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Research on Technological Interventions for Young Children with Autism Spectrum Disorders: A Scoping Review

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Correspondence concerning this article should be addressed to Marc J. Lanovaz, École de Psychoéducation, Université de Montréal, C.P. 6128, succursale Centre-Ville, Montreal, QC, Canada, H3C 3J7. Email: marc.lanovaz@umontreal.ca Phone: 1 514-343-6111 #81774**Abstract**

Researchers have widely reported using technological interventions to support young children with autism spectrum disorder. Given the abundance and diversity of research on the topic, the authors conducted a scoping review of 158 studies published from 1994 to 2019 to provide a current state of the literature and guide future research. Overall, the results indicate that video modeling, communication aids, and discrete trial instruction have been the topic of the most studies in the research literature. Moreover, most researchers have used single-case designs and combined technology with some type of adult provided support. Findings suggest that future studies should compare the use of different devices and interventions directly together while better isolating the unique contribution of technology when evaluating its effects.

Keywords: autism, intervention, early childhood, scoping review, technology

Research on Technological Interventions for Young Children with Autism Spectrum Disorder: A Scoping Review

Technology-based interventions, or technological interventions, refer to all interventions delivered using various electronic devices (e.g., video playing device, speech-generating device, tablet). Over the years, technological interventions have been developed and studied in various fields such as mental health, behavior analysis, and classroom education (Choo, Ranney, Aggarwal, & Boudreaux, 2012; Escueta, Quan, Nickow, & Oreopoulos, 2017; Ramsey & Montgomery, 2015). These interventions have also targeted individuals with autism spectrum disorder (ASD) to teach a variety of skills such as social behavior, communication, and school readiness (Goldsmith & Leblanc, 2004).

Even though treatment research has evolved considerably over the last two decades, access to high-quality services remains an issue for many families of children with ASD (Jones, Bremer, & Lloyd, 2017). For example, the high cost of services may limit accessibility for families who cannot afford them (Buescher, Cidav, Knapp, & Mandell, 2014). Families may also struggle due to long waiting lists, limited information, and lack of services in their area. These issues are particularly present in rural areas where families must travel great distances to obtain services such as behavioral interventions and parent support groups (Mello, Goldman, Urbano, & Hodapp, 2016). The use of technology to offer interventions to children with ASD thus seems to be an appropriate solution to address some of these accessibility issues by decreasing expenses, travel, and stress. Nowadays, most households possess at least one technological device (Ryan, 2018), which makes technological interventions highly accessible. Using technology to deliver services may help families and individuals with autism acquire new skills that can alleviate their reliance on professionals (Goodwin, 2008).

Another potential benefit of technological interventions for young children with autism is that the teaching algorithms can be personalized to each child by regulating the level of difficulty to his or her capacity (Bölte, Golan, Goodwin, & Zwaigenbaum, 2010), as well as by adjusting parameters to accommodate the child's needs (e.g., lowering the sound or brightness). For instance, the mobile application iSTIM asks the user (e.g., parent) a series of questions to automatically adjust the intervention based on child characteristics and targeted behavior (Préfontaine, Lanovaz, McDuff, McHugh, & Cook, 2019). By using algorithms, technological devices may respond in a manner that can be predictable for the user.

Furthermore, some children may prefer technological interventions when compared to other modes of delivery (Achmadi et al., 2014; Kim et al., 2013). For example, Achmadi et al. (2014) showed that children with ASD chose the iPod Touch the most often as a speech-generating device (SGD) amongst other types of alternative and augmentative communication (AAC) tools that did not use technology. Similarly, Kim et al. (2013) found that presenting a social robot rather than a human instructor to children with ASD facilitated social interactions with another adult. Children mainly expressed to the adult their excitement towards the robots. These results support the notion that some children with ASD may prefer technology more than other modes of interventions, which makes sense knowing that children with ASD have social and communication deficits (American Psychiatric Association, 2013). That said, the purpose of technology is not to replace the human instructor entirely but rather to offer additional support for the lack of human resources. Human instructors are still expected to work on generalization afterward in natural settings with the child. Social and communication skills may therefore be learned through technology and subsequently practiced (and generalized) with real people. Nevertheless, generalizations issues can be partly addressed with certain types of technology

such as virtual reality or the use of internet peers, which can offer a platform that is very similar to the naturalistic environment where the child can practice in a controlled and safe space (Bölte et al., 2010).

Finally, the American Academy of Pediatrics (AAP) recommends a limit of 1 hour per day of screen time, for young children between two and five years old (AAP Council on communications and media, 2016). As technological interventions are suggested as an additional service, these interventions do not have to be delivered to the child as often as regular interventions. Besides, the AAP recommendations also suggest professionals-approved educational content during screen time.

In the past ten years, researchers have studied the use of technology in individuals with ASD in multiple systematic reviews and meta-analyses (e.g., Ganz, 2015; Lorah, Parnell, Whitby, & Hantula, 2015; Mesa-Gresa, Gil-Gómez, Lozano-Quilis, & Gil-Gómez, 2018; Odom et al., 2015; Schlosser & Koul, 2015; Virnes, Kärnä, & Vellonen, 2015). In general, these reviews led to the conclusion that technology may be used as an effective means of teaching new skills to individuals with ASD. For instance, the use of SGDs effectively increases requesting although more research is needed for other communication skills such as labeling or maintaining conversations (Alzrayer, Banda, & Koul, 2014; Lorah et al., 2015; Schlosser & Koul, 2015; Still, Rehfeldt, Whelan, May, & Dymond, 2014; Van Der Meer & Rispoli, 2010). Another example is video modeling, which has been shown to be an effective procedure to teach social, communication, and functional skills (Bellini & Akullian, 2007; Gardner & Wolfe, 2013; Shukla-Mehta, Miller, & Callahan., 2009), and even meets the criteria for evidence-based practice (National Autism Center, 2015; Odom, Collet-Klingenberg, Rogers, & Hatton, 2010; Wong et al., 2013).

Researchers reviewing computer-based interventions in older studies call for more evidence regarding their effectiveness (Ramdoss et al., 2011; Ramdoss et al., 2012; Wainer & Ingersoll, 2011). However, researchers conducting more recent studies have shown that the use of computers is effective in teaching different skills such as communication, social behavior, and academic skills (Aresti-Bartolome & Garcia-Zapirain, 2014; Grynszpan, Weiss, Perez-Diaz, & Gal, 2014; Khowaja & Salim, 2013; Odom et al., 2015; Ploog, Scharf, Nelson, & Brooks, 2013). As for virtual reality-based interventions, moderate evidence has been demonstrated on their effectiveness in teaching different types of skills to children with ASD, but more evidence is needed to conclude (Mesa-Gresa et al., 2018). These interventions can be easily accessible for families of children with ASD when delivered through computer platforms or other internet-connected devices (Smith et al., 2014).

Albeit informative on a specific topic, most previous reviews have focused on a single technological intervention or single target at a time such as SGDs, video modeling, and computer-based interventions (e.g., Lorah et al., 2015; Shukla-Mehta et al., 2009; Khowaja & Salim, 2013). For researchers and practitioners, this issue presents a challenge as one must consult multiple sources to determine what has been done (or not) with each type of technology or target. One notable exception is a study by Virnes et al. (2015), but researchers only examined studies published until 2010 and focused on all children less than 14 years of age. Undeniably, the past few years have been marked by the arrival of innovative technologies, which are progressively used as learning tools in schools and at home. As a result, multiple new studies on the topic can be expected. At the same time, the growth of popularity in this topic comes with the difficulty of not knowing what has been done and what has not, which calls for a scoping review examining the extent of the present literature.

Another limitation of the previous reviews and meta-analyses is that researchers included participants from different age groups, with some combining data of preschoolers, children, teenagers, and young adults together. This organization of data makes it difficult to isolate the effects of the interventions to each population and, again, to understand for which group there is a lack of research. While other reviews should investigate different age groups, the current study focuses solely on young children (i.e., less than 7 years old), as early intervention has been shown to be one of the most effective for children with autism (Orinstein et al., 2014; Tachibana et al., 2017). Therefore, the purpose of the study was to provide a current state of the literature and guide future research on the topic by reviewing studies from 1994 to early 2019 that evaluate the effectiveness of interventions using technology with young children with ASD. More specifically, this review aims to synthesize what researchers have been evaluating in terms of types of intervention, devices used, skills targeted, and level of support provided, as well as their methodology by looking into their study design and settings.

Method

Scoping reviews aim to document existing literature on a research topic by exploring its nature and its range of coverage when the area of study is large and complex or has not been reviewed completely (Arksey & O'Malley, 2005). With the diversity in technology studied and skills targeted, data are too heterogeneous to undertake a systematic review. Besides, several reviews have already examined more specific topics. Rather than exploring the depth of the current results, the purpose was to examine the extent of the existing literature and determine its variety, for which a scoping review appears a better option. This kind of review is necessary to better understand the topic before focusing on more precise questions. Arksey and O'Malley (2005) present five stages for undertaking a scoping review: identifying the research question;

identifying relevant studies; study selection; charting the data; and collating, summarizing and reporting the results. These stages will be presented in each section.

Search Procedure

This section corresponds to the first and second stages proposed by Arksey and O'Malley (2005). The first stage (identifying the research question) aims to determine the important aspects of the research question and to define them, while the second stage (identifying studies) aims to search for articles, by different possible methods. Authors suggest starting with wide definitions and specifying them afterward to not miss any relevant articles.

The first author chose keywords to target young children who had ASD in studies that evaluated technological interventions (see Table 1 for keywords). The first author searched the PsycInfo, ERIC ProQuest and PubMed databases on May 17th, 2018 and again, on February 26th, 2019, in all fields. Searches only included peer-reviewed articles. Because of the large number of articles retrieved through data search, procedures do not include an ancestral search and limited to electronic databases.

Inclusion and Exclusion Criteria

This section corresponds to the third stage of a scoping review (study selection) by Arksey and O'Malley (2005), which determines systematic inclusion and exclusion criteria. The choice of criteria aims to only include relevant articles to the research question. Arksey and O'Malley (2005) divided their criteria, so that certain aspects are only analyzed through full-texts. The current study followed this method by adding two additional criteria only in the second classification round.

Inclusion criteria targeted studies that (a) were empirical, (b) included participants with ASD or a pervasive developmental disorder[1] (PDD; excluding Rett disorders), (c) used a technology as part of their intervention to teach skills or modify behavior, (d) evaluated its effectiveness, (e) involved at least one participant who was less than 7 years old for a single-case study or a group of participants all under 7 years old if it was a group study design, and (f) targeted the child. The research team excluded all studies that did not clearly indicate that participants were under 7 years old. This cut-off age was chosen because scales to assess young children often stop around the age of 7 (French, 2013; Newborg, 2005). In addition, criteria excluded systematic reviews, meta-analyses, case studies, dissertations, theses, and qualitative studies. Lastly, the current study only included articles that were published starting in 1994 as it was the year of publication of the fourth edition of the *Diagnostic and statistical manual of mental disorders* (American Psychiatric Association, 1994).

Figure 1 shows a flow chart of the procedures. Initially, the first and third authors independently proceeded to the screening of the title and abstract of each article. For the first screening, the two authors looked for criteria (a) to (d). When in doubt, the article was included for further investigation. Then, the first author retrieved the full texts of the remaining articles to assess their eligibility. The same authors independently read every full-text accessible in English and proceeded to their inclusion or exclusion. For the second classification round, criteria (e) and (f) were added. When a disagreement occurred, the two authors tried to reach a consensus. The second author made the final decision when a consensus could not be reached.

Data Extraction

[1] By "pervasive developmental disorder", the authors refer to the autistic disorder, Asperger's disorder, childhood disintegrative disorder, and pervasive developmental disorder, not otherwise specified.

This section corresponds to the fourth stage (charting the data) of a scoping review by Arskey & O'Malley (2005), which aims to determine a systematic way of extracting and sorting relevant information out of each included article. In the current study, experimenters identified aspects to systematically record when reading each study's intervention and method. While reading the full texts, the first author extracted the following characteristics for each study: the type of intervention, the type of device used (Table 2), the level of support provided, and the target skill (Table 3). At the same time, the number of participants, the setting in which the intervention took place and the design were recorded. The third author independently validated all the data extracted by the first author. When the first and third authors did not reach a consensus, the second author made the final decision.

Table 2 presents the detailed definition of the recurring types of technological interventions and devices used. In the classification, the research team categorized the types of intervention that were recurring in the literature: video modeling and prompting, communication aid, interaction-based interventions, discrete trial instruction, script- or story-based interventions, games, and other. The authors also recorded the technological devices that were used to have a better understanding of the accessibility of the interventions: mobile devices, computers, television, robots, DVD/CD players, communication devices, internet-connected devices, and other. Table 3 presents the detailed definitions of the categories for levels of support and target skills. The level of support consisted of the extent to which an adult had to intervene. Target skills were documented by categories adapted from those used by Wong et al. (2013) in a systematic review of interventions for ASD.

The first and third authors also documented the setting in which the intervention took place, whether it was in a school, a clinic, the participant's home, a laboratory or another setting.

Finally, the design of each study was recorded to provide an overview of the methodology. Authors first determined whether the design was a group or a single-case study. They then specified the subtype of design. In this review, the category "reversal designs" encompassed both reversal and withdrawal designs.

Analysis

This section corresponds to the fifth stage (collating, summarizing and reporting the results) of a scoping review, by Arksey and O'Malley (2005). Authors emphasize the difference between a scoping review and a systematic review, to justify their type of analysis: to present an overview of the literature, rather than to examine the evidence. This stage aims to analyze the data and report in a way that readers "quickly get a flavour of the main areas of interest" and "where the significant gaps are".

For each characteristic, the first author calculated the percentage of articles within each category. Oftentimes, the categories were not mutually exclusive, which is why the percentages may add up to more than 100%. For example, a study could combine two types of design or compare the effects of two types of devices. As presented by Arksey and O'Malley (2005), this analysis allows to meet the main purpose of the study, which was to provide a current state of the research literature. By analyzing which topics or which types of study are lacking, recommendations can then be made for future research.

Results

Search Results

Figure 1 shows a flow diagram with the number of articles included in each phase of the search, which is adapted from the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, Altman, & The Prisma Group, 2009).

During the initial search in 2018, 2,426 records were obtained through databases and other sources. More specifically, 1,757 articles were identified through PsycInfo, 214 through ERIC ProQuest, 453 through PubMed, and 2 additional records through other sources. The first author removed all duplicates, which counted for 337 records, leaving 2,089 articles to screen. During the second search in 2019, a total of 221 records were obtained. Precisely, 176 articles were obtained through PsycInfo, 11 through ERIC ProQuest and 34 through PubMed. All duplicates counted for 61 records, leaving 160 articles to screen. Together, these two searches yielded 2,249 valid articles for the screening phase. In the end, 625 articles remained after the screening phase and 158 after the eligibility phase (see Supplementary Material for complete list of articles reviewed).

Types of Intervention and Devices Used

Figure 2 shows the different types of intervention used to teach skills to young children with ASD. Video modeling and prompting have received the most attention. It should be noted that video modeling has also been combined with other types of intervention. For instance, one intervention consisted of an interactive schedule with embedded video modeling of play skills (Dauphin, Kinney, & Stromer, 2004). Other commonly studied types of intervention included communication aids, discrete trial instruction, and interaction-based interventions. Figure 2 displays the type of technological devices used to deliver the interventions. Results indicate that mobile devices and computers accounted for more than half studies. Following these devices, at least 10% of studies have reported using television and robots. In contrast, internet-connected devices were less used as a medium of intervention delivery.

Target Skill

Figure 2 shows that more than 80% of studies reported technological interventions to teach social, communication, and play skills to young children with ASD. These three types of skills were targeted by several kinds of interventions, such as communication aids, video modeling, and prompting, interaction-based interventions or even script- or story-based interventions. On the other end, researchers targeted cognitive behavior and joint attention in less than 5% of the studies.

Level of Support

Figure 3 displays the percentage of studies providing different levels of support from an adult. More than half of the studies in the database presented interventions with support from an adult. In these studies, the adult often prompted or reinforced the child's behavior beyond what technology was already doing. That said, a third of studies also presented interventions with no support. In these interventions, adults only provided an initial prompt to use the technological device and did not interfere further, regardless of the behaviors presented by the child. Interestingly, some studies compared the effectiveness of their intervention with and without the additional support of an adult. For example, a study evaluated the effects of video modeling with and without external manual prompts and reinforcements from an adult (Sancho, Sidener, Reeve, & Sidener, 2010).

Design and settings

Results indicate that most researchers used single-case designs (n = 142, 90%), while only a small proportion used group designs (n = 16, 10%). Nevertheless, almost half of these group studies (n = 5, 31%) consisted of randomized controlled trials (RCT). As for single-case studies, Figure 3 shows that the two most used designs were the multiple baselines and the alternating-treatment designs. Figure 3 shows the settings in which the interventions took place.

In order, the most recurrent settings for intervention were school, clinic, and home. Only 13% of studies were conducted in laboratory settings.

Discussion

Results indicate that video modeling and prompting have been the most studied type of technological intervention when teaching skills or modifying behavior of young children (National Autism Center, 2015; Odom et al., 2010; Wong et al., 2014). Similarly, communication aids and discrete trial instruction were also frequent interventions in the database. Mobile devices have been the most studied type of device by researchers, especially when contrasted with earlier types of devices (e.g. communication devices, DVD players, televisions). The use of tablets is particularly promising as it can deliver multiple types of intervention on a large, yet portable screen. Several interventions have been increasingly delivered using newer types of devices over the years, which are easier to access anywhere. As an illustration, the oldest study included in the review used a computer to deliver discrete trial instruction to teach academic skills (Kelly, Green, & Sidman, 1998). Since then, discrete trial instruction has been provided through mobile devices such as tablets (Lee et al., 2015). By using accessible devices, it is more likely that these interventions could assist families of children with ASD obtain services more easily.

Unexpectedly, results indicate that internet-connected devices were used infrequently to deliver interventions. The data collection procedure may partly explain these results. Experimenters have only considered devices presenting websites programs to be internet-connected and consequently did not include devices presenting online applications (e.g., apps, videos). Delivering interventions on internet-connected devices could reach more users,

regardless of their location and devices owned, which is a considerable advantage to improve accessibility.

Communication, social, and plays skills were three of four most targeted skills (the other being academic skills), which have impairments in communication and social skills, and restrictive behaviors have been associated with difficulties with play skills (Honey, Leekam, Turner, & McConachie, 2007). Challenging behaviors may have been less targeted because analyses only included interventions that exposed the child directly to the technological device. Existing interventions may have targeted parents instead of the child to reduce these behaviors and consequently have not been included in the review. The level of support required by the interventions also warrants further discussion. In most cases, adult support was required during technology use, which shows that incorporating technology in interventions does not necessarily remove the need for a human instructor. For example, this type of support often consisted of initially prompting the child to use the device, redirecting their attention, managing challenging behaviors or maintaining their motivation. While implementing technological interventions that do not require instructor support remains relevant as it may address accessibility issues, interventions with minimal support seem to be a good compromise. Parents or teachers can supervise the child without having to learn the systematic teaching procedures, and it does not require the undivided attention of the adult for the child to learn. Moreover, a child with ASD between the ages of 2- and 7-years old already requires minimal adult supervision, if not constant supervision; therefore, asking the parent or the teacher to supervise the child during technology use appears realistic.

From a methodological standpoint, high levels of support may have functioned as confounding variables. By having the adult prompt or reinforce correct responding during

technology use, researchers were often unable to draw conclusions on whether the technology was necessary or not. As a result, the research team suggests experimenters to better isolate the unique contribution of technological interventions to establish clearer conclusions on their effectiveness. Results also indicated that most interventions were delivered in ecological settings, which is desirable as it increases the generalizability of the results to practical settings.

From a practical standpoint, the large number of retrieved articles on interventions using technology suggests that practitioners have many means at their disposal to deliver services to children with ASD. Most studies reported using devices that are already highly accessible to both practitioners and families. To this end, practitioners may propose technological interventions to families that need more accessible or less costly services. Even when technology does not reduce costs or effort, practitioners may recommend technological interventions because they are preferred by the child or are more effective than alternative interventions. Technological interventions that do not require constant support from an adult may also find use in early intervention centers or preschools that would like to enroll more children, decrease costs for families, or reduce waiting lists. These types of technological interventions could then be integrated into supervised structured workstations. Moreover, researchers have thoroughly studied some types of interventions such video modeling, discrete trial instruction, and communication aids. These results suggest that research on these interventions is probably sufficient to formulate recommendations for adoption in practice.

This scoping review has limitations that should be considered when interpreting its results. First, this scoping review has included studies published since 1994, which may have impacted its results in terms of types of devices frequently used. Some devices recorded may have been switched to more current technologies (e.g. communication devices and DVD/CD

players to mobile devices or computers). Secondly, the first and third authors did not record the number of times agreements and disagreements occurred during the inclusion procedure, which does not provide a clear description of the methodology. Thirdly, authors did not examine the interaction between each category recorded in their analysis. Interactions results could provide a more precise overview of what has been done or not, which future studies should investigate. Finally, the first author did not categorize studies by their effects on behavior, which prevents authors from providing conclusions regarding effectiveness. The main purpose of the study was to explore the extent of the literature, not to examine the effects of each intervention. Nonetheless, experimenters should conduct a more in-depth analysis of intervention effects in future systematic reviews or meta-analyses to better identify the potential benefit of using technology as a tool to support young children with ASD.

Future research should focus on replicating and extending research, especially with interventions that have been the topic of few studies (e.g., games, story-based interventions). As indicated earlier, replicating and conducting novel studies examining the effects of technology on understudied targets such as cognition, adaptive functioning and challenging behavior. Furthermore, our scoping review indicates that a limited number of studies compared the use of different devices and interventions directly together. As treatment comparisons are an essential component in identifying empirically-supported treatments (Chambless & Ollendick, 2001), more comparison research appears important. This type of research would not only contribute to our understanding of treatment effectiveness, but also be most useful for practitioners who are attempting to identify the most appropriate technological interventions for young children.

Compliance with Ethical Standards

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Table 1

Keywords by Concepts

Concepts	Keywords
Young children	young child* OR preschool* OR toddler* OR kindergarten* OR nursery OR daycare
Autism	autis* OR asperger* OR pervasive developmental disorder*
Technology	technology OR phone OR iphone* OR ipad* OR tablet* OR internet OR online OR web-based OR computer* OR virtual reality OR virtual environment* OR robotic* OR speech generating device* OR shared active surface* OR interactive video* OR handheld device* OR touchpad device* OR software OR video modeling
Intervention	intervention* OR teach* OR training OR treatment* OR program* OR prevent*

Table 2

Definitions of types of technological interventions and types of devices used

Category	Definition
Technological interventions	
Video modeling and feedback	Interventions wherein the child watches videos of the target behavior (video modeling), or videos of both the correct and incorrect behaviors, along with cues and reinforcers (video feedback).
Communication aid	Interventions wherein the child uses a technological device to express his or her needs.
Interaction-based interventions	Interventions wherein the child interacts with a simulated environment or object such as virtual reality and robots
Discrete trial instructions	Interventions using algorithms based on the child's responses to deliver prompts and reinforcers.
Script- or story-based instructions	Interventions wherein the child reads, listens or watches a story, which is delivered by a technological device.
Games	Interventions using algorithms based on the child's play actions in the technological device to deliver animations.
Devices used in technological interventions	
Mobile devices	Devices that are easily portable such as smartphones, tablets, and portable media players, delivering interventions on the screen. Mobile devices offer the possibility for the child to interact with the content presented.
Computers	Devices composed of a screen, keyboard, and mouse, delivering interventions on the screen. Computers offer the possibility for the child to interact with the content presented.
Television	Devices used to deliver videos on a big screen, without any possible interactions between the child and the content presented.
Robots	Animated devices, often in forms of a person or a character, using algorithms based on its physical surroundings (sound or action), or controlled by a human, to interact with the child.
DVD/CD players	Devices used to deliver videos or sound, without any possible interactions between the child and the content presented.
Communication devices	Devices manipulated by the child to generate speech.
Internet-connected devices	Variable devices delivering interventions stored on online websites.

Table 3

Definitions of Levels of Support and Target Skills

Category	Definitions
Level of Support	
No support	No support, except for initial prompt to use the technological device
Minimal support	Supports that aim to maintain the child's attention or motivation on using the technological device
Support	Supports that aim to teach skills to the child (prompts, reinforcement, error-corrections)
Target Skill	
Social	Skills used to interact with others and to understand the subtleties in these interactions.
Communication	Skills used to understand others or to express the child's own needs or feelings.
Challenging behavior	Behaviors that prevent the child from doing his/her tasks and/or that present a danger to the child or others.
Joint attention	Skills used to understand where the attention should be oriented to, necessary for sharing experiences.
Play	Skills used by the child during his/her leisure time.
Academic	Skills that are taught in school or preschool, such as reading or counting.
School readiness skills	Skills necessary for optimal learning such as sitting and following rules.
Adaptive	Skills used for personal needs (e.g., toilet training, getting dressed).
Cognitive	Skills related to executive functioning, information processing, reasoning or problem solving
Motor	Skills that mobilize body parts (gross or fine motor) or the sensory system of the child.

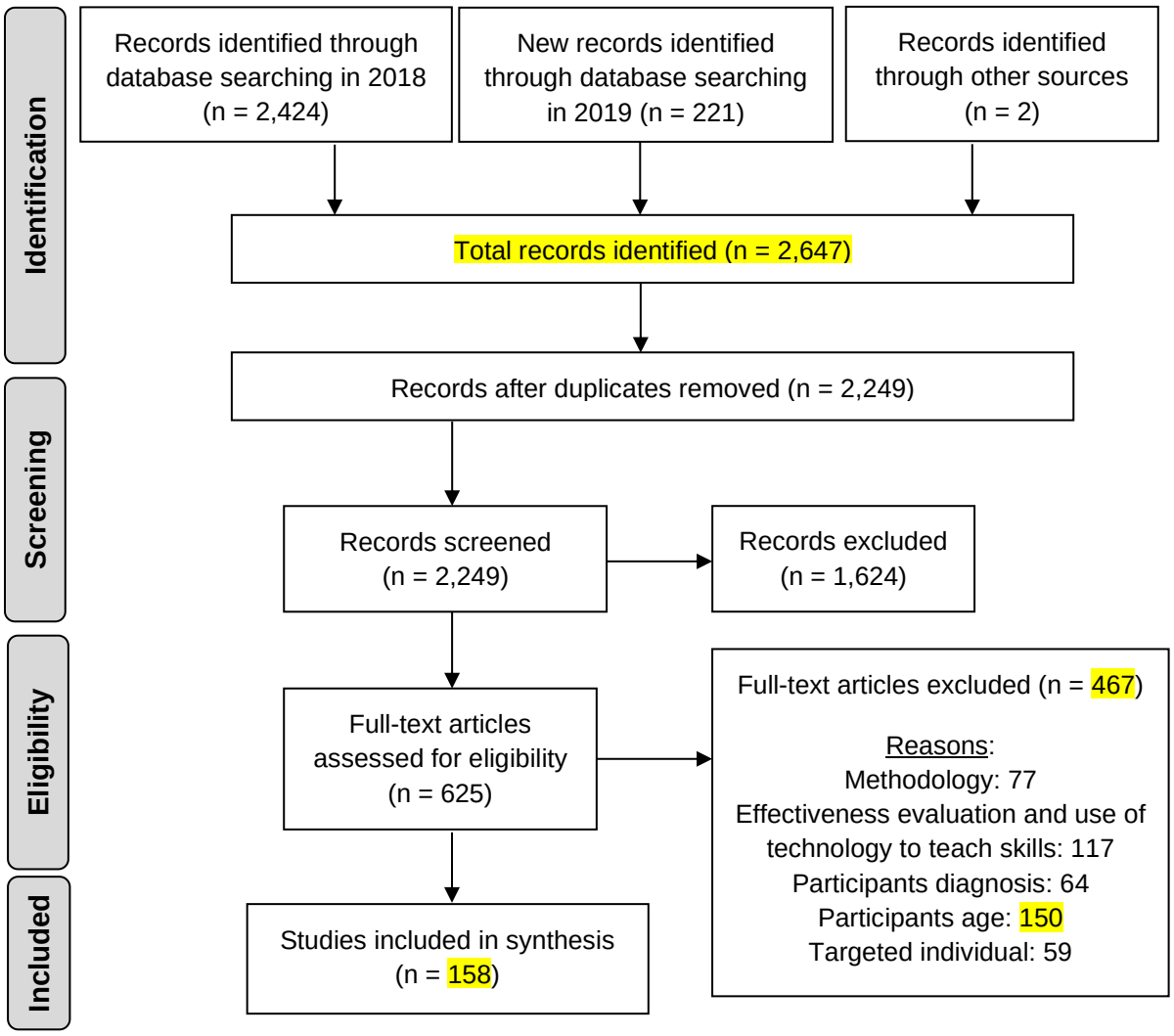

Figure 1. PRISMA flow diagram of the scoping review's process, adapted from Moher et al. (2009). This figure illustrates the number of included and excluded articles for each phase.

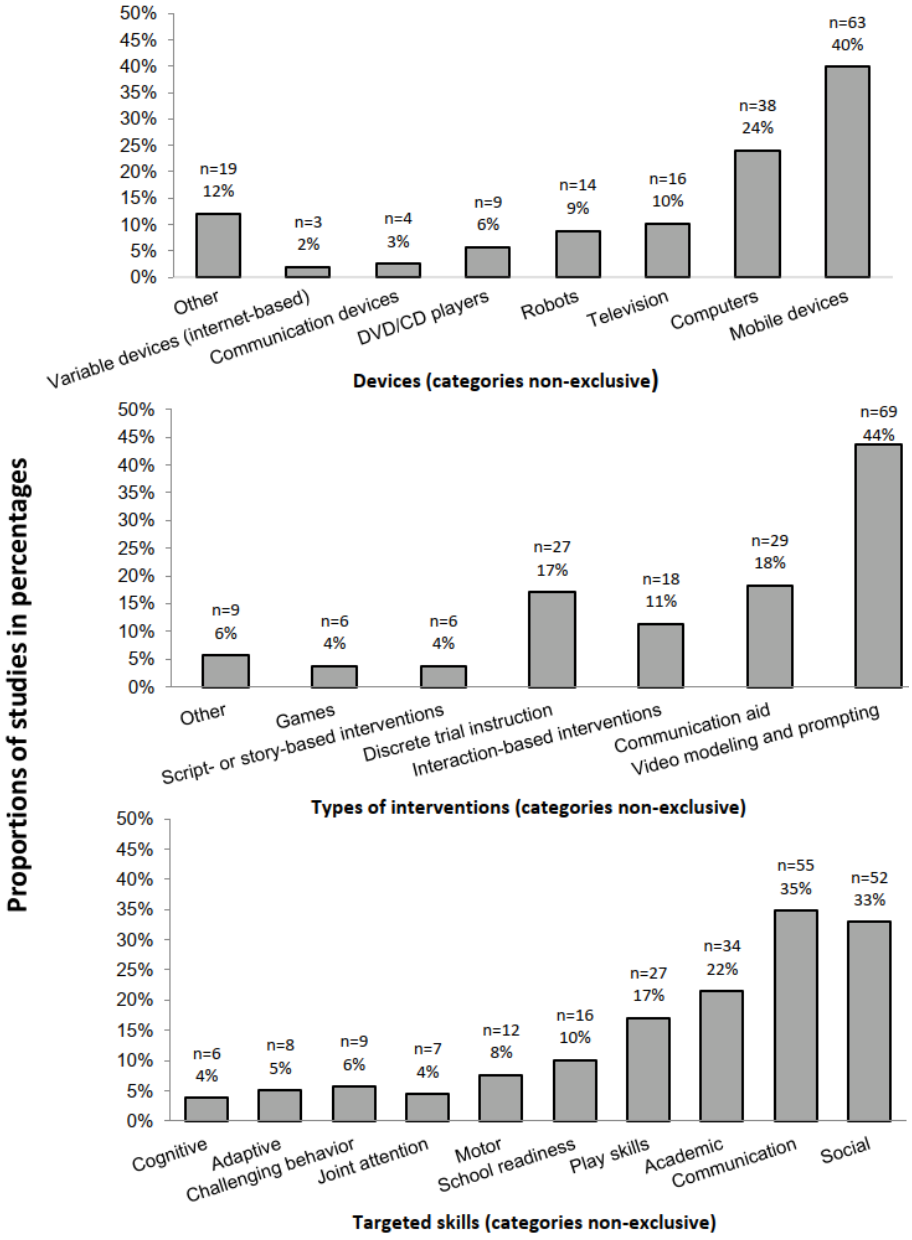

Figure 2. Proportions of studies by types of devices, types of interventions and targeted skills studied.

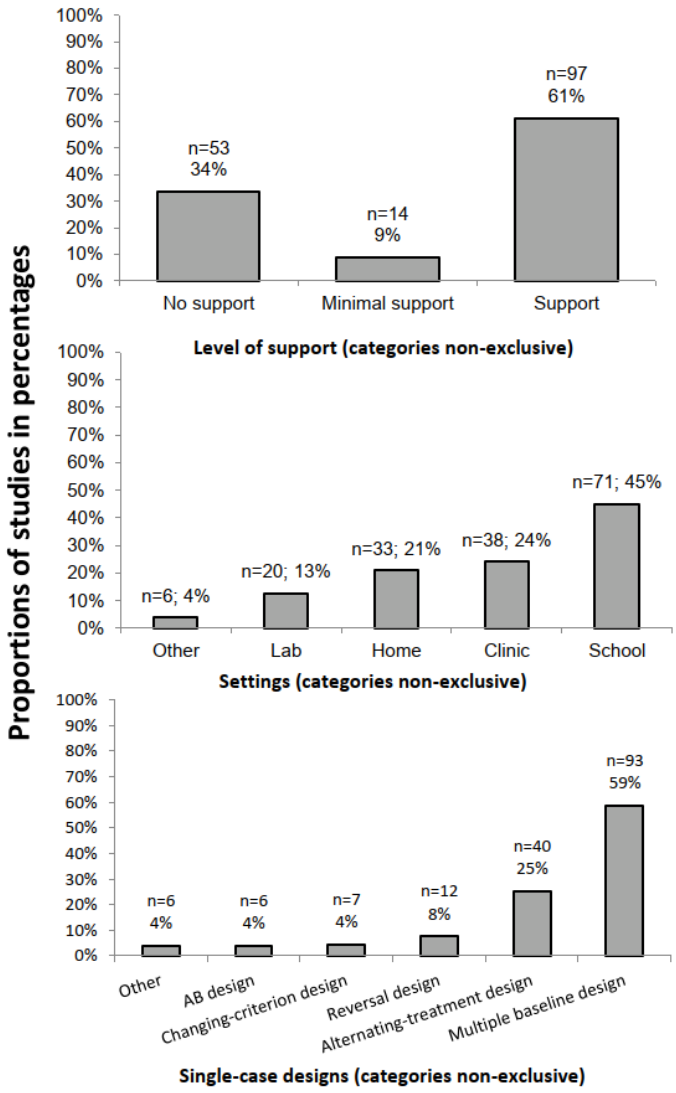

Figure 3. Proportions of studies by their level of support, settings and single-case designs.