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An Overview of Recent Technology-Aided Intervention Strategies to Help People with Intellectual and Multiple Disabilities Meet Relevant Rehabilitation Goals

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Abstract

The paper presents an overview of recent studies assessing technology-aided strategies aimed at helping people with intellectual and multiple disabilities reach relevant rehabilitation goals. The 16 studies included in the paper addressed four specific rehabilitation goals, that is, (a) performance of functional activities, (b) access to leisure and communication and performance of functional activities, (c) increase of adaptive responses and decrease of problem behavior or inadequate posture, and (d) increase of ambulation responses. For each study, the paper reports the participants involved, the technology and the assessment process used, and the results obtained. Following the presentation of the studies, the paper focuses on three practically relevant issues: the role of technology-aided strategies over time, the relative potential of various technology-aided strategies, and the accessibility and applicability of the strategies.

Keywords
Technology; intellectual disability; multiple disabilities; functional activities; leisure; communication; adaptive responses; problem behavior; ambulation

1. Introduction

The use of technology is increasingly part of everyday life for neurotypical people as well as for people with intellectual and other disabilities [1-5]. The technology employed with people with disabilities is usually adapted to their condition and aimed at helping them achieve goals (i.e., independent activity or leisure engagement) beyond their reach if not adequately supported [6-10]. In essence, the role of technology is being seen as instrumental in creating autonomy and independence over several daily situations in which the absence of technology would imply people's dependence on staff or caregivers and/or extended passivity [2, 4, 6, 7]. The goals pursued and the technology solutions employed change in relation to the characteristics (levels of disability) of the people involved and the priorities of their daily contexts. For example, one of the main goals pursued for people with mild or moderate intellectual disability is independent engagement in multistep occupational, domestic, or vocational activities [9, 11-16]. The achievement of this goal is considered highly relevant from the people's perspective and from the standpoint of their rehabilitation context. Indeed, countering people's dependence on staff and caregivers while helping them increase their self-determination and functional occupation can positively affect their role and general outlook within their living and social contexts [17-20].

Other rehabilitation goals critical for people with mild or moderate levels of intellectual disability (even when this disability is accompanied by sensory and/or motor impairments) may include (a) independent access to leisure events combined with independent performance of multistep functional activities, (b) independent access to communication with distant partners combined with independent access to leisure events, and (c) independent access to leisure events and communication with distant partners combined with different forms of activities [21-24]. The choice of these goals would be a clear recognition of the fact that (a) the difficulties of these people do not only concern independent activity engagement but also include other areas such as leisure and communication with distant partners, and (b) programs that concentrate on more than one area/goal are likely to be more functional because they allow people to vary their type of engagement and remain constructively and independently busy for relatively long periods [22, 23, 25].

Among the rehabilitation goals that might be targeted with people with severe or severe to profound intellectual disability and possible sensory or motor impairments, two could be considered of immediate relevance. They concern (a) the strengthening of adaptive responses that, in addition to bringing about specific response-related benefits, may be instrumental in curbing inappropriate behaviors or postures (e.g., object mouthing and head and torso bending) [26-30] and (b) the strengthening of ambulatory behavior with or without the support of walker devices [31-34].

Undoubtedly, achieving these goals would have significant positive implications for the people's constructive occupation, well-being, and social image, as well as their contexts' sense of accomplishment and serenity [3, 27-29, 31].

A variety of technology-aided intervention strategies have been developed recently to pursue the above rehabilitation goals. This paper aims to describe some of those technology-aided strategies and the results obtained by summarizing studies assessing their applicability and effectiveness. The studies were selected based on their recentness within the literature targeting the rehabilitation goals mentioned earlier, their ability to illustrate different aspects of the goals or different setups of the strategies used to achieve the goals, and/or their inclusion of participants with different characteristics. Table 1 provides a list of the studies summarized in the paper concerning each rehabilitation goal.

Table 1 Studies listed according to the rehabilitation goals, with the specification of their publication year, the number and age of the participants involved, and the technology used.

Rehabilitation Goals			
Studies	Participants		Technology
	Number	Age (years)	
Performance of Functional Activities			
Randall et al. (2020) [35]	4	19 & 20	iPhone 6 fitted with Task Analysis Lite application software
Resta et al. (2021) [36]	14	25-62	Samsung Galaxy smartphone fitted with the Easy Alarm YouTube application
Lancioni et al. (2021) [37]	7	21-62	(1) Samsung Galaxy smartphone fitted with MacroDroid application (2) Samsung Galaxy smartphone fitted with Amazon Alexa, MacroDroid, and Philips Hue applications, and a Philips Hue indoor motion sensor
Lancioni et al. (2022) [38]	6	35-61	The same as the second option of Lancioni et al. [37], but with two Philips Hue indoor motion sensors
Access to Leisure and Communication and Performance of Functional Activities			
Lancioni et al. (2020) [39]	8	25-66	Samsung Galaxy tablet fitted with a SIM card, WhatsApp Messenger, and MacroDroid application
Lancioni et al. (2020) [40]	7	27-68	Samsung Galaxy smartphone fitted with MacroDroid application and cards with radio-frequency identification tags
Stasolla et al. (2022) [25]	5	14-18	Laptop computer fitted with the Clicker 5 software package and a touch/pressure sensor

Lancioni et al. (2022) [41]	4	28-59	Samsung Galaxy smartphone or tablet fitted with MacroDroid application, a Bluetooth Blue2 switch, and a mini speaker
Lancioni et al. (2023) [42]	4	25-53	(a) Samsung Galaxy smartphone or tablet fitted with a SIM card, Internet connection, Google account, and WhatsApp Messenger and MacroDroid applications, (b) a Bluetooth Blue2 switch or two pressure sensors, and (c) a mini speaker
Increase of Adaptive Responses and Decrease of Problem Behavior or Inadequate Posture			
Perilli et al. (2019) [43]	6	13-18	Laptop computer fitted with the Clicker 5 software package, a pressure sensor, and an optic sensor
Stasolla et al. (2021) [44]	7	7-10	Laptop computer fitted with the Clicker 5 software package, a wobble sensor, and an optic sensor
Lancioni et al. (2022) [45]	8	22-54	Samsung Galaxy smartphone fitted with Google Assistant and MacroDroid application, a mini voice recording device, and a mini voice amplifier
Increase of Ambulation Responses			
Stasolla et al. (2017) [46]	2	5 & 6	An electronic control system linked to an optic sensor
Stasolla et al. (2018) [47]	5	13-17	The same as in Stasolla et al. [46]
Stasolla (2020) [33]	1	9	The same as in Stasolla et al. [46]
Lancioni et al. (2021) [48]	4	24-39	Samsung Galaxy smartphone fitted with MacroDroid application and linked via Bluetooth to mini speakers

2. Rehabilitation Goals

2.1 Performance of Functional Activities

Four studies assessing technology-aided strategies to support the independent performance of functional activities are reviewed in this section [35-38]. For example, Randall et al. [35] conducted a study with four young adults who had a diagnosis of moderate intellectual disability. They aimed to help these participants perform three office-related tasks/activities: shredding paper, copying, and scanning documents. Completing an activity required the performance of 10 to 13 steps. The technology consisted of an iPhone 6 with Task Analysis Lite application software, which allowed the presentation of a picture, an audio message, and a video for each step of the activities. In essence, the input for each step included the verbal directions for the performance of the step, a picture of the completed step, and a video showing a researcher completing the step while providing verbal instructions/tips. The participants had the opportunity to watch the overall sequence of instructions, pictures, and videos, that is, the input available for the entire activity, and the chance to access the information for the single steps (one step at a time). The participants could also replay the information available for any single activity step. Following a baseline assessment, the participants were provided specific training on using the technology. Then, they were guided to practice using the technology on activities other than those targeted within the study. Eventually, the intervention on the three target activities took place. Data showed that the participants (a) were able to use the technology to carry out the three activities daily, (b) relied on the technology to access information for one task step at a time, and (c) were successful in achieving correct and stable activity performance.

Resta et al. [36] worked with 14 adults. Six of them had a diagnosis of intellectual disability (of apparently moderate level), while the other eight presented with a psychiatric condition and comorbid cognitive impairments. The goal was to help the participants start and carry out about 10 activities per day. The activities could involve, among others, morning bathroom routine, dressing, dental hygiene, food preparation, and room cleaning. The number of steps included in those activities varied between 12 and 21, with a mean of 15. The technology available to each participant was a Samsung Galaxy smartphone, fitted with the Easy Alarm YouTube application and supplied with audio files concerning reminders for the activities and step instructions. When an activity was due, the smartphone emitted a verbal reminder. Then, it presented the verbal instructions for the single steps of the activity (one instruction at a time). The interval between the reminder and the instruction for the first step of the activity, as well as the intervals between the instructions for the following activity steps, were preset by staff responsible for the participants' daily program (i.e., staff who would have the best estimates of the times required by the participants to respond to the reminders and to carry out the activity steps). The baseline preceding the intervention with the technology showed that the participants started less than 20% of the activities independently. Their percentage of activity steps performed correctly varied between less than 20% and about 70%. The intervention data showed that the participants started more than 90% of the activities independently and carried out between about 65% and 90% of the activity steps correctly. The increase in the percentages of activities started and steps carried out correctly was statistically significant for all participants.

Lancioni et al. [37] worked with seven adults who presented with moderate intellectual disability and visual or hearing impairments. Participants were to carry out several activities, each consisting of collecting from various areas and arranging on a central desk 28-34 objects. For each object to be collected and arranged, the participants received an instruction, a simple verbal phrase or the object's photo on the smartphone's screen, depending on the type of instructions they typically used in light of their sensory impairments. The instructions were presented using two different strategies based on two technology solutions. One strategy involved using a Samsung Galaxy smartphone equipped with a MacroDroid application, which presented the verbal and pictorial instructions at preset time intervals (i.e., intervals decided by research assistants based on repeated observations of the participants' performance). The other strategy involved using (a) a Samsung Galaxy smartphone, which was equipped with Amazon Alexa, MacroDroid, and Philips Hue applications, and (b) a Philips Hue indoor motion sensor. This technology ensured that a new instruction was presented to the participants only after they had completed the response to the previous instruction (i.e., after the motion sensor had detected that they had reached the central desk with the object transported). The length of the intervals could vary between different pairs of instructions and across sessions based on the participants' response performance. The two strategies and technology solutions were used in parallel (i.e., according to an alternating treatment design). The results showed that the second strategy and second technology solution produced a significantly higher level of correct responses for all participants.

Lancioni et al. [38] extended the work described above. They developed a new technology solution (i.e., an upgrade of that used by Lancioni et al. [37]) for tying activity instructions to participants' performance. Six adults with moderate intellectual disability and visual or hearing impairments were involved in the study. Activities consisted of combinations of functional responses (steps) that were known and meaningful to the participants and valuable within the context (e.g., "Go to the cabinet store, take a water bottle, and bring it to the kitchen" or "Go to the cabinet store, take the toilet paper, and bring it to the bathroom"). At the time at which an activity was due, the participants were provided with a verbal reminder or vibration and light flashes from the smartphone, followed by the first instruction for the initial response of the activity (e.g., "Go to the bathroom and take the dirty towels" or a picture showing dirty towels in the bathroom being removed). The verbal instruction would be repeated at programmable intervals. In contrast, the pictorial instruction remained on the smartphone screen until the participants reached the bathroom and, in so doing, activated the motion sensor available in that area. Sensor activation was followed by the presentation of the instruction concerning the second part of the response (e.g., "Put the towels in the laundry machine" or the picture showing the towels in the laundry machine). The same process was followed for each response involved in the activity programmed. The baseline showed that the participants failed to start and carry out the activities independently. The intervention involving the aforementioned technology showed that the participants began virtually all activities available and performed more than 97% of the activity steps correctly, independent of any staff support.

2.2 Access to Leisure and Communication and Performance of Functional Activities

Different studies have been carried out to target two or all three of these goals/areas. For example, Lancioni et al. [39] devised a technology solution to help eight adults with moderate intellectual disability plus sensory and/or motor impairments to select and access leisure events and video calls independently. The technology consisted of a Samsung Galaxy tablet with a front camera, proximity sensor, and multimedia player, fitted with a SIM card, WhatsApp Messenger, and the MacroDroid application. Every session started with the tablet presenting three pictures concerning leisure events and three pictures/photographs concerning preferred partners. The pictures were scanned (illuminated) individually for 5 s. The participants could select a picture (i.e., leisure event or partner to reach via video call) by approaching/touching the tablet's proximity sensor when that picture was being scanned/illuminated. The selection of a leisure event led the tablet to present one of the four or five alternatives from which the participants could choose. The choice of a partner led the tablet to start a video call with that partner. During the baseline phase (i.e., without the technology), the participants could not independently access leisure events or make video calls. During the intervention, all participants learned to use the technology and, through its use, managed to select and access leisure events and make video calls independently. Moreover, the participants maintained a highly consistent engagement level in the two areas across time.

Lancioni et al. [40] devised a technology solution to help seven adults with moderate intellectual disability, which could be combined with hearing impairment, to select and access leisure events and carry out functional activities. The technology involved a Samsung Galaxy smartphone used in combination with special cards. The smartphone was fitted with the MacroDroid application serving to automate its functioning. The cards represented the leisure options available and were provided with radio-frequency identification tags, which the smartphone could recognize. Each session alternated the choice of (and access to) a leisure event with the performance of a daily activity for a total of four leisure choices and three activities. Within each session, the participants could choose among eight leisure options (e.g., comedy and songs) that were considered to be exciting/enjoyable for them. The choice of an option (i.e., taking one of the cards and holding it against the smartphone so this could recognize the card's tag) led the smartphone to present one of four possible events related to that option (e.g., one of four different film clips concerning a specific comedian). At the end of the event, the smartphone presented a picture of the activity scheduled and then pictures of the single activity steps. The research assistant programmed the time of exposure of each picture on the smartphone's screen. During the baseline, the participants did not manage to access any leisure event independently, and the percentage of activity steps carried out correctly varied between zero and 15. During the intervention and post-intervention periods (with the support of the technology), all participants were highly successful in accessing leisure events and displayed high levels of correct activity performance without any staff help.

Stasolla et al. [25] worked with five adolescents who were emerging from a minimally conscious state and were presenting with cognitive impairment. The authors planned to provide the participants with communication, occupation, and leisure options through a technology solution set up for them. The technology involved a laptop computer fitted with a Clicker 5 software package and interfaced with a touch/pressure sensor placed in the participants' hands. Initially, the computer presented three pictures, each scanned for 2 s. The pictures showed a child who was reading (academic option), a child who was asking for the father (communication option), and a child who was writing (literacy access option). The participants could choose any of the options by activating the sensor (i.e., by closing their hand). If the participants chose the communication option, the computer presented three pictures (e.g., snack, beverage, and leisure) and scanned them. The participants could choose any of the three through the hand response. This choice led the computer to present three new pictures representing specific events related to the option just selected. Now, the participants could choose and eventually access the preferred event. The same process was followed within the other option areas (i.e., academic and literacy). During the baseline (when the participants did not have the hand sensor for making their choices), responding to the options shown was absent. During the intervention and follow-up phases (when the hand sensor was available), all participants had consistently high levels of responding (i.e., independent selection of and access to the choice alternatives offered via the computer). During these phases of the study, the participants also showed a significant increase in their satisfaction indices.

Lancioni et al. [41] worked with four adults who presented with moderate intellectual disabilities and sensory and motor impairments. The technology used during the intervention sessions involved a Samsung Galaxy smartphone or tablet combined with a Bluetooth Blue2 switch (i.e., a device encompassing two adjacent pressure-sensitive buttons), and a mini speaker. The smartphone and tablet were (a) equipped with a SIM card, (b) provided with Internet connection and Google account, and (c) fitted with the WhatsApp Messenger and MacroDroid applications. For the three participants with functional hearing, the smartphone initially verbalized that they could listen to music by pressing one (the smooth) button and call somebody by pressing the other (rough) button. If they pressed the smooth button, the smartphone verbalized the names of four preferred singers and eventually played a song of the singer chosen. If the participants pressed the rough button, the smartphone verbalized the names of four preferred communication partners. Pressing the rough button in relation to one of these names set up a video or an audio call with that partner. Following the time allocated for music and calls, the smartphone invited the participants to carry out an activity and gave the verbal instruction for the first step of it. After completing this step, the participants were to press one button to obtain the next instruction. The same strategy was to be followed for each subsequent activity step. The smartphone would deliver reminders/encouragements if the participants failed to seek a new instruction for a preset period. At the end of the activity, the smartphone informed the participants again that they could listen to music or make telephone calls (i.e., as at the beginning). A session contained four time periods for music and telephone calls interspersed with three activities. The conditions for the participant with hearing problems who used the tablet were similar to those described above, except that the instructions were provided through pictorial images. Data showed that during the baseline, the participants failed to provide any successful response or only managed to access few music events. During the intervention phase (with the support of the technology), all participants managed to independently access leisure events, make telephone calls, and carry out activities.

Lancioni et al. [42] assessed two technology solutions, which represented variations and upgrades of those described above. The first involved a smartphone linked via Bluetooth to a 2-switch device like the one used by Lancioni et al. [41]. It was employed with two adults who were blind, had moderate hand control, and were interested in communicating with distant partners through voice messages rather than telephone calls. The second involved a tablet linked via a Bluetooth interface to two pressure sensors and was employed with two adults who possessed functional vision, had no or poor hand control (i.e., were unable to use the aforementioned two-switch device), and were interested in communicating with their partners through video calls. In addition to leisure and communication, both technology solutions also supported a third (functional) type of occupation: listening to brief stories dealing with relevant daily topics (e.g., sport and food) and answering questions related to those stories. Each session contained four time periods dedicated to music and voice messages or video calls, and three stories. During the baseline phase (when the specific technology solutions were unavailable), two participants failed to access any leisure, communication, or story event, while the other two managed sporadic access to leisure or leisure and communication events. During the intervention (when the specific technology solutions were used), all participants independently engaged in multiple leisure and communication events throughout the sessions, listened to stories, and answered story-related questions.

2.3 Increase of Adaptive Responses and Decrease of Problem Behavior or Inadequate Posture

People with severe to profound intellectual or multiple disabilities can be characterized by a low level of adaptive responses (i.e., responses functional to help them interact with their immediate environment and improve their general condition) and the presence of problem behaviors (e.g., hand mouthing and drooling) or inadequate postures (e.g., head and torso forward leaning). Technology solutions for intervening with these people may be set up to provide (a) positive stimulation for the performance of adaptive responses, (b) positive stimulation for the absence of the problem behavior or posture, or (c) positive stimulation for the performance of adaptive responses in the absence of the problem behavior/posture. The last type of technology solution involves using two or more sensors simultaneously to monitor the adaptive response and problem behavior or posture targeted for the intervention. This type of solution may be viewed as more relevant than the other two from a rehabilitation standpoint, even though its application may be more challenging to set up and carry out.

An application of this technology solution was reported by Perilli et al. [43], who worked with six adolescents with fragile X syndrome and severe to profound developmental disabilities. The technology solution relied on a pressure and an optic sensor linked to a computer fitted with the Clicker 5 software package. The adaptive response, monitored through the pressure sensor, consisted of putting an object in each of the three containers the participants had before them. The problem behavior, monitored through the optic sensor, consisted of hand biting. After an initial baseline, the technology was set to deliver a brief period of positive stimulation for each adaptive response irrespective of the problem behavior. Next, the technology was set to deliver the stimulation for the adaptive response, provided this was not accompanied by the problem behavior. Moreover, the stimulation lasted the scheduled time only if the problem behavior did not occur during that time. Data showed that all participants had a large increase in the frequency of the adaptive response and a drastic decline of the problem behavior during the intervention phases with the technology. The participants also displayed an increased level of satisfaction during those phases.

Stasolla et al. [44] worked with seven children with Angelman Syndrome who presented with severe to profound intellectual disability and a variety of problem behaviors, which included tongue protrusion. The technology entailed a laptop computer fitted with the Clicker 5 software package interfaced with a wobble sensor and an optic sensor. The wobble sensor was on the desk before the participants and monitored their adaptive response, which consisted of object manipulation. The optic sensor was fixed at the corner of the participants' lips and monitored their tongue protrusion. The study included (a) intervention phases, in which the participants received brief periods of positive/preferred stimulation for adaptive responses irrespective of whether the problem behavior accompanied them, and (b) intervention phases, in which adaptive responses were followed by preferred stimulation only if they occurred free from the presence of tongue protrusion. In the latter phases, moreover, tongue protrusion during the presentation of preferred stimulation caused the interruption of such stimulation. Data showed that the intervention led to an increase in the level of adaptive responding. The presence of tongue protrusion dropped particularly in the latter intervention phases when its presence caused the omission or interruption of stimulation.

Lancioni et al. [45] worked with eight adults who presented with severe to profound intellectual disability plus visual and/or motor impairments. The objective of the study was to lead the participants to exercise demanding arm responses considered to be beneficial for them (i.e., raising the arm/arms above the head or stretching the arm forward and up) and improve their posture (i.e., reduce the time they spent in an incorrect/unhealthy posture such as head and body forward leaning). The technology solution adopted for the participants included a Samsung smartphone, a mini voice recording device, and a mini voice amplifier. The smartphone was fitted with Google Assistant and the MacroDroid application. Emitting the adaptive response led the participants to touch/press the mini-recording device, which also served as a sensor. Once it detected the response, the device verbalized, “OK Google”. This verbalization activated the smartphone’s Google Assistant and started a period of preferred stimulation. During some intervention phases, the participants received preferred stimulation for their performance of the target arm response, and this stimulation lasted the scheduled time regardless of whether their posture (which was monitored by the smartphone through its proximity sensor) remained correct or not. During other intervention phases, the stimulation for the target arm response lasted the scheduled time only if the posture remained correct during that time. Participants showed significant increases in the frequency of the target arm response during all intervention phases. They also showed a substantial decline of the inaccurate posture (i.e., an increase in the time spent with a correct posture) during the latter intervention phases.

2.4 Increase of Ambulation Responses

Ambulatory behavior is critical for promoting physical activity, exploring the surrounding space, increasing interaction opportunities, and improving the social image. Given the importance of this goal and the problems people with severe to profound intellectual and multiple disabilities may have in achieving it, efforts have been made to develop technology-aided intervention strategies that could be of help. For example, Stasolla et al. [46] worked with two children who were considered to have severe to profound levels of intellectual disability and could take a few steps with the help of a walker device but were typically sedentary. The technology included an electronic control system connected to an optic sensor and various stimuli. The optic sensor, which was fixed on the walker used by the children, served to detect their step responses and activate the control system in relation to those responses. During the intervention phases of the study, the control system ensured the delivery of 3 s of multi-sensory stimulation contingent on each step response. During control sessions, the stimulation would be available to the participants non-contingently (i.e., with no specific connection to the emission of the step responses). Both participants had a substantial increase in the frequency of step responses during the intervention sessions with the stimulation contingent on the occurrence of those responses, and a decline of those responses in the sessions with non-contingent stimulation. The positive results obtained with contingent stimulation were replicated by Stasolla [33] in a subsequent study involving a single child.

Stasolla et al. [47] worked with five adolescents with Rett syndrome who were functioning in the severe to profound range of intellectual disability. The objective was to promote fluency in the participants’ ambulation, so the preferred stimulation did not follow each step made but each sequence of 4 steps performed within a 3-s interval. The technology included the same components used in the study by Stasolla et al. [46]. Like in that study, there were intervention phases with contingent stimulation (i.e., stimulation following the response sequences) and intervention phases with stimulation provided non-contingently. Data showed that all participants had a significant increase in the frequency of their step-response sequences during the intervention phases involving contingent stimulation and a decline of those frequencies during the intervention phases with non-contingent stimulation.

Lancioni et al. [48] worked with four adults who presented with severe to profound intellectual disability and blindness or deafness and motor impairments. The objective was to help the participants walk and transport objects. The technology used for the participants with blindness involved a Samsung Galaxy smartphone fitted with MacroDroid application and linked via Bluetooth to mini speakers. The smartphone was fixed on the participants' ankles and served to detect the shaking events produced by the participants' step responses and deliver stimulation related to those responses. The mini speakers could be at the opposite ends of a long corridor. The participants were accompanied to one hand of the corridor and asked to walk along the wall. Every shaking event led the smartphone to emit 3 or 4 s of preferred stimulation, which was delivered from the mini speaker in front of the participants. Lack of step responses led the smartphone to present encouragements/prompts from the same mini speaker (i.e., in front of the participants). At preset intervals, the smartphone turned off the speaker that had been working up to that point and activated the one at the opposite end of the corridor, which then started to emit stimulation and prompts. This was to help the participants turn and walk in the opposite direction, thus continuing their ambulation. The technology used for the participant with deafness included visual (rather than auditory) stimulation presented via a tablet. All participants showed a clear and significant increase in the frequency of step responses during the intervention sessions with the technology compared to the baseline in which no technology was available.

3. Discussion

The technology-aided intervention strategies described above represent clear examples of how technology can be instrumental in helping people meet relevant rehabilitation goals, which could be considered out of their reach because of lack of essential physical and cognitive prerequisites or lack of motivation. Indeed, the strategies set up to promote independent and correct activity performance, as well as the strategies set up to promote leisure and communication plus activity performance, may be seen as means to bypass the participants' weaknesses (lack of prerequisites) concerning the memory skills area and/or the motor and verbal skills areas [11, 12, 15, 25]. The strategies set up to (a) increase adaptive responses and decrease problem behavior or posture and (b) increase ambulation responses may be principally seen as means to give the participants the motivation to pursue objectives (to engage in types of performance) for which they have minimal or no personal appreciation [23, 43, 49, 50]. In light of the studies summarized in this paper and the technology-aided strategies they used to achieve the different rehabilitation goals, at least three general considerations may be in order. Those considerations may concern the role of the technology-aided strategies over time, the relative potential of various technology-aided strategies, and the accessibility and applicability of different strategies.

3.1 Role of the Technology-Aided Strategies Over Time

While the studies reviewed provide positive evidence as to the impact of the strategies, a question may be raised as to whether the use of those strategies can eventually be faded out without jeopardizing the participants' achievement. The data available do not allow a definite answer to this question. In fact, the answer might vary depending on the characteristics of the participants and the skill range required by the goal pursued. For example, studies have reported that participants could learn to perform the activities scheduled with a reduced reliance on the technology-aided strategies available (e.g., could start the activities independently and complete them using instruction chunks rather than single-step instructions [51-55]). Levels of independence may be more plausible when the participants have a mild or mild to moderate level of intellectual disability when they are taught to perform only few activities and when those activities contain a relatively small number of steps [20, 56-59]. A completely different picture may emerge when the participants' level of intellectual disability is moderate or moderate to severe, when the number of activities to be performed is not limited to very few, when the number of steps included in those activities is not small, and when the activities do not contain a fixed sequence of steps [38, 57-60]. In all these cases, the technology may have a critical and lasting role in supporting the participants (i.e., bridging the gap between the participants' potential and the skills required to carry out the activities correctly).

A lasting role of technology-aided strategies may also be hypothesized in most (or all) rehabilitation situations portrayed in the studies summarized above. For example, participants lacking fine motor control and speech may be unable to learn how to use a smartphone or tablet, operate choices, or start telephone calls through fine motor responses or specific verbal utterances. People with low levels of adaptive responding and problem behavior/posture may not maintain positive changes (i.e., increases of adaptive responding and reduction of problem behavior/posture) unless they are motivated to do so. Motivation cannot be expected to originate from their understanding/appreciation of the physical and social benefits of those changes. Instead, it may be ensured through environmental stimulation events that make their performance of adaptive responses and avoidance of problem behavior/posture meaningful to them (i.e., through the presentation of events that the technology can control reliably and without staff time costs) [43-45]. Similarly, people with intellectual and multiple disabilities may not be inclined to ambulate because this is a demanding engagement for them and because they have no specific reasons (no personal motivation) to be involved in such an engagement. Also, they may not have specific environmental areas to reach (e.g., areas that attract their attention and provide them with a pleasurable experience). Thus, a technology-aided strategy ensuring such a pleasurable experience may be critical in motivating them to maintain such an engagement over time [46-48].

3.2 Relative Potential of Various Technology-Aided Strategies

A fundamental question is whether there is a potential difference in impact and effectiveness among the strategies used to reach the same goal (e.g., performance of functional activities). The question cannot be answered since only occasional comparisons have occurred between approaches for achieving a specific goal. Those comparisons concern strategies for helping participants with moderate intellectual disability and visual and motor impairments carry out complex functional activities (i.e., food preparation or object collection and final arrangement [27, 37, 56]). The comparisons on food preparation involved a technology-aided strategy ensuring that the step instructions were automatically presented and a technology-aided strategy requiring the participants to seek each step instruction by activating a simple sensor. Results indicated that the strategy ensuring automatic presentation of the instructions produced a better performance than the strategy requiring the participants to seek the instructions. The comparison on object collection and arrangement involved a technology-aided strategy in which a smartphone presented instructions at preset time intervals and a technology-aided strategy in which a smartphone linked to a motion sensor presented the instructions in close connection with the participants' step performance. The latter strategy seemed more effective than the former in avoiding performance errors.

3.3 Accessibility and Applicability of the Technology-Aided Strategies

The essential technology components of all the strategies described above are commercially available and thus easily accessible. One point that needs to be considered here is that setting up those components according to the intervention conditions requires specific work from staff personnel. For example, the use of the Clicker 5 package and the use of the Macrodroid application require that staff (a) arrange the choice options to be targeted within the intervention, (b) program the computer, smartphone, or tablet to present those options in a way that is suitable to the participants, and (c) identify/select the type of responses through which the participants can choose among those options and eventually access the ones that they prefer. While this arrangement and programming may not be too complicated for staff and caregivers who have basic knowledge of and familiarity with technology and related issues, they may result somewhat problematic for staff and caregivers who have no experience in this area [3, 4, 9, 10, 25, 45, 61].

Concerning the applicability of the technology-aided strategies, the main questions involve the initial setup of the technology, its portability, and the daily requirements for its use. The question concerning the initial setup of the technology has been addressed above. As to the portability of the technology, it may be observed that all the technology solutions reviewed above would be easily portable and thus allow staff and participants to continue their work across contexts. The requirements for the daily use of the technology-aided strategies (i.e., for setting up and carrying out intervention sessions) are typically limited and thus quite compatible with staff’s busy schedules [22, 36, 40, 60-63].

4. Conclusions

The use of technology is increasingly part of everyday life for people living a typical life as well as for people with intellectual and other disabilities. This paper has reviewed a number of studies assessing technology-aided strategies to help people with intellectual and multiple disabilities meet rehabilitation goals otherwise elusive to them. The data obtained through the strategies reviewed are encouraging as to the overall effectiveness of those strategies and thus provide an incentive toward their use on a larger scale, particularly in daily contexts. Notwithstanding this reasonably positive picture, there are questions about those strategies that do not have specific answers and thus require further research and understanding. One of the possible questions concerns the discrimination of the situations in which the technology-aided strategies may be viewed as a permanent prosthesis from the situations in which those strategies may be considered a temporary support. Another question may concern ways of ensuring that the setting up of the technology-aided strategies is feasible within daily contexts regardless of the familiarity with technology and technology-related issues of the staff or caregivers involved.

Author Contributions

GL was responsible for conceiving the paper and writing it up. NS, MOR, JS, GA, and MOB collaborated in setting up and writing/editing the paper.

Competing Interests

The authors declare that they have no conflicts of interest.

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