practices with standard TAGteach or TAGteach RP? | Standard TAGteach | Standard TAGteach | TAGteach RP | TAGteach RP |
| | Do you think standard TAGteach or TAGteach RP, both, or neither helped you improve your skills? | Standard TAGteach | Both | Both | Both |
| Rating Scale | My yoga skills are better following (error-correction procedure). | | | | |
| | Standard TAGteach | 5 | 6 | 6 | 4 |
| | TAGteach RP | 5 | 4 | 5 | 5 |
| | Learning the skills with (error-correction procedure) will help me move onto more complex yoga poses. | | | | |
| | Standard TAGteach | 6 | 4 | 4 | 4 |
| | TAGteach RP | 5 | 4 | 4 | 4 |
| | I am more confident in the yoga poses I learned through (error-correction procedure) than I was at the beginning of the intervention. | | | | |
| | Standard TAGteach | 6 | 6 | 6 | 4 |
| | TAGteach RP | 5 | 4 | 5 | 5 |
| | I would like my teacher (or a future teacher) to train me using (error-correction procedure). | | | | |
| | Standard TAGteach | 4 | 6 | 5 | 4 |
| | TAGteach RP | 4 | 4 | 6 | 5 |

*Note.* TAGteach RP = TAGteach with reduced practice. The rating scale ranged from 1 (*strongly disagree*) to 6 (*strongly agree*).

performed after receiving TAGteach training, suggesting that both error-correction procedures produced enough change in participant performance to be detected by an outside expert. Figure 3 depicts mean post-TAGteach ratings across all social validity measures in the second social validity assessment. We found very small differences in the certified yoga teacher's ratings of both error-correction procedures. On average, the certified yoga teacher rated poses assigned to the standard TAGteach condition 0.8 points higher than yoga poses assigned to the TAGteach with reduced practice condition. We found a larger difference in the certified yoga teacher's ratings of these two error-correction procedures when we compared each to the yoga poses assigned to the control condition in which no teaching was provided. That is, relative to the yoga poses assigned to the control condition, the certified yoga teacher rated the yoga poses assigned to the standard TAGteach condition 1.5 points higher than those assigned to the control condition, whereas she only rated the yoga poses assigned to the TAGteach with reduced practice condition 0.7 points higher than the yoga poses assigned to the control condition. Although these differences in ratings are small, they may

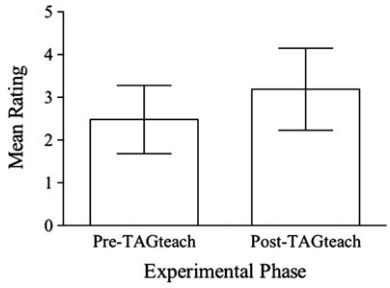


Figure 2. The certified yoga teacher's mean rating of participants' baseline and post-TAGteach performance collapsed across experience, mistakes, fluidity, and safety. Error bars indicate standard deviation.

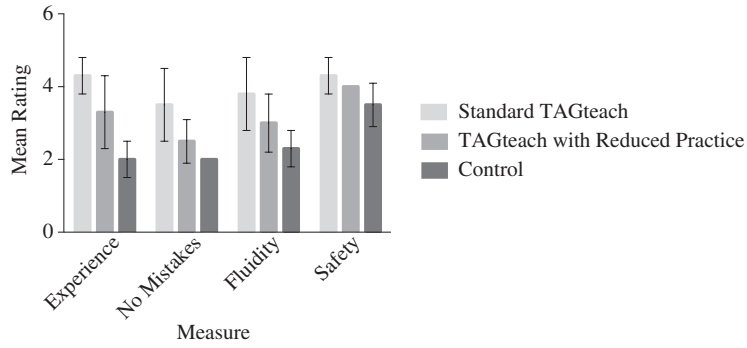


Figure 3. The certified yoga teacher's mean ratings collapsed across participants' performance in all conditions after TAGteach training. Light grey bars depict mean ratings of the standard TAGteach condition, medium grey bars depict mean ratings of the TAGteach with reduced practice condition, and dark grey bars depict mean ratings of the control condition. Error bars indicate standard deviation.

suggest that standard TAGteach produces a qualitatively superior performance to TAGteach with reduced practice across these four measures. Taken together, standard TAGteach was rated higher with respect to the participants' experience when performing the yoga poses, but the two error-correction procedures were rated roughly equally for (a) mistakes made when performing the yoga poses, (b) fluidity when performing the yoga poses, and (c) safety when performing the yoga poses.

## DISCUSSION

We established preliminary empirical evidence for the TAGteach error-correction procedure. In addition, we demonstrated that the standard and the modified error-correction procedures were efficacious for all four participants. However, we could not definitively conclude which error-correction procedure was more efficient because of the inconsistent results across three of our four efficiency measures.

The inclusion of a control condition during the error-correction comparison phase allowed us to detect multiple threats to internal validity, including practice effects, history effects, maturation effects, and multitreatment interference (Wolery et al., 2010). We measured responding in the control condition during baseline and intermittently throughout the error-correction comparison phase. We observed differentiated responding between the control and both error-correction conditions with all four participants, indicating that responding in each condition was not influenced by multitreatment interference from the two error-correction procedures. We also observed similar levels of responding in the control condition in both phases for all participants, suggesting that the participants' performance was not influenced by (a) the repetitive practice of the yoga poses during the intervention, (b) changes outside of the error-correction conditions, or (c) changes within the participants themselves over the course of this study.

This study adds to the existing research evaluating the efficacy and efficiency of the TAGteach intervention package when teaching physical skills in several ways. First, we confirmed previous findings (Levy et al., 2016; Quinn et al., 2015, Quinn et al., 2017) that TAGteach alone is an effective intervention package to teach physical skills to typically developing adults. This is an important contribution to the existing literature because only three studies to date have evaluated the

effectiveness of TAGteach alone. Numerous studies evaluating the effectiveness of TAGteach included one or more additional intervention components (Fogel et al., 2010; Persicke et al., 2014). It should be noted that Quinn et al. (2015) found that TAGteach alone was effective for three of four participants; however, an additional component was added for the fourth participant for whom TAGteach alone was not sufficient to improve performance.

Second, our study is the first to establish preliminary empirical support for an individual component of TAGteach. That is, we validated one component of the TAGteach intervention package—the error-correction procedure. We found that practicing a tag point three times was effective for all participants. We also found that practicing a tag point one time was effective for all participants, indicating that students can practice a tag point fewer times than is traditionally suggested by TAGteach International. While previous researchers have established the effectiveness of TAGteach alone (Levy et al., 2016; Quinn et al., 2015, Quinn et al., 2017) or in combination with other intervention components (Fogel et al., 2010; Persicke et al., 2016; Quinn et al., 2015), several individual TAGteach components (e.g., specific tag point phrasing, using personalized tag points, employing the three-try rule) have yet to be validated; therefore, researchers should establish empirical support for each of these individual TAGteach components. In addition, because TAGteach consists of many components, the contribution of each individual component to the increase in performance for participants in this study remains unclear. Researchers may consider conducting a component analysis to identify the necessary and sufficient components involved in TAGteach.

Third, we found several interesting results on the social validity measures. The certified yoga teacher rated participants' mean performance significantly higher post-TAGteach than in baseline across all four measures: experience, errors, fluidity, and safety. These findings suggest that the improvements obtained in this study were sufficiently robust for an outside expert to detect. However, even though each participant's performance increased, on average, from 37% in baseline to 100% post-TAGteach, the social validity ratings only increased, on average, from 2.47 to 3.19 on a 5-point scale. This finding may be explained by the fact that we trained participants to perform the targeted yoga poses to 100% accuracy within TAGteach sessions but did not include a measure of fluency in the acquisition criterion. The fluidity with which a participant entered a yoga pose or moved through the TA may have impacted the certified yoga teacher's rating of their performance. Researchers may consider training future participants to fluency when teaching a physical skill via TAGteach and including a measure of fluency within the acquisition criterion. Perhaps the most interesting finding is that the certified yoga teacher rated the participants' performance post-TAGteach higher in the standard TAGteach condition than the TAGteach with reduced practice condition when assessing the participant's experience with the yoga pose. One possible explanation for these findings may be that participants received a greater number of tags in the standard TAGteach condition ($M$ = 86.25; range, 66 to 144) than in the TAGteach with reduced practice condition ($M$ = 35.25; range, 12 to 62). Another possible explanation for these findings may be that participants received more practice on tag points in the standard TAGteach condition ($M$ = 53.25; range, 15 to 72) than in the TAGteach with reduced practice condition ($M$ = 28.75; range, 12 to 42). It is unclear if the greater number of tags, the greater number of times tag points were practiced, or a combination of the two produced the qualitatively superior performance ratings for experience with yoga poses assigned to the standard TAGteach condition; researchers should investigate

the underlying operant mechanisms of the TAGteach error-correction procedure.

There are four noteworthy limitations of this study. First, it was impossible to definitively conclude which error-correction procedure was more efficient because of the inconsistency across three of the four efficiency measures within and across participants. That is, for one (Madeleine) of four participants, we found that standard TAGteach was more efficient across all four measures. However, for the remaining three participants, we found that neither error-correction procedure was consistently more efficient across three of four measures—number of TAGteach sessions, total duration of TAGteach sessions, and average duration of TAGteach sessions. Further, the differences in efficiency between the two error-correction procedures across these three measures were small, making it difficult to conclude if one error-correction procedure was more efficient than the other. Because we only evaluated the relative efficiency of standard TAGteach and TAGteach with reduced practice once, we failed to include an intrasubject replication, which would have strengthened our findings. In addition, we did not collect IOA on these efficiency measures.

A second potential limitation is that we were unable to determine which, if either, TAGteach error-correction procedure resulted in fewer injuries because all participants performed yoga poses safely during all sessions. It is possible that there were safety differences between conditions and that we did not adequately capture these differences. Therefore, researchers should assess additional measures of risk and safety (e.g., pain rating scales before and after each session) to evaluate these relative differences among error-correction procedures. This is a particularly important area for research involving yoga, because yoga-related injuries have the potential to result in prolonged pain and missed work (Russel et al., 2016). Future research should be devoted to the study of increasing the safety of practicing yoga.

Third, for three of the four participants, we assigned the half pigeon pose to either the standard TAGteach or the TAGteach with reduced practice condition. That is, we failed to ensure that half pigeon pose was equally assigned as a control condition across participants; therefore, future researchers should consider increasing the number of participants to ensure that each pose is equally assigned to each condition. In addition, for these three participants, we found that the half pigeon pose was associated with the least (Madeleine and Nadine) or an equal (Edward) number of assessment sessions to meet the acquisition criterion. Despite our inclusion of a logical analysis and our use of expert ratings to ensure all yoga poses were of equal difficulty, it is possible that half pigeon pose was easier than our other yoga poses. Given that the adapted alternating treatment design requires that all behaviors be equally difficult, future researchers may consider conducting a more stringent test prior to the start of the study to ensure that that all behaviors are of equal difficulty. There are at least two additional strategies that researchers can use to accomplish this. First, researchers may consider conducting an experimental evaluation in which they teach the target behaviors to nonparticipants (who are similar to the participants) using the same intervention. If the behaviors are of equal difficulty, the nonparticipants should acquire the target behaviors with the same amount of instruction (Wolery et al., 2010). Second, researchers may consider selecting target behaviors for which norms with respect to difficulty already exist (Wolery et al., 2010).

Fourth, we did not assess generalization of these skills to real-world settings or to a large number of participants across age or abilities. To assess for generalization of performance to a real-world setting, researchers can conduct generalization probes in an actual yoga class at the beginning of baseline and intermittently throughout the comparison phase. We only

included four typically developing adults in this study, limiting conclusions about the generality of these results to other populations. Future researchers should evaluate the efficacy and efficiency of TAGteach (a) with a greater number of participants; (b) in more naturalistic settings; (c) with a more diverse population, including children, older adults, or individuals with intellectual and developmental disabilities; (d) across a wider range of sport-related skills (e.g., tennis, baseball, soccer, hockey, gymnastics); and (e) across a wider range of fluid behaviors that require precision, such as writing, shoe-tying, or playing a musical instrument.

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*Received February 1, 2018*
*Final acceptance December 7, 2018*
*Action Editor, Raymond Miltenberger*