Apps to Teach Social Skills to Individuals with Autism Spectrum Disorder: A Review of the Embedded Behaviour Change Procedures

Nicole Hanna[1] · Helena Lydon[1] · Jennifer Holloway[1,2] ● · Lorna Barry[3] · Edith Walsh[4]

Abstract

Social skill interventions have become increasingly popular in recent times, as well as the use of technology to deliver and aid interventions for the autism spectrum disorder (ASD) population. Little research exists on the use of apps to teach social skills to individuals with ASD, in particular the behaviour change procedures that exist within apps. The current review examines the behaviour change procedures that exist within apps according to the Behavior Analyst Certification Board Task List, 5th Edition. A total of 15 apps were included within this review. Results indicate that a variety of behaviour change procedures exist within apps. However, the quality of apps and the number of behaviour change procedures vary across app developers.

Keywords Social skill interventions · Behaviour change procedures · Apps · Task List 5th Edition

Autism spectrum disorder (ASD) is a developmental disorder that is characterized by deficits in social communication and social interaction, and restricted, repetitive patterns of behaviour, interests, or activities (McCoy et al., 2016). The Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) outlines that individuals who present with ASD often have deficits in social-emotion reciprocity; deficits in nonverbal communicative behaviours; and deficits in developing, maintaining, and understanding relationships (American Psychiatric Association, 2013). Individuals with ASD frequently have difficulty initiating and responding to social interactions, sustaining eye contact, responding to other's feelings, comprehending, and responding to nonverbal communication and deficits in social problem solving (Boyd et al., 2008; Camargo et al., 2014). ASD can vary in severity and different deficits exist across a broad spectrum; therefore, the research using interventions that target social skills varies considerably depending on the individual's current

capabilities and skill set. Crooke et al. (2008) highlighted that interventions differ from skill-based approaches for teaching social skills for individuals with limited or emerging language to interventions on more social cognitive tasks for those with more complex language abilities. Social skills deficits do not remit across an individual's life span in the absence of intervention; instead, these deficits can cause other impairments and distress as the individual develops and becomes more aware of these deficits (Williams White et al., 2007). Long-term and without direct intervention, these social deficits can result in problems in reciprocal peer relationships, a difficulty to demonstrate empathy and weak integration of social, emotional, and communicative behaviours (Ramdoss et al., 2012).

Current literature reviews suggest that no one social skill intervention is suitable for all individuals with ASD, and currently, there is no common, agreed upon approach to teach social skills to individuals with ASD (Flynn & Healy, 2012). The efficacy of a variety of interventions to increase social skills of individuals have been examined including, peer mediated interventions (PMI), social skills groups (SSG), pivotal response training (PRT), script fading, video modelling (VM) and reinforcement-based procedures (Flynn & Healy, 2012), structured teaching, and developmental/ relationship interventions (Walton & Ingersoll, 2013). Reichow and Volkmar's (2010) evaluation of evidence-based practice within social skills interventions highlighted that the most frequently used intervention techniques were

✉ Jennifer Holloway
jennifer.holloway@nuigalway.ie

[1] Applied Behavior Research Clinic, National University of Ireland Galway, Galway, Ireland

[2] School of Psychology, National University of Ireland Galway, Galway, Ireland

[3] i-TEACH Lab, University of Limerick, Limerick, Ireland

[4] Athlone Institute of Technology, Athlone, Ireland

based on Applied Behavior Analysis (ABA) principles such as prompting and reinforcement. The authors further highlighted that ABA principles were also used to augment other intervention types and therefore should be continued to be used in social skill interventions (Reichow & Volkmar, 2010). Treatments for individuals with ASD can be intensive and costly for parents and caregivers with limited resources available free of charge (Hourcade et al., 2013); therefore, it is vital to have a tool to refer to when examining interventions and examining the cost benefit of interventions. The Behavior Analyst Certification Board (BACB) has devised a Task List, 5th Edition (TL5) that is divided into two major sections. Section 1 Foundations includes (a) philosophical underpinnings; (b) concepts and principles; (c) measurement, data display, and interpretation; and (d) experimental design; and Sect. 2 Applications includes (e) ethics, (f) behaviour assessment, (g) behaviour change procedures, (h) selecting and implementing interventions, and (i) personnel supervision and management (Behavior Analyst Certification Board, 2017). The task list is developed based on job analyses, where individuals within the field are selected based on their experience and expertise across the field of behaviour analysis. These individuals are brought together to identify the key functions and duties within the field of behaviour analysis at that particular time. These professionals represent the latest practices or trends that are common among practitioners, while also highlighting content that is not widely accepted within the field and excludes procedures and practices that are not yet evaluated through research (Johnston et al., 2014). Section G lists each behaviour change procedure widely used among clinicians and practitioners within the field and includes mainly practice-oriented skills. Recently, innovative advancements in technology have paved the way for more cost-effective interventions for individuals with ASD as well as providing accessible interventions that target various outcomes and specific deficits (Wainer & Ingersoll, 2011). This advancement, along with the observation that individuals with ASD show an affinity to technology, led researchers to recognize computers as an effective and efficient tool in treatment (Ploog et al., 2013). Ploog et al. (2013) review of computer-assisted technologies (CATs) found that the most common technologies that are employed to teach individuals with ASD social skills are video modelling and virtual reality. Video modelling has extensive empirical evidence for increasing social skills in individuals with ASD, in particular with children and adolescents, showing increases in answering and asking questions, giving compliments, social initiation, and reciprocity (Mason et al., 2012).

In the past decade, there have been a number of reviews examining the use of technology and computer-assisted interventions to teach social skills to individuals with ASD (Grossard et al., 2017; McCoy et al., 2016; Ramdoss et al., 2012; Reed et al., 2011). Reed et al. (2011) review of using technology to teach social skills categorized social skills into the topography of each social skill targeted, resulting in 9 categories: (1) initiating conversations; (2) responding to others initiations through conversations; (3) social conventions as part of conversation (staying on topic); (4) nonverbal behaviours; (5) play skills; (6) social problem solving; (7) friendship/peer relationship (8) emotion identification, regulation, and reciprocity; and,(9) other social skills not outlined above. Results indicated that the most common social skills taught were conversational skills followed by play skills (Reed et al., 2011). Ramdoss et al. (2012) further examined the existing research on the use of computer-based interventions (CBI) to teach social and emotional skills to individuals with ASD. They found that using CBI to teach social skills showed positive results; however, concerns were highlighted as the literature failed to examine the generalization of these skills to real-life scenarios (Ramdoss et al., 2012). A more recent review and in-depth evaluation of video modelling, role play, and CBI interventions to teach social skills to individuals with high-functioning autism (HFA) found each intervention to be successful in targeting a variety of social skills, such as increasing sportsmanship and conversational turn taking (role play); recognition of body language and facial expression in others (VR); and perspective taking, greetings, and social initiations (VM) (McCoy et al., 2016). McCoy and colleagues further highlighted that although these interventions showed positive outcomes, CBI was the only intervention to meet Reichow's (2011) criteria for evidence-based practices. Lastly, a review of games to teach social interactions and emotions to individuals with ASD identified 31 games designed to teach social skills, 16 of which targeted emotion recognition and 15 of which targeted more general social skills such as interaction, collaboration, and adaption to specific social contexts, with the majority of these 15 focusing on collaborative skills such as negotiation, turn taking, and planning together (Grossard et al., 2017).

Advancements in the use of technology for teaching social skills to individuals with ASD have resulted in a growing number of applications targeting this specific repertoire. Shic and Goodwin (2015) noted that the popularity of apps has extended to the ASD population with increasingly more apps being developed and made commercially available for individuals with ASD and their families. The demand for social skills apps has increased due to the recent focus on using technology to teach social skills to those with ASD (Mintz, et al., 2012). Parents and clinician's satisfaction with the use of iPads as an education tool has further opened the market further for app developers (Draper Rodríguez et al., 2014). Hourcade et al. (2013) review of tablet apps to increase social interaction noted that the use of apps to teach social skills are helpful in relieving uncertainty and

the anxiety that real-life interactions may cause. Participants felt that interacting with the tablet was easier, more predictable, and controllable than interacting with people (Hourcade et al., 2013). Although more apps are being developed that target social skills, it is important to ensure these apps are of high-quality and incorporate evidence-based practices that target behaviour change. Hourcade et al. (2013) noted that although the apps had positive effects, this does not mean that tablet apps will benefit children with ASD. Interventions and treatments are increasingly being held to high standards such as "evidence-based practices", and the goal of research should be to provide interventions that are as effective as possible for clients and their families (Mesibov & Shea, 2011). This goal should extend to apps and computer-based interventions. Odom et al. (2015) highlighted that questions currently exist around applications and whether they meet current evidence-based practice standards. Many social skills apps that exist are not specifically designed for individuals with ASD (Ploog et al., 2013). Kim et al. (2018) found that only 4.9% of 700 apps labelled as evidence-based "Autism Apps" were found to have any actual clinical evidence. However, this does not conclude that these apps are harmful or ineffective; instead, it highlights that practitioners should examine apps and the risks and benefits of using them more closely (Kim et al., 2018) as individuals with ASD have the right to effective treatment and treatments that are scientifically validated (Van Houten et al., 1988). The lack of reviews examining the evidence-based procedures within apps is also a cause for confusion for parents who seek apps as a replacement for direct intervention. Dillenburger et al. (2004) examination of parent's perceptions of ABA interventions highlighted the importance for parents to have a knowledge of basic ABA principles in order to individualize treatment for their children as opposed to a "one-size-fits-all" treatment approach which parents without this knowledge may fall victim to. Papadakis and Kalogiannakis (2017) further noted that many apps that are marketed as educational are often a digital or interactive replica of work sheets and lessons that educators already use. Research has suggested that many apps do not keep their promise of supporting learning and evaluating each app is difficult due to the large number of self-proclaimed educational apps. This may potentially exploit parents who may associate cost with effectiveness (Papadakis & Kalogiannakis, 2017).

More recently, focus has been directed towards identifying effective and scientific techniques present within apps, specifically the behaviour change techniques and procedures. The Behavior Change Technique Taxonomy (BCTT) was developed to provide a shared, standardized terminology to be used to specify the active ingredients of behaviour change interventions (Scott et al., 2020). The BCTT has been used to determine the behaviour change techniques present within apps for physical activity, with results showing fewer than four techniques present in the descriptions of the apps reviewed (Conroy et al., 2014). Similarly, Morrissey et al. (2016) investigated the behaviour change techniques employed within apps for medication adherence, and they identified that only 12 out of a possible 96 behaviour change techniques were present across apps. At present, the literature is lacking in research on social skills apps and the behaviour change procedures (BCP) present in the available apps. Research has suggested that ABA principles are most commonly used within social skill interventions (Reichow & Volkmar, 2010) along with further research highlighting the importance of parent's knowledge of ABA and its principles (Dillenburger et al., 2004). Therefore, it is vital for current research to explore the existing BCP within apps that are marketed to teach social skills to individuals with ASD.

The aim of the current review is to examine the apps that exist for both Apple and Android devices that are marketed to teach social skills to individuals with ASD. The current review build on previous research by Hourcade et al. (2013) and Kim et al. (2018) by examining the BCP as outlined by the BACB TL5 employed within social skills apps. Apps will be categorized and reviewed based on the BCP that are embedded within the apps. The purpose of this review was to analyze the BCP that are embedded within the existing apps for teaching socials skills to individuals with ASD.

Method

Search Procedure

Systematic searches were completed in May 2020 of the Apple "iTunes" store and Google "PlayStore" to examine the existing apps relating to teaching social skills in individuals with autism. Apps included in this review are all currently available for download in July 2020 from each app store. App stores were individually searched using the search words "Social Skills". The description of each app on the app stores was screened and was included if they met the inclusion criteria listed below. Following initial screening, apps were downloaded and further assessed for inclusion criteria and the presence of BCP.

Inclusion and Exclusion Criteria

Apps were required to meet the following inclusion criteria: (a) the apps were designed to teach social skills (this included conversation skills, e.g. initiating/maintaining conversations, how to finish a conversation; friendship skills, e.g. joining a game, going to a friend's house, being a gracious loser; perspective taking, e.g. navigating others expected and unexpected behaviour, understanding behaviours that others may find uncomfortable; social interactions,

e.g. personal space, recognizing social cues), (b) were marketed for ASD, and (c) were a follow-on from an original app, e.g. beginner, intermediate or advanced versions of apps; these apps were included and rated separately to the original app. Apps were excluded if they (a) included content unrelated to changing social behaviours in people with ASD; (b) focused solely on teaching emotions as a target skill; (c) taught social expectations in isolation, e.g. social stories; (d) were not a stand-alone app, (e) were unable to use, i.e., apps that were freezing or crashing; (f) were not available in English; (g) were only available to download in a specific country (as this would not allow for generalization); and (h) required membership of a specific curriculum or school to use.

Data Extraction

Each app selected for inclusion was summarized in terms of (a) age range and price; (b) platform on which it is available; (c) social skill(s) targeted; (d) category of BCP; (e) specific BCP; (f) task list item code; and (g) how the BCP was presented.

The BACB task list is divided into two major sections: Sect. 1 Foundations and Sect. 2 Applications which includes section (g) behaviour change procedures (Behavior Analyst Certification Board, 2017). As the current review focused on skills acquisition of social skills for individuals with ASD, apps that were selected for inclusion within this review were examined and coded according to (g) BCP. The BCP listed in this section of the BACB task list was further categorized for the content analysis of this review (see Table 2). These categories were:

1. Antecedent-based interventions, e.g. motivating operations, instructions, and rules.
2. Procedures to increase skill acquisition, e.g. modelling, shaping, prompts.
3. Reinforcement-based procedures to strengthen behaviours, e.g. positive reinforcement, differential reinforcement of high rate behaviour (DRH).
4. Reinforcement-based procedures to weaken behaviours, e.g. differential reinforcement of low rate behaviour (DRL), differential reinforcement of other behaviour (DRO).
5. Programming for generalization and maintenance, e.g. response generalization, maintenance procedures.

Two raters (a graduate student in Applied Behavior Analysis and a doctoral student in Applied Behavior Analysis who is a board-certified behaviour analyst) performed the data extraction independently in June 2020. BCPs were coded using the BACB TL5; apps were trialled independently by each rater and screened for the presence of BCPs.

Quality Assessment

To examine the quality of the apps included, the Mobile App Rating Scale (MARS; Stoyanov et al., 2015) was used. The MARS is a standardized assessment tool that has been used to rate the quality of health apps, and is an easy to use and widely applicable measure of app quality. The MARS consists of 7 sections (A–F), assessing the following areas: (a) engagement, (b) functionality, (c) aesthetics, (d) information, (e) subjective quality, and (f) assess the perceived impact on the user's knowledge, attitudes, and intentions to change. Each section contains 3–7 items, and items are scored by the raters on a 5-point scale from 1 "inadequate" to 5 "excellent". Additional descriptors are provided for each item to assist with scoring based on the feature of the app being examined. A mean score for each section (a–f) is calculated, then mean scores for Sections A–D are combined to provide an app quality mean score and Section E is used to provide an app subjective quality score. Section F is excluded from scoring but provides additional app-specific information.

Reliability of Search Procedures and Inter-Rater Agreement

Inter-rater agreement (IRA) was conducted by two independent raters. Agreement was defined as both raters identifying the same apps to be included within the review. IRA was performed on three states of the review: inclusion/exclusion criteria, data extraction, and quality assessment.

Firstly, each rater independently searched both platforms and screened the app names and descriptions for inclusion criteria. Each rater then produced a list of apps that should be considered for inclusion. Agreement was calculated by calculating the sum of number of apps considered for inclusion by both raters and dividing this sum by the number of apps that were in agreement that were identified by the raters. IRA for the apps considered for inclusion in the review was calculated at 80%. Any disagreements on apps to be included was resolved by a third rater (a board-certified behaviour analyst—doctorate level) who examined each app based on the inclusion and exclusion criteria and further calculating agreement at 100%. Each app considered for inclusion was downloaded and used independently by both raters. Agreement was defined as both raters identifying the same apps to be excluded once downloaded and screened. Agreement was calculated by adding the number of apps chosen to be excluded by each rater and dividing it by the number of apps that were in agreement. IRA for the apps to be included within the review was calculated at 100%.

Secondly, for data extraction, agreement was defined as both raters identifying the same BCP embedded within each app. A random sample of 33.3% ($n = 5$) of included apps was generated. The second rater extracted the information from each app in the random sample. IRA was then calculated to determine the accuracy of the data extracted. IRA on data extraction was 100%.

Thirdly, IRA was also conducted on the MARS quality assessment on the same random sample used for data extraction. IRA was calculated by adding the number of questions scored on the MARS that were in agreement and dividing it by the total number of questions to be scored. IRA on the MARS was calculated at 61.8%.

Results

A total of 24 apps were initially identified as consistent with the inclusion criteria for this review. Once apps were downloaded for data extraction, a further 9 apps were excluded, resulting in the inclusion of 15 apps (see Fig. 1). Reasons for exclusion included apps not being a full version ($n = 1$), apps freezing/not loading ($n = 1$), apps providing instructions/tips rather than targeting behaviour change ($n = 2$), apps requiring membership of a curriculum ($n = 1$), apps using social stories ($n = 3$), and apps not targeting social skills ($n = 1$). Of the apps included, 33.3% ($n = 5$) specified a target age group with ages ranging from 2 to 12 years old (see Table 1). A large portion of apps included did not include a specific age

Fig. 1 Prisma diagram of app inclusion
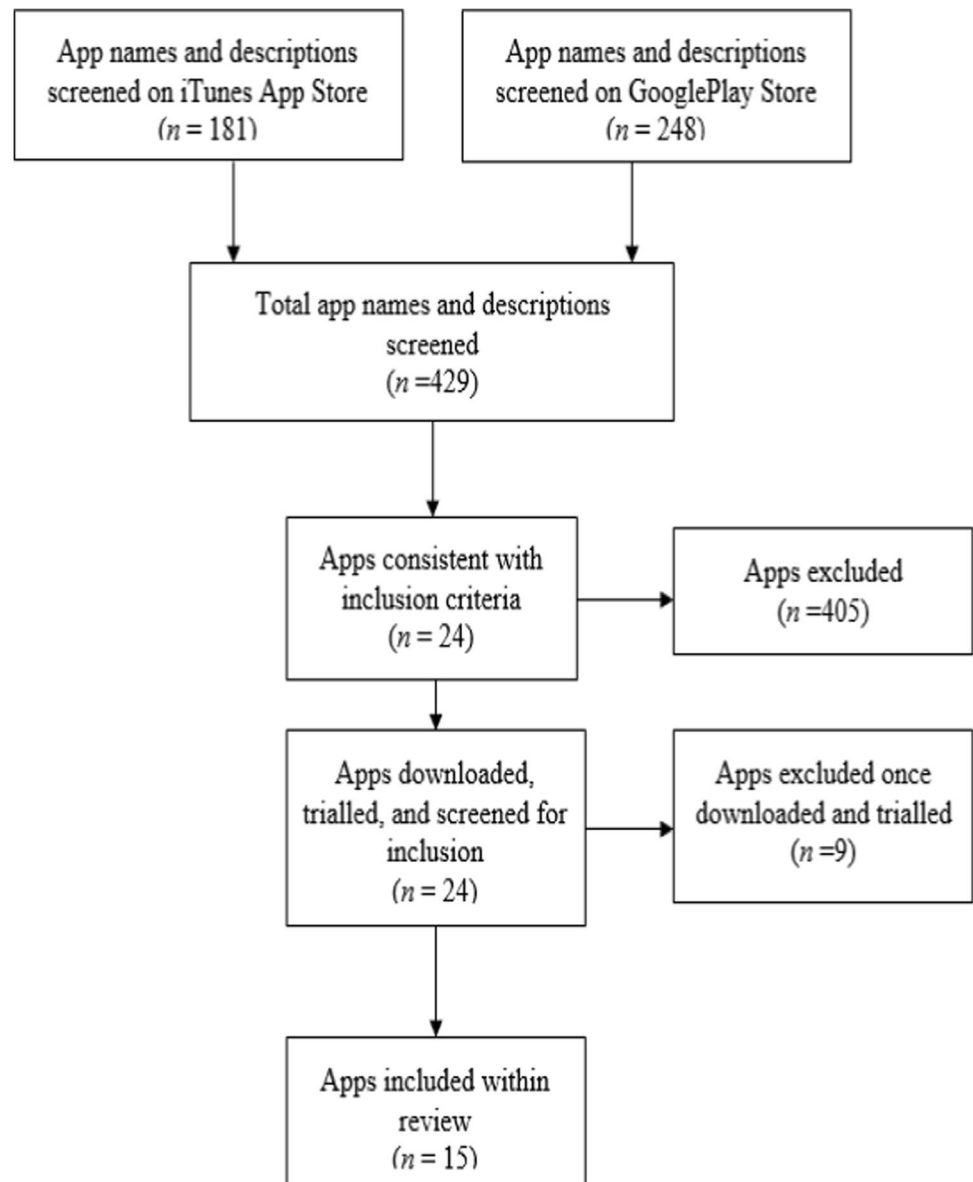
Table 1 Summary of apps to teach social skills

App name, age range, and cost	App store	Skills targeted	Behaviour change procedure Category	Specific	Task list item code	How the behaviour change procedure was presented
Circles Social Skills Utility (4+; €27.99)	iTunes	Targets social boundaries such as appropriate personal space, relationships, and safety	AI PISA R+SB	IR MIT R+	G-6 G-5 G-1	App introduces a social circle; each circle has colours and instructions and rules as to who fits into each circle and examples of behaviours a student may engage in with particular people in certain circles / Virtual characters model the behaviours students may engage in, e.g., handshake/hug / Verbal praise, e.g. "great", "well done", when correct answer is given
Conversation Planner SE (4+; €12.99)	iTunes	Targets key components of conversation such as how to start, finish, and repair conversations, how to know your talking partner is ready and perspective taking	PISA R+SB PISA MG	DT TSCD TE R^c R+ PPSRG	G-9 G-10 G-17 G-3 G-1 G-20	Questions presented in a discrete trial format. / Conversation skill questions asked and series answers presented (80% criteria to move onto next level) / Students discriminate between correct/incorrect behaviour / $ earned for correct answers that can be exchanged for items / $ act as conditioned reinforcers / $ earned and reward centre to use $ for games / Previously mastered skills embedded within questions on further levels
Conversation Skills (9–11 years; €12.99)	iTunes	Targets key steps in conversation: identifying a friend's interests, choosing an appropriate topic, figuring out what topic has already been talked about, joining a conversation, continuing a conversation with appropriate questions and comments	R+SB PISA	R^c TE R+ DT TSCD	G-3 G-17 G-1 G-9 G-10	$ act as conditioned reinforcer / $ earned and can be used to play games/ purchase clothes and accessories for virtual character / Earn $ for correct responses, games/accessories can be purchased with these / Scenarios/questions presented in discrete trial format / Students required to discriminate between correct and incorrect response
Do it… Or not? Social Skills for ASD (9–11 years; €14.99)	iTunes	12 levels targeting over 100 real-life situations a student may be faced with relating to family (levels 1–3), friends (4–6), community (7–9), and mixed (10–12) / Identifying how specific responses would make someone feel and whether a particular response is okay to do	R+SB PISA	R+ TE R^c DT TSCD	G-1 G-17 G-3 G-9 G-10	Reward centre / $ earned for correct responses / $ act as conditioned reinforcers / 10 scenarios/questions presented with 2 answers, pick which is correct / Student to discriminate between what to do/ what not to do

Table 1 (continued)

App name, age range, and cost	App store	Skills targeted	Behaviour change procedure		Task list item code	How the behaviour change procedure was presented
			Category	Specific		
I Know How You Feel (4+; €10.99)	iTunes	Targets understanding the concept of empathy and discriminate between appropriate and inappropriate responses for a particular situation	PISA R^+SB	DT TSCD R^+	G-9 G-10 G-1	Questions asked with 4 possible answers, question represented if answer is incorrect; Students discriminate between correct/incorrect responses; Verbal praise "well good" and "good" when correct answer is given
Let's Be Social: Social Skills Development (4+; Free)	iTunes	20 lesson plans targeting personal interactions, navigating the community, school behaviour, handling change, and social relationships	PISA R^+SB	R^+ R^c TSCD	G-01 G-03 G-10	Ding when correct answer is chosen; Scenarios presented, questions with student asked to identify correct/incorrect responses
My School Day (4+; €6.99)	iTunes	Targets friendships/life skills, understanding emotions, problem solving, perspective taking	R^+SB PISA	R^+ R^c MIT DIT TSCD	G-1 G-3 G-4 G-9 G-10	Verbal praise "great job" and "well done"; Short animations of animals/people celebrating when correct answer is given; Video modelling of children engaging in expected and unexpected behaviour; Questions presented in a discrete trial format; Students discriminate between correct/incorrect responses/behaviours
Peppy Pals Social Skills (2–8 years; Free)	iTunes and PlayStore	Variety of skills; being brave, sharing, dealing with a mishap	R^+SB PISA	R^+ Prompts MIT	G-01 G-04 G-05	Games when correct behaviour occurs, e.g. jigsaw, colouring a picture; Stimulus prompts on where to click/engage in behaviours; Characters model correct/incorrect behaviour
Say it… Or not? Social Filter Skills, School ED (9–11 years, €16.99)	iTunes	Targets understanding and practising what to say and not to say in real-life situations across categories of family, friends, community, and mixed	R^+SB PISA	TE R^c R^+ DT TSCD	G-17 G-3 G-1 G-9 G-10	$ earned for correct responses; $ earned as conditioned reinforcers; $ rewarded and reward centre to use $ to play games/buy accessories; Questions presented in a discrete trial format with 80% criterion to progress; Students discriminate between correct/incorrect dialogue responses

Table 1 (continued)

App name, age range, and cost	App store	Skills targeted	Behaviour change procedure		Task list item code	How the behaviour change procedure was presented
			Category	Specific		
Social Detective (7–12 years; €6.99)	iTunes	Targets understanding others expected and unexpected behaviour, understanding others comfortable and uncomfortable thoughts, learning to use social toolbox items (eyes, ears, brain), how to make smart guessing with the toolbox items	AI R$^+$SB PISA	IR R$^+$ R^c DT TSCD MIT	G-6 G-1 G-3 G-9 G-10 G-5	Rules how to are presented in a detective video at the beginning Earning items to become a detective, e.g. coat, badge "Great job" Items earned act as conditioned reinforcers Questions/video scenarios presented correct/ incorrect answer Students discriminate between correct/incorrect behaviours Video models of correct/incorrect behaviours
Social Detective Advanced (4+; €6.99)	iTunes	Targets expected and unexpected behaviours, feelings of others, how a person responded based on how they feel, the feelings that were felt based on how others responded	PISA R$^+$SB	DT TSCD MIT Prompts R$^+$	G-9 G-10 G-5 G-4 G-1	Pre-test discrete trial with 100% criteria. 44 questions in test mode, 5 possible correct answers for each question Students discriminate between correct/incorrect responses presented Video model of expected/ unexpected behaviours before each set of questions Prompts of how many correct answers exist within the 5 options "find 3 things" "Well done" after correct answers
Social Detective Intermediate (4+; €6.99)	iTunes	Next edition of "Social Detective Beginner" targets decoding thoughts and emotions of people students may interact with day to day and predict what people might say or do next	R$^+$SB PISA MG	R$^+$ R^c MIT DT TSCD PPM	G-1 G-03 G-5 G-9 G-10 G-20	Verbal praise "well done", "good job" Clips/cartoon models of right and wrong behaviour Questions presented in a discrete trial format Students discriminate between correct/incorrect responses for feelings, others thoughts and "smart guesses" Once 100% criteria is reached, skills are embedded within "test" scenario

Table 1 (continued)

App name, age range, and cost	App store	Skills targeted	Behaviour change procedure — Category	Behaviour change procedure — Specific	Task list item code	How the behaviour change procedure was presented
Social Skills for Autism 2: Kloog 2 (4+; Free)	iTunes and PlayStore	Friendships/relationships, joining a game, being a gracious loser/winner, arguing with friends, when your friend calls to your house, going to your friends' house, bullying, cyber bullying, dealing with bullying, safe use of smart devices	AI R+SB PISA MG	IR R+ R^c MIT TSC PPSRG PPM	G-06 G-01 G-03 G-05 G-10 G-20 G-21	Rules for how to behave using examples/non-examples in a video model of characters Unlocking different levels/items Items acting as reinforcers Imitation of skill with helper/video models Imitation of characters engaging in correct/incorrect behaviour Questions getting student to discriminate between correct/incorrect behaviour based on rules/instructions Quizzes with various scenarios at the end of each skill Various social scenarios presented
Social Skills for Autism 3: Cosmic Classroom (4+; Free)	iTunes	Classroom behaviour, break time behaviour, and dealing with stress	AI R+SB s PISA MG	IR R+ R^c TSCD PPSRG PPM	G-06 G-01 G-03 G-10 G-20 G-21	Rules for how to behave using examples and non-examples in a video model of characters "Well done" at the end of each quiz Items earned for completing levels/quizzes Quizzes for students to distinguish correct/incorrect behaviour Quizzes at the end of presenting various scenarios Various social scenarios presented
Social Skills with Billy (4+; €16.99)	iTunes	7 activity categories targeting correct responses in dialogue, wrong vs. right responses, stating correct responses in dialogue across 100 real-life situational dialogues	PISA MG	DT TSCD PPSRG	G-9 G-10 G-21	Scenarios and pictures presented with yes/no answers or multiple-choice answers with one correct response Discriminate between correct and incorrect responses Different pictures and scenarios used for emotional recognition and dialogues

rating within their description with 66.6% ($n=10$) subject to the automatic app store rating of ages 4 + . Four apps were free to download (26.6%), and 11 apps (73.3%) required payment with a mean price of €12.80 and a range of €21.00 (see Table 1). All apps ($n=15$) included in this review can be found on the iTunes app store; 20% of apps ($n=3$) are available on both the PlayStore and iTunes. No apps were solely available to the PlayStore ($n=0$) (see Table 1).

Target Skills

A variety of social skills were found to be targeted within the included apps. The most common skill targeted was understanding the behaviour of others, such as understanding others' expected/unexpected behaviour, feelings of others, and empathy with 5 apps (33.3%) targeting these skills. Conversation skills such as correct/incorrect responses in dialogue and initiating conversation was targeted in 4 apps (26.6%). Friendship/relationship skills such as being a gracious loser, sharing, personal space, and social behaviours was targeted in 4 apps (26.6%) and social behaviour in school such as following rules and appropriate classroom behaviour was targeted in 2 apps (13.3%). Although app descriptions described the skills that the app targeted, many did not directly teach the target skill. Instead, apps presented quizzes and questions on various skills without prior direct teaching of the skill, this was evident in 53.3% ($n=8$) of apps included; the remaining 46.6% ($n=7$) incorporated procedures to demonstrate the skill prior to quizzes and questions.

Categories of Behaviour Change Procedures

The most common categories of BCP found within apps to teach social skills were procedures to increase skill acquisition with all apps including these procedures ($n=15$; 100%) (see Table 2). This was closely followed by reinforcement-based procedures to strengthen behaviours which were found in 14 (93.3%) apps. Apps also included antecedent interventions in 4 apps (26.6%) and similarly maintenance and generalization procedures present in 4 apps (26.6%). Reinforcement-based procedures to weaken behaviours is the only category of BCP not present in apps to increase social skills.

Specific Behaviour Change Procedures

The TL5 consists of 22 BCP; Table 2 presents a summary of the BCP and number of apps they are present in. Of the 22 BCP, 45.4% ($n=10$) can be found in apps that teach social skills to individuals with ASD with a mean of 4.4 BCP in each app. The most commonly used BCPs included positive reinforcement (93.3%; $n=14$), the use of simple or

conditional discrimination (86.6%; $n=13$), the use of discrete trials (66.6%; $n=10$), and the use of modelling and imitation (46.6%; $n=7$). Other BCPs which presented less in apps included use of token economies 26.6% ($n=4$), use of instructions and rules 26.6% ($n=4$), use of procedures to promote maintenance 26.6% ($n=4$) and prompts 13.3% ($n=2$); and the use procedures to promote generalization 6.6% ($n=3$) which were also found in the included apps.

How Behaviour Change Procedures Are Presented

There were 10 specific BCP identified within apps (see Table 2). Results indicate that BCP are presented in similar ways across apps. Discrete trials were presented in the same format across apps by incorporating them as quizzes. A trial was presented where an antecedent is presented (the question); individuals are required to engage in a behaviour (choosing a correct answer for a multiple-choice question) and a consequence is presented (ding when correct/verbal praise/conditioned reinforcer). Similarly, discrimination training was presented in the same way across all apps. Discrimination training was used within quizzes throughout apps where a question was presented, and the user is required to discriminate between multiple correct and incorrect responses for the appropriate social behaviour.

The BCP of modelling was presented the same across all apps, using video models of real-life and cartoon characters to model correct and incorrect social behaviours. The use of rules was incorporated within the video models where the characters explained inappropriate and appropriate social behaviours and their consequences. Rules were introduced through a video model of a virtual character such as an alien or detective where appropriate and inappropriate forms of social behaviours were discussed and consequences of these appropriate and inappropriate social behaviours were discussed. Prompts were incorporated within apps in a variety of ways. Prompts were presented as stimulus prompts where an app used flashes of lights, virtual characters looking a certain direction etc. to show the student where to click and the correct behaviours to engage in. Prompts were also incorporated as response prompts where the user was presented with a multiple-choice question where various correct answers exist, a prompt of "choose 4 answers" or "choose 3 answers" to indicate how many responses were required.

Positive reinforcement was most commonly presented in apps in the form of earning items such "$" rewards, earning access to games, and unlocking different levels ($n=8$); positive reinforcement in the form of verbal praise such as "well done" and "great job" was also evident ($n=6$). Conditioned reinforcers were presented in a similar way as positive reinforcement. Reinforcers such as earning items, tokens, and access to other levels were considered conditioned reinforcers from their repeated use as reinforcers throughout the

Table 2 Summary of categories of behaviour change and behaviour change procedures

Category	Behaviour change procedure	TL5 code	Number of apps
Antecedent interventions			4
	Motivating operations	G-02	0
	High probability instructional sequence	G-13	0
	Instructions and rules	G-06	4 (26.6%)
	Functional communication training	G-14	0
	Non-contingent reinforcement	G-14	0
Procedures to increase skill acquisition			15*
	Use of positive and negative reinforcement	G-01	14 (93.3%)
	Use stimulus and response prompts and fading	G-04	2(13.3%)
	Use of modelling and imitation training	G-05	7 (46.6%)
	Use shaping	G-07	0
	Use chaining	G-08	0
	Teach simple or conditional discrimination training	G-10	13 (86.6%)
Reinforcement-based procedures to strengthen behaviours			14
	Establish and use conditioned reinforcers	G-03	9 (60%)
	Use token economies	G-17	4 (26.6%)
	Discrete trial	G-09	10 (66.6%)
	DRA	G-14	0
	Self-management	G-20	0
Reinforcement-based procedures to weaken behaviours			0
	Use positive and negative punishment	G-16	0
	Use extinction	G-15	0
	DRO	G-14	0
	DRL	G-14	0
Maintenance and generalization			4
	Use procedures to promote stimulus and response generalization	G-21	3 (6.6%)
	Use procedures to promote maintenance	G-20	4 (26.6%)

Note: *DRA* differential reinforcement of alternative behaviour, *DRO* differential reinforcement of other behaviour, *DRL* differential reinforcement of lower rates of behaviour

*More than one BCP was present within each of the 15 included apps

app. Token economies were embedded within the procedure of discrete trials and discrimination training. However, it should be noted that although discrete trials were present in 10 apps and discrimination training was present in 13 apps, token economies were only present in 4 of these apps. Tokens in the form of "$" coins were earned for correct responses, and these tokens could be exchanged to buy items for the student's virtual character or to play a game. Token economies were consistently presented in this manner across all apps they appeared in.

Maintenance was presented in the same way across all apps. Apps that included maintenance presented it by embedding previously mastered questions or skills within quizzing on various other levels that targeted new, not previously mastered skills. Generalization was presented within apps by incorporating various scenarios, pictures, and questions based on the same skill. For example, various scenarios

were presented across family and friend scenarios and users were presented various quizzes and questions on.

App Developers

Although 15 apps are included in this review, only 6 app developers exist. Janine Toole developed 26.6% ($n=4$) of the apps included within this review. Similarly, Social Skill Builder, Inc., developed 26.6% ($n=4$) of included apps and Shine Ireland has developed 13.3% ($n=2$) of apps. The remaining 33.3% ($n=5$) apps were developed by a variety of independent app developers (see Table 3).

Results indicate that apps with the same developer incorporated significantly more BCP throughout their apps and also utilized the same BCP across the apps, despite apps progressing to different levels or targeting a different skill. Apps that had the same developers incorporated between

Table 3 Apps presented by mean quality score

App	App developer	Section				Quality score	Subjective quality score
		A	B	C	D		
Circles Social Skills Utility	James Stanfield Co., Inc	4.6	4.75	5	4.16	4.63	3.5
Social Detective	Social Skills Builder, Inc	4	5	4.33	5	4.58	4.5
Social Skills for Autism 2: Kloog 2	Shine Ireland	4.2	4.75	4.66	4.33	4.49	4
My School Day	Social Skills Builder, Inc	4.4	5	4	4.5	4.48	4.5
Social Skills for Autism 3: Cosmic Classroom	Shine Ireland	3.6	4.75	5	4.33	4.42	3.75
Conversation Skills	Janine Toole	4.2	5	4	4.5	4.42	2
Social Detective Intermediate	Social Skills Builder, Inc	4	5	4.33	4.33	4.42	4.5
Social Detective Advanced	Social Skills Builder, Inc	3.8	5	4.66	4.16	4.40	4.5
Social Skills with Billy	Virtual Speech Center Inc	3.6	5	4.6	4.3	4.38	4.5
Do it… Or not? Social Skills for ASD	Janine Toole	4	5	4.3	4.16	4.37	4.25
Conversation Planner SE	Janine Toole	3.8	5	4.6	3.6	4.25	3.75
Say it… Or not? Social Filter Skills, School ED	Janine Toole	3.4	4.75	3.66	4	3.95	3.75
I Know How You Feel	Creative Social Learning, LLC	3.2	5	3.33	3.5	3.75	3.25
Let's Be Social: Social Skills Development	Everyday Speech *LLC*	2.8	5	4	3.16	3.74	2.75
Peppy Pals Social Skills	Peppy Pals AB	3	3.5	3.33	2.5	3.08	1.75

Note: Mean Score for A = engagement, B = functionality, C = aesthetics, D = information

5 and 8 BCP across apps with a mean of 5.6 BCP in each app, in comparison to apps with independent developers that included only 3 BCP in each app. The apps developed by Janine Toole ($n = 4$) incorporated 6 different BCP, with all apps including the same 5 BCP (token economy, discrimination training, positive reinforcement, conditioned reinforcers, and discrete trials) and one app including an additional procedure (maintenance). These procedures were presented in the same form across all apps.

Apps developed by Social Skill Builder, Inc. ($n = 4$), included 8 different BCP. All apps included the same 4 BCP (positive reinforcement, discrete trials, modelling, and discrimination training), 3 apps (75%) incorporating the same 2 BCP (prompts and conditioned reinforcers), 1 app (25%) incorporating rules, and 1 app (25%) using the BCP of maintenance. It should be noted that these additional BCP existed within the first 2 apps in a series of apps (social detective, social detective intermediate) and were not included in the final app in the series.

Apps developed by Shine Ireland ($n = 2$) embedded 6 different BCP within their apps. All apps included the same 5 BCP (positive reinforcement, rules, conditioned reinforcers, discrimination training, and maintenance and generalization). The BCP of modelling was included on one app. Procedures were presented similarly across apps.

Quality Assessment

The apps included within this review have a mean quality score of 4.22 with the lowest app scoring 3.08, Peppy Pals Social Skills, and the highest scoring app receiving a score of 4.63, Circles Social Skills Utility. Each app was rated individually to obtain a mean score for each section and an overall quality score (see Table 3) where apps are rank by their overall quality score.

The apps included in this review scored a mean engagement score of 3.77 (ranging from 4.6 to 2.8). Apps that obtained a high engagement score were those that were fun and interesting, customizable, allow user input and provide feedback, and were appropriate for the target audience. Apps that scored high on engagement were Circles Social Skills Utility, My School Day, Conversation Skills, and Social Skills for Autism 2: Kloog 2.

Apps that scored high on functionality were those that had fast app features, were easy to navigate/use, and were consistent and logical across screens. The apps included in this review scored a mean functionality score of 4.83 (ranging from the highest score of 5 to 3.5). A large percentage of apps scored the highest score of 5 (66.6%, $n = 10$): Social Detective, My School Day, Conversation Skills, Social Skills Intermediate, Social Detective Advanced, Social Skills with Billy, Do it… Or Not? Social Skills for ASD, Conversation Planner SE, I Know How You Feel, and Let's Be Social: Social Skills Development.

The apps included in this review scored a mean aesthetics score of 4.25 (ranging from 5 to 3.33). Apps that obtained a high aesthetics score pertained to the app having good resolution, visual appeal, and appropriate arrangement of buttons/icons/content. These apps were Social Skills for Autism 2: Kloog 2, Social Detective

Advanced, Social Skills with Billy, and Conversation Planner SE.

The apps included in this review received a mean information score of 4.03 (ranging from 5 to 2.5). Apps that scored high on this section are those that contain what they describe in the description, have specific and measurable goals, have correct and well-written content, have comprehensions but concise information, visually explain topics, and come from a legitimate source with an evidence base. These apps were Social Detective, My School Day, and Conversation Skills.

Results indicate that apps with the same developer incorporate and present the BCP similarly across apps; this is also evident in the mean quality score of apps with apps that present with the same developer scoring a similar quality score. Apps developed by Social Skill Builder, Inc., have a mean quality score of 4.47. Apps developed by Shine Ireland have a mean quality score of 4.38 and apps developed by Janine Toole have a mean quality score of 4.25, in contrast to apps developed by independent app developers that have a lower mean score of 3.92.

Apps included in this review have a mean subjective quality score of 3.68 (ranging from 4.5 to 1.75). Apps that scored high on the subjective quality score were those that the rater would recommend to a friend, would use repeatedly over 12 months, would pay for, and were given an overall high star rating.

Discussion

The aim of the current review was to examine apps targeted at teaching social skills to individuals with ASD in order to identify the BCPs present within the app. Apps were categorized and reviewed for the BCP they incorporated using the TL5. Overall findings of this review indicate that the number of BCPs incorporated within apps is relatively high and the categories of the BCP were as expected for a skills teaching app. However, how the BCPs are presented and quality scores of apps appear to vary across app developers. The current review found the apps currently available via app stores using BCPs vary in the social skills they target and the standard of the BCP varies across apps and developers. A large variation was also noted across pricing and age ranges that the apps aim to target.

Apps included within this review targeted a variety of different social skills. This is promising for practitioners who have experience with behaviour change and who may seek more specific target skills to tailor teaching to individuals or clients; however, there is no evidence to support that these apps are successful in targeting these skills. As well as this, the large variety of apps that exist upon initial searches may cause confusion for a parent or caregiver who is seeking out

a social skill app for their child or someone they are working with.

Of the apps included within the review, clear descriptions of the skills targeted within the apps were provided. However, a limitation of many of the included apps was that they failed to directly teach the skill. Many apps involved the use of procedures to increase skill acquisition and reinforcement-based procedures to strengthen the behaviour, but failed to directly present what the target skill is or incorporate procedures to model the skills to the user or use instructions or rules to explain the skill to the user. These are crucial elements for apps that claim to teach social skills, particularly cases where parents may be using the app as an alternative to other social skills interventions. This raises the question, if the apps do not directly teach the target skills as described should they be utilized more as a resource to support maintenance after a skill has been taught directly. For example, they could be used as an at home support for parents or caregivers after a social skills group, as opposed to relying on them solely to teach the relevant skills. This is a vital element of apps and it is important when apps are marketed that this information is made clearer for parents, caregivers, and practitioner who seek out apps. Although these apps may be beneficial for recall of the skill presented within them, this does not mean that the app user will generalize the skill which is ultimately the long-term goal.

The price and suitable age range of apps varied considerably across those included within this review. Given that some apps serve the purpose of maintaining skills, rather than skill acquisition, it could be concluded that the cost for some apps does not reflect the quality of the information and content within the app, in particular if they do not directly teach the target skills. Furthermore, many of the apps that are included within this review include levels that once they are completed, the app is no longer useful for that particular student. For example, many apps within this review consist of levels 1, 2, 3, and so on. Once these levels are completed, the app user would either need to restart the app or purchase a follow-on app if it exists. Restarting the app would not be appropriate as many social skills within the apps build onto one another and going back to the beginning may cause confusion and frustration for the app user; therefore, a follow-on app would be the best option for the student. This may not be beneficial for parents or caregivers who may be using apps instead of other forms of direct intervention, as it is not cost-effective. However, this could be advantageous for teachers and practitioners who may pay for the apps and could reuse them repeatedly across clients and students.

The variety of age ranges that apps target is advantageous for sourcing an app that is suitable for particular clients or for parents who seek apps for their children. However, a large portion of the apps included within the review do not specify the age range they are suitable for and have the

iTunes automatic age range of 4 + which is not always accurate. This is a fundamental element that app descriptions have failed to address and is vital especially when practitioners and parents are sourcing appropriate content for individuals with ASD. Apps that have an automatic rating of 4 + may not reach the target audience the app was designed for and may be overlooked by parents and practitioners who are likely to assume the app rating is accurate.

The categories of BCPs presented within apps to teach social skills was as expected, with apps incorporating procedures to increase skill acquisition and reinforcement-based procedures evident across all apps, showing that app developers have a knowledge of the basic principles that can be used to teach a target skills. For example, extensive research supports the use of video models to teach social skills and apps reflected this by incorporating video models and characters modelling incorrect and correct social behaviours. A further expected finding of this review was the lack of reinforcement-based procedures to weaken behaviours; this was an expected finding as skills teaching interventions usually do not aim to weaken a behaviour, instead the goal is to strengthen target behaviours. However, an unexpected finding of the current review was the lack of maintenance and generalization procedures across apps with this section being one of the lowest. This is a cause for concern due to the mode of delivery of the skills teaching; users should have the opportunity to generalize the skills learned, in particular in the natural environment. As mentioned, individuals with ASD have an affinity to technology such as iPads and tablets and research indicates that individuals with ASD prefer this method of teaching (Hourcade et al., 2013). It is vital to ensure that the skills learned are not just utilized within the app setting. Target skills should be practised and extended to the natural environment as that is where the behaviours are most likely to be reinforced and therefore maintained. Furthermore, the lack of maintenance procedures within apps is also a concern. Maintenance procedures are an important element in particular within social skills as target skills throughout the apps appear to build upon one another. For example, initiating a conversation may move onto continuing a conversation. Apps that fail to incorporate maintenance procedures in particular within an app setting which is a contrived environment may lead to users losing a previously mastered skill which may in turn affect the students' understanding and ability to perform the next target skill.

A variety of BCPs exist across apps for improving social skills for individuals with ASD; however, when an operational definition of the existing BCP is examined according to the TL5 and compared to how the BCP is presented within the app, it is clear that in some cases, the standard of these procedures is not always high. For example, there are some elements of a "gold standard" discrete trial missing such as prompts and correction procedures. The use of a correction or corrective feedback is limited within the apps with only 2 apps showing evidence of this; this is also evident with the use of prompts with only two apps incorporating prompts. The lack of these key elements across behaviour procedures causes concern for the standard of the procedures included within apps to teach social skills. These key elements are expected within apps as they are a fundamental part of procedures to increase skill acquisition that can be easy to programme and automate; without these elements, the user is not redirected to perform the correct response and fails to learn the correct response without a correction procedure. This omission could cause frustration for the user and affect the rate of skill acquisition. This inconsistency in the standard of BCP can be noted across other procedures such as positive reinforcement. Similarly, to discrete trials, positive reinforcement can only claim to be in effect when an increase in the target response is observed. However, many apps do not measure or have a baseline of the target behaviour which prohibits the ability to evaluate the effects of the app and the BCPs to determine if they are successful in increasing the skill targeted.

It should be noted that this is not the case across all procedures, procedures such as discrimination training, rules, token economies, modelling, and generalization are presented across apps and are consistent with their operational definitions. Although generalization and modelling procedures were presented accurately according to their operational definition, it is important to highlight that the content used to display modelling and promote generalization in some apps may be difficult to relate to for some users. Some apps use videos that were used in video models were quite outdated and involved scenarios such as within American high schools that may not always be relatable for users. This may in turn affect the generalization of the content presented within the apps.

Limitations

The current review is not without its limitations. Firstly, the use of the MARS as the mechanism for the quality assessment could be considered a limitation given its subjective nature. The MARS poses questions regarding how engaging the app was, if the app was interesting to use, how visually appealing the app was, did it function correctly, its visual appeal of the app etc. These questions could be answered differently depending on the raters personal opinion of the app itself; furthermore, the questions relating to how the app functions could have been skewed depending on other variables such as if the raters iPad was slow and what version iPad the rater used. This was clearly reflected in the poor IRA score for the MARS. The poor IRA score further highlights the subjective nature of the MARS and how some of the questions it poses could be open to interpretation and

scores can vary considerably across raters. However, we believe that the quality indicator should only be used as a guide and that the most important information for users is the number of behaviour change procedures included within the app, which are most likely to contribute to skill acquisition.

A second limitation of the current study is that the apps that were selected for inclusion were not trialled by individuals with ASD to get an accurate measure of the quality of the apps and also the standard of BCPs embedded within the apps. This may have provided more clarity on certain aspects of the review such as the previous concerns about how the BCPs were presented. For example, does the positive reinforcement embedded within the apps function as a reinforcer for the target population? Monitoring an individual using the app would have increased the accuracy of the quality scores.

Future reviews should source a more objective quality assessment measure; future research may also benefit from trialling the apps with individuals with ASD to provide more information on the standard of the BCP within the apps and if the apps show an increase in the target behaviours.

Considerations for App Purchasers

The current review has acknowledged that a variety of people may be looking to purchase social skills apps, such as parents, practitioners, and teachers. Based on the information in the current review app purchasers should explore the app stores to ensure the app they choose is suitable for their purpose. App store inconsistencies in price, age range, and skills targeted can make it difficult for purchasers to do this; therefore, further research may be required prior to purchasing, for example, finding app developers websites to determine age ranges of apps or additional app reviews etc. App purchasers should also be aware that a more expensive app does not necessarily determine it as high quality, in particular for parents who may not be able to reuse the apps across different children. It is important for app purchasers to understand the context of where and when it may be suitable to use apps included in this review. Results indicate that although apps include a variety of BCPs, it could be concluded that many may not be useful as the sole intervention to target social skills for individuals with ASD. Parents who seek out social skills apps for their children should be aware that the apps included within this review may be more beneficial as an additional support to a social skills intervention rather than a replacement for direct intervention. For example, where an individual may attend a social skills group, these apps could be used at home to ensure maintenance of the skills taught. Apps included within this review may also be a useful tool within social skills groups for practitioners to support maintenance and give app users an opportunity to engage in the skill in different scenarios which may aid

generalization of the skills that practitioners may be directly teaching. Prior to purchasing an app that targets social skills, parents should seek support from a clinician or practitioner who has knowledge of BCP procedures and the goals of the app user. App purchasers should also consider that based on the apps reviewed, it cannot be confirmed if they result in a significant increase in target behaviours. Should parents, clinicians, or other app users want to assess the level of behaviour change, they may need to use additional tools to monitor and analyze this such as collecting a baseline for target behaviours. However, this may only be feasible for practitioners with knowledge of data collection, data trends etc.

How to Improve Future Apps

There are many suggestions that can be considered for future developers of apps to teach social skill to individuals with ASD. Firstly, apps should be clear on how the skills will be targeted within the apps and how the apps should be used. It is vital for the user and those purchasing apps (parents, caregivers, teacher, practitioners etc.) to have a clear understanding of how the content is presented within the apps and if further supports will be required along with the app, for example, if a particular skill needs to be directly taught prior to app use or will the user be able to use the app alone or does it require support.

Currently, many of the apps claim to teach target skills but fail to present these within the app content. Clearly, outlining how the information will be taught will help app purchasers decide if the app is appropriate for their needs and if they have the skills to support the individual throughout the app usage. For example, if particular skills need to be taught prior to app usage, parents or caregivers may not have the skill set or knowledge to support the user. Future apps should highlight or provide additional resources for parents and users where a curriculum or videos can be used to teach the skill directly prior to app use if this information is not included within the app itself to allow for a more cost-effective app.

Secondly, the standard of BCPs within apps should be examined more closely, in particular using the TL5. Although current apps include a variety of BCPs, the standard and how they are presented is questionable. Introducing small changes such as prompts (prior to the incorrect answer) and correction procedures when an incorrect response is presented will increase skill acquisition for the user. Furthermore, generalization and maintenance procedures are fundamental procedures in future app development. Each level of the app should embed maintenance procedures of previously mastered skills to ensure the user continually is developing their skill set while practising learned target behaviours. Generalization should be

incorporated throughout apps through different scenarios, pictures, characters etc., but users should also be encouraged to generalize the skill in the natural environment. This could be achieved by introducing "practice" rounds or homework where users have an opportunity to practise the skill in real life. To further eliminate limitations relating to how BCPs and questions surrounding if certain BCPs are functioning correctly, for example conditioned reinforcers and positive reinforcement. It may be useful for apps to take a baseline measure or provide choice in reinforcers for the user to ensure that these procedures are resulting in an increase in the target behaviour throughout the apps. Having more options and choice throughout will not only make the BCPs more effective but will also allow for reuse of the apps with different clients, making them more cost-effective.

A final recommendation for future app development is for app developers who have a number of social skills apps on the market. It may be useful for app developers to build on the apps they have and include more BCPs and vary how these BCP are presented. A large portion of the apps included within this review have the same app developer; although the apps target different social skills, the BCPs are presented the same across apps, with most of them containing the same number of BCPs. It may be beneficial for app developers to examine the apps relating to the TL5 and incorporate more evidence-based procedures to build on the quality of the apps that exist and future apps that may be developed. Developers could also work collaboratively with behaviour analysts who can provide detailed input on the most effective BCPs for skill acquisition. This could help in developing more guidelines for app developers on the procedures that can be used for skills teaching, maintenance, and generalization or creating a standard for apps stating examples of evidence-based procedures that must be included within apps before they can be marketed as apps that teach social skills. This will aid both app developers as well as practitioners and parents who are seeking apps.

Currently, the apps that exist to teach social skills to individuals with ASD incorporate a number of evidence-based procedures according to the TL5 that are successful in increasing skill acquisition for individuals with ASD. Although the existing apps incorporate BCPs that would be expected from a skill teaching app, the apps vary in price, the skills they target, the number of BCPs present within the apps, and the quality score of the apps. The current review provides recommendations for future app development to ensure social skills apps incorporate evidence-based procedures to ensure high-quality and consistency within-app development.

Declarations

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