Advances in Neurodevelopmental Disorders
https://doi.org/10.1007/s41252-022-00250-0

ORIGINAL PAPER

Fostering Functional Occupation and Mobility in People with Intellectual Disability and Visual Impairment Through Technology-Aided Support

Giulio E. Lancioni[1] · Nirbhay N. Singh[2] · Mark F. O'Reilly[3] · Jeff Sigafoos[4] · Gloria Alberti[5] · Valeria Chiariello[5] · Chiara Abbatantuono[1] · Paolo Taurisano[1] · Lorenzo Desideri[5,6]

Accepted: 1 March 2022

Abstract

Objectives The study assessed a smartphone-based technology system, which was designed to support functional occupation and mobility in people with severe to profound intellectual disability and visual impairment.

Methods The technology system provided (a) verbal orientation cues to guide the participants to a desk with two containers (and two groups of 10 objects that were to be transported to two different destinations), (b) verbal instructions to take the objects (one at a time), (c) verbal orientation cues to reach the destinations where the objects taken had to be transported, (d) instructions to put away the objects at the destinations, and (e) praise and brief periods of preferred stimulation. Seven participants were involved in the study, which was carried out according to a nonconcurrent multiple baseline across participants design.

Results During the baseline (when the technology system was not available), the participants produced few or no correct responses (i.e., failed to collect, transport, and deposit objects at the right destinations). During the intervention phase (i.e., with the support of the technology system), their mean frequency of correct responses per session was between close to 19 and close to 20 (out of a maximum possible of 20) and their mean session duration varied between about 16 and 29 min.

Conclusions The data suggest that the technology system used in this study may be a viable resource to support activity and mobility in people with intellectual and visual disabilities.

Keywords Technology · Smartphone · Motion sensors · Intellectual disability · Visual impairment · Occupation · Mobility

People with severe to profound intellectual disabilities tend to be passive and detached from their environment (i.e., from objects and activities) when no direct staff supervision is available (Dairo et al., 2016, 2017; Dixon-Ibarra et al., 2013; Melville et al., 2017; Stancliffe & Anderson, 2017). The situation is even more serious and problematic when intellectual disability is combined with visual impairment (Desideri et al., 2021; Dijkhuizen et al., 2016; Hanzen et al., 2018, 2020). People with intellectual disability and visual impairment (a) may be largely unaware of objects and activities in their immediate surrounding, and (b) may also be unable to orient and move in their daily context thus experiencing widespread passivity and isolation (Jarjoura, 2019; Lancioni, Singh, et al., 2017; Lancioni et al., 2021a; Nair et al., 2020).

Extensive staff supervision to improve the situation may not be considered a realistic solution of the problem. In fact, staff supervision can hardly be ensured over protracted periods of time across different parts of the day within daily contexts. Moreover, the use of extensive supervision would interfere with the people's development of initiative and self-determination and would also hinder their social image (Lancioni, O'Reilly, et al., 2017; Lancioni, Singh, et al., 2017; Mumbardó-Adam et al., 2020; Wehmeyer, 2020). A

✉ Giulio E. Lancioni
giulio.lancioni@uniba.it

1 Department of Neuroscience and Sense Organs, University of Bari, Corso Italia 23, 70121 Bari, Italy

2 Augusta University, Augusta, GA, USA

3 University of Texas at Austin, Austin, TX, USA

4 Victoria University of Wellington, Wellington, New Zealand

5 Lega F. D'Oro Research Center, Osimo, Italy

6 University of Bologna, Bologna, Italy

Published online: 09 March 2022

better approach to the problem may be represented by the use of technology-aided programs providing the necessary supervision/support (Cuturi et al., 2016; Goo et al., 2019; Lancioni et al., 2018a, b; Shih et al., 2013; Taylor et al., 2016).

Several technology-aided programs have been reported to increase activity engagement and mobility in people with intellectual disability and visual impairment without the need of staff supervision. For example, Lancioni, Singh, et al. (2017) developed a program in which electronic boxes fitted with an optic sensor and regulated by a remote control system were used to support the participants. The boxes were located on different desks that the participants were to reach to collect objects or put away the objects collected. Every intervention session started with the activation of the box on one of the desks containing objects, which emitted verbal cues for spatial orientation. The participant was to reach the desk and take one of the objects available there. Reaching the desk activated the optic sensor and caused the box to provide 5 s of preferred stimulation. Subsequently, the box at a storage desk where the objects were to be put away started to emit cues. Bringing the object to the storage desk triggered the optic sensor available there and led the box to provide 20 s of preferred stimulation. At the end of it, the process started again and continued in the same way until the session time had elapsed.

Lancioni et al. (2019) set up a program in which smartphones, mini speakers, and portable light sources were used. Three smartphones were placed in three boxes, which contained different groups/types of objects. The other three smartphones were located at the destinations where the objects of the three boxes were to be put away. Each smartphone was connected to one of the aforementioned speakers and light sources. At the start of a session, one of the smartphones inside the boxes presented via the related speaker auditory spatial cues. The participant was expected to walk toward those cues and search inside one of the boxes. This caused the smartphone inside the box to (a) ask the participant to take an object and (b) trigger the smartphone at the destination where the object was to be transported. This latter smartphone then started to call (providing spatial cues to) the participant. Reaching the destination and triggering the light sensor of the smartphone available there caused that smartphone to ask the participant to put away the object, and activate 15 s of preferred stimulation. The end of this stimulation triggered the smartphones at the boxes and enabled one of them to start calling the participant. The process continued as just described throughout the session.

Lancioni et al. (2021b) developed a program involving the use of a smartphone with special applications and indoor motion sensors and mini speakers to help participants collect objects from different areas and bring them to a storage desk. The smartphone was linked to the sensors and speakers available at the areas where the participant was to collect the objects and at the storage desk where the objects were to be put away. Every session started with the mini speaker of one of the areas calling the participant. When the participant reached the area and was detected by the sensor available there, the speaker presented praise and the request to take an object. This was followed by the activation of the speaker of the storage desk presenting calls. Once the desk was reached and the sensor detected the participant's presence, the speaker presented praise, the request to put away the object and 15 s of preferred stimulation. The end of the stimulation was followed by the speaker of another area starting to call the participant, so that the participant could collect another object and transport it to the storage desk. The same process continued until the end of the session.

All three programs described above were reported to be successful in helping the participants engage in functional activity (collecting and putting away objects) and mobility. Notwithstanding the positive results, some questions about the different programs might be raised. For example, the first program was based on technology specifically built for the study, thus not directly accessible to others and relatively expensive. The second program had the advantage of relying on commercial technology and supporting activities that required differential use of material (i.e., different types of objects were to be transported to different destinations). Yet, the technology included several clusters of smartphones, mini speakers, and light sources that made it relatively complex and expensive. The third program relied on commercial technology, which was simpler and less expensive than the technology used for the second program, but it did not support differential use of objects (i.e., all objects collected were put away at the same storage desk).

The present study was to develop and assess a new program that (a) included a technology package even simpler than that used for the third program mentioned above and (b) supported activity engagement involving differential use of objects and mobility. In practice, the new program (a) relied on a smartphone linked to motion sensors and mini speakers and (b) was designed to help seven participants with severe to profound intellectual disability and blindness collect objects of two different groups and transport the objects of each group to a specific destination.

Method

Participants

Table 1 identifies the seven participants by their pseudonyms and reports their chronological age, and the age equivalents for their daily living skills on the second edition of the Vineland Adaptive Behavior Scales (Balboni et al., 2016;

Table 1 Participants' pseudonyms, chronological age, and Vineland age equivalents for daily living skills (personal sub-domain)

Participants (pseudonyms)	Chronological age (years)	Vineland age equivalents[1,2]
Jane	23	3; 1
Xavier	45	2; 11
Nylah	37	2; 7
Brady	23	2; 9
Adan	42	2; 4
Michah	44	2; 9
Matias	49	2; 5

[1]The age equivalents are based on the Italian standardization of the Vineland scales

[2]The Vineland age equivalents are reported in years (number before the semicolon) and months (number after the semicolon)

Sparrow et al., 2005). The participants (two women and five men) were between 23 and 49 years of age. One of the participants (Xavier) had a minimal residual vision that allowed him to see large obstacles in his way, while the others were totally blind. The Vineland age equivalents for their daily living skills (personal sub-domain) varied between 2 years and 4 months (Adan) and 3 years and 1 month (Jane). All participants attended rehabilitation and care centers. Their psychological records indicated that their level of intellectual disability had been estimated to be within the severe to profound range, but no specific tests were applied for their assessment.

The participants were included in the study on the following basis. First, they could use auditory spatial cues to orient and reach indoor destinations (within a room or across adjacent rooms). Two of them had also been involved in previous programs with the use of auditory spatial cues (i.e., Jane and Brady). Second, they were familiar with simple verbal instructions such as "take" and "put away" an object. Third, they seemed to enjoy (i.e., as indicated by behaviors such as alerting/orienting and smiling) various forms of reportedly preferred environmental stimulation including music, songs, praise, and familiar voices. Thus, it was thought that using those forms of preferred environmental stimulation contingent on their response performance could serve to motivate/strengthen such performance. Fourth, activities involving differential use of objects and mobility were considered relevant forms of functional occupation within the participants' context. Fifth, staff supported the study (of which they were informed in advance), as they thought that participants would largely benefit from a technology system supporting their activity engagement.

While the availability of preferred stimulation during the intervention sessions (see below) was thought likely to make the participants' involvement in the study a positive experience, it was impossible to reliably determine their assent to be involved. Thus, their legal representatives were asked to provide formal consent on their behalf before the start of the study. The study complied with the 1964 Helsinki Declaration and its later amendments and was approved by an institutional ethics committee.

Procedures

Setting, Activities, Stimulation, Sessions, and Research Assistants

Quiet rooms of the centers that the participants attended constituted the setting for the study sessions. Activities consisted of (a) collecting 20 objects from two different containers (each including a set of 10 objects) located in a specific area (on a specific desk) of the room, (b) transporting the objects to two different destinations (one set of objects to one destination and the other set to a second destination located within the same or adjacent room), and (c) depositing/putting away each of the objects at the destinations. Activities could vary across sessions with regard to the sets of objects to be collected, transported, and put away. The objects could involve kitchen tools, drink items, boxes, paper packs, and other sets of materials available within daily contexts. For each object to be collected, transported, and put away, the technology system provided the participants with verbal orientation cues, instructions, praise and other reportedly preferred stimulation events such as music and songs, and familiar voices (see the "Participants" and "Technology System" sections). Sessions consisted of the time periods the participants needed to complete an activity (i.e., collect and transport to different destinations the two groups of 10 objects). Sessions could also be interrupted before the activity was completed. Session interruption occurred when a 30-min time limit had elapsed or when research assistant's guidance had been used on four consecutive activity responses. Research assistants, who carried out the sessions and recorded the participants' data (see below), were familiar with the use of technology-aided interventions for people with intellectual and multiple disabilities as well as with data collection.

Technology System

The technology system used during the intervention phase of the study involved (a) a Samsung Galaxy A22 with Android 11 operating system that was equipped with Amazon Alexa, MacroDroid, and Philips Hue applications, (b) five Philips Hue indoor motion sensors, (c) a Philips Hue Bridge and Philips Hue smart bulb working via Bluetooth, (d) a 4G Long-Term Evolution Wi-Fi router, and (e) three Bluetooth mini speakers. The Philips Hue Bridge, smart bulb and application, and the router were instrumental for the functioning of the Philips Hue sensors.

The sensors were box-like devices with a 5.5-cm side and 3.5-cm height. One of the sensors was placed in front of the desk with the two containers and the two groups of objects to be transported to different destinations. Two sensors were placed in the containers (i.e., one sensor per container). The other two sensors were placed before the destinations to which the objects were to be transported (i.e., one sensor at each destination). Sensor activation (caused by the participant's arrival at the desk or destination or by the participant's hand being inserted in a container) was detected through the Amazon Alexa application and transmitted to the smartphone via the MacroDroid. The Bluetooth mini speakers, which were linked to the smartphone, were placed on the desk with the two containers, and at each of the two destinations where the objects were to be transported/deposited.

Figure 1 summarizes the working of the technology system. Switching on the system (i.e., starting a session) activated the mini speaker of the desk with the two containers with objects, which started to call the participant (i.e., one or two-word calls that could include the participant's name) at intervals of 5 s. The calls were spatial orientation cues guiding and encouraging the participant to reach the desk. As soon as the participant reached the desk (i.e., triggered the sensor before the desk), the mini speaker on the desk presented verbal praise and the instruction to take an object. The instruction was repeated at intervals of 5–10 s until the

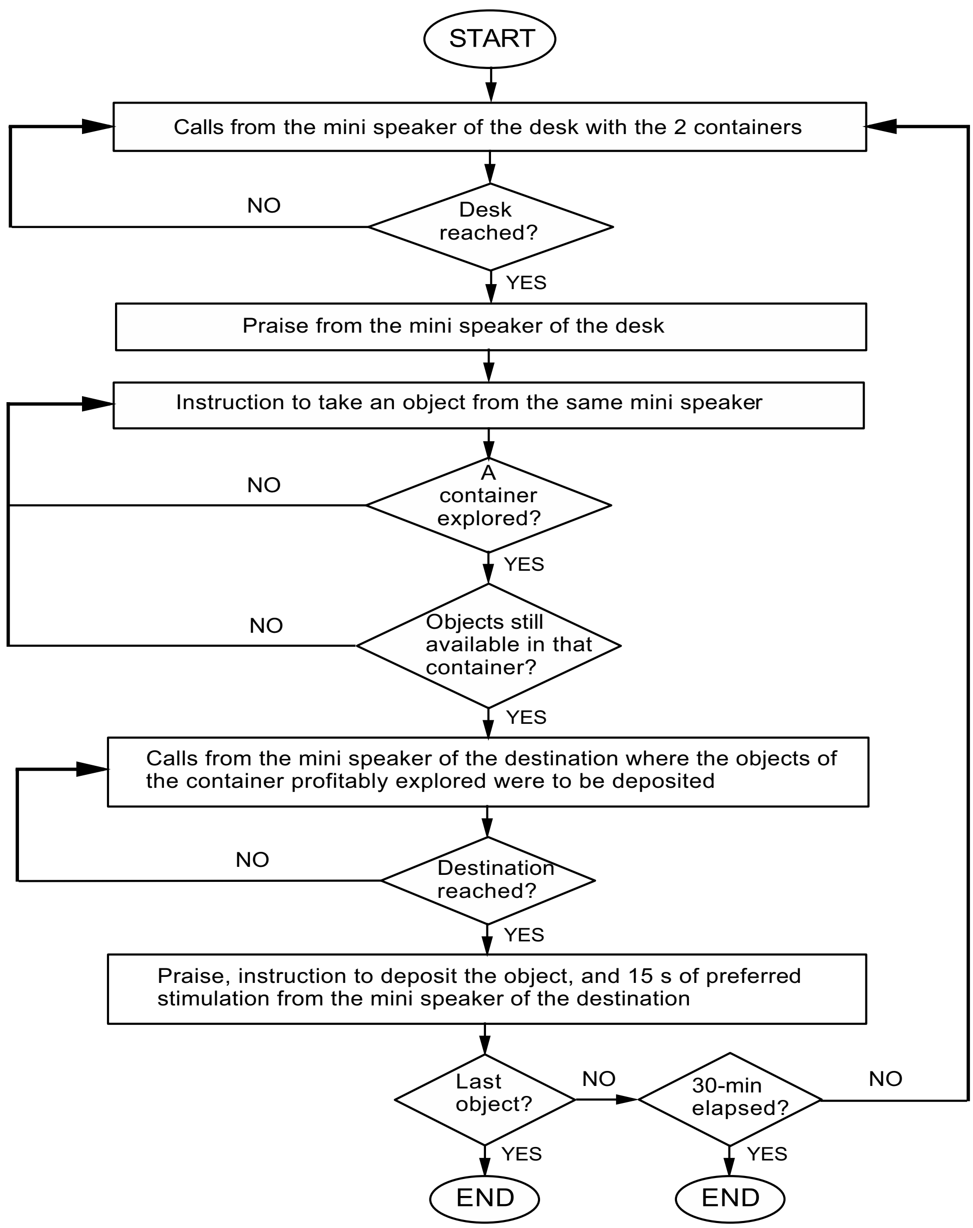

Fig. 1 The flowchart summarizes the working of the technology system

participant triggered the sensor of one of the two containers with objects. The sensor was triggered as the participant explored (i.e., inserted the hand into) one of the containers to take an object. Triggering the sensor of a container led to the automatic activation of the mini speaker of the destination matching that container, that is, of the destination where any of the objects taken from that container was to be transported and deposited.

The speaker at the destination kept on calling the participant until the participant reached it (i.e., triggered the sensor in front of the destination; as described above). Once the participant was at the destination, the mini speaker available there presented verbal praise, the instruction to deposit the object, and 15 s of a preferred stimulation event (e.g., a 15-s segment of a preferred song or music piece; see the "Participants" section). At the end of the stimulation event, the mini speaker of the desk with the containers was automatically activated (i.e., started to call the participant). When the participant arrived at the desk (i.e., triggered the sensor in front of it), the mini speaker presented praise and the instruction to take an object. If the participant took an object from the same container used before, the speaker of the destination previously reached was activated again. If the participant took an object from the other container, the speaker of the second destination (not targeted for the previous response) was activated. The process then continued as described above. The only exception occurred when the participant explored one of the containers, in which no more objects were presumably available (i.e., a container whose sensor had been activated on 10 previous response occasions). In that case, the system repeated the instruction to search and take an object at intervals of 5–10 s until the participant triggered the sensor of the other container. The session continued until (a) the system had provided support (i.e., spatial orientation cues, instructions, praise, and preferred stimulation events) for 20 activity responses, that is, for collecting, transporting, and putting away the two groups of 10 objects available or (b) a 30-min period had elapsed, whichever came first.

Experimental Conditions

The study was conducted according to a nonconcurrent multiple baseline design across participants (Barlow et al., 2009; Lancioni et al., 2021c). Consistent with the design requirements, the participants were provided with different numbers (i.e., between 5 and 10) of baseline sessions during which the technology system was not available. The baseline sessions were followed by intervention sessions, which were carried out with the support of the technology system. Between 46 and 80 intervention sessions were implemented for the different participants. The numbers of sessions varied across participants based on their availability. Video recordings of the sessions were regularly accessible to a study coordinator who would view them and provide feedback to the research assistants to promote their correct performance and thus ensure procedural fidelity (Sanetti & Collier-Meek, 2014).

Baseline

Before the start of a baseline session, the research assistant guided the participant physically and verbally to inspect the desk with the containers and objects (each container included a group of 10 objects) and the destinations where those objects were to be transported and deposited. Thereafter, the research assistant accompanied the participant near the desk with the containers (as it would occur during the intervention sessions with the technology system) and presented the participant with the instruction to take an object and transport it to a destination. If the participant remained inactive or showed no progress for 30–40 s, the research assistant intervened with guidance (i.e., guided the participant physically and verbally to take an object from one of the containers, transport the object to the right destination, and deposit it there). The right destination could include, among others, a table, a cupboard, or a combination of chairs. This was followed by a new instruction to take another object and transport it. The research assistant's guidance was used as indicated above. The session continued until the participant had responded to all the 20 instructions scheduled or until research assistant's guidance had occurred for four consecutive responses. Interrupting the sessions after four consecutive guidance instances was to minimize failure and frustration.

Intervention

The intervention phase was introduced by two or three practice sessions, which served to familiarize the participants with the functioning of the technology system. During these sessions, the research assistant could provide guidance to facilitate the participants' successful use of the system's support (i.e., spatial orientation cues and instructions). Yet, all participants had the prerequisites to manage such support independently (see the "Participants" section). During the regular sessions that followed the practice sessions, no research assistant's guidance was available. The research assistant would only accompany the participant near the desk with the containers and related groups of objects and switch on the technology system. Once switched on, the system worked as described in the "Technology System" section and summarized in Fig. 1. In practice, the system presented spatial orientation cues, instructions, praise, and preferred stimulation events in connection with each of the 20 objects (10 per container) the participant was scheduled to collect, transport to, and deposit at the right destination within a session. Sessions lasted until the participant had collected, transported, and put away all 20 objects or a 30-min limit had elapsed, whichever came first (see the "Technology System" section).

Measures

The measures were activity responses completed correctly and session duration. During baseline, an activity response was completed correctly if the participant (following the research assistant's instruction to take an object and transport it to a destination) reached the desk with the two containers, took an object from one of the containers, transported the object to the matching destination, and deposited/put away the object there independently. During the intervention, an activity response was completed correctly if the participant produced the performance sequence described above using the technology system's support (see the "Technology System" section and Fig. 1). The first measure (i.e., activity responses completed correctly) was recorded by the research assistants throughout the study. The second measure (i.e., session duration) was recorded by the research assistants during baseline, and by the smartphone during the intervention. The smartphone recorded the time elapsed from the delivery of the first instruction to take an object at the desk with the containers to the delivery of the last stimulation event at one of the destinations.

Interrater agreement was assessed (a) in more than 25% of the sessions of each participant on the first measure and (b) in all baseline sessions on the second measure. Agreement was checked through the involvement of a reliability observer in data recording. The percentage of agreement on the first measure (computed for the single sessions by dividing the number of responses on which research assistant and reliability observer had the same "correct" or "incorrect" score by the total number of responses and multiplying by 100%) was within the 90–100% range, with means exceeding 98% for all participants. The percentage of interrater agreement on the second measure (computed by dividing the number of sessions whose reported durations differed less than 1 min by the total number of sessions and multiplying by 100%) was 100%.

Data Analyses

The participants' data for activity responses completed correctly and session duration were reported in graphic form. In order to simplify the graphic display, the data were summarized into blocks of sessions. Accordingly, each data point appearing in the graphs represents a mean session frequency or a mean session duration computed over a block of sessions. The Kolmogorov–Smirnov test (Siegel & Castellan, 1988) was the statistical tool selected for analyzing the differences between the baseline and intervention frequencies of activity responses completed correctly for those participants who had some levels of data overlap between the two phases.

Results

The seven panels of Fig. 2 report the participants' mean frequency of activity responses completed correctly and mean session duration over blocks of sessions. Specifically, the black diamonds represent the mean frequency of activity responses completed correctly per session over blocks of three sessions during the baseline and the intervention phase. The empty circles represent the mean session duration for the same blocks of sessions. Baseline and intervention blocks including two sessions (i.e., blocks appearing at the end of the baseline or the intervention phase) are marked with an arrow. The practice sessions occurring at the start of the intervention phase are not reported in the figure.

During baseline, the frequency of activity responses completed correctly was zero or close to zero for all participants. All baseline sessions were interrupted following four consecutive responses with guidance from the research assistant. The participants' mean session duration ranged between about 6 and 7 min. During the intervention phase (i.e., with the support of the technology system), the mean frequency of activity responses completed correctly increased for all participants. In fact, the mean frequency ranged from close to 19 (Jane, Adan, and Michah) to close to 20 (Xavier). Occasional lower frequencies of correct activity responses were connected to sessions, which were interrupted because the 30-min time limit had elapsed, or to inaccurate response performance (e.g., failure to take or put away an object). The mean session duration during the intervention phase varied between approximately 16 min (Nylah) and 29 min (Michah).

The baseline and the intervention data for activity responses completed correctly showed no overlaps for any of the participants. Absence of overlaps was seen as clear evidence of the definite difference between the two phases and thus of the effectiveness of the technology system in supporting the participants' activity performance. Given this evidence, the application of the Kolmogorov–Smirnov test was deemed unnecessary.

Discussion

The data indicate that all participants were successful in using the technology system employed during the intervention. These data support previous findings in the area

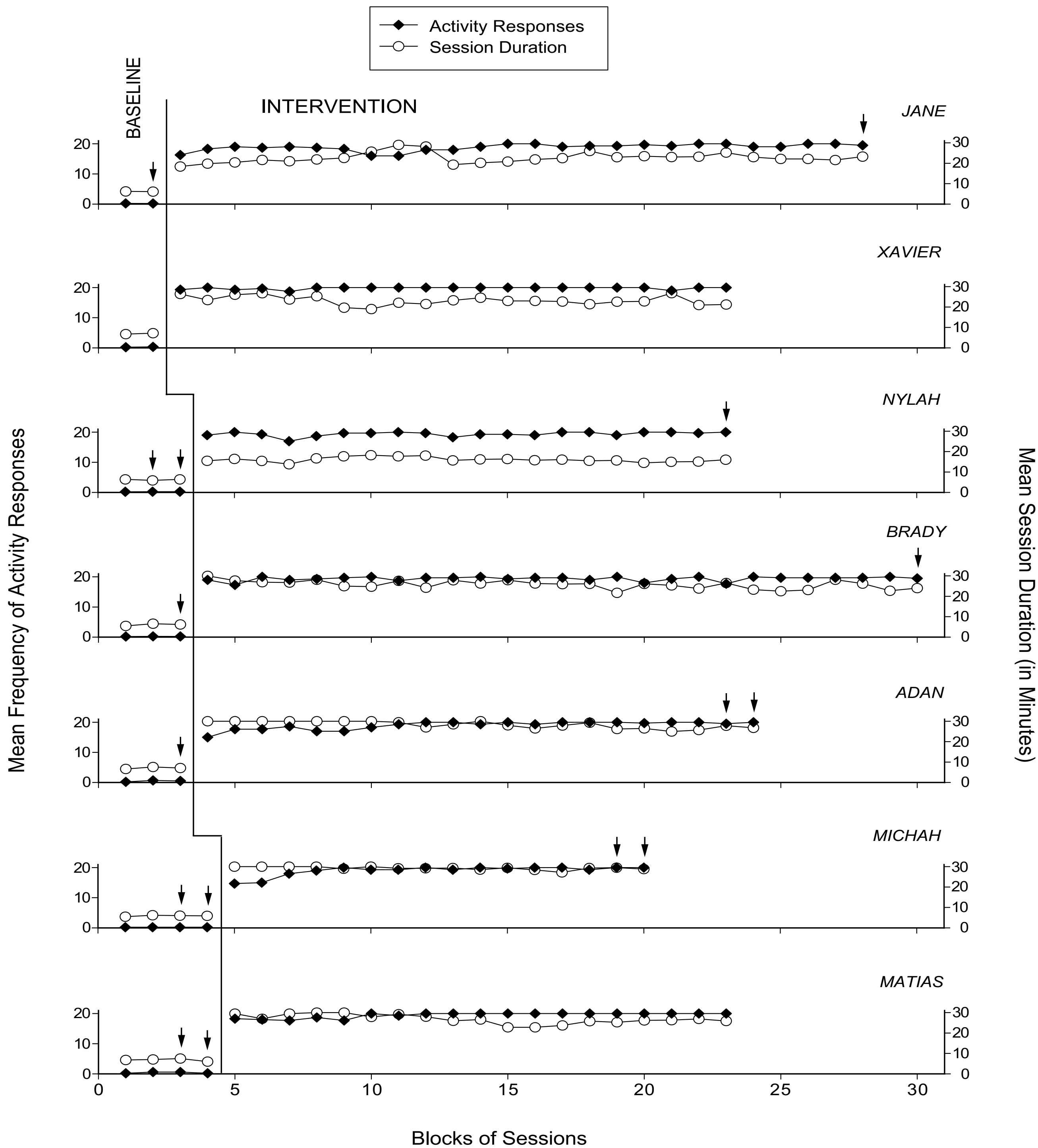

Fig. 2 The seven panels report the participants' mean frequency of activity responses completed correctly and mean session duration over blocks of sessions. The black diamonds represent the mean frequency of activity responses completed correctly per session over blocks of three sessions during the baseline and the intervention phase. The empty circles represent the mean session duration for the same blocks of sessions. Baseline and intervention blocks including two sessions (i.e., blocks which can appear at the end of the baseline or the intervention phase) are marked with an arrow

suggesting that technology-aided programs can be effectively used for promoting functional activity engagement and mobility with participants with intellectual disability and visual impairment (Lancioni et al., 2019, 2021b; Lancioni, Singh, et al., 2017). The same data add to previous evidence in that the technology system used in this study was relatively simple compared to those used before while supporting activities that required differential use of objects (i.e., the two sets of objects available in each session were to be transported to different destinations rather than to a same destination). In light of the above, several considerations may be made.

First, the relevance of technology-aided support for the participants of this study (as well as the participants of previous studies in this area) was emphasized by the great contrast between the highly positive data of the intervention period and the zero or near zero baseline performance. Indeed, the baseline performance suggests that the participants were unable to manage functional occupational engagement and mobility. The intervention performance shows the possibility of enabling the participants to reach constructive occupation as well as orientation and mobility with no need for staff supervision. This achievement can be viewed as meaningful in terms of participants' behavioral and cognitive growth, social image, and physical exercise (Bertelli et al., 2016; Bouzas et al., 2019; Kocman & Weber, 2018; Warburton & Bredin, 2019).

Second, the results obtained can be considered relevant also in view of the fact that the activities were not simply limited to transporting and putting away objects but involved a differentiated use of the objects, that is, the participants were enabled to transport the objects of one container to one destination and the objects of the other container to a different destination. The ability of using objects differentially may be viewed as a critical qualification for functional engagement (Lancioni et al., 2019; Wehmeyer et al., 2020). It may also be argued that the technology system used in this study could be expanded (i.e., with extra sensors and mini speakers) to include more than two categories of objects to be used differentially (Desideri et al., 2021; Desmond et al., 2018).

Third, the effectiveness of the intervention phase (with the support of the technology system) can easily be ascribed to the conditions implemented during that phase: (a) the calls from the mini speakers of the desk with the containers and of the destinations that were to be reached, (b) the instruction to take or deposit/put away an object, and (c) the praise and preferred stimulation events. The calls were apparently instrumental in helping the participants orient successfully and find the containers and destinations and may also have served to prompt/encourage their performance engagement (Lancioni et al., 2019; Lancioni, O'Reilly, et al., 2017). The instructions may have been essential to ensure that the participants were always aware of what to do with the objects (Lancioni et al., 2021b; Lancioni, Singh, et al., 2017). Praise and the preferred stimulation events available for the activity responses may have fostered the participants' motivation to carry out those responses throughout the sessions and possibly their satisfaction with the sessions (Catania, 2013; Kazdin, 2012).

Fourth, the technology system used in this study (a) represents a relatively simple and practical tool compared to the systems used by Lancioni, Singh, et al. (2017), Lancioni et al. (2019)), which were specifically built for the purpose of the study or included clusters of smartphones, sensors, mini speakers, and light sources, and (b) has the advantage of supporting differential use of objects compared to that used by Lancioni et al. (2021b). The cost of the present technology system may be estimated at about US $650 (i.e., approximately US $175 for the Samsung smartphone, US $250 for the five Philips Hue sensors, US $75 for the three mini speakers, and US $150 for the Philips Hue Bridge, the Philips Hue smart bulb, and the 4G Long-Term Evolution Wi-Fi router). This cost cannot be considered irrelevant. Yet, the system offers valuable occupation and mobility opportunities and is fairly easy to operate for personnel in charge of the sessions and friendly for the participants (Boot et al., 2018; Borg, 2019; de Witte et al., 2018; Scherer, 2019). A main obstacle in accessing and using such a technology system concerns the fact that it is not a ready-made (off-the-shelf) tool but rather a tool that needs to be arranged with the aforementioned commercial components and programmed for the intervention purpose.

Limitations and Future Research

Three limitations of the study should be noted. The first limitation concerns the relatively small number of participants involved in the study. This limitation, which makes it difficult to draw conclusions about the overall potential and usability of the technology system reported, needs to be addressed via direct and systematic replication studies. The results of these studies will help determine the reliability of such system and the possibilities of improving it and extending its use across individuals (Kazdin, 2011; Locey, 2020; Travers et al., 2016).

The second limitation concerns the lack of assessment of (a) the participants' satisfaction with the technology system and sessions and (b) the staff's perception of the applicability and impact of such system and sessions. To assess participants' satisfaction, one could observe their behavior during the sessions and determine whether they have expressions of positive mood (e.g., smiles) during their engagement (Dillon & Carr, 2007; Lancioni et al., 2020; Parsons et al., 2012). To assess staff's perception, one could show them video segments of the intervention sessions and ask them to rate those segments and the system being used in terms of efficacy, friendliness, and applicability (Lancioni, O'Reilly, et al., 2017; Plackett et al., 2017; Worthen & Luiselli, 2019).

The third limitation is the lack of generalization and maintenance assessment. With regard to this point, some basic assumptions could be made before any formal assessment is carried out. First, successful generalization results across settings and intervention agents might be expected. In fact, the system's support responsible for the participants' performance (i.e., spatial orientation cues, instructions, and praise and preferred stimulation events) would not change irrespective of the setting in which the system is used and of the personnel implementing the intervention sessions (Haegele & Park, 2016; Kazdin, 2012). Second, performance maintenance might also be expected quite realistically if preferred (motivating) stimulation continues to be available contingent on the participants' activity responses (Kazdin, 2012; Storey & Haymes, 2016).

In conclusion, the results suggest that the technology system evaluated in this study can help people with intellectual and visual disabilities achieve independent occupational engagement involving differential use of objects and mobility. While the results are encouraging, conclusions about the system's reliability and usability cannot be drawn until new research has addressed the limitations of this study. Future research may also investigate whether it is possible to further develop the present system so as to improve its functioning and adapt its use to more complex activity situations and/or participants with different characteristics.

Author Contribution GL was responsible for setting up the study, acquiring and analyzing the data, and writing the manuscript. NS, MO, and JS collaborated in setting up the study, analyzing the data, and writing/editing the manuscript. GA, VC, CA, PT, and LD contributed in working out the technological aspects of the study, acquiring and analyzing the data, and editing the manuscript.

Declarations

Ethical Approval Approval for the study was obtained from the Ethics Committee of the Lega F. D'Oro, Osimo, Italy. All procedures performed 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 Written informed consent for the participants' involvement in the study was obtained from their legal representatives.

Conflict of Interest The authors declare no competing interests.

References

Balboni, G., Belacchi, C., Bonichini, S., & Coscarelli, A. (2016). *Vineland II. Vineland adaptive behavior scales* (2nd ed.). Standardizzazione Italiana, OS.

Barlow, D. H., Nock, M., & Hersen, M. (2009). *Single-case experimental designs* (3rd ed.). Allyn & Bacon.

Bertelli, M. O., Munir, K., Harris, J., & Salvador-Carulla, L. (2016). Intellectual developmental disorders: Reflections on the international consensus document for redefining mental retardation-intellectual disability in ICD-11. *Advances in Mental Health and Intellectual Disabilities, 10*(1), 36–58.

Boot, F. H., Owuor, J., Dinsmore, J., & MacLachlan, M. (2018). Access to assistive technology for people with intellectual disabilities: A systematic review to identify barriers and facilitators. *Journal of Intellectual Disability Research, 62*(10), 900–921.

Borg, J. (2019). Commentary on selection of assistive technology in a context with limited resources. *Disability and Rehabilitation: Assistive Technology, 14*(8), 753–754.

Bouzas, S., Martínez-Lemos, R. I., & Ayán, C. (2019). Effects of exercise on the physical fitness level of adults with intellectual disability: A systematic review. *Disability and Rehabilitation, 41*(26), 3118–3140.

Catania, A. C. (2013). *Learning* (5th ed.). Sloan Publishing.

Cuturi, L. F., Aggius-Vella, E., Campus, C., Parmiggiani, A., & Gori, M. (2016). From science to technology: Orientation and mobility in blind children and adults. *Neuroscience & Biobehavioral Reviews, 71*, 240–251.

Dairo, Y. M., Collett, J., Dawes, H., & Oskrochi, G. R. (2016). Physical activity levels in adults with intellectual disabilities: A systematic review. *Preventive Medicine Reports, 4*, 209–219.

Dairo, Y. M., Collett, J., & Dawes, H. (2017). A feasibility study into the measurement of physical activity levels of adults with intellectual disabilities using accelerometers and the International Physical Activity Questionnaire. *British Journal of Learning Disabilities, 45*(2), 129–137.

Desideri, L., Lancioni, G., Malavasi, M., Gherardini, A., & Cesario, L. (2021). Step instruction technology to help people with intellectual and other disabilities perform multistep tasks: A literature review. *Journal of Developmental and Physical Disabilities, 33*(6), 857–886.

Desmond, D., Layton, N., Bentley, J., Boot, F. H., Borg, J., Dhungana, B. M., Gallagher, P., Gitlow, L., Gowran, R. J., Groce, N., Mavrou, K., Mackeogh, T., McDonald, R., Pettersson, C., & Scherer, M. J. (2018). Assistive technology and people: A position paper from the first global research, innovation and education on assistive technology (GREAT) summit. *Disability and Rehabilitation: Assistive Technology, 13*(5), 437–444.

de Witte, L., Steel, E., Gupta, S., Delgado Ramos, V., & Roentgen, U. (2018). Assistive technology provision: Towards an international framework for assuring availability and accessibility of affordable high-quality assistive technology. *Disability and Rehabilitation: Assistive Technology, 13*(5), 467–472.

Dijkhuizen, A., Hilgenkamp, T. I., Krijnen, W. P., van der Schans, C. P., & Waninge, A. (2016). The impact of visual impairment on the ability to perform activities of daily living for persons with severe/profound intellectual disability. *Research in Developmental Disabilities, 48*, 35–42.

Dillon, C. M., & Carr, J. E. (2007). Assessing indices of happiness and unhappiness in individuals with developmental disabilities. *Behavioral Interventions, 22*(3), 229–244.

Dixon-Ibarra, A., Lee, M., & Dugala, A. (2013). Physical activity and sedentary behavior in older adults with intellectual disabilities: A comparative study. *Adapted Physical Activity Quarterly, 30*(1), 1–19.

Goo, M., Maurer, A. L., & Wehmeyer, M. L. (2019). Systematic review of using portable smart devices to teach functional skills to students with intellectual disability. *Education and Training in Autism and Developmental Disabilities, 54*(1), 57–68.

Haegele, J. A., & Park, Y. P. (2016). Utilizing generalization tactics to promote leisure-time physical activity for students with intellectual disabilities. *Strategies, 29*(4), 19–23.

Hanzen, G., Waninge, A., Vlaskamp, C., van Nispen, R. M., & van der Putten, A. A. (2018). Participation of adults with visual and severe or profound intellectual disabilities: Analysis of individual support plans. *Research in Developmental Disabilities, 83*, 132–141. https://doi.org/10.1016/j.ridd.2018.08.012

Hanzen, G., van Nispen, R. M., Vlaskamp, C., Korevaar, E. L., Waninge, A., & van der Putten, A. A. (2020). Improving the participation of adults with visual and severe or profound intellectual disabilities: A process evaluation of a new intervention. *BMC Health Services Research, 20*(1), 319. https://doi.org/10.1186/s12913-020-05161-1

Jarjoura, W. (2019). Disorientation and loss of wayfinding in individuals with congenital blindness and other affecting comorbidities. *British Journal of Visual Impairment, 37*(3), 240–247.

Kazdin, A. E. (2011). *Single-case research designs: Methods for clinical and applied settings* (2nd ed.). Oxford University Press.

Kazdin, A. E. (2012). *Behavior modification in applied settings* (7th ed.). Waveland Press.

Kocman, A., & Weber, G. (2018). Job satisfaction, quality of work life and work motivation in employees with intellectual disability: A systematic review. *Journal of Applied Research in Intellectual Disabilities, 31*(5), 804–819.

Lancioni, G. E., O'Reilly, M. F., Sigafoos, J., Alberti, G., Perilli, V., Zimbaro, C., Chiariello, V., & Campodonico, F. (2017). Fostering indoor ambulation and object transportation as a form of physical exercise for persons with multiple disabilities. *Advances in Neurodevelopmental Disorders, 1*(4), 252–259. https://doi.org/10.1007/s41252-017-0032-6

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, J., Alberti, G., Campodonico, F., Perilli, V., Chiariello, V., & Zimbaro, C. (2017). A technology-aided program to support basic occupational engagement and mobility in persons with multiple disabilities. *Frontiers in Public Health, 5*, 338. https://doi.org/10.3389/fpubh.2017.00338

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, J., Alberti, G., Chiariello, V., Perilli, V., & Campodonico, F. (2018a). A smartphone-based technology package to support independent activity in people with intellectual disability and blindness. *Internet Technology Letters, 1*(5), e34. https://doi.org/10.1002/itl2.34

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, J., Campodonico, F., Zimbaro, C., Alberti, G., Trubia, G., & Zaccaria, T. (2018b). Helping people with multiple disabilities manage an assembly task and mobility via technology-regulated sequence cues and contingent stimulation. *Life Span and Disability, 21*(2), 143–163.

Lancioni, G. E., O'Reilly, M. F., Sigafoos, J., Desideri, L., Alberti, G., Campodonico, F., & Chiariello, V. (2019). Smartphone-based technology to support functional occupation and mobility in people with intellectual disability and visual impairment. *Advances in Neurodevelopmental Disorders, 3*(3), 334–342.

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, J., Grillo, G., Campodonico, F., Alberti, G., Schillaci, D., & Zagaria, T. (2020). A smartphone-based intervention to enhance functional occupation and mood in people with neurodevelopmental disorders: A research extension. *Life Span and Disability, 23*(1), 21–42.

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, J., Alberti, G., Chiariello, V., & Desideri, L. (2021a). Use of everyday technology to promote ambulation in people with intellectual and multiple disabilities. *Technology and Disability, 33*(3), 229–236.

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, J., Alberti, G., Chiariello, V., Campodonico, F., & Desideri, L. (2021b). Technology-aided spatial cues, instructions, and preferred stimulation for supporting people with intellectual and visual disabilities in their occupational engagement and mobility: Usability study. *JMIR Rehabilitation and Assistive Technologies, 8*(4), e33481. https://doi.org/10.2196/33481

Lancioni, G. E., Desideri, L., Singh, N. N., Sigafoos, J., & O'Reilly, M. F. (2021c). A commentary on standards for single-case experimental studies. *International Journal of Developmental Disabilities*.https://doi.org/10.1080/20473869.2020.1870420

Locey, M. L. (2020). The evolution of behavior analysis: Toward a replication crisis? *Perspectives on Behavior Science, 43*(4), 655–675.

Melville, C. A., Oppewal, A., Elinder, L. S., Freiberger, E., Guerra-Balic, M., Hilgenkamp, T. I., Einarsson, I., Izquierdo-Gómez, R. H., Sansano-Nadal, O., Rintala, P., Cuesta-Vargas, A., & Giné-Garriga, M. (2017). Definitions, measurement and prevalence of sedentary behaviour in adults with intellectual disabilities: A systematic review. *Preventive Medicine, 97*, 62–71. https://doi.org/10.1016/j.ypmed.2016.12.052

Mumbardó-Adam, C., Vicente Sánchez, E., Simó-Pinatella, D., & Coma Roselló, T. (2020). Understanding practitioners' needs in supporting self-determination in people with intellectual disability. *Professional Psychology: Research and Practice, 51*(4), 341–351.

Nair, V., Olmschenk, G., Seiple, W. H., & Zhu, Z. (2020). ASSIST: Evaluating the usability and performance of an indoor navigation assistant for blind and visually impaired people. *Assistive Technology*. https://doi.org/10.1080/10400435.2020.1809553

Parsons, M. B., Reid, D. H., Bently, E., Inman, A., & Lattimore, L. P. (2012). Identifying indices of happiness and unhappiness among adults with autism: Potential targets for behavioral assessment and intervention. *Behavior Analysis in Practice, 5*(1), 15–25.

Plackett, R., Thomas, S., & Thomas, S. (2017). Professionals' views on the use of smartphone technology to support children and adolescents with memory impairment due to acquired brain injury. *Disability and Rehabilitation: Assistive Technology, 12*(3), 236–243.

Sanetti, L. M. H., & Collier-Meek, M. A. (2014). Increasing the rigor of procedural fidelity assessment: An empirical comparison of direct observation and permanent product review methods. *Journal of Behavioral Education, 23*(1), 60–88.

Scherer, M. J. (2019). Assistive technology selection to outcome assessment: The benefit of having a service delivery protocol. *Disability and Rehabilitation: Assistive Technology, 14*(8), 762–763.

Shih, C. T., Shih, C. H., & Luo, C. H. (2013). Assisting people with disabilities in actively performing physical activities by controlling the preferred environmental stimulation with a gyration air mouse. *Research in Developmental Disabilities, 34*(12), 4328–4333.

Siegel, S., & Castellan, N. J. (1988). *Nonparametric statistics for the behavioral sciences* (2nd ed.). Macgraw-Hill.

Sparrow, S. S., Cicchetti, D. V., Balla, D. A. (2005). *Vineland Adaptive Behavior Scales* (2nd ed.). (Vineland II). Minneapolis: Pearson.

Stancliffe, R. J., & Anderson, L. L. (2017). Factors associated with meeting physical activity guidelines by adults with intellectual and developmental disabilities. *Research in Developmental Disabilities, 62*, 1–14. https://doi.org/10.1016/j.ridd.2017.01.009

Storey, K., & Haymes, L. (2016). *Case studies in applied behavior analysis for students and adults with disabilities*. Charles C. Thomas.

Taylor, M. J., Taylor, D., Gamboa, P., Vlaev, I., & Darzi, A. (2016). Using motion-sensor games to encourage physical activity for adults with intellectual disability. *Studies in Health Technology and Informatics, 220*, 417–423.

Travers, J. C., Cook, B. G., Therrien, W. J., & Coyne, M. D. (2016). Replication research and special education. *Remedial and Special Education, 37*(4), 195–204.

Warburton, D. E., & Bredin, S. S. (2019). Health benefits of physical activity: A strengths-based approach. *Journal of Clinical Medicine, 8*(12), 2044. https://doi.org/10.3390/jcm8122044

Wehmeyer, M. L. (2020). The importance of self-determination to the quality of life of people with intellectual disability: A perspective. *International Journal of Environmental Research and Public Health, 17*(19), 7121. https://doi.org/10.3390/ijerph17197121

Wehmeyer, M. L., Davies, D. K., Stock, S. E., & Tanis, S. (2020). Applied cognitive technologies to support the autonomy of people with intellectual and developmental disabilities. *Advances in Neurodevelopmental Disorders, 4*(4), 389–399.

Worthen, D., & Luiselli, J. K. (2019). Comparative effects and social validation of support strategies to promote mindfulness practices among high school students. *Child & Family Behavior Therapy, 41*(4), 221–236.