The Effectiveness of Mirroring- and Rhythm-based interventions for children diagnosed with Autism Spectrum Disorder: A Systematic Review

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Abstract

Autism Spectrum Disorder (ASD) is characterised as a neurodevelopmental disorder that has continuing deficits in communication skills and social development. Utilising techniques known as mirroring and rhythm, Dance and Movement therapy (DMT) has shown beneficial effects in the autistic population reducing these deficits. However, no review to date has investigated these individual techniques outside the practice of DMT. This systematic review of studies published between 1975 - 2020 aims to evaluate the effectiveness of both mirroring and rhythm as interventions that target communication skills and social development in children with ASD. Out of 1369 relevant articles, 11 of these met the inclusion criteria. All studies showed beneficial effects of mirroring and rhythm on communication skills and social development in children diagnosed with ASD. Therefore, incorporating these into new interventions and practices may offer substantial therapeutic benefits for children diagnosed with ASD.

Key words: *Autism Spectrum Disorders, Mirroring, Rhythm, Communication, Social Development*

1. Introduction

1.1 Autism Spectrum Disorders

The first description of autism was published in 1943, describing the observed phenomenon as an emotional disturbance that did not affect cognition (Kanner, 1943). By 1968, autism was clinically defined in the second edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-II) as a psychiatric condition — a form of childhood schizophrenia that was marked by a detachment from reality (American Psychiatric Associations, 1968; Mahler, 1952). After growing research into the biology and clinical representations of autism, the DSM-IV revised its definition of the disorder. Instead, characterising autism as a neurodevelopmental spectrum; thus, giving rise to the name Autism Spectrum Disorders (ASD; American Psychiatric Association, 1994). Since then, its prevalence has substantially increased with 1 in 59 children now diagnosed with the disorder in the USA alone (CDC, 2020). A number of symptoms are associated with its diagnosis, causing wide-ranging variability of clinical phenotypes and heterogeneity. The most common symptoms of ASD include repetitive and restricted patterns of behaviour, increased sensitivity to change and finally, persistent deficits in social communication and social interaction (American Psychiatric Association, 2013).

Continuing deficits in social communication and social interaction can be extremely problematic as communication skills and social development are crucial in everyday functioning and are often taken for granted in typically developing individuals. However, in children diagnosed with ASD communication and social interactions can be extremely difficult, as individuals may struggle to initiate social bids, engage in reciprocal conversation, and show abnormal patterns of eye gaze and joint attention (Bourdon, 1999; Charman & Stone, 2008; Dereu et al., 2012; Eigsti et al., 2011; Franchini et al., 2019;

Koegel & Rincover, 1977; Swanson & Siller, 2013; Tiegerman & Primavera, 1984). Moreover, children with ASD express poor imitation skills, a key social skill that allows for social connectedness and emotional sharing between humans (Hobson & Lee, 1999; Landa, 2007; Rogers et al., 2003). Such impairments can cause difficulty in developing and maintaining personal and professional relationships, leading to social isolation, loneliness and poor quality of life (QoL; Palmer et al., 2016; Wang et al., 2018). Research is consequently focusing on enhancing communicative and social skills in children with ASD to provide evidence-based therapeutic interventions to increase such life skills (Amos, 2013a; Devereaux, 2012; Friedrich et al., 2015; Hartshorn et al., 2001; Martin, 2014a; Matson et al., 2007; Sharda et al., 2018). Additionally, addressing communication deficits and social impairments, establishing effective interventions and providing useful tools for communication at a young age may enable children with ASD to develop successful communication skills, thereby improving QoL (Fortunato-Tavares et al., 2012; Inoue et al., 2008; Matson et al., 2011; Tobin et al., 2014).

1.2 Dance and Movement Therapy

Dance is not only a physical activity consisting of a purposefully selected sequence of human movement requiring the rhythmic coordination of different muscles, but is also an art form allowing the body to "personify symbolic meaning; thus becoming a tool of gestural expression" (Calvo et al., 2015; Camurri et al., 2003; DeJesus et al., 2020). It is a medium that encourages an inclusive environment, enabling any child, irrespective of their capabilities, to be expressive in a physical and non-verbal manner. Consequently, dance should not be restricted to performance as a goal (Scharoun et al., 2014; Takahashi et al., 2019). Through dance a child is able to explore and incorporate the physical self as an effective and expressive component of the complex social being (Scharoun et al., 2014;

Takahashi et al., 2019). As a result, creative movement and dance is a functional and viable form of integrated therapy for children with ASD (Berlandy, 2019).

Founded in 1966, the American Dance Therapy Association (ADTA) defines Dance and Movement Therapy (DMT) ‘‘as the psychotherapeutic use of movement to further the emotional, cognitive, physical, and social integration of the individual’’ (ADTA, 2014). Several studies, albeit predominantly qualitative, have highlighted the power of DMT in reducing symptoms associated with ASD and increasing communication skills and social development (Devereaux, 2012; Martin, 2014; Cozolino, 2014; Tortora, 2005; Field et al., 2001; Koch et al., 2015). DMT can involve a range of techniques that allow the therapist to tailor the intervention to meet the needs of the child. However, mirroring, emotional imitation, and rhythm (i.e. following beats, melodies and keeping in time to music) are key components that are extensively and consistently used in DMT. Several literature reviews have highlighted the positive effect of DMT on communication skills and social development in children with ASD, yet no review to date has sought to investigate the specific techniques of DMT (mirroring and rhythm) and their individual effects on communication skills and social development (Berlandy, 2019; Scharoun et al., 2014; Takahashi et al., 2019).

1.3 Mirroring

Mirroring describes the experimenter or dance and movement therapist imitating the exact shape, form, movement qualities and feeling of another’s actions. This technique forms a connection between a therapist and child with ASD and enhances meaningful imitation skills and social engagement (Berrol, 2006; Tortora, 2005). Several studies have demonstrated mirroring (sometimes referred to as imitation) as the most effective feature within DMT and a useful tool to enhance communication outside of DMT (Field et al.,

2001; Tiffany Field, 2017; Tiffany Field et al., 2001; Hartshorn et al., 2001; Heimann et al., 2006; Katagiri et al., 2010; Koch et al., 2015).

In the literature 'mirroring' and the process of 'imitation' outside of DMT are terms often used interchangeably. Therefore, in the current review we classify imitation as mirroring if the experimenter copies the exact movement and dynamics of the child's actions and will henceforth refer to imitation as mirroring. Despite many observed positive outcomes, mirroring is rarely used in treatment interventions and numerous studies investigating mirroring have been either single case studies or anecdotal articles on its effectiveness. The primary purpose of this study, therefore, is to review the efficacy of mirroring when used as a basis for interventions that aim to enhance communication skills and social development in children diagnosed with ASD. A second aim is to highlight the therapeutic potential of mirroring, measured by reliable outcomes for social development; such as, eye gaze, joint attention abilities and standardised outcome measures.

1.4 Rhythm

Referring to the use of a strong, regular repeated pattern of movement or sound, rhythm is incorporated in several aspects of DMT. Often the power of rhythm is utilised by the experimenter or dance and movement therapist to attune to the child and help organise the child's feelings, whilst facilitating interaction and communication (Amos, 2013; Levy et al., 2005; Martin, 2014). However, there is limited research focusing solely on rhythmicity in DMT and its beneficial effects for children with ASD. Outside the realm of DMT, the technique of rhythm has been extended to various rhythmically-facilitated interventions (e.g., dyadic drumming) and has shown several positive effects enhancing communication skills and developing social interactions (Srinivasan et al., 2016; Stephens, 2008; Willemin et al., 2018; Yoo & Kim, 2018). Therefore, in addition to mirroring, the

purpose of this study is to review the efficacy of rhythm when used as a core element for interventions aiming to enhance communication skills and social development in children diagnosed with ASD. Additionally, we investigate its therapeutic potential as measured by reliable outcomes.

1.5 Aims and objectives

No study to date has investigated the beneficial effects of the specific DMT techniques, mirroring and rhythm, as a basis for interventions targeting communication skills and social development in children with ASD. Therefore, this study aims to review literature that focuses on either mirroring or rhythm as an intervention/procedure and investigate studies that have reliable outcome measures assessing communication and social skills in children with ASD. We hope to highlight the potential therapeutic benefits of mirroring and rhythm and provide evidence that the techniques can be used effectively outside of DMT.

2. Methods

2.1 Criteria for study search

A combination of the PICO and SPIDER strategies were used to help formulate a relevant research question and enhance the search for evidence in the chosen databases (Methley et al., 2014). PICO, where: P: population, patient or problem; I: intervention, C: control or comparative intervention and O: outcome, is a useful tool commonly used for quantitative research. However, due to the nature of the studies we were expecting to assess, the SPIDER strategy was also utilised, where: S: sample, P: phenomena of interest, D: design, E: evaluation of outcomes and R: research type. Using the criteria above, the

following research question was formulated; "*What are the influences of the specific Dance and Movement Therapy techniques, mirroring and rhythm, on communication skills and social development in children diagnosed with Autism Spectrum Disorder?",* where: P/S: Children with Autism Spectrum Disorder, I/P: Mirroring/Imitation, Rhythm and Dance and Movement Therapy, O/E: Communication, Social interaction, Social attention and Social behaviour and R: Quantitative, Qualitative and/or Mix-methods.

2.2 Types of studies

This review includes both blinded and non-blinded randomised control trials, parallel group study designs, and pre- and post-intervention study designs published in English between January 1975 and March 2020. The interventions reported in the study had to primarily focus on either mirroring or rhythm in order to be included. Additionally, the primary outcome measures had to clearly relate to either social development or communication skills; such as measuring eye gaze, joint attention or standardised outcome measures. Studies that did not investigate mirroring or rhythm in samples of children with ASD, reviews, letters, conference abstracts or studies that had no relevant outcome measures were excluded from the review. Table 1 provides a summary of the criteria used for inclusion and exclusion.

2.3 Electronic searches

Six databases were searched for the most appropriate and relevant documents that corresponded with the objectives of this review. EBSCOhost; which included PsycArticles (American Psychological Association – APA), PsycINFO (APA), SPORTDiscus and MEDLINE; Scopus and Web of Science were searched using combinations of the

following descriptors: “autism”, “asd”, “autism spectrum disorder”, “autism spectrum disorders”, “mirroring”, “imitat*”, “rhythm”, “dance”, “dance and movement therapy”, “ communication”, “social*, “early childhood” and “child*”, alongside the Boolean operators “or” and “and”.

For example, the search on Web of Science:

("autism" OR "asd" OR "autism spectrum disorder")

AND ("mirroring" OR "imitat" OR "rhythm" OR "dance" OR "dance and movement therapy")*

AND ("communication" OR "social")*

AND ("early childhood" OR "child")*

2.4 Selection of studies and data extraction

The current review complies with the PRISMA guidelines for systematic reviews and meta-analyses (Moher et al., 2009). Electronic searches were performed to obtain numerous articles concerning mirroring and rhythm as interventions for children with ASD. A specific procedure was developed to extract relevant papers and articles and retrieve the necessary information.

A search was carried out in the aforementioned databases using the search terms and Boolean operators previously provided. A six-phase selection procedure was then performed: Phase 1) combining all extracted articles into a single folder, Phase 2) removing duplicates, Phase 3) analysing the article titles, Phase 4) reading abstracts of articles selected in phase 3, Phase 5) reading full text of articles identified in phase 4 and assessing them against an inclusion and exclusion checklist (see table 1) and finally Phase

6) analysing the reference list from articles that had been fully read for missed and relevant studies (figure 1).

Studies that matched the inclusion and exclusion checklist were fully read again and further analysed. A database was generated to retrieve particular information from the articles, including: author, year of publication, number and age of participants, how participants were diagnosed or assessed for ASD, study design, if the study had a control or comparison group and if the study was randomised and blinded, specific intervention/procedure, DMT technique of interest, outcome measures, general results and finally, conclusion.

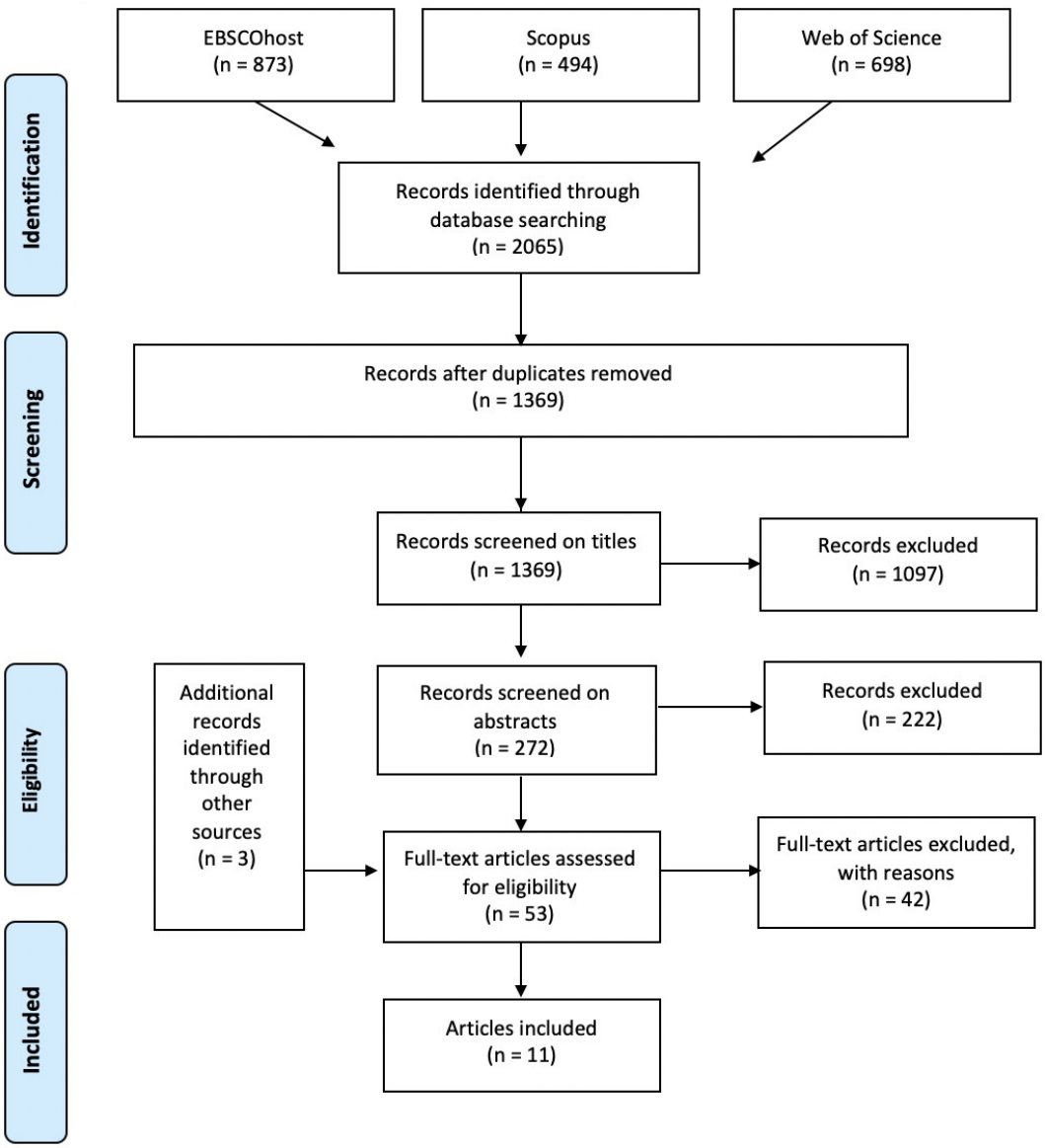
Table 1.

The requirements for inclusion and exclusion

Inclusion	Exclusion
Paper in English	Paper not in English
Paper published between 1975 and 2020	Paper published before 1975
Participants younger than 12 years old	Participants older than 12 years old
Diagnosis of ASD	Participants do not have a diagnosis of ASD
Main intervention must use either mirroring or rhythm If paper refers to mirroring as imitation then imitation must be of the child, ie the experimenter imitates the child	Single case studies and conference abstracts
Outcome measures must assess Communication, Social interaction, Social attention and/or Social behaviour	
Peer reviewed journals, articles and dissertations	

Figure. 1

PRISMA flow diagram of the systematic literature review search (Adapted from Moher et al. (2009))



2.4.1 Inter-rater reliability

Using the 'Dual Independent Review Approach' of the search results, the first author and an independent reviewer screened the titles and abstracts (Stoll et al., 2019). The level of agreement between the reviewers was calculated using Cohen's Kappa, which is a statistical coefficient that represents the degree of accuracy and reliability in a statistical classification (McHugh, 2012). Cohen's Kappa is routinely used to assess inter-rater reliability as it corrects for "chance" agreement between multiple researchers and allows for different types of disagreement to carry different weights (Jeyaraman et al.,

2020). The degree of agreement is quantified by Cohen's K. One way to interpret Cohen's K is within a scale, where agreement is: poor (0), slight (0.1-0.2), fair (0.21-0.4), moderate (0.41-0.6), substantial (0.61-0.8), or near perfect (0.81-0.99) (Landis & Koch, 1977).

2.5 Risk of bias in included studies

We employed the Cochrane risk of bias assessment guidelines in this review; however, we made adaptations as not all studies were randomised controlled trials. As reported by the Cochrane handbook, bias can be defined as "a systematic error, or deviation from the truth, in results" (Boutron et al., 2019). It is somewhat unattainable to know the full extent of which biases affect the result of any particular study or analysis; therefore, it is apposite to deem the result at risk of bias rather than stating with certitude that it is biased (Savović et al., 2012). Using the "*the criteria for judging risk of bias in the 'Risk of bias' assessment too*l" in the Cochrane Handbook, we were able to establish whether risk was low, high, unclear or not applicable for selection, performance, detection, attrition and reporting bias (Higgins et al., 2019a, 2019b; Sterne et al., 2019).

3. Results

3.1 Search results and description of studies

The initial search identified 2065 studies (EBSCO host = 873, Scopus = 494, and Web of Science = 698). After excluding duplicates and screening titles, 272 articles were selected. Abstracts were then screened to select specific studies for full-text reading. A total of 53 articles were fully read and eleven of these fulfilled the inclusion criteria. The weighted kappa score for agreement between the two reviewers was 0.900, 95% Cl: 0.839 to 0.962, indicating near perfect agreement.

Out of the eleven studies extracted, a total of seven were randomised controlled/parallel group trials (Escalona et al., 2002; Field et al., 2001; Heimann et al., 2006; Sandiford, 2013; Sharda et al., 2018; Srinivasan et al., 2016; Warreyn & Roeyers, 2014). Additionally, one study performed an alternating procedure design within subjects (Tiegerman & Primavera, 1984), one study was a parallel group baseline study (Katagiri et al., 2010), another was a simple pre-test, post-test intervention study (Yoo & Kim, 2018), and the final study performed a multiple baseline study within subjects (Reese, 2018). Only one study was fully blinded (Sharda et al., 2018) and 6 studies were fully randomised (Escalona et al., 2002; Field et al., 2001; Heimann et al., 2006; Sandiford, 2013; Sharda et al., 2018; Srinivasan et al., 2016). Warreyn & Roeyers (2014) attempted randomisation, however took into consideration the location of rehabilitation centres participants attended and so participants were only partially randomised.

3.2 Characteristics of participants

This review focuses on specific DMT techniques used to enhance communication skills and social development in children diagnosed with ASD. Therefore, all participants in the selected studies were under the age of 12 years old. The youngest age reported in all eleven studies was 2 years old and the oldest was 12 years old. Excluding Yoo and Kim (2018) as they did not report the mean age of participants in their study, the mean age of participants included in this review was 5 years and 7 months old.

All participants had a diagnosis of ASD, most commonly assessed using the DSM-IV (American Psychiatric Association, 1994). Additionally, the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000), Autism Diagnostic Interview – Revised (ADI-R; Mazefsky & Oswald, 2006) and Childhood Autism Rating Scale (CARS; Chlebowski et al., 2010) were used to measure ASD. Severity of ASD varied throughout

the selected studies; for example, in one study children's CARS scores ranged from 28–51.5 (Katagiri et al., 2010) whereas Escalona et al. (2002) implemented a cut-off CARS score of 38 for participants to be included in their study. This variability of ASD severity not only between studies but also within studies is reflective of the heterogeneity of the disorder. Table 2 summarises the participants and study design used for each study.

Table 2.

Characteristics of each study summarising the participants and study design used, including whether controls, randomisation and blinding was employed

Title	Authors and Date	Number of Participants	Age of Participants	Diagnosis of Participants	Control or comparison group	Randomised and blind	Study Design
Imitating the Autistic Child: Facilitating Communicative Gaze Behavior	Tiegerman & Primavera, 1984	n = 6	Pre-school age	Diagnosed with infantile autism by psychiatrist	No	No, No	Alternating procedure design
Children with autism display more social behaviours after repeated imitation sessions	Field et al., 2001	n = 20	4 - 6 years old	Diagnosed according to DSM-IV criteria	Yes, compared to contingently responsive play group	Yes, No	Randomised parallel group trial
Brief Report: Imitation Effects on Children with Autism	Escalona et al., 2002	n = 20	3 - 7 years old	Diagnosed using DSM-IV by clinical psychologist	Yes, compared to contingently responsive condition	Yes, No	Randomised parallel group trial
Imitative interaction increases social interest and elicited imitation in non-verbal children with autism	Heimann et al., 2006	n = 20	4 - 12 years old	Diagnosed according to ICD-10 criteria	Yes, compared to contingent interaction group	Yes, No	Randomised parallel group trial
Mirroring effect in 2- and 3-year-olds with autism spectrum disorder	Katagiri et al., 2010	n = 6	2 - 3 years old	Diagnosed according to DSM-IV by a clinical psychologist and assessed using CARS	No	No, No	Parallel group-baseline study
A pilot study on the efficacy of Melodic Based	Sandiford et al., 2013	n = 12	5 - 7 years old	Assessed using the ADOS	Yes, compared to traditional therapy	Yes, No	Randomised control trial

Communication Therapy for eliciting speech in nonverbal children with autism					group		
See what I see, do as I do: Promoting joint attention and imitation in preschoolers with autism spectrum disorder	Warreyn & Roeyers, 2014	n = 48	3 - 7 years old	Diagnosed according to DSM-IV criteria	Yes, compared to control group who received their normal treatment	Partially randomised (controlled for rehabilitation centres participants attended), No	Controlled trial
The effects of embodied rhythm and robotic interventions on the spontaneous and responsive verbal communication skills of children with Autism Spectrum Disorder (ASD): A further outcome of a pilot randomized controlled trial	Srinivasan et al., 2016	n = 36	5 - 12 years old	Clinically evaluated and assessed using the ADOS	Yes, compared to control group who received standard of care and also a robotic intervention group	Yes, No	Randomised control trial (pilot study)
Dyadic Drum Playing and Social Skills: Implications for Rhythm-Mediated Intervention for Children with Autism Spectrum Disorder (Study 2)	Yoo & Kim, 2018	n = 9	Primary to middle school age (mean age of 10.8 years)	Clinically diagnosed with ASD and assessed using CARS	No	No, No	Pre-test, Post-test intervention study design
Music improves social communication and auditory-motor connectivity in children with autism	Sharda et al., 2018	n = 51	6 - 12 years old	Diagnosed according to DSM-IV criteria and assessed using either ADOS, ADI-R or CARS	Yes, compared to structurally matched intervention group, which focused on play	Yes, Yes	Randomised control trial
The effect of mirroring on the social engagement of young children with autism spectrum disorder	Reese, 2018	n = 4	3 - 5 years old	Diagnosed by a paediatric neuropsychologist with ASD and	No	No, No	A multiple baseline design across participants

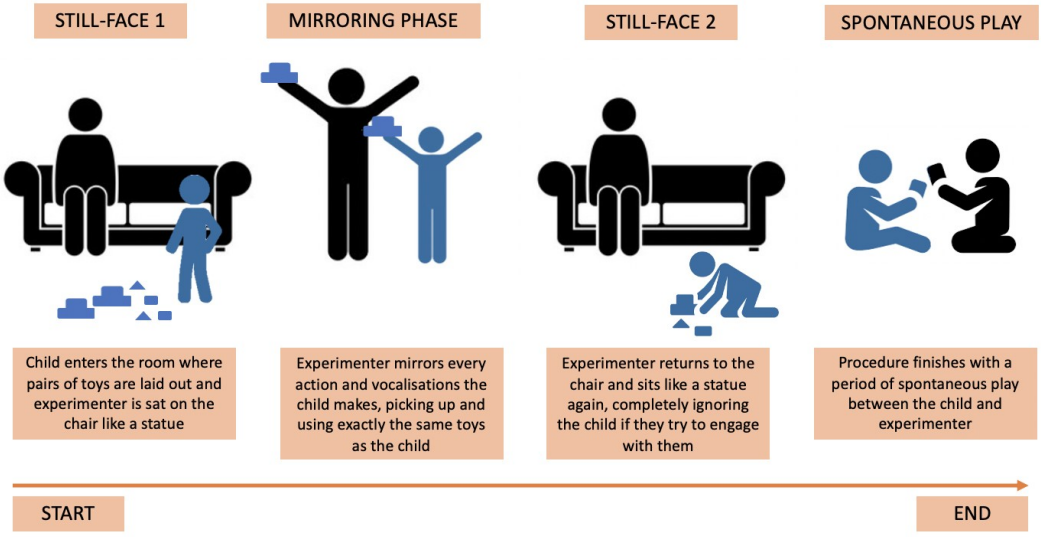
	assessed using ADOS	with replication

3.3 Characteristics of interventions

Interventions were either delivered on a single day of testing or delivered on a weekly basis. Four of the selected studies carried out their interventions over one day, with two of these repeating their procedure within the same day. The other seven studies delivered their interventions via weekly sessions. Three studies provided an intervention for 8 weeks or less, two studies provided an intervention for 16 weeks or less, one study provided an intervention for 5 months and one study omits the length their study ran for. Most weekly sessions appeared to last between 30-45 minutes; however, one study provided a weekly session for only 10 minutes.

All of the eleven studies either used the DMT techniques mirroring (imitation) or rhythm as the main component of their intervention to enhance communication skills and social development. Seven studies utilised mirroring in their intervention, whereas the remaining four studies utilised the technique of rhythm. The most common mirroring interventions used were variations of the still-face paradigm (Nadel et al. 2000; Figure 2).

Fig. 2 Graphical representation of Nadal et al. (2000) still-face paradigm



Rhythm interventions differed across studies substantially. For example, one study focused on variations of rhythmic drum tapping, whilst another study used rhythmic clapping over a recorded melody to learn new words. Despite using different techniques, most studies employed dyadic groups (i.e. child with ASD and experimenter) within the intervention; however Srinivasan et al. (2016) employed triadic groups (i.e. child, model adult and experimenter).

Table 3.

Interventions and procedures carried out in each individual study, noting the Dance and Movement Therapy technique of interest

Title	Authors and Date	DMT technique of interest	Intervention/Procedure	Duration of intervention
Imitating the Autistic Child: Facilitating Communicative Gaze Behavior	Tiegerman & Primavera, 1984	Mirroring	3 phases: 1) Experimenter sat opposite the child and mirrored every object-only action performed by the child 2) Experimenter used the same object as the child but performed different actions to the child 3) Experimenter performed different actions with a different object.	17 sessions, which were scheduled on Monday, Tuesday, Wednesday and Friday for 6 consecutive weeks.
Children with autism display more social behaviours after repeated imitation sessions	Field et al., 2001	Mirroring	4 phases: 1) Experimenter sat on sofa like a statue ignoring the child 2) Experimenter mirrored all of the child's behaviours 3) Experimenter returned to sofa 4) Spontaneous play interaction between child and experimenter. Alternatively, during phase 2, the experimenter was contingently responsive to the child, but did not mirror them.	The intervention repeated across 3 sessions. Authors did not specify the time scale for the 3 sessions.
Brief Report: Imitation Effects on Children with Autism	Escalona et al., 2002	Mirroring	4 phase procedure, same as above.	One, single session
Imitative interaction increases social interest and elicited imitation in non-verbal children with autism	Heimann et al., 2006	Mirroring	4 phase procedure, same as above.	The procedure was repeated across two sessions with a 30 - 60 minute pause in between session A and session B on a single day

Mirroring effect in 2- and 3-year-olds with autism spectrum disorder	Katagiri et al., 2010	Mirroring	3 sequential phases: 1) 2-minute baseline phase, experimenter manipulated toys different from those the child manipulated 2) 3-minute mirroring phase, experimenter reproduced everything that the child did 3) 2-minute baseline phase, same as the first baseline phase.	One, single session
A pilot study on the efficacy of Melodic Based Communication Therapy (MBCT) for eliciting speech in nonverbal children with autism	Sandiford et al., 2013	Rhythm	The children listened to a CD recording of 25 words set to rhythmic melodies while the therapist simultaneously presented the stimulus item to the child. Therapy progressed from listening to a recording of the word set to melody, to various clapping and singing formations over the rhythmic melody.	5 weeks of intervention, with four 45-minute individual sessions a week.
See what I see, do as I do: Promoting joint attention and imitation in pre-schoolers with autism spectrum disorder	Warreyn & Roeyers, 2014	Mirroring	Involved a variety of games including mirroring and joint attention exercises. For example, one exercise was called a game of "goose".	24 sessions including two 30-minute sessions per week for 4.5 - 5 months
The effects of embodied rhythm and robotic interventions on the spontaneous and responsive verbal communication skills of children with Autism Spectrum Disorder (ASD): A further outcome of a pilot randomized controlled trial	Srinivasan et al., 2016	Rhythm	Intervention consisted of several different aspects: 1) Hello song. 2) Action song where fingerplay was engaged. 3) Beat copying involving copying the trainer during rhythmic actions, 4) Music making. 5) Moving game, where the child was asked to copy trainer during gross actions. 6) Farewell song.	32 sessions including 4 sessions per week (2 expert trainer sessions and 2 parent sessions) for 8 weeks
Dyadic Drum Playing and	Yoo &	Rhythm	3 phase intervention: 1) Engagement - tapping to the tempo	8, 30-minute sessions

Social Skills: Implications for Rhythm-Mediated Intervention for Children with Autism Spectrum Disorder (Study 2)	Kim, 2018		of beats 2) Interpersonal coordination - tapping to the beat of an experimenter and mirroring the rhythm. 3) Adaptive adjustment - tapping to the drumming of an experimenter, paired with rhythmic cueing.	
Music improves social communication and auditory-motor connectivity in children with autism	Sharda et al., 2018	Rhythm	Intervention delivered by an experienced therapist who made use of music, instruments, songs and rhythmic, whilst targeting communication, turn-taking, sensorimotor integration and social appropriateness.	45-minute individual weekly sessions conducted over 8–12 weeks
The effect of mirroring on the social engagement of young children with autism spectrum disorder	Reese, 2018	Mirroring	The therapist entered the room in which the child had been for 10 minutes and music began playing. The experimenter began to mirror the participant. The experimenter mirrored the children's behaviours for the entire 10-minute session.	Up to 15 sessions repeated once a week.

3.4 Outcome measures utilised

Although all studies from the systematic search had a primary objective of improving communication skills and social development, the studies extracted used different combinations of various outcome measures to assess change in communicative and social behaviour (Table 4). Many of the studies videotaped interactions between the child and experimenter for later observational assessment and behavioural coding. During behavioural analysis eye gaze was continuously assessed throughout most of the chosen studies. Similarly, joint attention was also commonly assessed. Behaviours towards the experimenter; such as smiling, touching the experimenter, offering the experimenter toys and vocalisations/verbalisations were coded in most of the studies that replicated Nadel et al.'s (2000) still-face paradigm. Very few studies used standardised outcome measures to assess changes in communication skills and social development; however, Reese (2018) utilised the Social Skills Improvement Scale, Yoo & Kim (2018) used the Korean-Social Skills Rating System and Sharda et al. (2018) employed a battery of standardised outcome measures, including the Children's Communication Checklist-2 (CCC-2), the Social Responsiveness Scale-2 (SRS-2) and the Peabody Picture Vocabulary Test-4 (PVT-4).

3.5 Results reported

All eleven studies noted changes and improvements, either within subjects or compared to control groups, in communication skills and social development of children with ASD following a mirror- or rhythmic-based intervention (Table 4).

Table 4.

Outcome measures used in each study and the results obtained, noting the authors conclusion for each study.

Title	Authors and Date	Outcome measures specific to communication and social behaviours	Results	Authors conclusion
Imitating the Autistic Child: Facilitating Communicative Gaze Behavior	Tiegerman & Primavera, 1984	Measured eye gaze including frequency of eye gaze and duration of eye gaze	Frequency of eye gaze was greatest during the mirroring phase. This increased with number of sessions, then decreased. Duration of eye gaze was highest during mirroring phase, also increasing with number of sessions.	Autistic subjects initially interacted with various objects without gazing at the experiment, as a result of mirroring the children became more socially aware of the experimenter. It is now important to understand how gaze behaviours interface with other developmental behaviours.
Children with autism display more social behaviours after repeated imitation sessions	Field et al., 2001	*Coded behaviours including: 1) Stereotypy, inactivity, playing alone, 2) Object play and mirror play, 3) Smiling, laughing and vocalising towards the adult, 4) Being proximal to the adult, sitting next to or touching the adult, 5) Showing recognition of being imitated and engaging in reciprocal play.	Mirrored children spent less time showing typical behaviours, being inactive and playing alone compared to contingently responded to children. Children who were mirrored spent more time showing object behaviours, distal social behaviours and more time showing imitation recognition and engaging in reciprocal play. Effect increased with multiple sessions.	Results suggest both distal and proximal social behaviours are increased in children with autism by repeated sessions of the experimenter mirroring the child's behaviours; highlighting the potential usefulness of mirroring.
Brief Report: Imitation Effects on Children with Autism	Escalona et al., 2002	*Coded behaviours including: 1) Looking at adult's face or body, 2) Silence (no discernible sound or vocal stereotypy), 3) Distance from adult (more than 5 feet away), 4) Touching adult in a socially positive way (smooth, light touch vs. abrupt, rough	Children in both groups showed an increase in proximal behaviours towards the adult. Only the mirroring group showed significantly less motor activity. The increase in the children's socially touching of the adult was significantly greater for the mirroring group compared to the contingent response group.	The contingency condition appeared to be a more effective way to facilitate distal social behaviours, whereas the mirroring condition was a more effective way to facilitate a proximal social behaviour. The data from this study suggest that mirroring by adults may be an effective intervention in young non-

		touch).		verbal children with autism.
Imitative interaction increases social interest and elicited imitation in non-verbal children with autism	Heiman n et al., 2006	Coded behaviours including: 1) Touch as a proximal category, 2) Look at a person as distal category, 3) Request as proximal or distant depending on the context. Also used the imitation subscale of the Pyscho-Educative Profile for imitation rating.	The mirroring group looked more at the experimenter and also displayed an increase in socially touching and requesting behaviours compared to the contingently responsive group. More children in the mirroring group increased their scores than in the contingently responsive group, although this did not reach statistical significance.	Overall the study suggests that children with autism are sensitive to being mirrored, highlighting usefulness of mirroring as a clinical or educational tool. The results from this study indicate intense mirroring can facilitate both distal and proximal positive social behaviour.
Mirroring effect in 2- and 3-year-olds with autism spectrum disorder	Katagiri et al., 2010	*Coded behaviours including: gazing at the experimenter's face, giving positive socio-emotional signals smiling, verbalizing, vocalizing, approaching, touching to the experimenter; offering toys to the experimenter, and requesting the experimenter to imitate his/her own action)	Social attention increased during and after the mirroring phase in all participants and socio-emotional behaviour appeared in 4/6 of participants. IQ was negatively correlated with the mirroring effect for social attention and was positively correlated with the mirroring effect for socio-emotional behaviours.	The findings suggest that the mirroring effect exists in children with ASD regardless of their developmental stage or severity of autistic symptoms. Additionally, dyadic interaction in a mirror-image fashion appears to be promising as an early intervention for a wide range of children with ASD.
A pilot study on the efficacy of Melodic Based Communication Therapy (MBCT) for eliciting speech in nonverbal children with autism	Sandiford et al., 2013	Measured the number of verbal attempts, correct words, number of words reported by parent in home environment and number of imitative attempts.	Both treatment groups showed an increase in number of verbal attempts, number of correct words and number of imitative attempts following treatment. The MBCT group displayed more verbal attempts overall. Only parents of children who were in the MBCT group reported a significant improvement in new words heard at home. For number of imitative attempts, the participants in the MBCT group showed significantly greater overall gains than the traditional group.	While both therapies were found to be effective at the completion of the study, results suggest a possible faster rate of improvement for the MBCT group as well as greater overall gains in verbal attempts and imitative attempts. Research should continue to support the benefits of music-based rhythmic interventions for the autistic population
See what I see, do as I do: Promoting joint attention and imitation in pre-schoolers with autism	Warreyn & Roeyers, 2014	**Measured: 1) Reaction to ambiguous behaviours, 2) Gaze following, 3) Initiating requests, 4) Following requests, 5)	Both experimental groups made significant gains in joint attention ability, with the experimental group showing more progress than the control group. Both groups made	The findings show that it is possible to promote joint attention in a limited number of sessions, over a short period of time. The results concerning imitation

spectrum disorder		Initiating joint attention, 6) Spontaneous joint attention, 7) Gestural imitation, 8) Verbal imitation, 9) Object imitation, 10) Symbolic imitation, 11) Spontaneous imitation	advancements in imitation skills and the experimental group had higher total imitation scores compared to the control group.	were less pronounced and although the experimental group showed a significant improvement on this domain, the improvement was not significantly larger than that in the control group.
The effects of embodied rhythm and robotic interventions on the spontaneous and responsive verbal communication skills of children with Autism Spectrum Disorder (ASD): A further outcome of a pilot randomized controlled trial	Srinivasan et al., 2016	**Used a standardised test of joint attention, training-specific measures of response to social bids and training-specific measures of vocalisation/verbalisation patterns.	No between-group differences in joint attention performance, however both the rhythm and control group improved their scores. The rhythm group showed an increase in total word counts and verbalized more with the trainer compared to the model across all 3 sessions.	Children in the rhythm and robot groups increased levels of social verbalization over training sessions. The rhythm group also generalized learned skills to a standardized test conducted outside the training context with a novel examiner. Clinicians should consider adding music and movement- based active play activities to the standard-of-care treatment of children with ASD.
Dyadic Drum Playing and Social Skills: Implications for Rhythm-Mediated Intervention for Children with Autism Spectrum Disorder (Study 2)	Yoo & Kim, 2018	Used the: 1) Korean-Social Skills Rating System (K-SSRS), 2) Scoring a selection 20 gestures, 3) Scoring of target social behaviours including eye gaze, joint action, synchronous movement.	The group significantly improved in cooperation and self-control and showed an increase in eye gaze, engagement in joint action and synchronous movements. Guardians of participants with more severe autistic symptoms and lower levels of social skills reported more immediate positive effects on their children's motor coordination–related skills and social relationships.	The social skills of children with ASD improved after receiving the rhythm-mediated music therapy intervention. This study presents the structured framework with regard to the use of rhythmic cueing for the social domain of children with ASD, which makes this area of research a promising avenue for further research.
Music improves social communication and auditory-motor connectivity in children with autism	Sharda et al., 2018	Used the: 1) Children's Communication Checklist-2, 2) Social Responsiveness Scale-II, 3) Peabody Picture Vocabulary Test-4	The music intervention group made significant improvements in social communication skills based only on the Children Communication checklist compared to the no-music intervention group.	The findings demonstrate that 8–12 weeks of music intervention (relative to non-music behavioural intervention) can improve parent-reported social communication, family quality of life in school-age children, thus supporting the use of music as a therapeutic tool for individuals with ASD.

The effect of mirroring on the social engagement of young children with autism spectrum disorder	Reese, 2018	**Measured children's Social skills score and problem behaviour scores. Additionally, initiations (verbal or non-verbal acts towards the adult) and gaze (child directed eye contact or visual gaze towards the adult) were measured	Individually most of the children showed a reduction in problem behaviour and showed an increase in social skills. All children showed an increase in initiations, gaze behaviour and engaging in positive affect towards the adult.	The findings contribute to current research and practice as they add to the DMT/mirroring in autism literature by demonstrating that an intervention solely implementing mirroring techniques results in positive change in quantifiable, objectively-measured social engagement behaviours when implemented with fidelity.

* Procedure was videotaped and behaviours were coded from the videotape

** Outcome measures were taken pre and post intervention

Each study completed differing statistical analyses to establish the significance of their observed effect. Tiegerman and Primavera (1984) indicated that both gaze frequency directed toward the experimenter ($F(10,50) = 15.65$, $p < 0.001$) and gaze duration ($F(10,50) = 13.07$, $p < 0.001$) differed significantly across sessions. With gaze duration continuing to increase following the mirror-based intervention and gaze frequency initially increasing before decreasing across sessions.

Field et al. (2001) highlighted that children who were mirrored spent more time engaging in mirror play ($t= 2.05$, $p < 0.05$), more time being proximal to the adult ($t = 2.45$, $p < 0.05$), sitting next to the adult ($t = 2.85$, $p < 0.01$) and touching the adult ($t = 3.47$, $p < 0.001$), than children who were contingently responded to.

Similarly, Escalona et al. (2002) reported that children who were mirrored were more likely to socially interact with and touch the experimenter compared to children who were contingently responded to ($t = 1.98$, $p < 0.05$).

Heimann et al. (2006) reported that social interest (sum of touch, looking at the experimenter and initiating requests) was significantly greater in the post-intervention phase compared to the pre-intervention phase, but only in the mirroring condition ($z = -2.29$, $p < 0.05$) and not in the contingently responsive condition.

Katagiri et al. (2010) highlighted that social attention and social emotional behaviours

increased in children with ASD during and/or after the mirroring phase of their procedure ($F(2, 28) = 8.99$, $p < .001$).

Sandiford (2013) suggested that their rhythmic-based melody intervention caused children with ASD to perform more verbal attempts than children in the traditional therapy group. This did not reach statistical significance, although it showed a positive trend ($z = -$

1.4, p = .08). Additionally, parents reported a significant improvement in the number of new words heard in the home and other environments for participants in the Melodic Based Communication Therapy (MBCT) group (z = -2.0, p = .04).

Warreyn and Roeyers (2014) stated that children who were in the mirror- and joint attention-based intervention group made significantly more gains in overall joint attention ($F(1, 34) = 9.341$, $p < .01$); specifically, gaze following ($F(1, 34) = 6.507$, $p < .05$) and initiating requests ($F(1, 34) = 3.976$, $p < .05$) than the control group.

Srinivasan et al. (2016) revealed that both their rhythmic intervention group and robotic intervention group demonstrated significant improvements in joint attention and that this did not differ between groups. However, the rhythmic group showed a greater increase in total word count compared to the robotic and control group ($p < 0.03$).

Yoo and Kim (2018) noted significant improvements on the K-SSRS following the rhythm-based drum tapping intervention (- $z = -2.201$, $p < 0.028$), specifically in areas of cooperation (- $z = -1.992$, $p < 0.046$) and self-control (- $z = -2.201$, $p < 0.028$). Additionally, comparison of the occurrence of the target behaviours (eye gaze, joint attention and synchronous movement) between the second and eighth sessions showed that children with ASD demonstrated increases in all behaviours.

Sharda et al. (2018) reported a significant improvement in communication skills based on the CCC-2 ($t = 1.43$, $p < 0.024$). However, no other significant effects were observed using either the SSRS-2 or the PBVT-4.

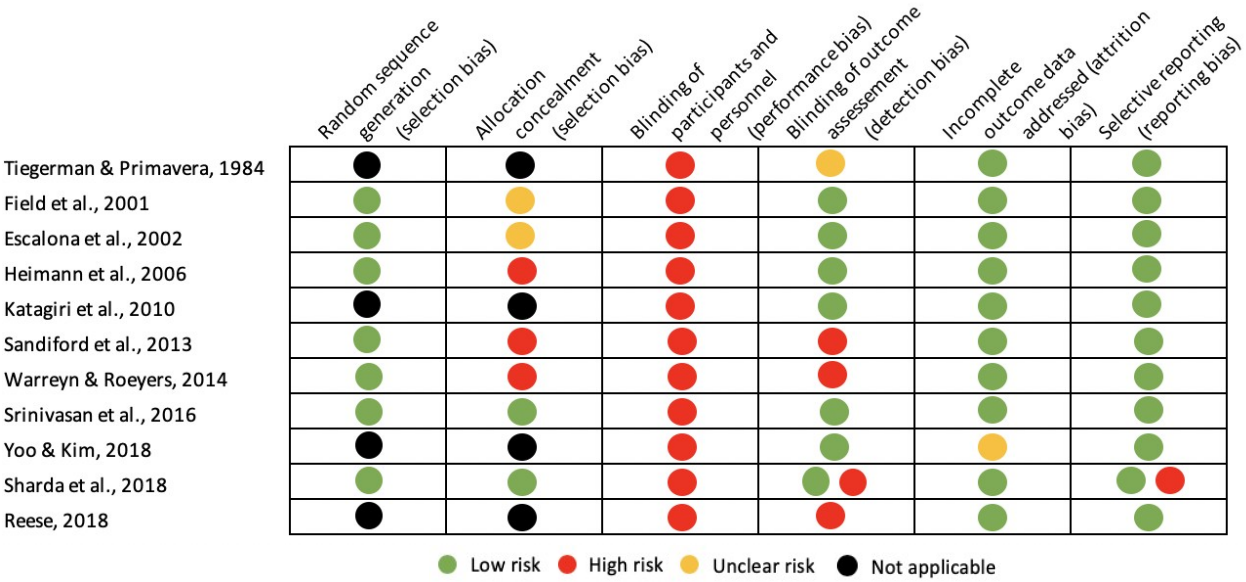
Reese (2018) adopted a case by case approach and it appears no statistical analysis was carried out. However, they reported an increase in social skills based on the SSIS and also highlighted an increase in initiations and eye gaze towards the adult.

3.6 Risk of bias in included studies

Risk of bias (low, unclear and high risk) was reported for all studies according to selection, performance, detection, attrition and reporting bias. However, risk level was not applicable for all categories in each study. For example, Tiegerman and Primavera (1984) did not have a control or parallel group, therefore the category of randomisation was not applicable due to randomisation not being needed.

It is evident that all studies had difficulty blinding participants and personnel due to the nature of the practical interventions with children. It would be near impossible for the child or the experimenter not to know what intervention they were receiving or delivering. Additionally, behavioural coders were often not blind. However, most authors accounted for this by having multiple coders and assessing inter-rater reliability or training coders, before behavioural assessment began, for minimal and insignificant disagreements; thus, limiting bias. Most studies had low reporting bias; reporting all outcome measures listed in the methods in the results and had low risk of attrition bias; explaining and accounting for all missing data (Figure 3).

Fig. 3 Risk of bias assessment of selected studies (Adapted from Cochrane Handbook (Higgins et al., 2019a; Sterne et al., 2019)



4. Discussion

To our knowledge, this is the first systematic review that focuses on the specific DMT techniques, either mirroring or rhythm, as the primary component of interventions targeting communication skills and social development in children with ASD. After successfully reviewing the literature, which focused on either mirror- or rhythm-based interventions, and investigating studies that had reliable outcome measures, which assessed communication and social skills in children with ASD, it is clear that the studies included in this review demonstrate the positive effects of mirroring and rhythm.

ASD is characterised by severe communicative and social deficits, affecting an individual's ability to form and maintain purposeful relationships, both professionally and personally. The results of this study clearly highlight the therapeutic potential of mirroring and rhythm in enhancing communication skills and social development, which may combat poor QoL.

4.1 Mirroring and communication skills

Studies evaluating the effect of mirroring on communication skills and social development utilised a variety of outcome measures, including: eye gaze, joint attention and the scoring of proximal (touching, sitting next to or on and being close to the adult) and distal (looking, vocalising, smiling and engaging in reciprocal play) social behaviours towards the adult.

The eyes and their gaze are important social signals as they have the ability to enhance social connections, indicate that you are paying attention to someone and show a range of social meanings such as intimacy and aggression. Additionally, the eyes are used to observe and retrieve social information from others around you, making the eyes an effective tool with a dual function and an active element in social interactions (Cañigueral & Hamilton, 2019; Risko et al., 2016). Therefore, monitoring eye gaze is indicative of social competence in communicative interactions, demonstrated by its consistent use as an outcome measure in five out of the six studies investigating mirroring in this review (Escalona et al., 2002; Heimann et al., 2006; Katagiri et al., 2010; Reese, 2018; Tiegerman & Primavera, 1984; Warreyn & Roeyers, 2014). Likewise, joint attention is a valuable social skill that was also measured (Warreyn & Roeyers, 2014). Joint attention is defined in early communicative development as the capability to coordinate social attention between an adult, an infant and an object or event (Beuker et al., 2013). Consequently, joint attention abilities is a relative measure of social communication competence (Charman & Stone, 2008). All studies revealed an increase in socially relevant eye gaze behaviour and joint attention abilities, following their mirroring intervention, indicative of improved communication skills and social development.

Studies that employed variations of Nadel et al.'s (2000) still-face paradigm all noted an increase in communicative social behaviours following the mirroring phase. They

suggest that the experience of being acutely mirrored creates a social expectancy for the autistic child, making social situations more interesting (Escalona et al., 2002; Field et al., 2001; Heimann et al., 2006). Therefore, the saliency of the social world is elevated and the probability that the child will offer social responses following the mirroring phase is increased. This was observed in all studies that employed a variation of the still-face paradigm. Children with ASD may be markedly susceptible to the positive effects of mirroring because it strongly contrasts with one of their innermost struggles – lack of social interest (Heimann et al., 2006).

Additionally, mirroring may offer a form of social reward and increase social attention due to sharing the same body movement or emotional state (Contaldo et al., 2016). It is well established that typically developing children find social situations salient, whereas children with ASD do not. This is clearly indicated by the limited social behaviour towards the adults during the first still phase in all studies which employed variations of Nadel et al (2000) still-face paradigm. In this framework, reduced social attention is believed to lead to impaired social development. Known as the "social motivation theory", deficits in the social reward system of children diagnosed with ASD are anomalous at the neurological level consequently leading to changes in the way children with ASD engage with and adapt to social stimuli (Dawson, 2008). For example, abnormal activations in the orbito frontal-striatum-amygdala circuit in response to social stimuli have been reported (Dichter et al., 2012; Scott-Van Zeeland et al., 2010). The neural circuitry related to social reward, such as the orbitofrontal circuit, is activated when individuals are being mirrored (Kühn et al., 2011; Mainieri et al., 2013). Therefore, the mirror-based interventions included in this review could enhance communication skills and social development by improving the neural circuits that might be impaired in ASD.

Similarly, at a neurobiological level, the beneficial effects of the mirror-based interventions explored in this review may be explained by the 'broken mirror' hypothesis in ASD (Chen et al., 2008). The broken mirror hypothesis refers to the mirror neuron system (MNS), in which the same neurons that are activated in an individual watching a movement/performance, are activated in the individual performing the movement – essentially, the activation of neurons in each individual somewhat mirror each other (Rizzolatti & Craighero, 2004). This also extends to observing the emotions or behaviours of another, translating to empathy (Berrol, 2006; Iacoboni & Dapretto, 2006). It is believed that the MNS is somewhat deficient in individuals with ASD (Becchio & Castiello, 2012; Iacoboni & Dapretto, 2006). However, rather than global dysfunction of the MNS, it is proposed that individuals with ASD may have dysfunctional anatomical connectivity or impaired functional synchronization within specific nodes of the MNS (Kana et al., 2011). As a result, the specific mirror-based interventions may improve impairments within these certain nodes and promote connections with alternative neural networks involved in social cognition, resulting in the observed positive effect of increased eye gaze, joint attention and proximal and distal social behaviours towards the experimenters in the given studies (Contaldo et al., 2016; McGarry & Russo, 2011).

In contrast, Katagiri et al. (2010) believes their findings are not supported by the broken mirror hypothesis as their results suggest that the primal mirror system function somewhat remains in toddlers with ASD. Additionally, it is unclear if the child being mirrored needs to *know* that they are being mirrored to observe positive results and to what extent recognition of mirroring behaviour correlates to improvements in communication and social development. Nonetheless, it appears the DMT technique of mirroring is successful at increasing and improving communication skills and social development in children with ASD; whether that be through improving damaged networks, increasing

social expectancies or another mechanism, mirroring demonstrates substantial therapeutic potential that could be exploited by heathcare providers (Escalona et al., 2002; Field et al., 2001; Heimann et al., 2006; Katagiri et al., 2010; Reese, 2018; Tiegerman & Primavera, 1984; Warreyn & Roeyers, 2014).

4.2 Rhythm and communication

Studies that looked at the ability of rhythm to improve communication skills and social development used a range of outcome measures to assess its efficacy. Studies reported either an increase in verbal attempts at home, total word counts, levels of co-operation and self-control or improved CCC-2 scores; inferring improvements in communication skills and social development following their rhythmic-based interventions.

These rhythmic based interventions may be successful in improving social skills of children with ASD as they harness their musical strengths while alleviating their impairments (Simpson & Keen, 2011). Children with autism have a predisposition for musical stimuli, demonstrating intact musical perception despite their substantial lack of communicative social skills (Heaton, 2003; Simpson & Keen, 2011; Srinivasan et al., 2015). Therefore, the rhythmic interventions; such as dyadic drumming or MBCT, utilised a non-threatening and acquiescent medium that is often well-received by individuals with ASD (Sandiford, 2013; Yoo & Kim, 2018). Moreover, the rhythmic and musical interventions provided several opportunities for developing social skills such as imitation, joint attention, social reciprocity, shared affect, and empathy (Overy & Molnar-Szakacs, 2009; Sandiford, 2013; Sharda et al., 2018; Srinivasan et al., 2016; Yoo & Kim, 2018). The observed increase in key communication skills measured in Srinivasan et al. (2016) and Yoo and Kim (2018) may show the child attuning to the actions of their social partner

(the experimenter) through the rhythmic exercises; gradually developing an appreciation and awareness of their partner's emotions and intentions (Srinivasan & Bhat, 2013).

Within ASD profound challenges to neurological connectivity are observed. This may disrupt the typical rhythms of sensory and social connectivity, resulting in a sequence of disorientated perceptual experiences that affect the delicate 'choreography' of social interactions (Amos, 2013). Research on audio-visual processing in ASD has revealed that the "binding window" (the window of time in which inputs from various sensory stimuli occur in quick enough succession to ascribe them to a single event) is twice as long for subjects with autism compared to typically-developing controls (Foss-Feig et al., 2010; Wallace & Stevenson, 2014). At a neurological level, this small difference in time can be sufficient to prevent or even inhibit multisensory experiences from blending into one single and coherent perception. Consequently, social interactions in individuals with ASD may be burdened with irrelevant and confusing associations. As the rhythmic interventions included in this review targeted the child's ability to synchronize with the external rhythms in their environments, this may have reduced the large binding window; thus, making social situations more salient and resulting in the improved communication skills observed in the chosen studies.

4.3 Limitations within studies

All studies had a relatively small sample size, ranging from the smallest group of four participants to the largest group of 51, where 25 individuals were in the intervention group and 26 individuals were in the control group. Consequently, the statistical power of all studies is limited. Additionally, the clinical relevance of findings is somewhat reduced due to the small sample sizes and whether the sample of participants reflects the general ASD population. Besides the small sample sizes, participant groups were often recruited

from a singular school, charity or catchment area, introducing a geographical bias which again, reduces the notion that the samples of participants used are reflective of the general ASD population.

Although most studies measured and reported the severity of autism in their sample size, either by using the CARS, ADOS or ADI-R, there was substantial variability in scores across studies. Controlling for autism severity is useful during scientific research as it limits potential variability, enables matching across groups and may allow you to establish what intervention is most effective for different severities of autism. However, Warreyn and Roeyers (2014) did not confirm the child's ASD diagnosis with either the CARS, ADOS or ADI-R; therefore the severity of autism for each participant was unknown and was not matched between the control and intervention groups. Similarly, Yoo & Kim (2018) did not consider the developmental level or inconsistency of autistic symptoms across participants. Analysis of feedback in terms of the effectiveness and acceptability of the intervention from the guardians of participants highlighted this limitation. It could be argued that by not controlling for autism severity you establish a more generalisable scientific study – in that, your intervention is successful (or not) across all levels of autism severity. None-the-less, this would still require a reliable measurement of autism severity to be taken for each participant.

None of the studies in this review examined if their intervention produced effects that were long term. Therefore, it is unknown whether the positive effects of mirroring or rhythm in the given studies are transient. Many of the authors expressed concerns regarding follow up examinations due to time constraints, the nature of the population they were working with and that they often had to rely on parents, who already had busy family lives, to bring their children to the pre-assessment, intervention and post-assessment

sessions. Consequently, adding a follow-up assessment seemed unmerited with the logistical difficulties.

Very few studies successfully examined if the positive effects observed were generalised to a more naturalistic environment; for example, at school or at home (Ingersoll, 2008). Only Sandiford (2013) reported findings observed in the home environment, noting a significant improvement in the number of new words heard at home by parents of children in the rhythmic group. Additionally, the risk of bias for outcome measures was reportedly high as most parents were not blind to which intervention their child was receiving (Figure 3 and SM1). Some may argue that in variations of Nadel et al. (2000) still-face paradigm an increase in social behaviours during the spontaneous play/free play phase is evidence of generalisation (Contaldo et al., 2016). Yet, the environment is anything but representative of "real life" – a small room, with an unfamiliar adult and cameras or observers in the surrounding areas (Spradlin & Siegel, 1982). Therefore, it is not plausible to imply a generalising effect following the still-phase paradigm without examining effects in a more naturalistic environment.

4.4 Review limitations

The lack of standardised outcome measures, variability in ASD population and inconsistency in the duration and frequency of interventions of studies covered in this review made comparison between studies and analysis of the results extremely difficult. To this end, a meta-analysis or meta-synthesis was not performed due to the substantial variability across studies. Furthermore, there were limited papers published within this area that demonstrated sound methodological quality, as most studies lacked control or comparison groups or were not blinded or fully randomised, as demonstrated by our risk

of bias check. Additionally, the research often relied on qualitative outcome measures that may be subject to interpretation and bias.

As the main aims of this review were to focus on mirroring and rhythm as the central components of interventions targeting communication skills and social development in children, many articles were excluded from the review due to mirroring or rhythm being used in combination with other techniques or as an element of a multi-step procedure. However, these articles may still offer valuable information regarding the power of mirroring or rhythm within an intervention even though they were not the main component. Additionally, articles were excluded if participants were over the age of 12, therefore it is unclear if the positive effects of mirror-based and rhythmic-based interventions would be replicated in adolescents and adults diagnosed with ASD.

4.5 Implication of findings for practice

All the studies selected for the systematic review showed the benefits of mirroring and rhythm for children with ASD in terms of communication skills and social development. A key factor to consider is the attendance of participants for interventions that lasted over 8-weeks. Often dropout rates in the autistic population for scientific studies is relatively high (Magán-Maganto et al., 2017; Parracho et al., 2010). However, in this review three studies, which had interventions lasting 8-weeks or longer had no drop-out rates, two studies had only one participant fail to complete the full duration of the intervention and one study had three participants drop out. Perhaps this highlights the desire of children to attend multiple sessions, enjoyment felt by each participant, and the willingness of parents to take their children to the intervention. As a result, it seems

plausible that mirroring and rhythmic interventions are useful and well-received strategies that hold therapeutic potential and could therefore be integrated into practice.

Despite the heterogeneity of the studies included in this review, it is evident that mirroring and rhythm are effective interventions for improving communication skills and social development in children with ASD. However, it is not clear what the optimum duration and frequency of mirroring or rhythmic sessions are needed in order to obtain the best outcomes following the intervention. For example, Warreyn & Roeyers' (2014) intervention lasted 5-months, whereas Sandiford's (2013) intervention only lasted for 5-weeks. To this end time, period and frequency of interventions may influence their success (DeJesus et al., 2020). Therefore, in order to be implicated into practice the most beneficial duration and frequencies would need to be known.

These specific DMT techniques, especially mirroring, are relatively inexpensive and cost effective. The healthcare system asserts demand for more evidence-based, cost-effective treatments and this review highlights valuable studies demonstrating the effectiveness of mirroring and rhythm to improve communication skills and social development in children with ASD (Warreyn & Roeyers, 2014). Additionally, mirroring and rhythm-based tasks could easily be implemented into school routines in order to improve communication skills and social development of pupils on the autistic spectrum. For example, elements of mirroring or rhythm could be integrated into physical education sessions or music lessons, respectively, either at special education facilities or main-stream schools.

4.6 Future Research

From this review, it is clear that both mirroring and rhythm-based interventions have beneficial effects on the communication skills and social development of children with ASD. However, the lack of homogeneity between study designs, classification of participants and outcome measures used means it is difficult to conclusively state their therapeutic potential. Consequently, more research is needed to verify the optimum duration and frequency of mirroring or rhythm-based interventions and the effects of these interventions in different populations/severity of children with ASD. Moreover, reliable, informative and standardised outcomes measures are needed in order to compare and contrast the effectiveness of interventions, highlighting the most beneficial interventions for clinical and social practice.

On the other hand, DMT has already shown the usefulness of rhythm and mirroring in combination to increase communication skills and social development in children with ASD in a clinical/therapy-based environment (Scharoun et al., 2014). It would now be worth exploring the combination of rhythm and mirroring techniques in a more practical and naturalistic setting; for example, in a school environment or in groups of children (rather than 1:1). All the studies utilised either a dyad or triad; however, group based interventions with more than one child in the group have shown significant positive effect in individuals with ASD (Eren, 2015; Hildebrandt et al., 2016; Koch et al., 2015). Therefore, future research might investigate the use of mirroring and rhythmic techniques in groups of children with ASD rather than individually.

In addition, all of the studies in this review focused on the experimenter mirroring the child or a rhythmic procedure between the experimenter and the child. None investigated child-to-child based mirroring or rhythmic procedures between children. In common social contexts, children typically interact and play with other children.

Therefore, creating a common social context within an intervention may further enhance its positive effects on communication skills and social development (Garfinkle & Schwartz, 2002). Future research may wish to investigate child-to-child based mirroring and child-orientated rhythmic procedures in groups of children to establish their effectiveness in increasing communication skills and social development in a more naturalistic setting.

5. Conclusion

In conclusion, the findings from this review confirm the positive effects of the DMT techniques, mirroring and rhythm, on the communication skills and social development of children with ASD. The studies included in this review used mirroring and rhythm independently and outside the realm of DMT, therefore providing evidence that the techniques can be used effectively to increase communication skills and social development. Although each study used a range of outcome measures, eye gaze and joint attention were most commonly used as an index for improved communicative social behaviours, suggesting they were reliable outcome measures. Overall, this review highlights the use of mirroring and rhythm to increase communication skills and social development, hopefully demonstrating their therapeutic potential for children with ASD.

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