Article

High-Tech Augmentative and Alternative Communication Devices: Observing Children's Need for Help and Interaction with Caregivers

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Abstract: There are many children with disabilities who need specialised devices to communicate and to be understood, which poses an added challenge for their caregivers. This study aims to diagnose the training needs of informal caregivers concerning high-tech devices for augmentative and alternative communication (AAC), to enhance the use of these devices in the home setting. The aim is to study children's performance and their interaction with caregivers, to improve practices and contribute to reducing technology abandonment at home. Participant observation sessions were carried out in three home settings to describe the interaction between children and their caregivers, as well as to assess the former's need for assistance in using the Grid3 software when combined with eye-gaze-controlled technology. The findings seem to demonstrate the importance of interactions between caregivers and children for carrying out tasks and improving performance. Therefore, it can be inferred that positive reinforcement is important to foster children's motivation to overcome difficulties in using such devices, along with corrective feedback. The data suggest the need to promote technology-mediated communicative interaction in all life contexts. It is also possible to infer that the lack of regular device use at home compromises skills development. These findings have contributed to the planning and implementation of parental training intervention regarding using assistive technology for augmentative and alternative communication.

Keywords: augmentative and alternative communications systems; home environment; high-tech devices; caregivers; social interaction; family support

1. Introduction

"The public has been deceived by believing the illusion that AAC [augmentative and alternative communication] technology by itself causes someone to talk who cannot speak". Although written almost three decades ago, this quotation by David Beukelman (1991, p. 2) remains relevant today and highlights the importance of receiving training for and using a communication device regularly, in order to be proficient in using it. Indeed, the use of AAC devices imposes significant learning costs since individuals must learn not only how to operate a computer-based device but also how to use the technology to successfully participate in communicative interactions (Kent-Walsh and Mcnaughton 2005; Light and Mcnaughton 2015; Mcnaughton et al. 2008). Moreover, the literature reinforces the importance of ensuring that both children and their families are active members of the intervention team, alongside therapists and teachers (Bailey et al. 2006; Brotherson et al. 1996; Mandak et al. 2017; O'Neill et al. 2017; Parette et al. 2000).

In light of the above, this study considers the research problem of how to promote assistive technology (AT) use by children with cognitive and/or motor limitations in the home setting. This study aims to analyse children's performance and also their interaction

with their caregiver(s) to improve practices regarding the use of AT, thus contributing to reducing the problem of AT abandonment at home. In this way, we aim to describe caregivers' interactions, abilities and training needs, thereby answering one of our main research questions: what are the training needs of informal caregivers to support the use of high-tech devices for AAC?

Many caregivers still have little or no idea of what AAC options are available for the children in their care (Williams et al. 2008), despite increasing recognition of the importance of early intervention with AAC (O'Neill et al. 2017; Romski et al. 2011). Furthermore, it has also been shown that having only one technique, one communication partner, or one environment in which the AAC system can be used is insufficient (Williams et al. 2008). AAC users must develop sufficient skills to meet the functional communicative demands of real-world interactions with various partners in their natural environment (Holyfield et al. 2019; Light and Mcnaughton 2015). The lack of attention towards communication partners in AAC intervention is especially worrying, given the convincing evidence establishing the efficiency of partner instruction and its positive impact on the communication of individuals with complex communication needs (Borgestig et al. 2016; Kent-Walsh and Mcnaughton 2005; Romski et al. 2011). Furthermore, AAC systems must be customised to meet users' needs, in terms of ease of use and learning, and each device must fit the age and personality of its user (Mcnaughton et al. 2008; Williams et al. 2008). Williams et al. (2008) also emphasise the ethical responsibility of involving individuals in decision-making regarding every aspect of AAC research, development, and intervention. However, individuals with complex communication needs often have limited information and restricted access to training. Furthermore, they are often restricted in their communication partners and opportunities and are, thus, hindered from fully participating in society (Williams et al. 2008). In this context, gaze-based assistive technology, for instance, has the potential to provide opportunities for communication, interaction and activities to children affected by severe impairments that inhibit the use of limb or head movements (Borgestig et al. 2016; Holmqvist et al. 2017).

As adversity often does not appear in a single form, due to the COVID-19 pandemic, 2020 and the subsequent years were particularly difficult for children with disabilities. Distance learning and communication, whether due to scarce resources, novelty, isolation, or little or no digital literacy, made interacting and learning for most students challenging enough. For those with disabilities and also for their carers, it was still more difficult, even overwhelming. To everyone's difficulties was added the despair of their already atypical ways of functioning, which were often dependent on assistive technologies and augmentative communication systems. Regarding this issue, Puli et al. (2021) explored the experiences and impacts of the COVID-19 pandemic on AT providers. They stressed that the public health response to COVID-19 further exposed and exacerbated existing weaknesses in AT systems and services and posed new challenges. The authors also emphasized the need for AT providers to be better prepared and supported in the future, although barriers to access to AT resources existed long before COVID-19.

Therrien et al. (2022) and Biggs et al. (2022) sought to understand the impact of COVID-19 on children, families, service providers and the delivery of AAC-related communication services. They believed that the global pandemic instigated a dramatic change in service delivery for students with communication disorders, including students with complex communication needs who used aided augmentative and alternative communication (AAC), such as speech-generating devices. From the perspective of the parents and speech-language pathologists who participated in the study conducted by Therrien et al. (2022), COVID-19 will have lasting impacts on the lives of children with complex communication needs.

Therefore, recent research highlights the essential role of the family and access to quality AAC services for children during the pandemic and onwards (Puli et al. 2021; Therrien et al. 2022; Biggs et al. 2022). According to these studies, it is believed that characterisation of the family environment and training tailored to the needs and skills

of the users of augmentative communication systems and their carers in a (family) care context is an option that should be considered in order to bridge the gaps often overlooked by conventional methods.

Through an exploratory descriptive study with a limited number of participants, it is possible to find details that are often ignored and thus deepen our knowledge of the area under study. What is lost in length, and consequently in generalisation, is gained in the depth with which the theme is addressed, allowing us to discern details that should be considered and that are transferable to similar situations, in order to meet the needs encountered and those that may occur in various family environments.

2. Materials and Methods

2.1. Participants

A description of each participant's age, gender, health condition, school level, relationship to caregiver and the device used is shown in Table 1. The inclusion criteria for the participating children were: (i) under 12 years old; (ii) the presence of cognitive and/or motor limitations; (iii) the use of high-tech AAC communication devices in the home setting.

Table 1. Characterisation of the participants and devices used.

	Participant A	Participant B	Participant C
Gender of the child	female	male	male
Age/school level of the child	4 years old/preschool	8 years old/grammar school	11 years old/lower secondary
Caregiver	Mother	Mother	Father
Health condition	Cerebral palsy (tetraparesia)		
AT devices used	PC + software Grid 3 + Tobii PC Eye mini		

The data were collected in the participants' home settings, with the written consent of their caregivers. The three children participating in this study use a personal computer with Smartbox® Grid 3, a comprehensive AAC software that enables alternative communication, environment control and computer access. This software can be used with every type of alternative access, from eye-gaze and switch technology to touch and pointing devices, making it suitable for people with cognitive and/or motor disabilities. Since the participants in this study have severe motor limitations, they use eye-gaze technology to access the computer—the Tobii® PC Eye Mini. This is a small eye tracker that replaces the standard mouse, meaning that a target is selected when the user fixates on it for a certain length of time (Holmqvist et al. 2017).

2.2. Research Design

This exploratory and descriptive study has a qualitative approach intended to explore the characteristics of caregivers' interactions with the children in their care, emphasising their attitudes and perceptions (Amado et al. 2017; Moreira and Caleffe 2008). It aims to obtain a comprehensive and holistic understanding of the situation's historical, socioeconomic and cultural background and to interpret it through an inferential and inductive process (Amado et al. 2017). Thus, the objectives of this study are to identify the training needs of informal caregivers, to devise a training programme adjusted to them and, ultimately, to contribute to reducing the abandonment of AT.

This investigation qualifies as action research since, alongside the researcher, the caregivers have a participative role in identifying their training needs and contributing to the development of a training programme adjusted to their circumstances. Three observation sessions were conducted with each participant and their caregiver in the home setting. Ethical principles and requirements were taken into consideration, such as informed con-

sent and confidentiality. Therefore, the participants were informed about the ongoing investigation and were guaranteed confidentiality and anonymity.

2.3. Materials

Task guidelines for 3 twenty-minute observation sessions were planned with each caregiver, considering the pre-existing contents/grids in the participants' computers. For instance, participants A and B had grid sets created by their therapists and their own special education teacher, with vocabulary games, songs, and rhymes. The researcher met with the participants' speech therapists and teachers before the sessions to learn about the specific child's skills and the tasks usually performed at school. Participant C had very few grid sets in place and was not using their device at school when the first and second observation sessions occurred. Moreover, it was not possible to meet their teacher beforehand, so the task guidelines for participant C were defined according to the caregiver's feedback. The action of calibrating the eye-gaze camera was chosen to initiate each session because of its relevance to the children's performance. Gaze calibration is performed by having the user look at a set of on-screen targets before usage. It is essential to obtain reliable results for the specific user during usage (Borgestig et al. 2016; Holmqvist et al. 2017). After each set of sessions, each caregiver was asked to answer a post-observation questionnaire consisting of two parts. The first part included a Likert scale to ascertain the caregiver's opinion of the sessions' duration, relevance, usefulness and contribution. It also included two closed questions to assess the continuity and regularity of AT device use after the sessions. The second part consisted of three open-ended questions to obtain the caregivers' opinions regarding their training needs.

2.4. Procedures

Sessions of participant observation were carried out in the home setting, where the children used the devices to describe the interaction between the child and caregiver and the child's need for assistance in using the device. A structured, systematic observation protocol was followed, task guidelines were predefined, and observation categories were organised according to the research aims, allowing content analysis of the references and extracting numerical data from the observation (Cohen et al. 2003).

The task guidelines for each session were defined with each caregiver, and the sessions were video-recorded to allow later visualisation and detailed written narrative description of the tasks carried out by the child and to ensure the reliability of the observation. The child was present throughout the whole process, so as to become familiar with the researcher and the dynamics of the observation. The researcher had a significant level of involvement since there was interaction with the participants in preparing the task guidelines and giving suggestions to the caregivers during the sessions. The literature on AAC associates several advantages with participant observation, which is considered the best way to obtain deeper, more detailed and concise information. This also provides a valid image of the social reality, which, in this case, is the use of assistive AAC devices in the home (Moreira and Caleffe 2008). Bearing in mind that participant observation may raise data validity issues, it is advisable to have gained previous access to the observation context to interact with participants and gain their trust. In this case, the caregivers had previously been interviewed by the researcher regarding their perception of the child's ability to use the AT device and their own training needs (Almeida et al. 2019a); thus, they promptly accepted the need to carry out these observation sessions in the home.

The video recordings were analysed with the qualitative data processing software, WebQDA. Based on the literature, predefined categories of data content analysis were used, namely, the executive function performance test (EFPT) developed by Baum et al. (2007), which provided a theoretical framework for the categories of analysis regarding the child's independence in fulfilling the tasks that were proposed. The main objective of the EFPT is to determine an individual's ability for independent functioning and the amount of assistance necessary to complete a specific task (Baum et al. 2007).

To analyse the content of the observed data in terms of the need for assistance to complete a task, the subcategories used to analyse the content of the sessions were based on the EFPT system of cues and help, which ranges from no cues required to indirect verbal guidance, gestural guidance, direct verbal assistance, physical assistance and, at the other extreme, performing the step on behalf of the participant.

The cues from the EFPT shown in Table 2 were converted into specific categories of analysis regarding the video-recording content of the observation sessions. Moreover, the analysis of the data that were gathered in the observation sessions resulted in the creation of an additional category of analysis—visual cues—to describe situations when the child is provided with visual support for a written word, picture or object in order to complete the task, or when the caregiver intentionally places the cursor on the icon that the child is supposed to click and select.

Table 2. Subcategories of analysis of the child's independence/need for help.

Description of the Cues and Help from EFPT (Baum et al. 2007)	
No cues required	The participant requires no help or reassurance, does not ask questions for clarification, goes directly to the task and does it.
Indirect verbal guidance	The participant requires verbal prompting, such as an open-ended question or a statement, to help them move on. Indirect verbal guidance should come in the form of a question, not direct instruction.
Gestural guidance	The participant requires gestural prompting. Such gestures should mimic the necessary action to complete the task or make a movement that guides the participant.
Direct verbal assistance	It is necessary to deliver a one-step command so that the participant is cued to take the intended action.
Physical Assistance	The participant is physically assisted with the step, but no one is doing it for him or her.
Act for the Participant	It is necessary to perform the step for the participant.

Likewise, categories regarding the interaction between the caregiver and child, as shown in Table 3, emerged during the content analysis of the data, in an inductive, exploratory process of units of meaning during the search for patterns, consistencies and/or exceptions. It is worth noting that vocalisations coded within the category "request for help" are only those interpreted as clear evidence that the child asked the caregiver for help to fulfil the task, for instance: "The child vocalises/emits a vocalisation". Other references coded as a request for help may be described more explicitly, for example, when the child uses the vocative "Mummy/Daddy", points, or intentionally looks at the caregiver.

Table 3. Subcategories of analysis of the interaction caregiver>child during the sessions.

Category of Analysis: Interaction Caregiver>Child	
Subcategory	Description
Positive reinforcement	Encouragement given by the caregiver to the child for their good performance, in a verbal form (compliment) or non-verbal (a kiss, a hug).
Corrective feedback	Verbal feedback given by the caregiver to the child when they make a mistake.
Incentive to overcome difficulty	Verbal or non-verbal encouragement given by the caregiver to motivate the child to overcome difficulty.
Request for help	The child requests verbal or non-verbal assistance from the caregiver.

The three open questions of the post-observation questionnaire, posed by the researcher in person and the answers audio-recorded with the respondents' consent, were transcribed verbatim and then sent to the respondents for validation. The content of the answers was analysed using the WebQDA software. Repeated readings allowed their codification under the emerged categories from the data, as shown in Table 4.

Table 4. Categorisation of the open-ended questions in the post-observation questionnaire.

| Question	Categories	Subcategories
Are there areas where you feel the need to have further training?	Training needs	Setting up software to meet the identified needs Motivating the child to use the device Contribution of these sessions Need for further training
How could the child's communication interactions be more effective?	Ways to promote effective communication interaction	Combining the device with other AAC forms Using practical, lightweight devices Regular use of the device at home Identifying obstacles to effective interaction
Can you handle technical issues, software installation or setting up?	Caregivers' ability to solve technical issues	Autonomy Difficulties Online technical support

3. Results

3.1. Participant A

With caregiver A, some tasks were chosen from the three grid sets of Communication, Music and Games, as depicted in Table 5. The child was initially asked to click on specified photos/songs/games but did so only after the caregiver insisted. Therefore, in the subsequent sessions, they were granted more freedom to select their favourite songs, which proved to be a successful strategy. Likewise, associating particular body parts with photographs of their clothes appealed to the child, as evidenced by their smiling. Again, the data seem to point to the importance of incorporating the child's own experiences, interests and preferences (Mcnaughton et al. 2008; Williams et al. 2008).

Regarding the category of analysis known as "independence of the child/need for help", the second session not only stands out for its longer duration (thirty-seven minutes), on the one hand, but also for its greater number of references to actions performed without assistance, on the other. In some situations, these actions (opening grids, selecting symbols and returning) were fulfilled after several attempts, as illustrated by references such as: "Finally, the child selects the song requested". Moreover, in all sessions, there are references to direct verbal assistance. Many of these direct verbal commands are complemented with gestural guidance, for instance: "The caregiver points to the school activities grid set and adds: 'Here, this one!'" Indeed, even though some indirect verbal guidance is provided (" . . . reads the options and says they need to answer in the symbols below"), caregiver A uses mostly gestural guidance, accompanying their instructions with gestures, mainly to point out the grid sets or the icons. For this reason, many references are coded in all sessions, as shown in Figure 1.

Table 5. Tasks guidelines—Participant A.

	Session 1	Session 2	Session 3
Date	11 June 2019	25 June 2019	2 July 2019
Duration	~22 min	~37 min	~21 min
Initiation		Calibrating the eye-gaze camera	
Task 1	Access the Communication grid set	Access the Communication grid set	Access the Communication grid set
Task 2	Identify the photos of some relatives	Answer the questions: How are you? Do you like working?	Identify the photos of some classmates, teachers and school staff
Task 3	Choose an activity: listen to music or play with a doll	Identify the photos of some classmates, teachers and school staff.	Access the Music grid set
Task 4	Access the Music grid set	Access the Music grid set	Select a song and play it
Task 5	Select a specific song and play it	Select a song and play it	Access the School Activities grid set
Task 6	Access the Games grid set	Access the School Activities grid set	Select a specific activity and associate jobs with tools
Task 7	Select a specific game and play it	Select the Clothing activity and associate clothes with parts of the body	
Task 8	Access the rhymes grid set	Access the Colours game	
Task 9	Listen to a specific rhyme	Identify the colour of an object or fruit	
Finalise		Go back to the main menu	
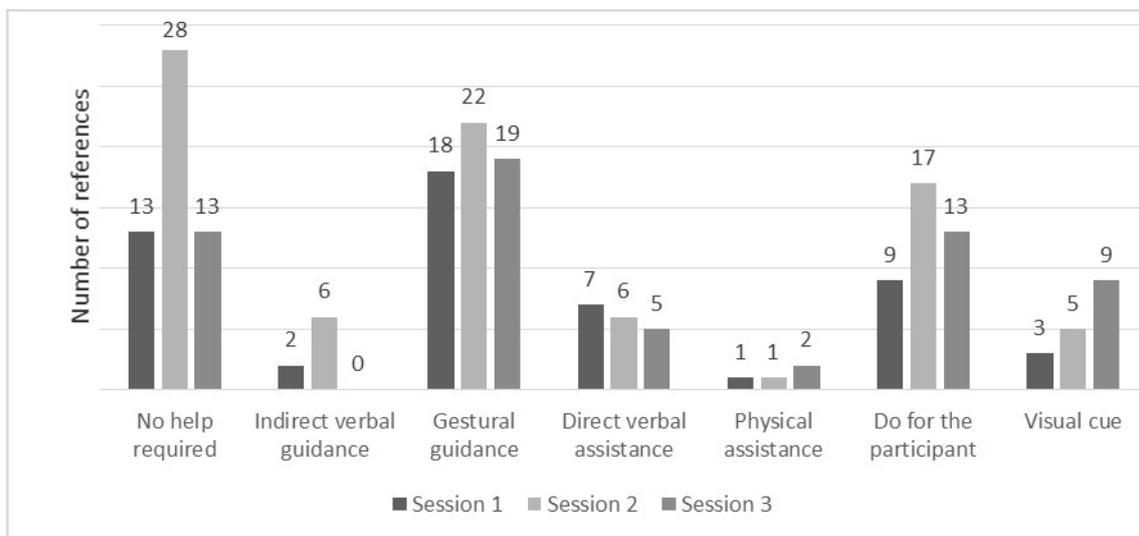
Figure 1. Participant A—References coded in the subcategories of analysis of the category "Independence of the child/need for help".

It is worth mentioning that the references coded as visual cues shown to participant A refer to those situations where caregiver A placed the cursor on the desired icon/symbol, e.g., "the caregiver places the cursor on the Music icon". This occurrence was more frequent in the third session, as seen in Figure 1. It should be noted that there are very few references to physical assistance throughout the sessions, referring only to those situations when the caregiver tries to improve the child's posture on the chair, to overcome difficulty in clicking on the icons ("The caregiver straightens up the child's upper body and head"). However, in all sessions, there was a significant number of references to actions performed by the caregiver on behalf of the child, such as clicking to go back to a previous item and opening and closing grid sets and folders.

Concerning the interaction between caregiver and participant, Figure 2 shows that references coded as positive reinforcement are present in all sessions, both in verbal and gestural form, but were more frequent in the first session. Some examples are: "The caregiver says 'Good' and gestures OK"; "That's right!"; "Very good!" In turn, there are also references to the child's responding with happy vocalisations and smiles. Thus, these caregivers' positive reinforcement produced joyful, positive responses, and it can be inferred that this fosters children's self-fulfilment and motivation.
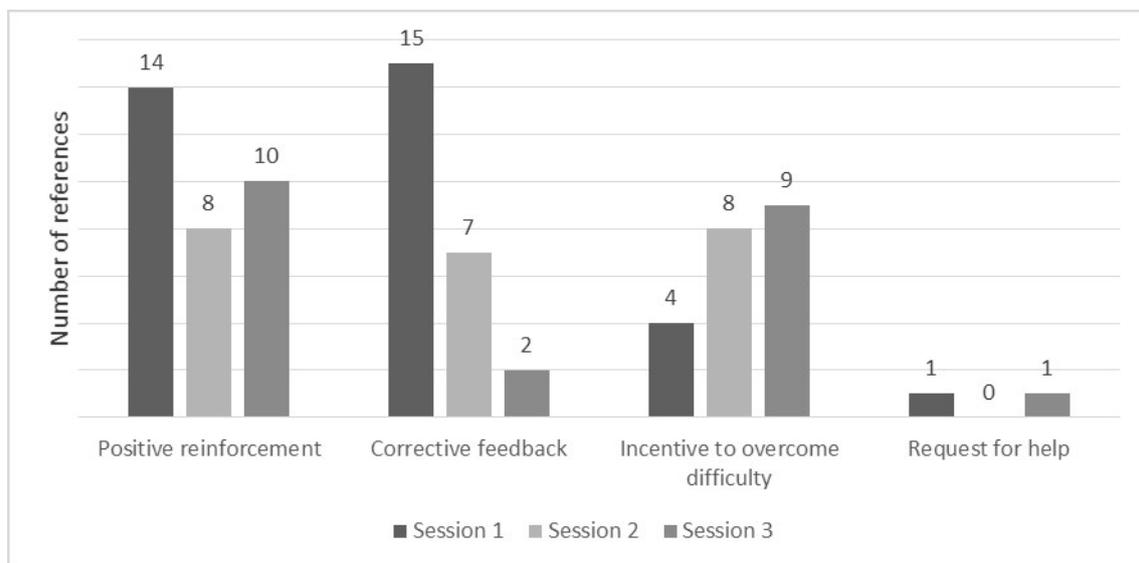
Figure 2. Participant A—References coded in the subcategories of analysis of the category "Interaction between caregiver and child".

Similarly, the number of references to corrective feedback is more frequent in the first session, as observed in Figure 2. Caregiver A provides feedback to direct the child towards the intended task: "The mother says she hasn't asked for that one and points at the desired icon". There are also references to corrective feedback intended to confirm whether the child intentionally selected an item; for instance: "The child selects pause several times and the caregiver asks if the child really doesn't want to play anymore".

Despite the child's difficulty in clicking, only two references of requests for help can be found throughout the sessions. In the first session, "The child sighs with effort", then in the third session, "The child produces vocal sounds/vocalisations denoting effort in clicking on the symbols".

Faced with the child's difficulty, caregiver A also tried to increase the participant's motivation, with references found mostly in the second and third sessions, as shown in Figure 2, such as: "The caregiver encourages trying again and not giving up". Some references also contain gestural guidance, such as: "Come on, click, see...? Here, here"; "The caregiver points and repeats: Come on, click here, go on!" The child reacts positively to that incentive, emitting joyful vocalisations.

Regarding the duration of the interaction, Table 5 shows that sessions 1 and 3 were within the expected time (twenty minutes), although a reduced number of tasks may have contributed to this shortened duration in session 3. On the other hand, in session 2, the interaction time was beyond the expected duration, despite many references to the category "No help required", compared to the other sessions. To sum up, the participant's data seem to point to an uneven performance in terms of independence throughout the sessions, even though the child willingly attempted to fulfil all tasks. Interaction with caregiver A in the subcategories of positive reinforcement, corrective feedback and incentives to overcome difficulty were referred to in all sessions, but the data seem to point to the child's

limitations in asking for help with either verbal or non-verbal signals (gestures, glances, vocalisations, etc.).

3.2. Participant B

Participant B had been using Grid 3 and the eye-gaze system for over a year. Since the child attends a school following the standard elementary school curriculum, the following tasks were proposed: writing words and short sentences, internet research, and Portuguese and Maths homework exercises (see Table 6).

Table 6. Tasks guidelines—Participant B.

	Session 1	Session 2	Session 3
Date	26 September 2019	9 October 2019	14 November 2019
Duration	~36 min	~40 min	~40 min
Initiation		Calibrating the eye-gaze camera	
Task 1	Search YouTube for a song that is of interest to the child	Write their name and surname	Write three sentences about their daily routine
Task 2	Write some sentences about the child's birthday	Write the date	Play a game: four-in-a-row
Task 3	Choose and play a game of interest to the child	Search the internet for information about their hometown	Write the parents' names
Task 4		Write a sentence about the school	Perform Maths homework task: completing a diagram
Task 5		Perform some Portuguese homework tasks: writing short sentences	
Finalise		Go back to the main menu	

Regarding the participant's independence, the analysis of Figure 3 shows a large number of references to the subcategory "No help required" throughout the sessions. These relate to diverse actions: "The child successfully calibrates after the first attempt"; "Clicks to open the Word processor"; "Adjusts the volume"; "Reopens the Grid and accesses the games"; "Selects the words in the text predictor"; "Scrolls down".
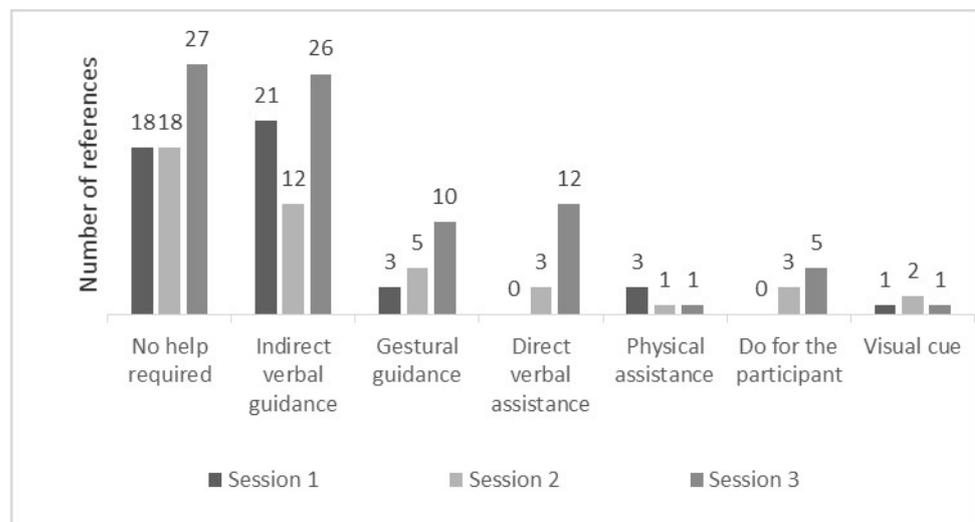
Figure 3. Participant B—References coded in the subcategories of analysis belonging to the category: "Independence of the child/need for help".

Nevertheless, Figure 3 shows an equally high number of references to indirect verbal guidance from caregiver B, for instance, in the internet research tasks: "Caregiver says which icon to click on the toolbar to open Google". Most references coded as indirect verbal guidance are related to writing tasks, comprising name, date, birthday and school: "The caregiver dictates the graphemes"; "The caregiver repeats the syllables". Given the child's difficulty in writing some words, such as their hometown and the months, visual cues were shown: a piece of paper with their written form.

Having noticed this constant need for help to fulfil writing tasks, resulting in delays and weariness, the researcher suggested using text prediction at the end of the second session, as this strategy would turn writing into a faster and easier process for both the child and the caregiver. It is worth noting that participant B reached for the prediction bar in the third session, as shown in these references: "The caregiver starts dictating the next word and the child selects it from the prediction bar". Caregiver B sometimes provides indications to that effect, as in: "The caregiver adds that it is already in the prediction bar and the child clicks on it". Indeed, despite several references to actions performed with no help required (opening the Grid, selecting symbols and clicking to open folders), there are also references to the indirect verbal guidance provided by caregiver B, dictating the sentences and orienting the child towards the right symbols.

Due to delays in the writing tasks, the interaction time in the sessions was beyond what had been expected, due to the child's need for verbal, gestural and even physical assistance. For instance: "Caregiver B comments that they aren't reaching the top of the screen and adjusts the child's position on the chair".

Participant B's slowness in using the writing board may be responsible for the extended time taken in performing both the writing tasks and the Maths task (completing a diagram) since the child needed verbal and gestural guidance: "The child hesitates and the caregiver points to the graphemes and numbers that can be used". Caregiver B even reached for a visual cue to help complete the diagram ("Caregiver B shows the child an egg package to visualise half a dozen eggs in it"). Despite the predominance of verbal guidance, Figure 3 also shows some references to actions performed by the caregiver on the child's behalf, for instance: "The child tries to place the sensor twice and the caregiver ends up doing it".

Regarding the interaction between the caregiver and child, Figure 4 shows an increasing number of references to positive reinforcement in the second and third sessions, both in verbal and non-verbal forms. For instance: "Caregiver B smiles"; "Comments: 'That's it!'". Nevertheless, it is also noticeable that there are references to corrective feedback throughout all sessions, particularly in the sentence writing tasks, where the expected performance time was exceeded. There are also references coded as incentives to overcome difficulty, such as: "'Come on'"; "'Once more, there you go'".

In summary, this observation data indicates a relatively steady performance in carrying out the tasks throughout the sessions, adding to the child's high levels of motivation regarding the device, allowing them access to the regular curriculum and full participation in school classes. Despite references to corrective feedback and the incentive to overcome difficulties throughout the sessions, Figure 4 shows few references to the subcategory of requests for help. It is worth mentioning that in the first and second sessions, there are very few references regarding vocalisations interpreted as a request for help, while the references coded in the third session occur during the writing task, the performance time of which was exceeded, as mentioned above.
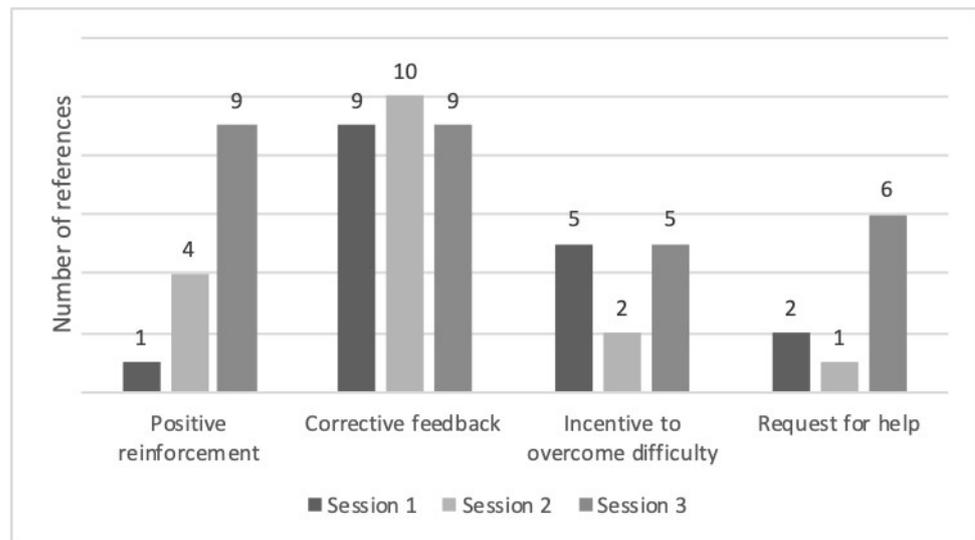
Figure 4. Participant B—References coded in the subcategories of analysis to the category "Interaction between caregiver and child".

3.3. Participant C

Since participant C had used Grid 3 and the eye camera gaze equipment for only a few months and the parents had reported rarely using the devices at home, simple tasks were chosen, such as writing words and short sentences and playing games, as described in Table 7.

Table 7. Tasks guidelines—Participant C.

	Session 1	Session 2	Session 3
Date	21 October 2019	4 November 2019	31 January 2020
Duration	~21 min	~20 min	~16 min
Initiation		Calibrating the eye-gaze camera	
Task 1	Write their name and surname	Write their name and surname	Write their name and surname
Task 2	Write the date	Write the date	Write the date
Task 3	Choose and play a game of interest to the child	Watch a presentation about a school field trip	Write the name of their hometown
Task 4		Choose and play a game of interest to the child	Write a sentence about the school
Task 5			Choose and play a game of interest to the child
Finalise		Go back to the main menu	

Concerning the category of analysis named "Independence of the child/need for help", Figure 5 shows that throughout the sessions there was a growing number of references coded as "No help required," related to diverse tasks such as calibrating the camera, clicking on the icons, deleting, and selecting the relevant word in the text prediction bar. It is worth noting that, despite successfully calibrating the camera on their first attempt, the child struggled to access some icons throughout the sessions.
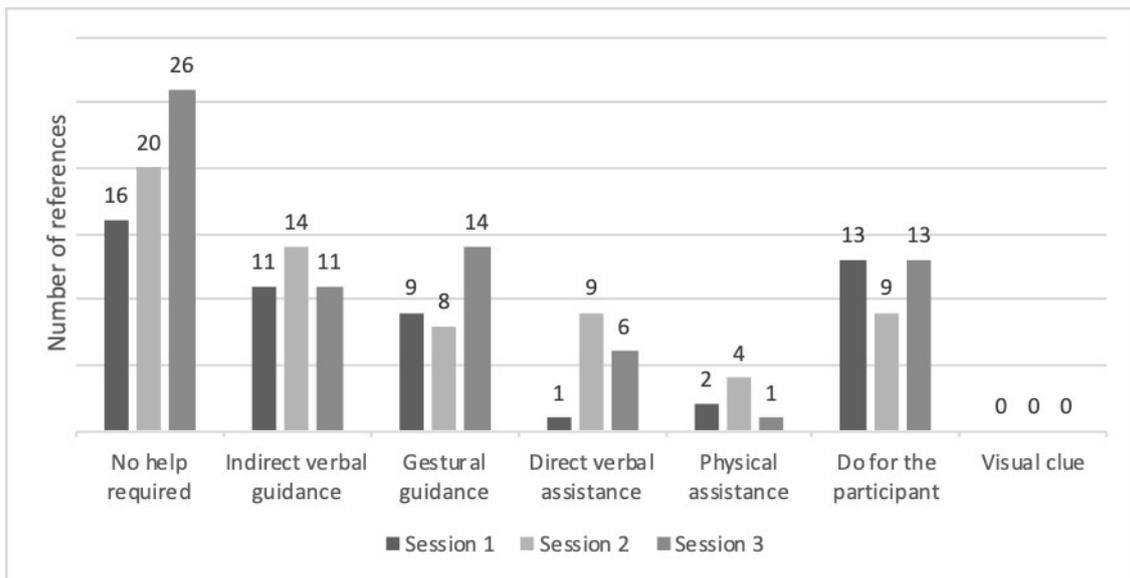
Figure 5. Participant C—References coded in the subcategories of analysis of the category "Independence of the child/need for help".

Figure 5 also shows an equally high number of references in all sessions to the indirect verbal guidance provided by the caregiver. For example, to carry out writing tasks—their name and the date—that were common to the three sessions, there followed: "Caregiver C prompts to open the writing board on the top"; "Suggests using the words in the prediction bar". The child's difficulties in writing the name and date are evidenced in references coded as verbal guidance, gestural guidance and even the caregiver's physical assistance. Caregiver C felt the need to provide physical assistance to the child ("The caregiver straightens the child's head"; "The caregiver repositions the child on the chair"), to deal with the child's efforts to use the eye-gaze camera. Figure 5 shows that there were no references to visual cues throughout the sessions with participant C.

In the first and second sessions, two weeks apart, despite successful calibration, the child revealed some difficulty in using the equipment (an eye-gaze camera and touch-screen PC with an articulated mounting system), which, on both occasions, was set on a wooden sitting-room chair. A few days later, the parents were asked to take the equipment to the child's school for an intervention by a technician, who set it on a chair equipped with specific ergonomic features to fit it correctly. The caregiver reported that the equipment would have to be used only with that ergonomic chair, but its large dimensions did not fit the car that transports the child to school, making it impossible to take the device home. Therefore, the third observation session was only conducted almost three months later since it was not possible to take the equipment home, not even during the Christmas school holidays. As a result of the researcher's insistence, the caregiver transported the chair, the mounting system and the computer and set them up just before the third session.

As in the previous sessions, the child was asked to calibrate the camera, which was successfully achieved on the first attempt. However, the data indicated that between the second and third sessions, the child's skill was not evolving in terms of using the eye-gaze camera. In all sessions, besides references to verbal and gestural guidance, there is a large number of references to actions taken by the caregiver on the child's behalf, such as clicking to open the programme, clicking on the username, clicking on the icons, deleting, and going back to the main menu. It is also worth mentioning that in the second and third sessions, there are several references to direct verbal assistance. On the other hand, Figure 6 shows a similar number of requests for help in all sessions through vocalisations or moaning: "The child vocalises while struggling to select the icon"; "The child sighs and vocalises". Moreover, there are references to corrective feedback in all sessions, but the writing tasks

in the first session stand out as having the most references. Some references illustrate the feedback provided by the caregiver: "The caregiver comments: 'No! Go further left! Come on, delete it'"; "'The caregiver comments, smiling: 'Is that your name? Not quite right. Come on, delete that'".
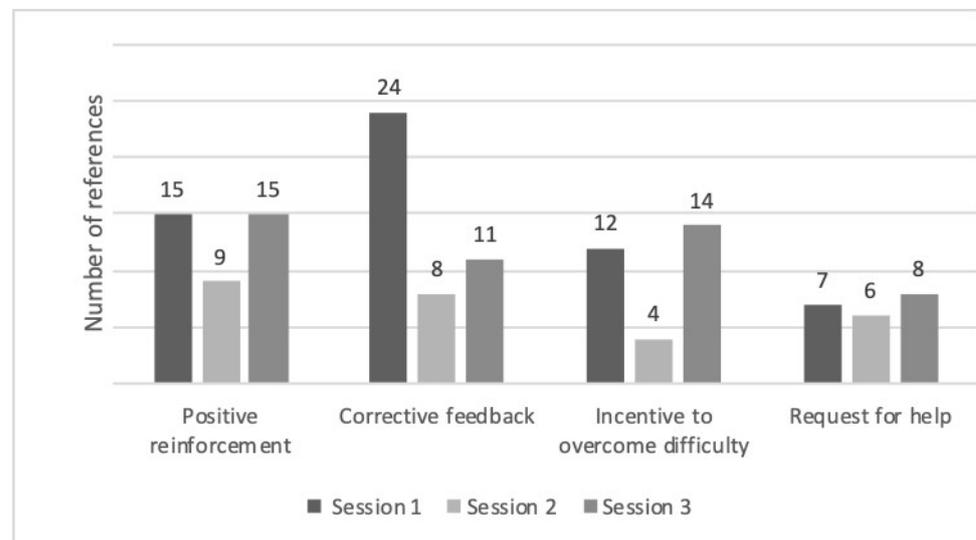

Figure 6. Participant C—References coded in the subcategories of analysis of the category "Interaction between caregiver and child".

Still, regarding the interaction between caregiver and child, it should be noted that the child willingly collaborated in all sessions. There are references to the positive verbal reinforcement provided by the caregiver in all sessions, such as: "'Yes, Good! Well done!'"; "'Good, now you can go on'"; "'Ah! Finally!'"; "'And that's it'"; "'Look! Good! Now you made it!'". References coded as positive reinforcement are more frequent in the first and third sessions, as well as references to incentives to overcome difficulty, for instance: "'Go on'"; "'Once more, come on'"; "'Come on, you were almost there'". This participant's difficulties in using the eye-gaze device slowed the performance time, resulting in weariness and demotivation. Nevertheless, participant C willingly attempted to complete all the proposed tasks and managed to perform quite a few tasks, considering the number of references to the subcategory "No help required". It should be noted that the task guidelines for participant C were adjusted to the limitations derived from the fact that the equipment was away from home for two months between the second and third sessions.

3.4. Post-Observation Questionnaire

A questionnaire containing three open-ended questions (Table 4) was given to the caregivers a month after the sessions. The data gathered show that caregivers A and B mentioned training needs related to software set up to adapt to the child's needs, in references such as: "'Yes, yes, of course. Training so that we could change the cells.'" [Caregiver A]; "In the future, I may need training on the Grid programme. I would like to know how to create grid sets." [Caregiver B]. There is a reference to the subcategory "Motivating the child to use the device", as Caregiver A mentions that "it depends on their willingness to collaborate with us or not.", reflecting this caregiver's need to learn how to motivate the child and raise awareness to the advantages of the AT device.

Regarding the subcategory of analysis "Contribution of the sessions to address needs", caregiver C mentions that: "The observation sessions were good because I got more familiar with the equipment", but also adds: "I think I won't need more training because the computer is going to be used at school" and proceeds to justify that: "'At home, we understand what my son means, in part we do'" [Caregiver C]. This caregiver reported that after the observation sessions, the child had not used the computer at home ever again and

stressed: "At school, yes, it will be better to use the computer there" adding that the child "will even have the support of two therapists who will work on the computer at school" [Caregiver C].

Within the second category of analysis ("Ways to promote effective communication interaction"), caregivers were questioned about what could be done to foster the child's communicative interactions. Caregiver B stressed that the child "should have more speech therapy to promote such interaction" [Caregiver B]. These data are in line with the references coded as obstacles to the child's effective interaction, namely, a shortage of specialised resources, both at school and from the Cerebral Palsy Association. For instance: "We are waiting for the Cerebral Palsy Association to build the communication board (. . .) I don't know if it will take one, two or three weeks . . . " [Caregiver A]. "At the Cerebral Palsy Association, they only have speech therapy for one hour every two weeks, which is too little" [Caregiver B]. Furthermore, caregiver C refers to architectural barriers: "At first, my child used to attend church classes, but due to difficulty to access the church class floor, their mother now teaches the catechism at home". Another aspect relates to the need to use practical, lightweight devices, the portability of which is likely to make interactions easier. This aspect is justified by caregiver C in the reference: "Because they can't walk around carrying the computer to communicate with other people". Portability is also the reason indicated by this caregiver for not using the equipment at home: "The chair does not fit in the car that daily transports the child to and from school (. . .) I would have to go there myself to pick it up and carry the device home, which is very difficult with my busy working schedule" [Caregiver C]. According to this caregiver, that was a major obstacle to using the device at home during the Christmas and Carnival school holidays.

All respondents expressed their willingness to combine the device with other ways of AAC communication, such as boards: "As I don't have so much possibility to work at the computer, the paper communication board was designed for me" [Caregiver A]; "To communicate with outsiders, a board with pictures and symbols would be useful" [Caregiver C]. Caregiver B considered that it would be effective to use non-verbal language in some contexts, as evidenced in the references: "My child attends church classes. The catechist poses questions which are answered with vocalisations similar to the intended word and are usually understood" [Caregiver B]; "Classmates play and interact through sounds and gestures because my child does not carry the computer to the school playground" [Caregiver B]. A reference from caregiver B also reinforces the need for regular use of the device when the child is at home.

Regarding the category of analysis "Caregiver's skills to solve technical problems", there are two references coded in the "Autonomy" subcategory: "I can do the essential" [Caregiver B]; "One programme or other I could install. I could manage to change the Grid definitions" [Caregiver C]. Nevertheless, a reference from the same caregiver was coded in the subcategory "Difficulties": "It is more complicated to solve technical matters (. . .) I am not very familiar with that" [Caregiver C]. To try and solve these problems, users of Grid 3 have mentioned benefiting from online technical support, both by the Cerebral Palsy Association and by a training team: "We have a helpline, and I call whenever I need (. . .) there is a password, and they enter our computer and do whatever is needed." [Caregiver A]; "To prepare their settings for the final evaluation tests, I will need some help. An Anditec trainer can perform online access and make those changes" [Caregiver B]. Anditec is a company based in Portugal, which sells assistive technology equipment and provides training and assistance in augmentative communication, digital accessibility and mobility.

To sum up, from the respondents' answers, it can be inferred that using the Grid 3 programme, along with the issues it raises, requires technical support skills and specialised training. This data-gathering instrument has provided significant contributions to the diagnosis of training needs, limitations and the resources available to the caregivers of children who use Grid 3 when combined with eye-gaze technology.

4. Discussion

The interaction between caregiver and child was a subject of analysis both in these observation sessions and in interviews with caregivers that were previously conducted by Almeida et al. (2019a). All respondents mentioned the home as being their main interaction context with the children, mostly during daily life activities and for homework tasks at the end of the day (Almeida et al. 2019a). Therefore, these observation sessions were carried out at home and aimed at analysing the caregiver's interaction with the child during the tasks mediated by the AT device. The importance of positive reinforcement to foster the child's motivation to overcome difficulties is noteworthy, along with corrective feedback. Indeed, it was found that all caregivers provided positive reinforcement with either words, clapping, gesturing or kisses. Applied behaviour analysis for verbal behaviour identifies the importance of reliable, immediate and high-quality responses for building new AAC skills (Holyfield et al. 2019; Johnston et al. 2004). Therefore, according to Johnston et al. (2004), besides providing a socially responsive environment, communication partners should provide immediate and high-quality reinforcement, thereby contributing to ensuring that a learner's AAC system is efficient. At the same time, all caregivers provided corrective feedback to direct the child to the intended task or to instruct them to correct their errors by themselves and be resilient. Resilience is a psychological factor that influences whether or not the individual perseveres with communication despite the many challenges and potential failures encountered (Light and Mcnaughton 2014). Furthermore, frequent references to the subcategory "Incentive to overcome difficulty" reflect these caregivers' strong desire to motivate the children.

Motivation is also considered by Light and Mcnaughton (2014) to be another important factor impacting communicative competence in individuals with complex communication needs. Since communication via AAC is a complex process with significant motor, cognitive, sensory, and linguistic demands, individuals will be more likely to tackle the demands involved if the motivation to communicate is high. On the other hand, when motivation is low, they may be overwhelmed by these demands and may miss many communication opportunities (Light and Mcnaughton 2014).

Throughout the session, all participants requested the help of their caregivers through vocalisations, glances and gestures. Taking into account participants B and C's constant need for help to use the writing board, which resulted in delays and tiredness, the fact that these two children were already familiar with the use of the text predictor suggests a positive and useful strategy to make writing quicker and more efficient.

The data gathered with these observation sessions meets a need, widely mentioned in the literature, to promote technology-mediated communicative interaction in all contexts of the life of the child, with a particular focus on the home setting (Brotherson et al. 1996; O'Neill et al. 2017). Moreover, an effective augmentative communication system requires a commitment from all social partners, including family members. A lack of regular use of the AT device at home also prevents the development of skills (Bailey et al. 2006; Parette et al. 2000).

Indeed, it was observed that even though the children carried out many actions without requiring any help, subcategories for indirect verbal guidance, gestural guidance and direct verbal assistance were referred to in all sessions. It was often observed that an order or direct verbal assistance was supplemented by gestural guidance. Caregivers verbalise as the child performs the task, to keep them focused and motivated. Since individuals with complex communication needs require numerous positive and successful communication experiences to build their motivation (Light and Mcnaughton 2014), the caregivers' drive to foster the participants' interest and focus on the task plays an important role.

On the other hand, according to the type of task proposed in each session, the children may have needed more verbal and gestural guidance. Despite this need for assistance, the data gathered seem to show that children participating in the study reveal initiative regarding some actions. The few references to physical assistance refer to situations where the children had difficulty selecting the icons, and caregivers tried to improve their posture

to facilitate their performance. Many references stand out in the subcategory reporting on actions performed by the caregiver on behalf of the participant, which may be derived either from the participant's difficulty in understanding the caregiver's instructions or from limitations calibrating the eye-gaze camera.

The general opinion of the focus group conducted by Almeida et al. (2019b) was that teachers should not be the only ones to be trained in the use of AT devices. Likewise, all respondents in the study by Almeida et al. (2019a) agreed that caregivers should give continuity to the training at home. The main reason for suggesting this is the need to involve and assign responsibility to everyone intervening on the child's behalf (teachers, therapists, relatives, tutors, etc.). The need to generalise the use of the device to all the life contexts of the child was also pointed out by the focus group, not only due to the advantages of using the technology both at school and/or in the context of therapies but also to embed their use into the daily routines at home. Furthermore, the study's respondents to the interview also stressed that using the device at home increased the child's motivation and awareness of the advantages of its use (Almeida et al. 2019a).

However, the data gathered in the post-observation questionnaire referenced caregiver C, who deflected the responsibility of using the device at home, arguing that it was meant to be used at school by the teachers and therapists. These data are in line with the findings of previous studies focusing on the reasons behind the abandonment or discontinuity of use of the AT device: lack of material and technical conditions; lack of time; lack of articulation with professionals; absence of the perception of the need to use the AT device (Almeida et al. 2019a, 2019b). This unawareness may refer to the child's perception or that of the caregivers. For instance, caregiver C argued that they understood their child's non-verbal language and could manage without the AAC device.

Similarly, the subcategory "lack of awareness of the need to use AT" is the most salient factor in the data from the interviews conducted by Almeida et al. (2019a). One possible reason for the limited use of an AAC system may involve the device's efficiency compared with the efficiency of other competing behaviours, such as gesturing, facial expressions or vocalising. The option that results in the greatest reinforcement value for the least work is likely to be the one that is most frequently used (Johnston et al. 2004). Therefore, it is important to model the use of AAC within the interaction context, which can increase the likelihood that beginning communicators will use the AAC technology successfully during the interaction (Holyfield et al. 2019).

The literature suggests that gaze-controlled technology can provide children who have severe multiple disabilities with new opportunities to communicate, interact, and perform activities independently (Borgestig et al. 2016; Holmqvist et al. 2017). Holmqvist et al. (2017) showed gains for the children regarding empowerment, social interaction, learning opportunities and efficient computer use. Time spent, expert support, collaboration, and enthralling content were considered prerequisites to making the technology useful and sustainable.

Recruiting participants in the authors' geographical area proved difficult since few children met the inclusion criteria for using these high-tech devices in the home setting with their caregivers. The fact that only three pairs of participants (caregiver and child) were observed might be considered insufficient to generalise the results or to replicate such a study. Indeed, the data collected through observation depend greatly on the researcher's interpretation and are specific to a place and time (Moreira and Caleffe 2008). Nevertheless, having a sample of children attending different school levels allowed us to design individual task guidelines for each and achieve a deeper analysis of the data gathered.

Despite observing only a small number of participants, relevant data were gathered, and a deep content analysis was conducted. The data regarding the child's need for help/independence in fulfilling tasks were interpreted according to the predefined categories of analysis. However, the time intervals between the three observed sessions were too short, considering the findings from similar studies. For instance, Borgestig et al. (2016) examined changes in eye-gaze performance in children with severe physical impairments,

without speaking ability, using gaze-based AT. Their findings showed that the children improved in time on task after 5 months and became more accurate in selecting targets after 15–20 months. It indicates that these children could improve eye-gaze performance, but they need long-term practice to acquire the skills needed to develop fast and accurate performance (Borgestig et al. 2016). Therefore, future research should be conducted on a long-term basis to evaluate the development of fast and accurate eye-gaze performance.

5. Conclusions

Assistive technologies are likely to promote communication, autonomy and the inclusion of children with cognitive and/or motor disabilities. It opens a wide range of opportunities for learning and participating in all contexts of life, as long as the caregivers have an active role in implementing the AAC devices and promoting their regular use in the home setting. This research, in particular, sought to study children's performance and their interactions with caregivers. To accomplish this, we conducted observation sessions in the participants' homes, video-recorded them while carrying out predefined tasks with their caregivers, and analysed the audio-visual data gathered through qualitative data analysis software. The data seem to demonstrate the importance of the interaction between the caregiver and the child to fulfil the tasks and improve the child's performance, hence emphasising the need to extend the use of these devices to all contexts of the child's life and significant activities. Therefore, professionals should be sensitive to the specific needs of each individual and their family (Mcnaughton et al. 2008). Aligned with this thought, Williams et al. (2008) remarked that the failure to provide appropriate AAC technology, strategies and services means a loss of opportunities for the individual and for society.

This study, taking a qualitative approach, using a limited number of individuals, allowed us to deepen the research and elaborate on this idiosyncratic problem. However, a more extensive survey of the needs of the targeted users and their families is considered useful, in order to scrutinise some of the aspects that should also be targeted in their functionality.

Continued research, education and advocacy work are needed to ensure that all individuals and their caregivers have access to the appropriate technology and support (Williams et al. 2008) to develop their operational, linguistic, social and strategic competence (Mcnaughton et al. 2008).

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