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ORIGINAL PAPER

Comparison of TAGteach and Video Modeling to Teach Daily Living Skills to Adolescents with Autism

Jennifer L. Wertalik[1] · **Richard M. Kubina**[2]

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Abstract The development of independent behavior, specifically for daily living skills, proves critical as individuals with autism spectrum disorder (ASD) pass through the high school environment into adulthood. The present study examined the short-term effects of two instructional methods (i.e., TAGteach, video modeling) to improve accuracy on daily living tasks for adolescents with ASD. The experimenter implemented an adapted alternating treatments design to compare the effects of TAGteach and video modeling for teaching daily living skills (i.e., teeth brushing, face washing, applying deodorant). Participants included three 17-year-old male students diagnosed with ASD who made minimal progress acquiring these skills in the past. Results indicated that short-term instruction using both TAGteach and video modeling produced immediate improvements in performance on targeted tasks for all three students.

Keywords Daily living skills · Video modeling · TAGteach · Autism spectrum disorder · Adolescents

Introduction

Throughout life, individuals experience many transitions, with the transition from school to young adulthood considered one of the most pivotal. The transition often includes completing school, gaining employment, participating in post-secondary

✉ Jennifer L. Wertalik
Jennifer.wertalik@armstrong.edu

[1] Department of Psychology, Science Center 231, Armstrong State University, Savannah, GA 31419, USA

[2] Special Education Program, The Pennsylvania State University, University Park, PA 16802, USA

education, contributing to a household, participating in the community, and experiencing satisfactory personal and social relationships (Wehman et al. 2014). For many, the transition represents an exciting time filled with anticipation of all the new challenges ahead. However, for young people with autism spectrum disorder (ASD) transitions can pose significant challenges (Hendricks and Wehman 2009). Approximately 50,000 students with ASD exit high school each year without the skills needed to transition successfully to adult life (Roux et al. 2015). As a result, individuals with ASD experience poor outcomes across a variety of areas with low rates of college completion, employment, independent living, and friendships following graduation (Roux et al. 2015; Wehman et al. 2014).

In order to improve outcomes, individuals with ASD should receive instruction targeting the skills needed to live as independently as possible. The ability to independently perform daily living skills (e.g., personal-care, domestic, community) can allow individuals with ASD to care for themselves, increase their quality of life, and decrease their dependence on others (Briggs et al. 1990; Cameron et al. 1992). Yet many individuals with ASD have difficulty acquiring daily living skills (Hendricks and Wehman 2009). Although improvement in daily living skills can occur with age, many individuals experience significant lifelong impairments (Hong et al. 2015). Additionally, researchers have found that individuals with ASD have lower performance levels for daily living skills when compared to their IQ-matched peers without ASD (Liss et al. 2001). Therefore, identifying effective educational interventions focused on daily living skill acquisition remains a critical task for researchers and practitioners (Delano 2007).

Video modeling (VM), a popular instructional method for students with ASD, represents one method that can help improve performance on daily living skills (Hong et al. 2015). VM involves creating a video of a model performing a behavior or task sequence. During instruction, the learner watches the video from beginning to end and then attempts to perform the behavior or task sequence (Cannella-Malone et al. 2006). Empirical evidence supports the use of VM as an established, evidence-based intervention to teach individuals with ASD (Wilczynski et al. 2009). Further, experimenters have found strong evidence to support the use of VM methods in teaching a variety of daily living skills to individuals with ASD including cleaning a sink (Van Laarhoven et al. 2009), setting a table (Shipley-Benamou et al. 2002), caring for a pet (Shipley-Benamou et al. 2002), cooking related skills (Shipley-Benamou et al. 2002; Shrestha et al. 2013; Van Laarhoven et al. 2009), grooming tasks (Charlop-Christy et al. 2000; Lasater and Brady 1995) and vocational skills (e.g., Allen et al. 2010).

Video modeling instruction includes several features that may contribute to the benefits seen when used with individuals with ASD. For instance, VM combines observational learning and visually based instruction. Bandura (1977) highlighted that individuals learn a vast array of skills by observing others. According to the social learning theory literature, behavior learned through observation of another person can later act as a guide when individuals attempt to perform the targeted skill on their own. In addition, researchers have identified motivation and attention as critical components to effectively learn an observed behavior (Bellini and Akullian 2007). Therefore, observational learning through VM incorporates visually based instruction that mirrors common learning strengths of individuals with ASD as well as aims to improve attention to the behaviors being modeled by restricting the field of focus. By restricting the field of focus, VM allows students to focus on the relevant stimuli associated with the task (Bellini and Akullian 2007; Charlop-Christy et al. 2000).

Although VM has many benefits, some researchers have indicated that VM does not address the well-documented memory impairments experienced by many individuals with ASD (Quill 1997). Specifically, VM requires an individual to watch the entire skill before having an opportunity to imitate the behaviors observed in the video. For some, the task can prove demanding with regard to attention and retention, especially when the videos may last several minutes in length and/or when the tasks increase in complexity in term of number of steps (Sigafoos et al. 2007). The deficits pose particular concern for using VM to teach daily living skills because such behaviors often include complex tasks with a large number of steps.

Teaching with Acoustical Guidance (TAGteach) constitutes another instructional method gaining popularity for students with ASD (Persicke et al. 2014; TAGteach International 2016) that can address learning challenges faced by individuals with a diagnosis of ASD, such as difficulties sustaining attention, planning, and memory (Hume et al. 2009). TAGteach, a methodology based on principles of behavior analysis, incorporates use of auditory feedback. The method includes breaking down a complex behavior into a sequence of smaller steps, clearly identifying the target behavior or “tag point” (e.g., picks up toothbrush), and then delivering an auditory stimulus (i.e., “click sound”) immediately after the student engages in a desired behavior (Pryor et al. 1969; TAGteach International 2016). The auditory feedback pinpoints and reinforces the precise moment the student engages in the correct response. The use of auditory feedback provides the student with immediate feedback and aims to increase the probability of correct responding in the future (Fogel et al. 2010; Stokes et al. 2010; TAGteach International 2016).

Although small in number, studies on TAGteach have shown promising results. Experimenters have found that TAGteach effectively enhanced performance in golf (Fogel et al. 2010), dance (Quinn et al. 2015), and football (Harrison and Pyles 2013; Stokes et al. 2010). In addition to use in sports, experimenters have evaluated TAGteach in the field of education. Levy et al. (2016) evaluated a modified TAGteach procedure to teach surgical skills to medical students and found that the participants receiving instruction via TAGteach took longer to acquire the surgical skills; however, they performed the skills with more precision. The results of these studies provide initial support for the use of TAGteach as an effective form of performance feedback with adults and children without disabilities.

The research base at the time of this paper finds only one study evaluated the use of TAGteach with individuals with ASD. Persicke et al. (2014) evaluated the use of TAGteach to decrease toe-walking by a 4-year-old boy with ASD. The experimenters delivered an auditory stimulus (i.e., “click”) contingent on every flat-footed step while also applying a correction procedure for toe-waking. Before and during training, the experimenters paired the “click” sound with an edible reinforcer. Persicke et al. (2014) found that when using TAGteach and the correction procedure, the participant engaged in higher rates of flat-footed walking.

The experimenters, however, did not include a condition in which TAGteach was isolated. Therefore, the experimenters could not conclude that TAGteach alone produced the increase in flat-footed walking.

TAGteach incorporates a number of empirically supported learning principles that can prove beneficial when used with individuals with ASD. For instance, TAGteach includes use of task analysis, which includes breaking down an overall, complicated skill into smaller, simpler, and sequential steps for individuals to learn and perform (Cooper et al. 2007). As a result, the student works on the task one part at a time instead of trying to master the whole task at once (Szidon and Franzone 2009). Additionally, the auditory stimulus used in TAGteach allows for immediate and consistent feedback. Ideally, delivery of feedback should occur immediately after the target behavior with the best-case scenario including a delay of 0 s (Cooper et al. 2007), which proves difficult when using verbal or tangible forms of feedback. Furthermore, the auditory stimulus allows for quick and clear feedback that eliminates the use of any unnecessary language (TAGteach International 2016).

The purpose of the present study was to directly compare the effectiveness of VM and TAGteach in the acquisition of daily living skills. VM represents a well-established intervention using behavioral principles such as visually cued instruction. Although TAGteach also utilizes behavioral principles and procedures, it lacks scientific validation. Therefore, the aim of the present study was to compare two different instructional methods to teach daily living skills to individuals with ASD and answer the following experimental question: What effects will video modeling versus TAGteach have on students' acquisition of daily living skills among adolescents with autism?

Methods

Participants and Setting

Three male students attending a self-contained school program for students with ASD served as the participants for this study. To participate in the study, the students needed to have a current IEP goal associated with increasing daily living skills, demonstrate limited progress over the past year with targeted daily living skills tasks. The above criteria resulted in 10 possible participants for inclusion within the study from the school program. The experimenter then conducted a pre-assessment measure to assess the student's current performance on each targeted task and confirm that they met performance criterion of completing 30% or less of the steps of each task (i.e., applies deodorant, brushes teeth, washes face). The above criteria resulted in four possible students for inclusion within the study. However, one student did not continue with the experimental sessions because he chose not to participate in the experiment.

All three students participating in the study had instructional programming that focused on daily living, vocational, and functional academic skills. Instruction was designed and delivered using principles of applied behavior analysis. However, none of the students had any prior exposure to video modeling or TAGteach. Carter, a 17-year-old male, had a previous diagnosis of ASD. Carter did not use vocal speech and communicated his basic wants and needs using a picture communication system. Information gathered from Carter's Individualized Education Plan (IEP) indicated that he obtained a score of 40 on the Adaptive Behavior Assessment System, 3rd Edition (ABAS-III; Harrison and Oakland 2015), which indicated his adaptive skill performance falls within the extremely low range. Carter received speech therapy two times per week for 30-min sessions and occupational therapy one time per week for a 30-min session. Based on teacher report, Carter required verbal and gestural prompts to complete functional life skill tasks. He also needed frequent redirection to remain on task and required a high level of supervision throughout the school day. During the pre-assessment, Carter performed 0% of the steps for applies deodorant, 9% for brushes teeth, and 9% for washes face.

Maxwell, a 17-year-old male, had a previous diagnosis of ASD. He did not use vocal speech and based on teacher report did not have a communication system in place. Information gathered from his IEP indicated that he obtained a score of 32 on the Vineland Adaptive Scales, 2nd Edition (Vineland-II; Sparrow et al. 2005), which indicated severely deficient adaptive behavior. Maxwell received speech therapy two times per week for 30-min sessions and occupational therapy one time per week for 30-min. Based on teacher report, Maxwell had minimal independent skills and was dependent on staff to complete most tasks throughout the school day. Specifically, Maxwell needed hand-over-hand prompting to complete functional life skill tasks. Results of the pre-assessment indicated Maxwell did not perform any steps correctly for any of the tasks.

The third student, Robert, was also a 17-year-old male with a previous diagnosis of ASD. Robert did not use vocal speech and communicated his immediate wants and needs using an iPad mini with the application Proloquo2Go. Information gathered from his IEP indicated that he obtained a score of 47 on the ABAS-III (Harrison and Oakland 2015), which translated to an extremely low adaptive performance level. He received speech therapy, occupational therapy, and physical therapy two times per week for 30-min sessions. Teacher reports indicated that Robert needed constant prompting to complete functional life skill tasks. Additionally, Robert required a one-to-one aide during the school day due to his limited skill set as well as high rates of problem behavior (e.g., bangs head, bites hand, pinches others); however, during the time of the experimental study, Robert did not engage in any instances of problem behavior. During the pre-assessment, Robert performed 25% of the steps for applies deodorant, 0% for brushes teeth, and 0% for washes face.

Sessions took place in an empty classroom at a large rectangular table located in the middle of the room and in a small bathroom. All sessions occurred between the hours of 8:30 am and 12:00 pm. The students worked individually with the experimenter with no other students present in the classroom. The first author served as the experimenter for the present study and implemented all experimental conditions. At the time of the study, the first author was a doctoral candidate in special education and held a master's degree in applied behavior analysis. The first author was also a board certified behavior analyst and had 12-year experience working with students with ASD.

Materials

Student materials included a toothbrush, toothpaste, face wash, a small washcloth, deodorant, and teacher identified rewards (e.g., candy, small donut or cookie, iPad) for participating. For the video modeling condition, students viewed videos on an Apple fourth-generation iPad. The device was 9.5 × 7.31 × 0.37 inches in size and contained a 64 GB storage capacity. The experimenter used an Otterbox Defender Series Case to hold the iPad to prevent damage to the device. Additional materials included a digital timer, a tagger (i.e., small handheld device that makes a click sound when pressed), data collection sheets, procedural integrity checklists, an assessment schedule, and laptop computer with video capability for recording all sessions.

Video Modeling Videos

The experimenter created a video for each of the targeted tasks (i.e., brushes teeth, washes face, applies deodorant) using recommendations from previous research. A familiar male staff member of the school the students attended served as the model for all three videos. The experimenter chose to use a familiar adult based on past research demonstrating adults served as effective models (McCoy and Hermansen 2007) and respond quickly to training and direction (Miltenberger and Charlop 2015). In addition to the model, another male staff member served as a narrator to provide verbal instructions for steps within the video.

The experimenter filmed the videos from a third person perspective (i.e., viewing a model performing the task) using an Apple fourth-generation iPad with a 64 GB storage capacity. For two of the three videos (i.e., applying deodorant, brushing teeth), the model looked directly into the camera. However, due to constraints of the setting, the filming of face washing occurred from an angle with the model facing the sink/mirror. Each video consisted of the narrator delivering a one-sentence verbal instruction (e.g., "put deodorant on armpit") for each step. After each instruction, the model demonstrated the target behavior at a very slow pace, as suggested by previous research (e.g., Charlop and Milstein 1989).

Response Measurement and Accuracy

Dependent Variable

The frequency of steps performed correctly on a task analysis for each of three target behaviors (i.e., brushes teeth, washes face, applies deodorant) served as the response measure or dependent variable. Prior to the beginning of the study, the experimenter task analyzed each of the three tasks (i.e., brushes teeth, washes face, applies deodorant) into multiple steps (see Table 1). In the present study, the experimenter targeted the movement cycle for each task and eliminated steps related to deficits in fine motor skills (i.e., unscrewing cap of toothpaste and face wash, pulling off top of deodorant). The experimenter counted the number of steps performed correctly and used a count up procedure to monitor the elapsed time

Table 1 Task analysis for target behaviors

Applies deodorant	Brushes teeth	Washes face
1. Picks up deodorant	1. Picks up toothbrush	1. Puts hands under water
2. Uses other hand to reach down and grasp bottom of shirt on same side	2. Puts toothbrush into mouth on left side	2. Removes hands from water
3. Lifts shirt up toward shoulder	3. Brushes bottom teeth on left side 5 times	3. *Experimenter pumps soap into palm of students hand
4. Puts deodorant on armpit	4. Brushes top teeth on left side 5 times	4. Rubs soap over entire face 3 times
5. Moves deodorant up and down 3 times	5. Moves brush to right side of mouth	5. Puts hands under water
6. Pulls shirt down to waist	6. Brushes bottom teeth on right side 5 times	6. Splashes water on face and rubs
7. Moves deodorant to other hand	7. Brushes top teeth on right side 5 times	7. Puts hands under water
8. Uses other hand to reach down and grasp bottom of shirt on same side	8. Moves brush to front of mouth	8. Splashes water on face and rubs
9. Puts deodorant on armpit	9. Brushes front teeth 5 times	9. Picks up wash cloth
10. Moves deodorant up and down 3 times	10. Takes brush out of mouth	10. Wipes wash cloth over face 2 times
11. Pulls shirt down to waist	11. Puts brush down on sink	11. Put wash cloth down on sink
12. Put deodorant down on sink		

during each assessment. The trial ended if the student did not initiate the task within 30 s or complete subsequent steps within 30 s of a previous step. Additionally, the steps of the task did not require a lockstep order, as specified in the task analysis, for a correct score. For example, with the teeth brushing task, a student would be given credit for having completed step 7 (i.e., brushes top teeth on right side five times) if the student successfully brushed his top teeth on the right side at any time during the assessment.

Accuracy

In order to calculate the accuracy of the dependent variable, the experimenter video recorded each experimental session. The recorded video sessions and the scores derived from the video represented the true value. After the experimenter viewed the video recordings for data collection purposes, a second observer viewed each video to determine the extent to which observed scores corresponded to a true value (Johnston and Pennypacker 2009). If the observed score did not match the true value, the experimenter recorded it as inaccurate. The accuracy of the dependent measure came to 98%.

Independent Variable and Procedural Integrity

Independent Variable

TAGteach and VM functioned as the two independent variables for the present study. A control condition (i.e., no instruction or feedback) also occurred along with the two independent variables. The control condition served as a comparison and evaluation for the other two interventions.

TAGteach

Intervention 1 consisted of a 5-min instructional session using TAGteach. TAGteach involved use of an acoustical signal (i.e., short, sharp sound) to mark successive approximations to the target behavior. The experimenter used the task analysis of each behavior to identify initial and intermediate behaviors to serve as approximations during the instructional sessions.

Video Modeling

The second intervention involved a 5-min instructional session using a VM procedure. VM sessions included the student viewing a video of someone modeling the entire skill sequence for the specified task. Immediately following, the student had an opportunity to imitate the behaviors modeled in the video. After providing the student with an opportunity to complete each step of the task, the experimenter represented the iPad and played the video again.

Procedural Integrity

To assess procedural integrity, the experimenter developed a checklist specifying the procedural methods described below. A second observer viewed 25% of randomly selected videotaped sessions for each student and recorded whether or not the experimenter correctly implemented each procedural step in its proper sequence. The procedure for calculating procedural integrity consisted of dividing the number of procedural steps correctly completed by the total number of possible steps and multiplying by 100 (Gast 2010). Procedural integrity came to 95% (range: 89–100%) for Carter, 98% (range: 89–100%) for Maxwell, and 98% (range: 89–100%) for Robert.

Experimental Design

The current study used a single-case experimental design called an adapted alternating treatments design (AATD; Wolery et al. 2010) to examine the effects of the TAGteach and VM. The AATD allows the experimenter to apply the interventions to two or more different but equally difficult, independent behaviors or skills. By systematically alternating the two instructional methods (i.e., VM, TAGteach) and control condition, the design isolates the influence of the independent variable assigned to each condition.

The present study consisted of three conditions including (a) control condition, (b) TAGteach condition, and (c) VM condition. The control condition served to assess possible multiple treatment interference (threat to internal validity), the effects of history and maturation, and to provide intrasubject replication (Wolery et al. 2010). Each student was taught a different skill within each condition, and the experimenter randomly selected the presentation order of the conditions each day to minimize the possibility of sequencing effects (see Table 2).

The authors conducted a logical analysis in order to ensure the tasks contained equal response difficulty. A logical analysis entails matching the tasks on the number and nature of the discriminations students would need to make as well as on the number and nature of the actual movements necessary to perform the task. If the discriminations and response requirements appear similar across tasks, those tasks are considered equally difficult (Holcombe et al. 1994). Two behavior analysts and one special education teacher with at least 5-year experience independently rated the tasks and deemed them equivalent based on the number of steps and response requirements (Wolery et al. 2014).

Procedure

Control Condition

The experimenter set up all materials needed to complete the task and positioned the student in front of the task materials. The experimenter then provided the instruction to engage in the specified task (e.g., "Wash your face"). After delivering the instruction, the experimenter started the timer. The experimenter did not provide any prompts or feedback for correct or incorrect responses during the control condition. The trial ended if the student did not initiate the task within 30 s or complete subsequent steps within 30 s of a previous step.

TAGteach Condition

The experimenter set up all materials needed to complete the task and positioned the student in front of the task materials. The instructional session began with the vocal instruction to start the specified task (e.g., "Brush your teeth") and activated a timer

Table 2 Intervention schedule

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12
CT, 2, 1	2, 1, CT	1, CT, 2	2, 1, CT	1, CT, 2	CT, 2, 1	1, CT, 2	2, 1, CT	CT, 1, 2	1, 2, CT	2, CT, 1	CT, 1, 2

CT: control; 1: TAGteach; 2: video modeling set for 5 min. The experimenter used a handheld device (i.e., tagger) that produced a short, sharp sound to mark successive approximations to each target behavior in the chain using a forward chaining procedure.

During the instructional session, the experimenter marked the initial response each time it occurred and withheld marking other responses until the student performed the initial behavior consistently (i.e., three times consecutively in one session). The experimenter then shifted the criterion from marking the initial behavior to tagging the intermediate behavior. For instance, during the TAGteach condition for the task of applies deodorant, the experimenter began by marking the initial behavior of “moves hand toward deodorant.” After the student performed the initial behavior three times in a row, the experimenter withheld the auditory stimulus for the initial behavior and waited for the student to engage in the next approximation (i.e., puts hand on deodorant). When the student placed their hand on the deodorant, the experimenter pressed the tagger, delivering the auditory stimulus.

If after 1-min the student did not make any movements that successively approximated the behavior, the experimenter removed the instructional materials and conducted a 15-s distraction trial. During the distraction trial, the experimenter activated a vibrating timer pre-set for 15 s and allowed the student to stand up from their chair or leave the bathroom and walk around the room. When the timer vibrated, the experimenter directed the student to sit back in their chair or return to the bathroom and presented the materials to the student. The experimenter then delivered the instruction to engage in the task and began marking the approximation again. The procedures continued until the timer sounded, signaling the completion of the instructional session.

Following the TAGteach instructional session, the experimenter asked the student to perform the skill again in order to assess performance on the dependent variable. After delivering the instruction to complete the task (i.e., “Wash your face, brush your teeth, put on deodorant”), a count up timer captured the elapsed time. During the assessment, the experimenter did not provide the auditory stimulus or any other feedback. The assessment ended when the student performed the last step of the task or if the student did not engage in any of the target behavior steps for 30 s. Immediately following the intervention, the student received a preferred tangible item regardless of how well he performed during the assessment.

Video Modeling Condition

The experimenter set up all materials needed to complete the task (e.g., iPad, deodorant) and directed the student to sit in a chair at the table in front of the iPad. The experimenter initiated the session by providing the instruction to watch the video of the model performing the task (i.e., “watch the video”), pressing play, and starting a timer set for 5-min. If the student looked away from the screen, stood up, and/or walked away from table, the experimenter immediately provided a verbal or gestural prompt to redirect the student back to the video. Delivery of verbal praise occurred contingent upon attending to the iPad screen (e.g., “Good job watching the video”).

Immediately after video presentation, the experimenter set the iPad aside and placed the materials needed to complete the task in front of the student. The experimenter then provided the verbal instruction, “Do what you saw in the video.” When the student completed a step accurately, the experimenter delivered behavior specific verbal praise corresponding to the particular step (e.g., “good job picking up the deodorant”). If the student failed to perform a step after 10 s, the experimenter completed the step for the student. If the student performed a step inaccurately, the experimenter did not deliver corrective feedback. During instruction, the experimenter did not provide any additional prompts. After providing the student with an opportunity to complete each step of the task, the experimenter showed the video again. The procedure continued until the timer sounded indicating the end of the instructional session.

The experimenter used the same procedure to assess the students’ performance on the dependent variable as in the control and TAGteach conditions. During the assessment, the student did not receive a video model or any other type of feedback. Immediately following the assessment, the student received a preferred tangible item regardless of how well he performed during the assessment.

Data Display

All data appear on segments of Standard Celeration Charts or SCC (Graf and Lindsley 2002; Pennypacker et al. 2003). Figures 1 and 2 display key features from the SCC. The SCC provides an accurate depiction of changes in behavior over time and displays behavior change proportionately. Additionally, the SCC quantifies changes in behavior and produces precise, numerical measures. The following measures supplement visual analysis on the SCC: Level and Celeration.

Level

Level represents the mean performance for the frequency of steps performed correctly for each target behavior. In order to calculate the level, the experimenter employed a method using the geometric mean (Kubina et al. 2017). Advantages to using the geometric mean include (a) regulation of the range of numbers calculated so one set of numbers does not have more weight than another set of numbers, and (b) minimization of the influence of very small or very large numbers that can skew data (Clark-Carter 2005).

Level Comparison Analysis

In the present study, a Level Comparison revealed the difference in levels (average performance) of the frequency of correct steps to the frequency of correct steps between control and the experimental conditions. To calculate the difference, the larger value divided by the smaller value produced a quotient. The quotient then takes on the multiply or divide sign of the greater initial value depending on the positions of the two compared levels. For example, a student produces a level of 5 for frequency of correct steps during the control condition and a level of 8 for

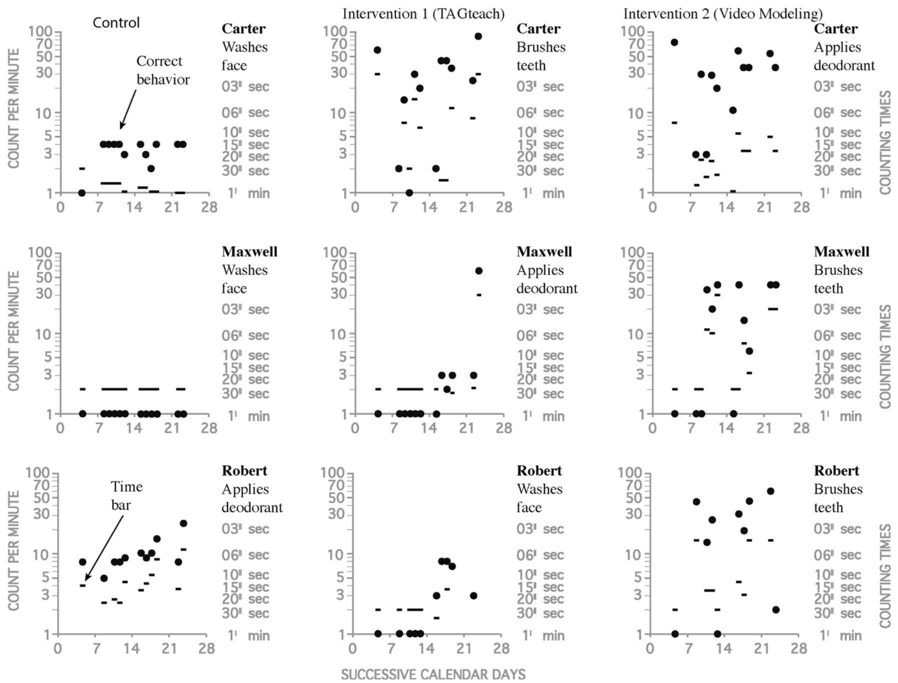

Fig. 1 Frequency of correct steps per minute

frequency of correct steps during an experimental condition. The Level Comparison, or difference in mean performance between the student's control and experimental condition performance equals a ×1.6 (60%) average difference in the frequency of steps correct (i.e., 8 ÷ 5 = 1.6; apply the × sign because the intervention produced corrects occurring ×1.6 greater than the control condition).

Celeration

Celeration describes the change in frequency of responding over time (Johnston and Pennypacker 2009). As an example, a student performs 4 correct responses per min on Tuesday's assessment and then accelerates to 6 per min on the following Tuesday's assessment, will produce a celeration value of ×1.5, a 50% weekly growth rate. Another student who accelerates from 4 correct responses per min to 8 per min will double his or her performance and as a result produce a celeration value of ×2.0 or a 100% weekly growth rate.

Celeration Comparison Analysis

The Celeration Comparison Analysis quantifies the differences in speed when comparing the frequency of correct steps for the control and the experimental conditions. In addition to accounting for the speed differences, the Celeration Comparison Analysis calculation must account for the directions of the celerations.

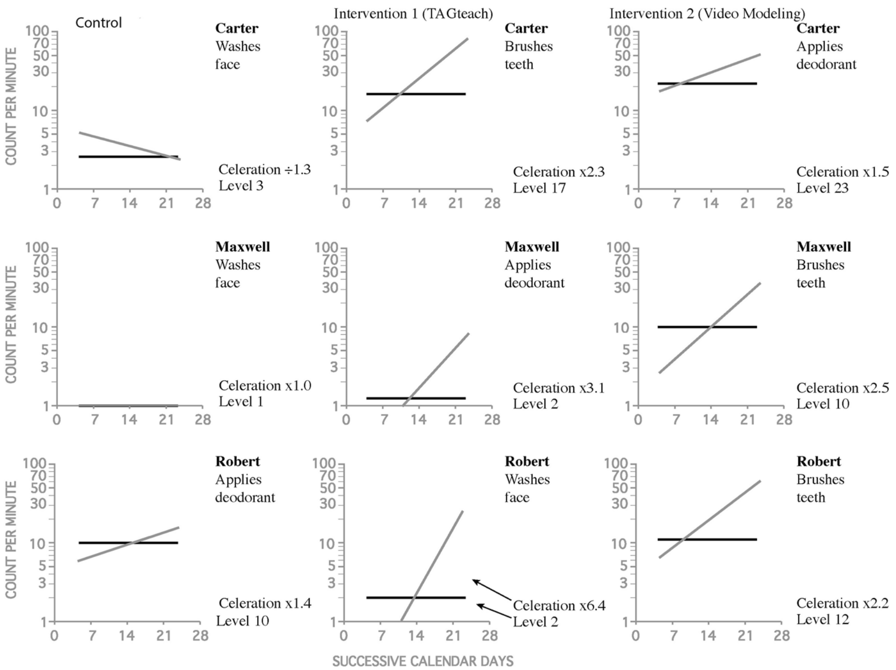

Fig. 2 Celeration lines and level lines

Hence, the calculation includes the following rules: if both celeration values have the same sign (i.e., both × or both ÷), divide the larger value by the smaller value and use the sign that indicates the comparison of the change (i.e., if the resulting change from the control condition to intervention became faster, an × sign would appear; for cases where the speed declined, a ÷ sign would appear).

On the other hand, if the celeration values have different signs (i.e., × to ÷ or ÷ to ×), the rule states to multiply the values together and apply the sign signifying the speed difference (i.e., × for accelerating speed difference or ÷ for decelerating speed difference). For instance, a student with a celeration of ×1.0 for frequency of correct steps during the control condition also has a celeration of ×2.0 for frequency of correct steps during the experimental condition. The Celeration Comparison, or speed comparison, of the student's control and experimental condition performance equals ×2 (i.e., 2.0 ÷ 1.0 = 2; apply a × sign because the speed accelerated when contrasting the control condition to intervention). Therefore, a ×2 signifies the speed comparison of the intervention value occurred twice as fast, or ×2 faster, when compared to the control condition.

Social Validity

The experimenter conducted informal interviews with the two classroom teachers and two teaching assistants from each classroom at the conclusion of the study. The questions posed in the interview mainly addressed the acceptability of the procedures used, the acceptability of the results (Wolfe 1978), and the staff's use of the procedures in the future.

Results

Table 3 includes all of the performance outcomes for each student for level and celeration. Table 4 provides the Level and Celeration Comparison Analysis for the control condition versus Intervention 1 (TAGteach) and the control condition versus Intervention 2 (VM). Figure 1 displays celeration (or trend) on segments of the SCC. Figure 2 separately shows the celeration and level lines on segments of the SCC for each student.

Traditionally when using an AATD each student's data would appear on one graph. In the present study, due to similar conventions (i.e., time bars, dots for acceleration data) of the SCC, placing all data on one graph would confuse the visual analysis. Furthermore, the separation of data into separate tiers clearly shows the effects each condition had on behavior and allows for straightforward comparisons. In Fig. 1, the black dots represent correct performance frequencies. The small horizontal dashes, or time bars, display the time interval for the measured behavior.

In order to calculate the "per minute" frequency, one must multiply the number of corrects by the time bar value. The time bar value appears visually and mathematically. For example, in the bottom tier of Fig. 1, the time bar appears at 15 s (i.e., the time Robert spent performing the behavior occurred in 15 s). The time bar sits on the 4 line represented by a tick in between 3 and 5. Because four 15-s intervals occur in 1-min, the time bar rests on the 4 line. All time bars on the SCC follow the same convention. A time bar for 30 s will appear on the 2 line. The subsequent data, then, measured in the original time interval also undergo multiplication to display a count per minute. In Fig. 1, Robert's performance data of 2 in 15 s transforms into 8 per min (i.e., $2 \times 4 = 8$). The SCC displays all behavior as a "per minute" frequency in order to facilitate comparisons while

Table 3 Student change measures

	Condition	Skill	Level	Celeration
Carter	Control	Washes face	3	÷1.3
	TAGteach	Bushes teeth	17	×2.3
	Video modeling	Applies deodorant	23	×1.5
Maxwell	Control	Washes face	1	×1.0
	TAGteach	Applies deodorant	2	×3.1
	Video modeling	Bushes teeth	10	×2.5
Robert	Control	Applies deodorant	10	×1.4
	TAGteach	Washes face	2	×6.4
	Video modeling	Brushes teeth	12	×2.2

Table 4 Comparison analysis

	Condition	Level Comparison	Celeration Comparison
Carter	Control compared to…		
	TAGteach	×5.7	×3.0
	Video modeling	×7.7	×2.0
Maxwell	Control compared to…		
	TAGteach	×2.0	×3.1
	Video modeling	×10.0	×2.5
Robert	Control compared to…		
	TAGteach	÷5	×4.6
	Video modeling	×1.2	×1.6

maintaining the integrity of the real time measurements communicated by the time bars.

Figure 2 displays the level lines and celeration lines as they would appear on the data in Fig. 1. The gray lines indicate the level, determined by the geometric mean, of frequency of steps performed correctly for each condition and student. The black lines indicate the celeration and offer a visual representation of how quickly the performance frequencies grew or decayed during each condition. Presenting level and celeration lines together creates a visual reference for the average performances and rate of change, respectively, for the separate conditions for each student.

Performance Outcomes

Level

During the control condition, Carter produced an average of 3 responses during the task of face washing. During the TAGteach condition, Carter averaged 17 responses for teeth brushing and a mean of 23 responses during the VM condition for applying deodorant. Maxwell produced on average 1 response during the control condition for the task of face washing. During the TAGteach condition, Maxwell averaged 2 responses for applying deodorant and an average of 10 responses during VM for teeth brushing. Robert had an average of 10 responses in the control condition for the task of applying deodorant. During TAGteach, Robert produced an average of 2 responses for face washing and an average of 12 responses during the VM condition for teeth brushing.

Celeration

Celerations for the frequency of steps performed correctly ranged from ÷1.3 (23% decay rate in corrects) to ×6.4 (540% weekly change rate) over all conditions of the experiment. All three students produced the largest gains in celeration via TAGteach intervention. Carter's behavior decelerated at ÷1.3 (23% weekly decay) in the control condition. During this condition, the time it took for Carter to perform the steps of the task increased; the time bars show a trend of longer counting times across the condition. On the SCC, Fig. 1, as the time bar moves lower on the chart that means the time is becoming longer. The "Counting Times" shown on the far right of Fig. 1 display the time intervals. However, during TAGteach and VM conditions, his behavior accelerated at ×2.3 (130% weekly growth) and ×1.5 (50% weekly growth), respectively. During the VM condition, the time it took for Carter to perform the steps of the task lessened, meaning he performed steps of the task more quickly than he had at the beginning of the condition.

Maxwell produced a flat celeration or trend for frequency of steps correct of ×1.0 during the control condition. The time bars displayed no trend, indicating that Maxwell became neither faster nor slower at performing steps of the task across the condition. During the TAGteach condition, Maxwell's behavior grew by ×3.1 (210% weekly growth). In the VM condition, Maxwell's behavior grew by ×2.2 (120% weekly growth) and across the condition Maxwell took less time to perform the steps of the task as indicated by the time bars moving upward on the chart toward the end of the intervention.

Robert produced a celeration of ×1.4 (40% weekly growth) during the control condition and the time required to perform steps of the task lessened across the condition. During TAGteach condition, Robert's behavior grew by ×6.4 (540% weekly growth). Robert's behavior grew by ×2.2 (120% weekly growth) during the VM condition, and the time bars show a trend of efficiency across the condition (i.e., lessening of time).

Comparison Analysis

Level Comparison

Carter had a ×5.3 (430% more than control) higher average level of responding for TAGteach and ×7.7 (620% more) for VM when compared to the control condition. Maxwell also had a higher average rate of responding as indicated by the Level Comparison value of ×2.1 (110% more) for TAGteach and ×10.0 (900% more) for VM compared to the control condition. Robert's average response rate from control to TAGteach differed by ÷5 (80% less) but produced a higher average level, ×1.2 (20% more) in VM compared to the control condition.

Celeration Comparison

For Carter, celeration during the TAGteach condition occurred 3 times faster than celeration in the control condition and celeration in VM condition occurred 2 times faster than in the control condition. For Maxwell, celeration occurred 3.1 times faster in TAGteach condition when compared to the control condition and 2.5 times faster in VM condition compared to the control condition. Robert's celeration in the TAGteach condition occurred 4.6 times faster than in the control condition and 1.6 times faster in VM condition compared to the control condition.

Social Validity

Results from the informal interviews with the two teachers and four teaching assistants indicated the staff members all had favorable opinions concerning the VM and TAGteach interventions. Overall, the teachers and teaching assistants felt the procedures used were acceptable for their students. All respondents agreed both procedures helped the students improve their performance on the targeted daily living skills. In addition, the majority of the respondents agreed they would like to implement VM and TAGteach in the future; however, they indicated they would feel more comfortable implementing the instructional methods if provided instruction first.

Discussion

The present experiment examined the effects of two interventions (i.e., TAGteach and VM) on the acquisition of daily living skills among adolescents with ASD. The experimenter used visual and quantitative analysis derived from the SCC to evaluate the present study. In the present study, the intervention effects favored the VM and TAGteach conditions with data indicating an improvement in performance for all three students when compared to the control condition.

During the control condition, Carter displayed a worsening of performance on the frequency of steps completed correctly and Maxwell had a stable trend indicating the behavior neither grew nor decayed during the condition. Following intervention, both students showed strong, positive changes in celeration and mean of steps performed correctly. Carter had a $\times 3.0$ and $\times 2.0$ speed differential in frequency of correct steps for TAGteach and VM when compared to the control condition as indicated by the Celeration Comparison. In other words, the speed at which Carter learned his self-care skills occurred three times and two times, respectively, TAGteach and VM, faster when compared to the control condition. Using the same comparison, Maxwell had a $\times 3.1$ and $\times 2.5$ faster growth rate when comparing TAGteach and VM to the control condition. All measures demonstrate a meaningful difference in speed of learning when compared to the control condition.

Robert did have an accelerating trend in the control condition, but the AATD does not demand the absence of trend. The comparative design contrasts the control condition with subsequent intervention condition. In Robert's case, his behavior in the control condition grew, but the Celeration Comparison demonstrated that the behavior grew even faster in the TAGteach and VM conditions. Therefore, when comparing TAGteach and VM, both had accelerative effects on self-care skills. By growing self-care skills, an individuals' potential to flourish in educational, vocational, and domestic settings dramatically increases as well as improves one's quality of life (Shrestha et al. 2013).

The other change statistic supporting intervention conditions over the control condition appear in the Level Comparison. The level communicates the average number of responses a person exhibits in a condition. The Level Comparison, then, conveys the magnitude of level changes. Only one student had a significant level difference for TAGteach (i.e., Carter). All three students demonstrated notable differences in the average number of steps completed in their self-care skills when compared to the control condition. Existing research shows strong evidence for VM (e.g., Allen et al. 2010; Miltenberger and Charlop 2015; Shipley-Benamou et al. 2002) and the present study further supports such a conclusion.

The differentiation between the control condition, TAGteach, and VM demonstrated that experimental effects occurred. The greater contrast in performance seen between the control and experimental conditions, the more confidence one has that the intervention had an effect on student performance (Sindelar et al. 1985). Although TAGteach produced faster changes in behavior compared with VM, VM still had celeration values that fell in the robust (i.e., Carter, ×1.5) to massive growth range (Robert and Maxwell, ×2.5 and ×2.2; Kubina and Yurich 2012). Additionally, VM consistently produced a greater number of average responses for all three students. Therefore, the results suggest that TAGteach may hold value for teaching self-care skills and provide further support of VM.

Beyond the direct intervention effects, the findings of the present study add to previous research that supports the use of VM for individuals with ASD (e.g., Gardner and Wolfe 2013; Hong et al. 2016). All three students in the current study produced larger gains with VM when compared to the control task condition. Therefore, the findings lend further support for the use of VM to improve performance of daily living skills for students with ASD.

The findings also contribute to the literature on TAGteach. To date, the experimenters represent the first to use TAGteach to improve performance on daily living skills. Although observation of improvements in performance occurred with implementation of TAGteach, we cannot conclude that TAGteach represents an effective method to teach daily living skills. However, the results of the present study prove encouraging and warrant further exploration of TAGteach.

Limitations

Although the results of the present experiment appear promising, several limitations exist. The present study used a pre-assessment criterion of the student performing 30% or less of the specified task. Due to this criterion, the students could have some of the skills already in their repertoire. For example, Robert entered the study with one skill (i.e., applying deodorant) somewhat in his repertoire (25%). Therefore, the level for this skill started out higher than the other two skills, thus making comparison difficult when trying to compare skills that were higher than other skills from the start.

Furthermore, all three students improved performance, yet none of the students achieved criterion (i.e., acquired all of the steps of the tasks) during either the TAGteach or VM condition. The experimenter conducted the study at the end of the school year, and as a result, experimental sessions only took place for 10–12 days suggesting that TAGteach and VM may have improved performance for the majority of the students; however, increasing the length of intervention may have led to more robust performance gains. Additionally due to time constraints, the experimenter was unable to collect maintenance or generalization measures.

Therefore, durability as well as demonstration of the skills across settings and contexts within the student's natural environment remains unclear.

Another potential limitation includes the fact that the experimenter did not teach the entire skill sequence. The experimenter focused on teaching the steps of each task that comprised the movement cycles related to the targeted skill (i.e., brushes teeth). Therefore, even if the students had performed all the steps identified in the task analyses, they would not have reached full independence with the tasks.

Future Directions

The ability to independently perform daily living skills represents one of the key components necessary for individuals with ASD to make a more successful transition into adulthood. The present study sought to examine the effects of VM and TAGteach to improve performance on daily living skills for adolescents with ASD. The findings suggest that both VM and TAGteach interventions demonstrated accelerated effects when compared to the control condition; however, none of the students independently performed all the steps of the tasks. Additionally, the experimenter did not teach the entire skill sequence due to fine motor skill deficits, thus limiting the student's ability to obtain full independence on the targeted tasks. Therefore, future research should continue to build the support base for VM to teach self-care skills as well as further explore the efficacy of TAGteach. Moreover, future research should investigate effective instructional methods to remedy fine motor skill deficits, which may impede student's ability to complete daily living skills tasks independently.

For daily living skills, ensuring generalization and maintenance of acquired skills proves critical, as individuals primarily need these behaviors within natural settings. However, individuals with ASD often have difficulty generalizing and maintaining skills over time (Weiss et al. 2008). Hence, identifying and evaluating instructional methods that promote generalization and produce long-lasting behavior change remains an important task for experimenters. Future research should strive to examine the generalization and maintenance of skills learned via VM and TAGteach in order to identify methods that will lead to larger effects in the sustained use of daily living skills for individuals with ASD.

In the present study, the experimenter implemented the instructional methods outside of the typical classroom environment. Based on the social validity assessment, the teachers and teaching assistants indicated they would be willing to use VM and/or TAGteach; however, they expressed the need for training. Therefore, future research should investigate the effects of training teachers to implement the interventions and analyze the feasibility of using TAGteach and VM within the natural classroom environment.

Implications for Practice

The results of the present study have implications for practicing teachers. The experimenter used the SCC, which permitted calculation of celeration, or the speed in which behavior changed (Graf and Lindsley 2002; Lindsley 2005; Pennypacker et al. 2003). As a result, the experimenter numerically quantified how fast the students learned their self-care tasks. For instance, the results demonstrate that both VM and TAGteach produced robust changes in learning (range: ×1.5 to ×6.4) within a short duration of time (i.e., 2 weeks). Considering the increasing needs of adolescents with ASD and the limited instructional time available, using celeration to identify a students' rate of learning could better help teachers guide their decision-making as well as assess the significance of behavior change (Kubina and Yurich 2012).

In addition, teachers should keep in mind that although VM has been identified as an effective practice for students with ASD (Wilczynski et al. 2009), an evidence base for use of TAGteach with individuals with ASD does not currently exist. The findings of the present study provide preliminary data that suggest TAGteach may help improve performance with daily living skills; however, replication of these results is needed. Therefore, one should interpret the results with caution and consult the evidence base before selecting an instructional method to teach daily living skills to students with ASD.

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Compliance with Ethical Standards

Conflict of interest No conflict exists between the two authors.

Ethical Approval All procedures performed in studies involving human participants 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.

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

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