Article

The role of technology-mediated music-making in enhancing engagement and social communication in children with autism and intellectual disabilities

Journal of Intellectual Disabilities
2020, Vol. 24(1) 118–138

DOI: 10.1177/1744629518772648
journals.sagepub.com/home/jid
SAGE

Lila Kossyvaki
University of Birmingham, UK

Sara Curran
University of Cambridge, UK

Date accepted: 23 March 2018

Abstract

Very little research has explored the impact of interventions combining music and technology on children with a dual diagnosis of autism and intellectual disabilities (ID) incorporating the active involvement of school staff. Video recordings and group interviews were used to collect data in this study. Video recordings of five children with autism and ID were conducted as they engaged with a technology-mediated music-making intervention over a period of 5 weeks. Additionally, five group interviews with classroom staff were carried out. This study is the first to explore the impact of a technology-mediated music-making intervention on the engagement levels and social communication skills of children with autism and ID at school. Some positive outcomes, especially regarding social communication skills, are reported, which are of significant value to educational researchers and school staff.

Keywords

autism, intellectual disabilities, music, technology, school-based research

Corresponding author:
Kossyvaki Lila, Department of Disability, Inclusion and Special Needs (DISN), School of Education, University of Birmingham, Birmingham B15 2TT, UK.
Email: a.kossyvaki@bham.ac.uk

Introduction

Autism[1] is a neurodevelopmental condition characterized by difficulties in social communication and interaction as well as restricted, repetitive and stereotyped patterns of behaviour and interests (American Psychiatric Association, 2013). Its occurrence ranges between 0.6:100 (World Health Organisation, 2017) and 1:68 (Centre for Disease Control and Prevention, 2014) worldwide. Although there is little research and inconclusive evidence on the prevalence of intellectual disabilities (ID) among individuals with autism, some studies report that this figure can be as high as 84% (Magnússon and Sæmundsen, 2001).

Music-making, encompassing musical performance, listening and responding to music, can provide an accessible and fundamentally important channel of communication for pupils with ID, fostering their engagement even where spoken language is not possible (MacDonald et al., 2002). All human beings are born with a propensity for music: everyone hears the rise and fall of their mother's voice and feels the rhythms of her walking and her heartbeat. Because of its universal and innate nature, music is an essential human experience (Nordoff and Robbins, 2007), and everyone, no matter what their physical or mental capacity, is engaged with music before birth (Trevarthen, 2002). As 'a mode of communicative action, a way of sharing time and space', music is potentially transformative: through music-making, people of any ability can become singers and musicians (DeNora 2013: 141).

Small's concept of 'musicking' (Small, 1998) strongly emphasizes human relationships in the context of musical performance, as well as the very activity, the *doing*, involved in music-making. Uniquely then, musicking places performance and relationships in pivotal roles when exploring, analysing and documenting different forms of music-making. Starting from the premise of innate musicality, Small suggests that the meanings of doing and making music are located both in the relationships between the musical sounds involved in performance and between the people involved in musical performance. His theory, however, has been little explored in the context of the musicality of non-verbal individuals. Given Trevarthen's (2002) comments, it is reasonable to argue that when children with ID hear music, they can be as capable, musical and responsive, within their own capabilities, as their typically developing (TD) age-related peers.

Individuals with autism often show an interest in listening and producing music (Kern and Aldridge, 2006), possibly because music offers structure and predictability which those with autism often prefer (Attwood, 2007). For Milton (2016, personal communication), an autistic academic and activist, 'music is a way of connecting with the world'. Relevant studies in the field have reported that people with autism tend to respond to elements of music, yet much more research is needed to explore the application of music in this context (Simpson and Keen, 2011). Although several reviews investigating the use of music with individuals with autism have been conducted (Simpson and Keen, 2011), evidence concerning the impact of curricular school-based music education on these pupils' engagement levels and social communication skills is still scarce.

Technology such as personal computers, tablets, smartphones, robots, interactive whiteboards, speech-generating devices and video game consoles is particularly attractive to people with autism because of the structure, visual supports, control over the environment and the opportunities for repetition it offers (Murray, 1997). Because of this, the last few years have seen a great number of primary studies on technology and autism as well as reviews and meta-analyses on the topic. Literature has evidenced the role of technology in scaffolding a number of skills in children with autism: social skills (e.g. Bellini et al., 2007b; DiGennaro Reed et al., 2011), communication skills (e.g. Ploog et al., 2013; Shane et al., 2012), academic skills (e.g. Knight et al., 2013; Pennington, 2010) or a combination of skills (e.g. Diehl et al., 2012; Light and McNaughton, 2012). However, evidence is inconclusive regarding the impact of technology on individuals with autism and ID (Pérez-Fuster, 2017), while research is also scant on school-based interventions combining technology and music for this group.

The concept of engagement is both under-researched and under-theorized (Lawlor, 2009). More precisely, although literature clearly states that engagement plays a crucial role in the learning process, especially for pupils with ID (Carpenter et al., 2015) and autism (National Research Council, 2001), the concept presents some difficulties in its definition and measurement (Simpson et al., 2013). In studies involving individuals with ID, engagement is often defined (e.g. by Carpenter et al., 2015) as the connection with the environment (other people, materials etc), whereas in studies with participants with autism, engagement tends to be synonymous with social engagement (Bellini et al., 2007a; Wimpory et al., 2007). Relevant research has reported that children with autism are less engaged with both social and non-social activities when compared with their TD peers (McWilliam and Bailey, 1995) or peers with other developmental disabilities (DD) (Ruble and Robson, 2007). However, it has also been shown that music has the potential to facilitate engagement in the former population (Simpson et al., 2013) especially when combined with structured, preferred activities and opportunities for positive social interaction (McConnell, 2002).

Difficulties in social communication are common in people with autism, regardless of their language abilities (Kasari, 2002). Many studies comparing children with autism and TD children or children with DD show differences in their social communication skills (Murdock et al., 2007; Wetherby et al., 2007). Regardless of the existence of additional ID, children with autism tend to experience significant difficulties in initiating communication; when they do so, they communicate primarily for behaviour regulation purposes (e.g. request an object, reject/protest an activity) (Chiang, 2009; Chiang and Lin, 2008; Drain and Engelhardt, 2013; Potter and Whittaker, 2001). These difficulties can be exacerbated by additional ID, with their attendant poor attention and memory skills, perceptual difficulties, inflexibility of thinking, behaviour and/or sensory processing difficulties (Jordan, 2001).

The current study

This study is of substantial value for a number of reasons. Firstly, it contributes to existing knowledge through focusing on a largely under-researched population, namely that of individuals with autism and severe intellectual disabilities (SID) (Kasari and Smith, 2013; Pellicano et al., 2014). Secondly, this is one of the few studies involving teaching staff in the research process from the outset (Kossyvaki et al., 2016), giving them an active role in developing and implementing an intervention to be embedded in the school curriculum. Thirdly, the study intends to address a gap in the music education literature where there is a near-absence of any discussion of the social and relational aspects of the music-making of young children with autism and SID (Curran, 2016), especially in the form of advice for teachers in school (Ockelford, 2008).

Methodology

A case study approach was followed. Case study is 'an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular [. . .] programme or system in a "real

Table 1. Data on children.

Children's name[a]	Andy	Zaineb	Rehan	Sahil	Saadi
Sex	Male	Female	Male	Male	Male
Age	7.01	6.08	5.11	5.05	5.10
CARS[b] score	40.5 (severe autism)	36 (moderate autism)	44 (severe autism)	47.5 (severe autism)	51 (severe autism)
Average P-levels	P4	P4	P4	P4	P3ii
SPT[c] score	12	9	12	0	1
SPT age equivalent (months)	21.9	18	21.9	below 12	below 12
Social communication	Prefers his own company	Enjoys interacting with adults	Enjoys interacting with adults	Initiates communication very irregularly	Initiates communication very irregularly
Affinity for technology	√	√	√	X	√
Affinity for music	X	X	√	X	√

[a] All children's names are pseudonyms.
[b] CARS: Childhood Autism Rating Scale.
[c] SPT: symbolic play test.

life" context' (Simons, 2009: 21). The main research aims were to measure the impact of a technology-mediated music-making intervention on the engagement levels and the social communication skills of children with autism and ID at school and to obtain staff views on the applicability and effectiveness of the system for the specific population. Specifically, the study aimed to answer the following research questions:

1. To what extent does the use of a technology-mediated music-making intervention influence the engagement levels of children with autism and ID?
2. To what extent does the use of a technology-mediated music-making intervention influence the social communication skills of children with autism and ID?

Setting and participants

The study was conducted in a primary special school and, more precisely, with a Year 1/2 class (5–7 years old) following an adapted version of the National Curriculum for England designed to meet the needs of learners with ID. The class was selected by the school's senior leadership team (SLT), who expressed an interest in developing research-informed interventions and resources for classes following this adapted curriculum, as other interventions (e.g. phonics and lunch time clubs) were inappropriate because of the pupils' ID.

Five children with autism and ID and five classroom staff members, comprising one newly qualified teacher (NQT) and four teaching assistants (TAs), agreed to participate in the study. Parents gave consent on behalf of their children. Table 1 shows the details of the children.

The NQT completed the Childhood Autism Rating Scale (CARS) (Schopler et al., 1988), a behaviour observation scale used to assess the severity of autism symptoms, for all participating children, as she had been teaching the specific cohort for 5 months prior to the start of the study and was deemed to have a good knowledge of their characteristics. CARS scores ranged from 36 to 51, classifying four children as severely autistic and one as moderately autistic. The teacher also provided the researchers with the pupils' P-levels. These use eight level descriptors for attainment targets in all subjects in schools in England, which apply to pupils aged 5 to 16 years with special educational needs who cannot access the National Curriculum (Department for Education, 2014). The average P-levels for English, Maths, Science and Personal, Social and Health Education were calculated and the results ranged from P3ii to P4 classifying four children as having SID (<P4) and one (P3ii) as having profound intellectual disabilities (PID). To confirm the ID of the participating children, the first author administered and scored the Symbolic Play Test (SPT) (Lowe and Costello, 1988). SPT assesses the children's early concept formation and symbolization and gives an age equivalent. The SPT scores for participating children ranged from 0 to 12, giving an age equivalent range of between below 12 and 21.9 months. Information on children's social communication and affinity for technology and music was extracted from their 'Passports for Learning and Life' (i.e. school documents completed by classroom staff which identify each child's strengths and needs around the areas of social interaction, independence, engagement; they also list the child's preferences and activities which may increase their anxiety levels).

The intervention

The system: Cosmo units. Cosmo hardware consists of a set of six switches which provide auditory (i.e. sounds and music) and visual cues (i.e. multi-coloured lights). They also have a dynamic weight sensor and connect wirelessly to computers. The switches connect to the software platform enabling the selection of a specific activity. The software allows for full customization of the hardware (i.e. number of units, light colour and switch sensitivity) and of the activities (i.e. musical genre, length and volume of samples, difficulty level, songs). The music samples themselves can be customized to specific musical styles and/or instruments and may be mono- or polyphonic. This means that single tones, notes, instruments or any combination of these can be incorporated into an activity.

Cosmo units were selected on the basis that they combine music and technology and can be used in very simple ways. Additionally, they do not involve any verbal instructions, which could be off-putting for young children with autism and ID. To run the sessions, the researcher made the Cosmo units visible and accessible to the children (within an arm's length distance) while controlling the software (e.g. changing activities) from a laptop placed in a plastic box at the corner of the room. She also used a speaker placed next to the box to increase the sound levels. See Figure 1 for an example of the room arrangement.

Piloting. After a pilot trial at the school having followed a participatory action research approach (Nind, 2014), it was decided that five activities focusing on engagement and social communication would be tested. The trial was conducted with a classroom following an adapted curriculum (Year 4/5: 8–9 years old). The pilot class was selected on the basis that it was the school's curriculum lead teacher's class and it was believed that she would be the most appropriate person in school to provide feedback on the activities most likely to be beneficial for children with autism and ID within the school. The whole process lasted for 2 months as this was felt to be sufficient time for both the curriculum lead and the researcher (first author) to complete the activities to be included in the main study.

Figure 1. Room arrangement during the sessions with the Cosmo units.

The activities. The activities to be included in the main study were chosen because of their focus on engagement and social communication (as opposed to activities focusing on academic or fine/gross motor and independence skills which were also tested during the pilot phase). They are as follows:

- *Improvization:* Each Cosmo unit was assigned one note; the child played along with a backing track as she/he wished to, touching each unit to make sounds.
- *Exploration:* The units, programmed to be touch-sensitive, enabled the music's volume or sound effects to be altered according to the amount of pressure applied by each child.
- *Follow the light:* One unit was lit, inviting the child to make a sound; after she/he did this, another unit lit up, providing another invitation for the child to play.
- *Orchestration:* Each unit was programmed to play a single instrument (e.g. guitar or drums) and the child was encouraged to build up layers of sound.
- *Turn-taking:* The units were divided equally between the child and the researcher. When the researcher's units lit up, she made sounds with them. After a short time, these lights went out, while the child's units lit up, signalling their turn.

The delivery of the intervention. The children participated in two 12-min sessions with Cosmo units each week over a period of 5 weeks. The length of the sessions was decided on two bases: firstly, the average length similar activities take at school where children remain focused, and secondly, the researchers' wish to have 10 min of video recordings to code per session, similarly to studies such as Kossyvaki et al. (2012). The sessions ran on consecutive mid-week days in a small room (2 m $\times$ 3 m) located within the classroom. During each session, the TA or the NQT working with each child (always the same person for the duration of the study) was present in the room in order to help the researcher to interpret the child's communication signals correctly and make suggestions concerning the customization of the system (e.g. lower the sound volume, suggest a child's favourite music) and the way it is used by the researcher. Due to pupil or staff absence, and glitches in the system, no child took part in all ten of the planned sessions. All, however, took

Table 2. Coded sessions in which each child participated.

Sessions	Andy	Zaineb	Rehan	Sahil	Saadi
1	√	√	√	√	√
2	√	√	√	√	√
3	√	√	√	√	√
4	√	√	√	√	√
5	√	√	√	√	X
6	√	√	√	√	√
7	√	√	√	√	√
8	X	X	X	X	X
9	√	√	√	√	√
10	X	√	√	√	√

√: the sessions each child attended; X: the sessions each child missed; grey cells: the sessions which were coded per child.

part in at least eight. See Table 2 for a list of the sessions each child participated in and the ones that were coded.

Most of the aforementioned activities were covered in each session but the order in which they were presented varied according to the child's preferences and the flow of the session (the school staff were consulted where necessary during the session and would often share their views with the researcher during these). The theoretical background of the intervention used to facilitate the Cosmo activities draws principles from three interventions used in the field of autism and ID, namely Intensive Interaction (Nind and Hewett, 2001), Musical Interaction (Methley and Wimpory, 2010) and Responsive Imitation Training (RIT) (Ingersoll, 2010). Following the Intensive Interaction and Musical Interaction principles, the researcher was observant, 'tuned in' and responsive while allowing pauses. She let the child lead by imitating their sounds as well as their movements and physical actions, used short running commentaries and simple repetitive routines which built up anticipation. The researcher's way of working not only reflected the principles of Intensive Interaction, but also Small's musicking framework (1998) in that she was beginning to build a musical and personal relationship between the child and herself. In addition, following the RIT model, the researcher also often modelled actions with the Cosmo units, showing the child what was expected from them in each activity. To ensure consistency, the intervention was delivered in full by the second author, a doctoral researcher at the time with 20 years of music teaching experience. Before delivering the intervention with the Cosmo units, the latter familiarized herself with the use of Intensive Interaction and Musical Interaction as well as RIT. This happened first through study and then through discussion with the first author who is trained in these interventions.

The data collection process

Video recordings and group interviews were employed to collect data for this study. Teaching staff video-recorded each session using a hand-held camera. This was the most appropriate way to proceed in this context, as the staff were in the room with the children whom they knew and who knew them, and because the room's size and the children's unpredictable movements made the use

Table 3. The engagement and social communication checklist.
DATE _____________ CHILD'S NAME __________________ CODER ___________________.

	1	2	3	4	5	6	7	8	9	10	TOTAL
ENGAGEMENT											
Engaged											
Disengaged											
SOCIAL COMMUNICATION											
Behaviour regulation	1	2	3	4	5	6	7	8	9	10	
Requests desired objects or actions											
Protests/rejects undesired objects or actions											
Joint attention											
Comments on objects or actions											
Social interaction											
Takes turns											
	1	2	3	4	5	6	7	8	9	10	

of a tripod impossible. Staff were asked to avoid interacting with the children while video recording was taking place. In addition, five group interviews lasting approximately 10 min each were conducted with the four TAs and the NQT once per week; this was either prior to the start or immediately after the end of the school day. The length of the interviews was imposed by the availability, within the school day, of the five interviewees.

Ethics

Ethical approval for the study was given by the University of Birmingham's Ethical Review Committee (Application for Ethical Review: ERN_15-0559A). Principal ethical concerns included obtaining participants' informed consent and ensuring confidentiality for research participants' identities. Written consent was obtained from all teaching staff and from children's parents. The children's young age and ID made it impossible for them to provide assent. To ensure confidentiality, pseudonyms respecting their ethnic backgrounds are used for children, and roles rather than names of staff (e.g. TA or NQT).

Results

Data coding and analysis

Since the minimum number of sessions per child for the 5-week intervention period was 8, the first eight sessions per child were coded.

Video coding. Partial interval sampling (Wilkinson, 2000) was used to code children's video recordings, with each 10-min session being split into twenty 30-s intervals. If one of the coded behaviours (see Table 3 for a full list and Appendix 1 for a glossary of definitions) was exhibited at any point during the interval, an occurrence was recorded. Both engagement and disengagement were coded in a 30-s interval if occurrences of each lasted for longer than 5-s. Otherwise, if a specific behaviour appeared more than once during each 30-s interval, only one occurrence was coded. Although such a decision can be argued against, it was made to facilitate the video coding, given time and resource limitations. The coding system used has been taken into account when discussing the study's findings and limitations. Within each 12-min session, coding began with the first second of minute 2 and ended after 11-min. This allowed child and researcher time to settle, and to close, each session. Only engagement with and social communication acts towards the researcher were coded (the few interactions between pupils and staff, such as children's requests to get involved in the Cosmo activities, or their seeking reassurance from the TA/NQT were not coded). The authors developed a coding schedule, '*The Engagement and Social Communication Checklist*' based on the Social Communication Emotional Regulation Transactional Support (SCERTS) Assessment Process (SAP) observation form (Prizant et al., 2006) and the Engagement Profile and Scale (Carpenter et al., 2015). All video coding was conducted by the second author. A blank copy of this checklist can be found in Table 3 and a glossary of definitions in Appendix 1.

Inter-coder reliability for videos. To lessen confirmation bias, 25% of the video recordings (i.e. 10 out of 40 sessions) were coded by an independent researcher. This person was trained in the use of '*The Engagement and Social Communication Checklist*' by the two authors before conducting the coding checks until a high percentage of agreement was reached (i.e. 80% as recommended by Reichow et al., 2008). The mean agreement between the two coders was 80% (range from 65% to 99%), calculated by dividing the number of agreements for each code by the number of agreements and disagreements multiplied by 100 (Watkins and Pacheco, 2000).

Group interviews. Group interviews were conducted in order to enhance the validity of video data and to provide specific examples of the impact of Cosmo units on children's engagement and social communication skills (Gray, 2018; Thomas, 2015). The questions followed a framework referencing the Engagement Profile and Scale indicators of engagement: awareness, curiosity, investigation, discovery, anticipation, persistence and initiation (Carpenter et al., 2015). The 24 pages of transcripts of the group interviews were thematically analysed using NVivo 11 (Edhlund and McDougall, 2017) by two researchers independently (the second author and the researcher who checked the inter-coder reliability for the videos). Codes were both *a priori* and data-driven: the researchers drew upon the seven indicators of engagement from Carpenter et al.'s (2015) scale, and further codes referring to relationship (reflecting Small's, 1998, musicking framework) and the child's or staff's reception of and reaction to the Cosmo units. The first author of the paper synthesized the two analyses. No inter-coder check was conducted for the group interview data. This accords with Krippendorff (2004), who recommends inter-coder checks only when preconceived coding schemes are used. This was not the case for the group interview schedules; a grounded approach was used, giving the interviewees the chance to talk about aspects of the study they consider important and the researchers the freedom to come up with data-driven results.

Results based on the video data

Video data for engagement levels and social communication skills are presented first, followed by the group interview data. The authors felt it would provide the closest picture of what happened in each session to present the children's engagement levels as percentages of time and their social communication skills in terms of 'frequency of occurrence' to obtain comparable data to similar studies in the field. All video data are presented in Figures 2 to 7 below.

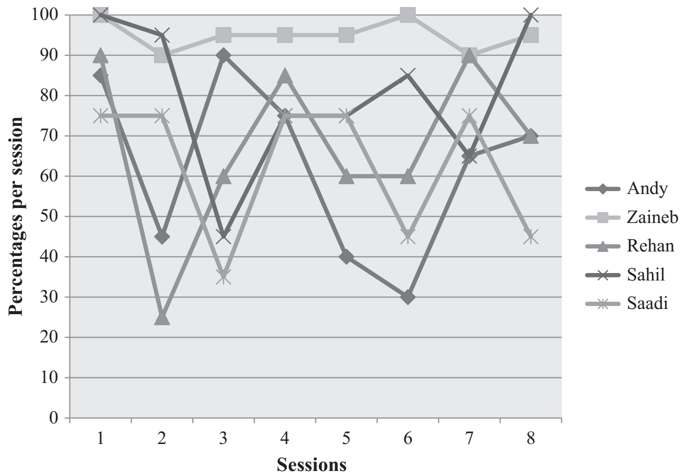

Figure 2. Percentages of engagement for all five children during the eight sessions.

Engagement. Zaineb was the child who engaged the most throughout the eight sessions, her engagement levels never dropping below 90% in any session. Rehan, Andy, Sahil and Saadi showed high levels of engagement in some sessions but at the same time their engagement presented great fluctuation reaching very small percentages in other sessions (engagement levels range: Rehan 25–90%, Andy 30–90%, Sahil 45–100% and Saadi 35–75%).

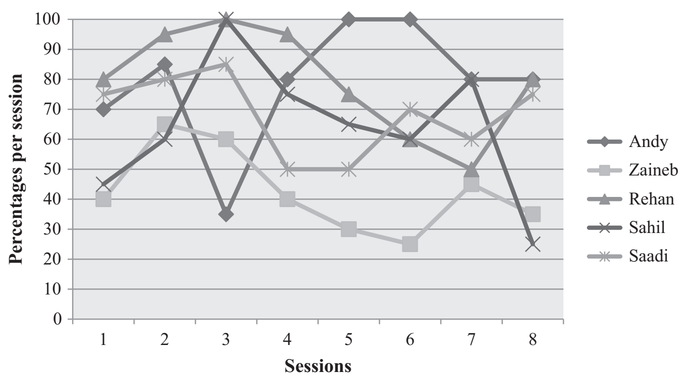

Figure 3. Percentages of disengagement for all five children during the eight sessions.

Disengagment. Andy and Rehan displayed the highest percentages of disengagement, with Andy showing 100% disengagement in two sessions, and Rehan being coded with disengagement ≥95% in 3 sessions. Sahil showed great variation in his disengagement levels across sessions (disengagement levels range: 25–100%), while Saadi presented medium to high disengagement (disengagement levels range: 50–85%). Zaineb showed the least disengagement, with disengagement levels being below 40% in most of the sessions.

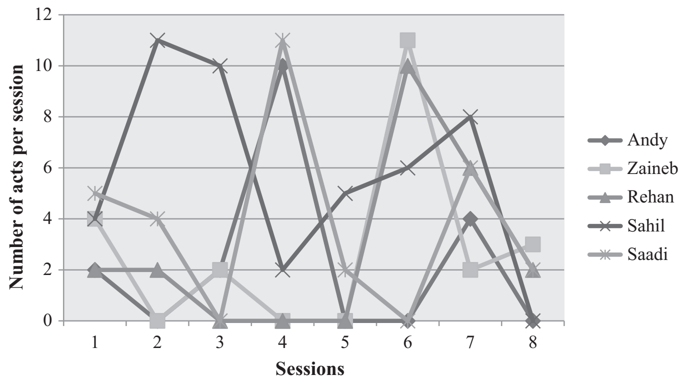

Figure 4. Number of requests for all five children during the eight sessions.

Requests. Sahil and Zaineb showed requests for most of the sessions; these two children and Saadi requested as many as 11 times in one session each. Rehan did not display many requests at the beginning of the intervention but showed an increase in requests following session 5. Andy overall initiated few requests with the exception of session 5, when he requested 10 times.

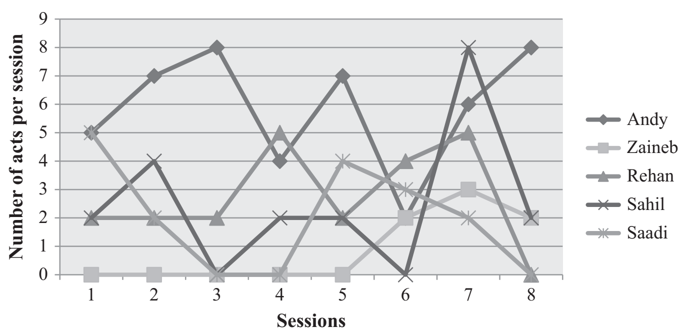

Figure 5. Number of protests for all five children during the eight sessions.

Protests. Andy communicated to protest in all sessions with the number of protests per sessions ranging between 2 and 8 times. Rehan also showed a high number of protests as he protested at least twice in every session but the last. Both Sahil and Saadi protested in most of the sessions, with Sahil doing so eight times in session 7. Zaineb showed a few protests towards the end of the intervention period.

Comments. Zaineb initiated communication many times to comment. As the sessions progressed, this behaviour increased from four comments in session 2 to nine comments in session 8. Andy and Rehan also had high numbers of comments in some sessions, whereas Sahil and Saadi had steadily low numbers of comments not going above three comments per session.

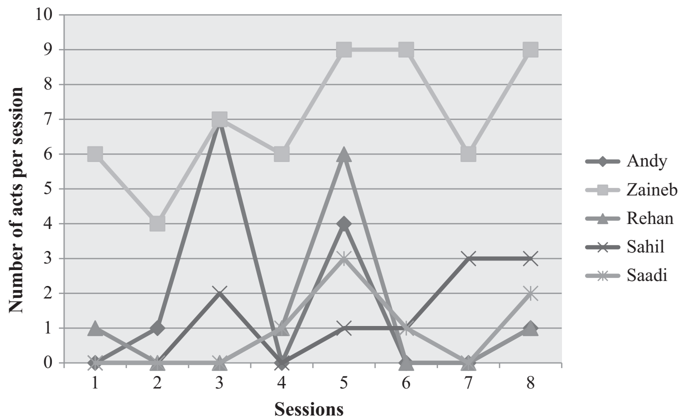

Figure 6. Number of comments for all five children during the eight sessions.

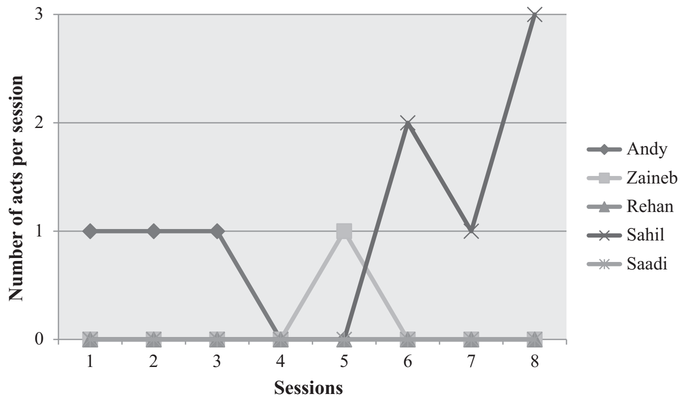

Figure 7. Number of turn-taking for all five children during the eight sessions.

Turn-taking. Sahil initiated turn-taking the most, but this only appeared from session 6 onwards. Andy showed some turn-taking during the first three sessions (once per session) and Zaineb engaged in turn-taking only once. Rehan and Saadi displayed no turn-taking.

Overall initiations. Table 4 shows the total number of initiations for each child throughout the eight sessions. Zaineb was the child who initiated the most followed by Sahil and Andy who also initiated an equivalent number of times. Both Rehan and Saadi initiated communication considerably fewer times.

Results based on the group interview data

This section presents the main themes from the group interviews and it is structured in two sections: (i) the Engagement Profile and Scale (Carpenter et al., 2015) areas and (ii) data-driven themes.

Table 4. Children's overall initiations for the 8 sessions.

Children	Total initiations
Andy	81
Zaineb	86
Rehan	53
Sahil	84
Saadi	53

The engagement profile and scale areas

Awareness. The school staff felt that it took children some time to reach an understanding of how the Cosmo units worked. Some children like Rehan started showing awareness in week 3 when they understood what was expected of them, while others like Saadi 'finally figured out that if you press this button, something happens' by week 5, according to the NQT.

Anticipation. Staff reported that anticipation increased for all five children as the intervention progressed. Building anticipation seemed to have worked very effectively for Andy. His TA mentioned that with the time he was getting better at using the Cosmo units as 'it's just like his workbox, the expectation he knows'.

Curiosity. According to staff, children showed some curiosity from week 2 onwards. Specifically, Zaineb, Rehan and Sahil were curious to find out what was in the box.

Initiation. Zaineb was identified as the child with most initiations during the sessions with the Cosmo units confirming the video data. Staff claimed that following the intervention, Saadi began to transfer some skills to other contexts. In week 5, the NQT reported that he 'will now come and ask for help when he wants help', a point which was confirmed by another two TAs too.

Investigation, discovery and persistence. The above three areas were coded infrequently.

Data-driven themes

The need for customization. The staff asked for certain elements of the system to be altered to fit the children's preferences and needs. For example, a removable silicone ring on each unit was removed after the first session as the children became preoccupied with it, preventing their engagement with the activities or the researcher. Personal music preferences were also added to the system to motivate certain children. For example, Rehan was only interested in engagement with the units and the researcher when Bhangra music was playing and the sound was loud. His TA mentioned in week 4, 'when you put the Bollywood music on [. . .] he is really into it pressing all the buttons [. . .] But when it is the other music, all he does is stack the two of them (i.e. units) together'.

The combination of music and technology. The staff mentioned that the technology element of the Cosmo units could compensate for children for whom music was not a great motivator. For example, Andy's TA said that '[he] doesn't really like music but anything flashy attracts his eye' referring to the lights of the units. It is interesting to note here that the intervention seemed to have worked with Sahil as well who according to his 'Passports for Learning and Life' had no affinity for either music or technology.

The impact of technology glitches. As expected in all projects involving technology interventions, there were some glitches with the units, which at the time of the study were still relatively newly developed. The staff mentioned that Andy 'gets a bit frustrated when [the Cosmo units] are not working and he chucks them away'. Her TA mentioned about Zaineb that 'as soon as she realised that the buttons were not working properly, she lost interest'. However, there were some positive side effects, when the units were not working properly. At week 5, the NQT said 'I think they are a bit more accepting of when things aren't working' relating this to the technology glitches experienced during the sessions with the Cosmo units. Her viewpoint was confirmed by some of her colleagues.

Discussion

The current study raised some significant points in terms of the use of school-based technology–mediated music-making interventions to promote engagement levels and social communication skills for children with autism and ID. It reported some positive outcomes for all children in the sample, suggesting that the intervention can be an effective tool for all teaching staff working with such populations. This section will discuss the findings with a particular focus on engagement levels and social communication skills.

The video data showed high percentages of both engagement and disengagement for the five children during the eight sessions with the Cosmo units. Zaineb, who pre-intervention was reported to have affinity for technology but not for music, appeared the most engaged. There were, however, considerable within-child variations in the engagement levels from one session to the next (e.g. Rehan). Within the group interviews, all teaching staff reported an increase in children's engagement levels as they became more familiar with the researcher and the activities, confirming, to a certain extent, the video data and adding social validity (Reichow et al., 2008) to the intervention.

The above findings echo some previous studies in the field. Although Wimpory et al. (2007) reported that children with autism are more likely to show social engagement when adults provide a musical input, Simpson et al. (2013) found considerable variability in levels of engagement between children with autism when they were exposed to singing. To interpret similar findings, one should bear in mind that individuals with autism might experience engagement in non-observable ways (Bagatell, 2012). To this end, it has to be mentioned here that although certain aspects of engagement such as awareness, anticipation, curiosity and initiation (initiation was measured as part of social communication in this study) were reported to have increased in the sample of the current study, during the group interviews, other areas of engagement were not reported to change (i.e. investigation, discovery and persistence). More research is therefore needed to operationalize engagement among individuals with autism. Engagement has been broadly explored among individuals with SID/PID (Carpenter et al., 2015) but less so when there is an additional diagnosis of autism (Carpenter et al., 2016). It has to be mentioned here that the authors ascribe to Carpenter et al.'s (2015) definition of engagement which not only precedes social communication but is also a precondition for it to take place.

Behaviours belonging to the three broad categories of social communication, namely behaviour regulation, joint attention and social interaction (Bruner, 1981) were measured for this study. Specific subcategories of social communication were measured following an adaptation of measures having been used in previous studies with similar participants (Kossyvaki et al., 2012): request and reject from behaviour regulation, comment from joint attention and turn-taking from social interaction. In terms of behaviour regulation, all five children showed both behaviours. Some children tended to request more (i.e. Zaineb, Sahil and Saadi) while others showed more protests (i.e. Andy). This is in accordance with previous studies having reported that request is often the most commonly used communicative function among individuals with autism (Chiang, 2009; Chiang and Lin, 2008; Drain and Engelhardt, 2013) or that requesting and rejecting are equally frequent (Potter and Whittaker, 2001). Regarding joint attention, the function of comment was measured. All children commented a few times throughout the study, but Zaineb was the only child who commented a significant number of times (56 times in 80 min). This is uncommon, as the function of comment has been reported in previous studies (Stone and Caro-Martinez, 1990) to account for a small percentage of spontaneous social communication in children with autism (i.e. 15%). In terms of social interaction, only the function of turn-taking was measured in this study; it was not coded frequently (10 times over the total number of sessions). This finding echoes that of previous studies which reported that children with autism need extra support to acquire turn-taking skills (Porayska-Pomsta et al., 2013).

One point, which needs to be noted here in the light of previous studies, is the frequency with which children with autism and SID/PID initiate social communication when engaged in a technology-mediated music-making intervention. The current study shows a range of mean initiations per minute per child from 0.66 to 1.07 (Andy = 1.01, Zaineb = 1.07, Rehan = 0.66, Sahil = 1.05 and Saadi = 0.66). The reader has to bear in mind that these figures were obtained using an interval sampling coding scheme, meaning that they are likely to give a conservative estimation of children's social communication skills. Despite this, figures of the current study are well above those of previous studies which reported that children with autism and ID tend to initiate communication less often. For example, Chiang (2009) gave a 0.2 mean initiation per minute and Stone and Caro-Martinez (1990) a 0.06 mean initiation per minute. This finding suggests that a technology-mediated music-making intervention can be conducive to supporting social communication in children with autism. Increases in social communication behaviours when individuals with autism are exposed to different music interventions have been reported by a number of studies and reviews (e.g. James et al., 2015). However, most of these explored the use of Music Therapy (MT) with people with autism (Gattino et al. 2011; Kim et al., 2008; McFerran et al., 2016); and given MT's limited application (i.e. specific qualifications are required in order to practise MT and school budgets are currently restricted), more research needs to be conducted on the broader use of music at school and its impact on pupils' social communication.

The active involvement of teaching staff in the running of the study reflects de Bruin's (2015) model of inclusive research in which the external researcher assumes the role of participant co-researcher. More precisely, in the current study, a bottom-up approach was followed with teaching staff of all levels from SLT to TAs having participated in different stages of the research (e.g. selection of the class to work with, piloting the activities and adapting them to the children's needs and preferences). Literature increasingly recognizes the need for researchers and schools to forge effective and collaborative partnerships for the benefit of both (Parsons et al., 2013). By working together, school staff can often show researchers ways of finding solutions to everyday problems (increasing the ecological validity of the research) while recognizing the constraints of doing research in 'real-world' environments. On the other hand, researchers can support school staff in conducting methodically robust and ethically sound research. Such collaborations considerably enhance opportunities for knowledge co-production in research, especially with individuals who have been traditionally ignored or silenced (e.g. TAs and NQTs).

Study limitations

Due to the small sample size and the absence of a control group, the findings of this study cannot be generalized beyond the specific sample. However, generalization is not always the optimal goal in any inquiry process, as getting the richness of a given picture can be a valid and equally scientific research process (Thomas, 2015). It should also be noted that changes in the children's behaviour might have occurred due to other factors external to the intervention (e.g. the development of relationship between researcher and the children) which cannot be ruled out in case studies. Finally, and importantly, the interval sampling coding might mean that the results are somewhat conservative. Some behaviours might have appeared more than once per 30-s interval but they were only coded once suggesting that the impact of the Cosmo unit activities might have been even greater if an event sampling coding system was used. The length and intensity of the intervention (5 weeks) can be another reason to account for the lack of more significant findings as there is scarce evidence on the effect of brief and time-limited interventions on children with autism (Vismara et al., 2009), which is expected to be even weaker when autism co-exists with ID.

Conclusion

This study is the first to explore the impact of a technology-mediated music-making intervention on the engagement levels and social communication skills of children with autism and ID at school. It reported positive outcomes, particularly as far as social communication skills are concerned. Teaching staff were involved in the research from the outset responding to the current need for 'a new generation of research that is practitioner-led, inquiry-focused and evidence-based' (Carpenter et al., 2015: 15). Additionally, the current study is one of very few in the field catering for 'pedagogical reconciliations' (Carpenter et al., 2015): when two conditions (e.g. autism and ID) co-exist and effective teaching approaches for each condition fit and are used together. One way of extending this study would be to further enable teaching staff 'to be active agents in research' (Guldberg et al., 2017: 410) by training them in similar interventions with a request to then put them into practice with minimal/no support from researchers. Exploring the impact of technology-mediated music making when this is facilitated by parents at home would be another interesting area of further research.

Acknowledgements

The authors wish to thank the children and the school staff who participated in the study. They would also like to thank Filisia Interfaces, specifically Georgios Papadakis, Eirini Maliaraki and Panagiotis Tigkas, for their tireless support with the Cosmo hardware and software. The authors extend their thanks to Aikaterini Giannadou for having conducted the inter-coder rating of the videos and part of the thematic analysis of the group interview transcripts.

Declaration of conflicting interests

The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: The first author is a governor at the school where the research was conducted. Filisia Interfaces provided the authors with six Cosmo units for the duration of the study and trained them how to use them. They provided technical support during the intervention period but had no involvement in any part of the research from design to conclusion.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by Filisia Interfaces Ltd.

ORCID iD

Lila Kossyvaki https://orcid.org/0000-0002-9661-604X

Note

1. The term 'autism' as opposed to 'autism spectrum disorder' is used throughout this article respecting the wish of many individuals with autism who consider autism as a different way of being and not a disorder.

References

American Psychiatric Association (2013) *Diagnostic and Statistical Manual of Mental Disorders*, 5th ed. Arlington, VA: American Psychiatric Publishing.

Attwood T (2007) *The Complete Guide to Asperger's Syndrome*. London: Jessica Kingsley Publishers.

Bagatell N (2012) Engaged moments: mediated action and children with autism in the classroom setting. *OTJR: Occupation, Participation and Health* 32(1): 258–265.

Bellini S, Akullian J and Hopf A (2007a) Increasing social engagement in young children with autism spectrum disorders using video self-modeling. *School Psychology Review* 36(1): 80–90.

Bellini S, Peters JK, Benner L, et al. (2007b) A meta-analysis of school-based social skills interventions for children with autism spectrum disorders. *Remedial and Special Education* 28(3): 153–162.

Bruner J (1981) The social context of language acquisition. *Language and Communication* 1(2–3): 155–178.

Carpenter B, Egerton J, Cockbill B, et al. (2015) *Engaging Learners with Complex Learning Difficulties and Disabilities*. London: Routledge.

Carpenter B, Carpenter J, Egerton J, et al. (2016) The engagement for learning framework: connecting with learning and evidencing progress for children with autism spectrum conditions. *Advances in Autism* 2(1): 12–23.

Centre for Disease Control and Prevention (2014) *Prevalence of Autism Spectrum Disorder among Children Aged 8 Years – Autism and Developmental Disabilities Monitoring Network, 11 Sites, United States, 2010*. United States: Centre for Disease Control and Prevention. Available at: http://www.cdc.gov/media/releases/2014/p0327-autism-spectrum-disorder.html (accessed 28 November 2017).

Chiang HM (2009) Differences between spontaneous and elicited expressive communication in children with autism. *Research in Autism Spectrum Disorders* 3(1): 214–222.

Chiang HM and Lin WT (2008) Expressive communication of children with autism. *Journal of Autism and Developmental Disorders* 38(3): 538–545.

Curran S (2016) *Why aren't we doing more with music? An exploration of two integrative mainstream-special school music-projects*. PhD Thesis, Birmingham: University of Birmingham.

de Bruin CL (2015) Conceptualizing effectiveness in disability research. *International Journal of Research & Method in Education* 40(2): 113–136.

DeNora T (2013) *Music Asylums: Wellbeing through Music in Everyday Life*. Farnham: Ashgate.

Department for Education (DfE) (2014) P scales: attainment targets for pupils with SEN, London: DfE.

Diehl JJ, Schmitt LM, Villano M, et al., (2012) The clinical use for robots for individuals with autism spectrum disorders: a critical review. *Research in Autism Spectrum Disorders* 6(1): 249–262.

DiGennaro Reed FD, Hyman SR and Hirst JM (2011) Applications of technology to teach social skills to children with autism. *Research in Autism Spectrum Disorders* 5(3): 1003–1010.

Drain S and Engelhardt PE (2013) Naturalistic observations of nonverbal children with autism: a study of intentional communicative acts in the classroom. *Child Development Research* 2013: 10. Article ID 296039.

Edhlund B and McDougall A (2017) *Nvivo 11 Essentials*. http://Lulu.com

Gattino GS, Riesgo RDS, Longo D, et al. (2011) Effects of relational music therapy on communication of children with autism: a randomized controlled study. *Nordic Journal of Music Therapy* 20(2): 142–154.

Gray DE (2018) *Doing Research in the Real World*, 4th ed. London: SAGE.

Guldberg K, Parsons S, Porayska-Pomsta K, et al. (2017) Challenging the knowledge-transfer orthodoxy: knowledge co-construction in technology-enhanced learning for children with autism. *British Educational Research Journal* 43(2): 394–413.

Ingersoll B (2010) Brief report: pilot randomized controlled trial of reciprocal imitation training for teaching elicited and spontaneous imitation to children with autism. *Journal of Autism and Developmental Disorders* 40(9): 1154–1160.

James R, Sigafoos J, Green VA, et al. (2015) Music therapy for individuals with autism spectrum disorder: a systematic review. *Review Journal of Autism and Developmental Disorders* 2(1): 39–54.

Jordan R (2001) *Autism with Severe Learning Difficulties*. London: Souvenir Press (EandA) Ltd.

Kasari C (2002) Assessing change in early intervention programs for children with autism. *Journal of Autism and Developmental Disorders* 32(5): 447–461.

Kasari C and Smith T (2013) Interventions in schools for children with autism spectrum disorder: methods and recommendations. *Autism* 17(3): 254–267.

Kern P and Aldridge D (2006) Using embedded music therapy interventions to support outdoor play of young children with autism in an inclusive community-based child care program. *Journal of Music Therapy* 43(4): 270–294.

Kim J, Wigram T and Gold C (2008) The effects of improvisational music therapy on joint attention behaviors in autistic children: a randomized controlled study. *Journal of Autism and Developmental Disorders* 38(9): 1758–1766.

Knight V, McKissick BR and Saunders A (2013) A review of technology-based interventions to teach academic skills to students with autism spectrum disorder. *Journal of Autism and Developmental Disorders* 43(11): 2628–2648.

Kossyvaki L, Jones G and Guldberg K (2012) The effect of adult interactive style on the spontaneous communication of young children with autism at school. *British Journal of Special Education*, 39(4): 173–184.

Kossyvaki L, Jones G and Guldberg K (2016) Training teaching staff to facilitate spontaneous communication in children with autism: adult interactive style intervention (AISI). *Journal of Research in Special Educational Needs* 16(3): 156–168.

Krippendorff K (2004) *Content Analysis: An Introduction to Its Methodology*, 2nd ed. Thousand Oaks, CA: SAGE.

Lawlor MC (2009) Narrative, development, and engagement: intersections in therapeutic practice. In: Jensen U and Mattingly C (eds) *Narrative, self and social practice*. Aarhus, Denmark: Aarhus University, pp. 72–84.

Light J and McNaughton D (2012) Supporting the communication, language, and literacy development of children with complex communication needs: state of the science and future research priorities. *Assistive Technology* 24(1): 34–44.

Lowe M and Costello A (1988) *Symbolic Play Test*, 2nd ed. Windsor, Berkshire: NFER-NELSON.

MacDonald RAR, Hargreaves DJ and Miell D (eds.) (2002) *Musical Identities*. Oxford: Oxford University Press.

Magnússon P and Sæmundsen E (2001) Prevalence of autism in Iceland. *Journal of Autism and Developmental Disorders* 31(2):153–163.

McConnell SR (2002) Interventions to facilitate social interaction for young children with autism: review of available research and recommendations for educational intervention and future research. *Journal of Autism and Developmental Disorders* 32(5): 351–372.

McFerran KS, Thompson G and Bolger L (2016) The impact of fostering relationships through music within a special school classroom for students with autism spectrum disorder: an action research study. *Educational Action Research* 24(2): 241–259.

McWilliam RA and Bailey D (1995) Effects of classroom social structure and disability on engagement. *Topics in Early Childhood Special Education* 15(2): 123–147.

Methley A and Wimpory D (2010) *Music Interaction Therapy for Children with Autism* [DVD]. Bangor: Bangor University.

Murdock LC, Cost HC and Tieso C (2007) Measurement of social communication skills of children with autism spectrum disorders during interactions with typical peers. *Focus on Autism and Other Developmental Disabilities* 22(3): 160–172.

Murray DKC (1997) Autism and information technology: therapy with computers. In: Jordan R and Powell S (eds) *Autism and Learning*. London: David Fulton Publishers, pp. 100–117.

National Research Council-NRC (2001) *Educating Children with Autism*. Washington, DC: National Academy Press.

Nind M (2014) *What is Inclusive Research?* London: Bloomsbury.

Nind M and Hewett D (2001) *A practical Guide to Intensive Interaction*. Kidderminster, Worcestershire: Bild Publications.

Nordoff P and Robbins C (2007) *Creative Music Therapy: A Guide to Fostering Clinical Musicianship*. Dallas, TX: Barcelona Publishers LLC.

Ockelford A (2008) *Music for Children and Young People with Complex Needs*. Oxford: Oxford University Press.

Parsons S, Charman T, Faulkner R, et al. (2013) Bridging the research and practice gap in autism: the importance of creating research partnerships with schools. *Autism* 17(3): 268–280.

Pellicano E, Dinsmore A and Charman T (2014) What should autism research focus upon? Community views and priorities from the United Kingdom. *Autism* 18(7): 756–770.

Pennington RC (2010) Computer-assisted instruction for teaching academic skills to students with autism spectrum disorders: a review of literature. *Focus on Autism and Other Developmental Disabilities* 25(4): 239–248.

Pérez-Fuster P (2017) *Enhancing skills in individuals with autism spectrum disorder through technology-mediated interventions*. PhD Thesis. Valencia: University of Valencia.

Ploog BO, Scharf A, Nelson D, et al. (2013) Use of computer assisted technologies (CAT) to enhance social communicative, and language development in children with autism spectrum disorders. *Journal of Autism and Development Disorders* 43(2): 301–322.

Porayska-Pomsta K, Anderson K, Bernardini S, et al. (2013) Building an intelligent, authorable serious game for autistic children and their carers. In: Reidsma D, Katayose H and Nijholt A (eds) *Advances in computer entertainment*. Cham: Springer, pp. 456–475.

Potter C and Whittaker C (2001) *Enabling Communication in Children with Autism*. London: Jessica Kingsley Publishers.

Prizant BM, Wetherby AM, Rubin E, et al. (2006) *The SCERTS Model: A Comprehensive Educational Approach for Children with Autism Spectrum Disorders*. Vol. 1: Assessment. Baltimore, MD: Paul H. Brookes Publishing.

Reichow B, Volkmar F and Cicchetti D (2008) Development of the evaluative method for evaluating and determining evidence-based practices in autism. *Journal of Autism and Developmental Disorders* 38(7): 1311–1319.

Ruble LA and Robson DM (2007) Individual and environmental determinants of engagement in autism. *Journal of autism and developmental disorders*, 37(8): 1457–1468.

Schopler E, Reichler R and Rochen Renner B (1988) *The Childhood Autism Rating Scale (CARS)*. Los Angeles: Western Psychological Services.
Shane HC, Laubscher EH, Schlosser RW, et al. (2012) Applying technology to visually support language and communication in individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders* 42(6): 1228–1235.
Simons H (2009) *Case Study Research in Practice*. London: SAGE Publications.
Simpson K and Keen D (2011) Music interventions for children with autism: narrative review of the literature. *Journal of autism and developmental disorders* 41(11): 1507–1514.
Simpson K, Keen D and Lamb J (2013) The use of music to engage children with autism in a receptive labeling task. *Research in Autism Spectrum Disorders* 7(12): 1489–1496.
Small C (1998) *Musicking: The Meanings of Performing and Listening*. Middletown, Connecticut: Wesleyan University Press.
Stone WL and Caro-Martinez LM (1990) Naturalistic observations of spontaneous communication in autistic children. *Journal of Autism and Developmental Disorders* 20(4): 437–453.
Thomas G (2015) *How to Do Your Case Study*, 2nd ed. London: SAGE.
Trevarthen C (2002) Origins of musical identity: evidence from infancy for musical social awareness. In: MacDonald RAR, Hargreaves DJ and Miell D (eds) *Musical Identities*. Oxford: Oxford University Press, pp. 21–38.
Vismara LA, Colombi C and Rogers SJ (2009) Can one hour per week of therapy lead to lasting changes in young children with autism? *Autism* 13(1): 93–115.
Watkins MW and Pacheco M (2000) Interoberver agreement in behavioural research. *Journal of Behavioral Education* 10(4): 205–212.
Wetherby AM, Prizant BM and Schuler AL (2000) Understanding the nature and language impairments. In: Wetherby AM and Prizant BM (eds) *Autism Spectrum Disorders: A Transactional Developmental Perspective*. Baltimore, MD: Brookes, pp. 109–141.
Wetherby AM, Watt N, Morgan L, et al. (2007) Social communication profiles of children with autism spectrum disorders late in the second year of life. *Journal of Autism and Developmental Disorders* 37(5): 960–975.
Wilkinson J (2000) Direct observation. In: Breakwell GM, Hammond S and Fife-Shaw C (eds) *Research Methods in Psychology*, 2nd ed. London: SAGE, pp. 224–238.
Wimpory DC, Hobson RP and Nash S (2007) What facilitates social engagement in preschool children with autism? *Journal of Autism and Developmental Disorders* 37(3): 564–573.
World Health Organisation (2017) Autism spectrum disorders factsheet. Available at: http://www.who.int/mediacentre/factsheets/autism-spectrum-disorders/en/ (accessed 23 February 2018).

Appendix 1. Glossary of definitions for the engagement and social communication checklist

Definitions
Engagement The child is 'on task' interacting with the researcher or the Cosmo equipment. She/he shows, verbally or non-verbally, awareness, curiosity, investigation, discovery, anticipation and perseverance (adapted from Carpenter et al., 2015).
Disengagement The child appears 'off task' (e.g. self-stimulatory behaviours, staring into space or at the wall, wandering off towards teaching staff, exploring other objects such as transitional objects).
Social communication
Behaviour regulation • *Requests desired objects or actions:* The child directs non-verbal or vocal signals (e.g. reaches towards an out-of-reach object or bangs and looks towards it) to get researcher to give it or perform an action with it. • *Protests/rejects undesired objects or actions:* The child directs non-verbal or vocal signals (e.g. pushes away, cries paired with gaze) to get researcher to cease an undesirable action or get self out of an undesirable activity.
Joint attention • *Comments on objects or actions:* The child uses non-verbal or vocal signals to show researcher or comment on an object or action (e.g. holding out/pointing to an object, echoing researcher's words 'it's gone')
Social interaction • *Takes turns:* The child keeps a cooperative social exchange going at least twice with the researcher through non-verbal or vocal signals. This involves waiting for the researcher to take a turn.

Notes: Only behaviours addressed to the researcher are coded. In order to code social communication, pay special attention to communicative intent using Wetherby et al.'s (2000: 124) definition of communicative intent: '*The systematic use of conventional behaviors to deliberately affect another person*'.