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ORIGINAL PAPER

Teaching Science Facts to Students with Autism Spectrum Disorders via Telehealth

Uzeyir Emre Kiyak[1] · **Ozlem Toper**[2]

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Abstract

The interruption in the education of students with autism spectrum disorders (ASD) during the COVID-19 pandemic has necessitated telehealth services offered both to the individuals and their parents. Therefore, this study aimed to examine the effects of the simultaneous prompting procedure and observational learning in teaching science facts to middle-school students with ASD by using multiple probe designs with probe trials via telehealth. The researchers also conducted follow-up and novel adult probe sessions to assess the effects of simultaneous prompting procedure and observational learning along with the opinions of students and their mothers in terms of social validity. Results indicated that students acquired the target science facts and observational learning skills, maintained them over time, and generalized them across different people. The implication of the findings and directions for future research was additionally discussed.

Keywords Simultaneous prompting · Observational learning · Telehealth · Autism spectrum disorders · Science facts · Academic skills

Introduction

The novel coronavirus disease (COVID-19) interrupted the education system all around the world. As the continuity of services delivered to them is vital, this interruption caused many problems in meeting the complex learning needs and individualized education program (IEP) goals of the students with autism spectrum disorders (ASD) (Tekin-Iftar et al., 2021). The education systems of almost all countries across the globe switched to distance education not only for general education but also for special education schools (Yazcayir & Gurgur, 2021). With the help of the

✉ Uzeyir Emre Kiyak
uzeyiremre@gmail.com

[1] Department of Special Education, Usak University, Usak, Turkey

[2] Department of Special Education, Bursa Uludag University, Bursa, Turkey

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recent advancements in technology, telehealth practices have begun becoming an alternative context to deliver instruction (Unholz-Bowden et al., 2020) utilizing distance education which can be realized via TV programs, asynchronous web-based lessons, or telehealth practices (Tekin-Iftar et al., 2021).

Past research on telehealth services in the provision of behavioral interventions has largely focused on caregiver training in the treatment of challenging behavior (Lerman et al., 2020; Wacker et al., 2013). To date, only three studies have used telehealth to directly teach skills to individuals with developmental disabilities (Ferguson et al., 2020; Nohelty et al., 2021; Pellegriono & DiGennaro Reed, 2020). This represents a critical need for research as the transition to telehealth-based services impacted educators' access to evidence-based instructional strategies.

Previous research supports the use of simultaneous prompting (SP) procedures to teach academic skills to students with ASD (e.g., Akmanoglu & Batu, 2004; Pennington et al, 2014). A typical SP procedure includes daily probe and training trials. Daily probes serve as an assessment of the student's acquisition of the target relations. During probes, correct responses result in reinforcement, while incorrect/no responses are ignored. During training trials, the controlling prompt is immediately presented after the task direction on all trials. The prompt is never faded during training trials and training continues until the student's performance on daily probes meets the mastery criterion (Collins, 2012). A recent review and meta-analysis by Tekin-Iftar et al. (2019) indicate that SP should be considered an evidence-based practice (EBP) as it has been shown to (a) be effective in teaching a wide range of skills including academic skills, (b) produce similar levels of maintenance and generalization to other prompting procedures, and (c) be implemented with high procedural fidelity by different stakeholders (e.g., parents, peers). Nevertheless, gaps in the research on SP exist, including with middle-school aged participants that include grade-appropriate content domains (e.g., science, history).

When using evidence-based instructional practices, such as SP, instruction would ideally be presented to as many students as possible. Small-group instruction, consisting of at least two students and no more than 10 students, may increase instructional efficiency by arranging for conditions that may support observational learning (Collins et al., 1991; Tekin-Iftar & Birkan, 2010; Tekin-Iftar & Olcay-Gul, 2017). Observational learning is defined as "learning based on observing the responding of another organism (and/or its' consequences)" (Catania, 2006, p. 399). Previous research has shown that students with ASD may exhibit performances consistent with observational learning (e.g., Brown & Whiten, 2000; Garfinkle & Schwartz, 2002; Griffen et al., 1992; Leaf et al., 2012; Ozen et al., 2012; Tekin-İftar & Birkan, 2010). However, only one study has examined observational learning outcomes by students with ASD during small-group instruction using SP (Tekin-Iftar & Olcay-Gul, 2017).

The purpose of the current study was to evaluate the efficacy of SP when teaching science content to students with ASD via telehealth during dyadic instruction. The following research questions were addressed in this study: (a) will the SP procedure delivered via telehealth be effective in teaching science content to students with ASD?, (b) will students with ASD learn the target academic skills when observing instruction being delivered to a peer consistent with observational learning?, and (c)

how will the participants and their mothers respond to questions regarding the social validity of the study?

Method

Participants

Three participants with ASD were recruited through social media advertisements. All participants attended a special education and rehabilitation center for 2 h a week to receive support services in academic, daily living, and social skills and had a diagnosis of ASD. Participants were included if they were able to (a) follow directions, (b) reply to short questions, (c) attend to visual and/or audio stimuli for at least 5 min, and (d) to provide a relevant response to questions regarding a short essay. The Gilliam Autism Rating Scale-2 Turkish Version (GARS-2 TV [Diken et al., 2012]) was conducted by the first author with each of the participants' mothers. The participants had not previously received instruction using SP.

All participants were male, between the ages of 13 and 14 years old, and received scores on the GARS-2 TV indicating that they were "very likely of having ASD." Kaya's and Mehmet's individualized education plan (IEP) included goals in science-related content domains including the universe, galaxy, plants, and living creatures. Ali's IEP included goals in organ systems, living creatures, and reflection of light. Additionally, the experimenter conducted a sixth- and seventh-grade curriculum assessment with the participants. Each participant exhibited sub-mastery levels of performance on this assessment.

Settings and Materials

All sessions were conducted remotely using Zoom™ using the experimenter's personal computer. The participants were instructed to use a quiet room in their home. The participant's parent was present for all sessions, and the participant used their parent's mobile phone to connect to the Zoom session.

Experimental Design

The researchers used a multiple probe design across participant dyads, to evaluate the effectiveness of the SP procedure in teaching science content to students with ASD. Specifically, SP was introduced during instruction for a single participant, while another participant was present in the Zoom™ call as an observer (e.g., dyad 1). Following mastery, instruction was introduced in the second panel (e.g., dyad 2).

Dependent Variable and Response Measurement

All data were recorded using a paper-and-pencil data collection system. The dependent variable of the study was the percentage of the correct responses during

daily probes. A correct response was defined as the participant emitting the defined response given the target antecedent (see Table 1). Prompted correct responses were defined as the participant emitting the target response within 4 s of the echoic prompt. Only prompted correct responses were possible during training. The mastery criterion was set at 100% correct responses for three consecutive daily probes.

Baseline

Baseline sessions were conducted with each participant individually and included each training and observational target presented three times for a total of 24 trials. Each session began with an attentional cue (e.g., "…, are you ready?"); after receiving an affirmative response from the participant, the experimenter presented the task direction (e.g., "Tell me the organs in the circulatory system.") and allowed 4 s for the participant to respond. Correct responses produced praise and incorrect or no response resulted in no differential consequences.

Daily Probes

Participants were assigned to dyads that included the target participant and another participant as an observer. Each participant served as the target participant or observer in a single dyad: Dyad 1 included Kaya and Mehmet, Dyad 2 included Mehmet and Ali, and Dyad 3 included Ali and Kaya. Daily probes consisted of 12 probe trials (each target presented three times in a randomized sequence). Daily probes were always conducted before training trials using procedures identical to the baseline phase.

Daily probes were always conducted with the observing participant (hereafter *observer*) before the target participant. Before the target participant connected to Zoom™, the experimenter conducted the daily probe with the observer. After the observer completed the daily probe, the target participant as added to the Zoom™ session, and the daily probe was conducted with the target participant.

Simultaneous Prompting

After the daily probes were completed for both participants in the dyad, SP was conducted with the target participant. SP sessions were conducted twice on weekdays, and there were 12 trials in each SP session (each target presented three times in a randomized sequence). Before each session, the researcher drew the observer's attention (e.g., "I am going to ask some questions to your friend. Please, watch us carefully!"). Then, as in the probe trials, the researcher gave an attentional cue (e.g., "…., are you ready?"), reinforced their affirmative response (e.g., "Great, let's start!"), and delivered the target (e.g., "Tell me the states of matter.") and immediately presented the controlling prompt (e.g., "Solid, liquid, gas."). The target participant was required to echo the prompt. The experimenter then allowed 4 s for a prompted correct response. Prompted correct responses produced praise (e.g.,

Table 1 Target and observational learning behaviors of the participants

Dyad	Target participant	Observer participant	Target skill	Response
Dyad 1	Kaya	Mehmet	1. What are the inner planets? 2. Tell me the microscopic creatures 3. Tell me the states of matter 4. What is a meteorite?	1. The closest planets to the Sun. Mercury, Venus, World, Mars 2. Bacteria, ameba, euglena, paramecium 3. Solid, liquid, gas 4. If a meteoroid runs into the Earth and survives going through the atmosphere, the rock that lands on the Earth is a meteorite
Dyad 2	Mehmet	Ali	1. Define the asteroids 2. Define the incident ray 3. Tell me the organs in circulatory system 4. Define the sublimation	1. Asteroids are small, rocky objects that orbit the sun 2. A ray of light that hits a surface 3. Heart, vein, blood 4. Sublimation is the transition of a substance directly from the solid to the gas state, without passing through the liquid state
Dyad 3	Ali	Kaya	1. Define the chemical digestion 2. What are the gas planets? 3. What is the purpose of urinary system? 4. Define the cartilage	1. Chemical digestion is the enzyme-mediated, hydrolysis process that breaks down large macronutrients into smaller molecules 2. Jupiter, Uranus, Saturn, Neptune 3. The purpose of the urinary system is to eliminate waste from the body 4. Cartilage is a stiff yet flexible connective tissue that presents at joints between bones

"Perfect!") and incorrect or no responses were ignored. The researcher thanked both participants for their attendance at the end of the session.

Follow-Up and Novel Adult Probes

Follow-up probes were conducted 1, 2, and 4 weeks after the mastery criterion was met. We also assessed the participants' performance of the target skills in the presence of a novel adult during the 4-week probe. A male graduate student in special education conducted the novel adult probes with each participant using Zoom™. The participants had no previous interaction with the novel adult. All procedures were identical to those used in baseline.

Interobserver Agreement and Procedural Integrity

The second author collected reliability data for 30% of each condition. The researchers calculated interobserver agreement (IOA) data using a total agreement method of which formula is number of correct responses divided by number of correct plus incorrect responses multiplied by 100. IOA was 100% across all phases. Procedural integrity was also recorded during 30% of sessions. Percent of trials with procedural integrity was 100% for Kaya, 93.6% (range, 82.5% to 100%) for Mehmet, and 97.25% (range, 88.9% to 100%) for Ali.

Social Validity

The experimenters collected social validity data from the participants and their mothers using semi-structured interview at the end of the study. The researchers developed open-ended questions. Participants were asked the following questions: (a) Did you like attending sessions delivered via telehealth?, (b) do you want to attend similar treatments in future?, (c) was it easy to learn academic skills delivered by the researcher?, and (d) do you prefer small-group instruction or one-to-one instruction? The participants' mothers were asked (a) how was your children attitudes toward to the treatment conducted in the study?, (b) what are your opinions about SP procedure?, and (c) what are your opinions about general procedure? All responses were transcribed by the experimenter.

Results

Figure 1 shows the results of the SP procedure across dyads. Participants emitted no correct responses during baseline. Following the intervention, the target participants (closed data paths) met the mastery criterion in eight, nine, and eight sessions, in Dyads 1–3, respectively. Moreover, the target participants performed all target responses correctly during the follow-up sessions 1, 2, and 4 weeks after mastery and during novel adult probes.

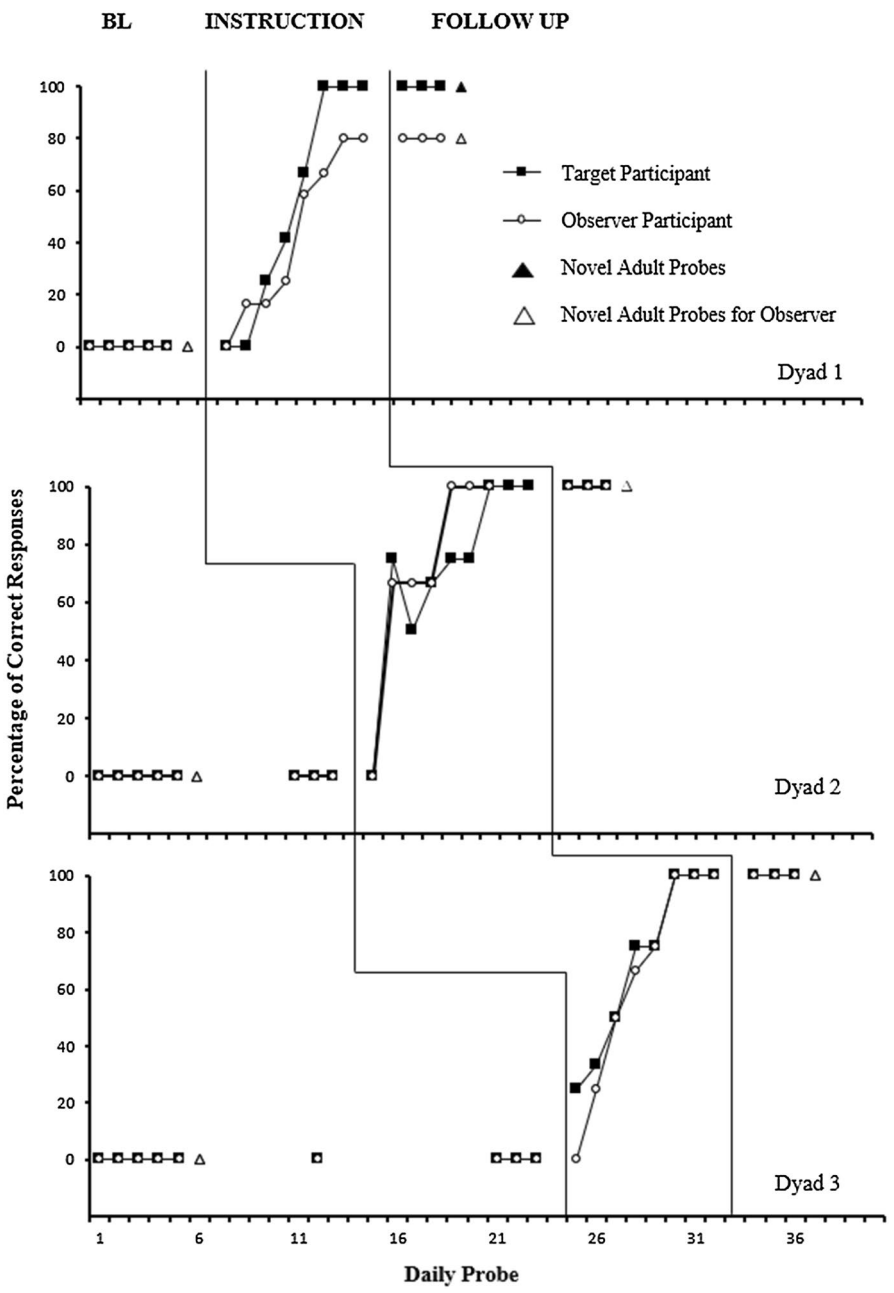

Fig. 1 The percentage of correct responses of participants on daily probes. BL—baseline

Figure 1 also shows the results of the acquisition, follow-up, and novel adult probes of the observers in each panel (open data paths). Mehmet was the observer in the top panel of Fig. 1. This participant exhibited performance at 80% unprompted correct responses following six sessions. Their performance remained at this level during all follow-up and novel adult probes. For Ali (middle panel) and Kaya (bottom panel), correct responding increased immediately after the first observational learning session, and they exhibited 100% correct responses after four and six sessions, respectively. They maintained 100% accuracy after 1, 2, and 4 weeks and during the novel adult probes.

Social Validity

The answers of participants about their participation in the study via telehealth varied across participants. Kaya expressed that they did not like the training. In contrast to Kaya, Ali stated that they stated that they would like to participate in similar treatments in the future. Mehmet did not reply to the question. Mehmet and Ali reported that they would prefer small-group instruction to one-to-one, while Kaya liked both arrangements.

During the social validity assessments with the participants' mothers, only Ali's mother said that their child eagerly attended. Kaya's mother reported that the reason for their difficulty in attending to the sessions was the repetitive questions, especially during the baseline sessions. There was a consensus between the first two mothers on the fact that they found it hard to persuade their children to attend the sessions even though their children were willing initially. Ali's mother reported a positive opinion about the procedure, while Kaya's and Mehmet's mothers stated that the SP procedure seemed to be based on memorization.

Discussion

The results of the study demonstrated that the SP procedure delivered via telehealth was effective in teaching science content to participants with ASD. Moreover, the participants met the criterion at follow-up sessions and novel adult probe sessions. Additionally, the participants responded exhibited performance consistent with observational learning which maintained 1, 2, and 4 weeks after mastery and during novel adult probes.

This study extends prior research by investigating the effectiveness of the SP procedure in teaching academic content to middle-school students with ASD. The findings of the study are noteworthy in that participants acquired target behaviors, which is in line with those of previous studies targeting science-related domains (Johnson et al., 1996; Riesen et al., 2003; Tekin-Iftar & Olcay-Gul, 2017; Tekin-Iftar et al., 2017). We also extended previous research by investigating the effectiveness of SP procedures delivered via telehealth. This research is timely as there has been a dramatic increase in the use of instruction delivered via telehealth. Finally, we included a second participants as an observer during all SP instruction and these participants consistently exhibited performances that rivaled those

of the participants directly exposed to the SP procedure. This finding is consistent with those of previous research on observational learning during SP instruction (Tekin-Iftar & Olcay-Gul, 2017).

Finally, the social validity findings of the study are noteworthy. Only Ali reported positive opinions about the whole process. Kaya did not like remote instruction, while Kaya and Mehmet expressed that they liked the SP procedure, although they both would not like to participate in similar treatments again. In addition, the mothers of Participant Kaya and Mehmet described the SP procedure as being based on memorization. Although it may be perceived to be unfavorable, repetition may be an important aspect of instruction for individuals with ASD. Nevertheless, the endorsement that the current procedures were "boring" may be a result of several factors. First, we used only verbal prompts. Future studies may use other prompt types (e.g., visual cues) or other response prompt procedures that may be more preferred by the participants. Second, each target set included only four targets; thus, repeated presentation of the same targets might cause them to perceive the procedure to be boring. Third, we collected at least five baseline data points for each participant. Extended exposure to baseline sessions may have been unnecessary as the participants exhibited no correct responses during this phase. Future studies might limit the number of initial baseline probes. Finally, although certain aspects were not socially valid, all three of the participants' mothers reported being satisfied with their children's attendance in group instruction via telehealth.

The findings of the current study should be considered in light of its limitations. First, we included only three participants with ASD. Hence, future research should be conducted using similar procedures and populations to determine the generality of our findings. Second, participants were arranged in dyads, which may not be representative of small groups in typical classroom settings. Future studies might include more than two participants in each group to determine the efficacy of these procedures when applied to a greater number of participants. Finally, we included praise for performances by the observers, which may not be typically arranged during observational learning procedures. Future research might exclude direct reinforcement of these responses to determine the extent to which these performances align with traditional definitions of observational learning.

The results of the current study demonstrate that SP delivered via telehealth was effective in teaching science facts to middle-school students with ASD. In addition to this, when the participants were not directly exposed to the intervention, but observed teaching sessions, they still acquired the targets at a similar rate as the participant exposed to training. This study may guide practitioners in their use of similar instructional methods for students with ASD via telehealth.

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Author Contributions The authors are grateful to IK and SO for their insightful proofreading.

Data Availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest We have no conflict of interest to disclose.

Ethical Approval Bursa Uludag University IRB approved this study.

Informed Consent All procedures followed were in accordance with ethical standards of the responsible committee on human experimentation(institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from allparticipants for being included in the study.

Human and Animal Rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutionalresearch committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The presentstudy was approved by the Institutional Review Board at the Bursa Uludag University.

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