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Association between Motor and Language Skills Development in Children with Autism Spectrum Disorder: A Scoping Review

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ABSTRACT

An emerging body of literature suggests that early motor skills may be a key predictor of language development in children with autism spectrum disorder (ASD). However, characteristics of subject groups, targeted skill areas and their assessment tools, and methodological approaches significantly vary across existing studies. This scoping review aimed to map out the associative nature of motor and language skills among children with ASD according to different age groups and ancillary attributes by investigating empirical studies published in the past 20 years. We searched research articles published in peer-reviewed journals between January 2000 and December 2020 using PsycINFO, PubMed, and ERIC. A total of 11 studies were selected and analysed using the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews Checklist. Available evidence indicates that despite a lack of agreement among available instruments for skills assessments, there exists a positive relationship between motor and language development in that early motor skills predict the rate of both receptive and expressive language development in children with ASD. More studies on such relationship in later childhood and adolescence are warranted to provide practical implications of motor and/or language delay in children with ASD and further timely intervention development.

KEYWORDS

Motor development; language development; children with autism; scoping review; developmental delay

Introduction

The estimated prevalence of autism spectrum disorder (ASD) has steadily increased over the past few decades across the globe, with being 1 in 54 children now diagnosed with ASD in the U.S. (Maenner et al., 2020). Individuals with ASD are likely to encounter social challenges due to prominent deficits in social interaction and communication skills (Dawn & Wehman, 2009; Liptak, Kennedy, & Dosa, 2011; Shattuck, Lau, Anderson, & Kuo, 2018). With a growing interest in social skill development in children with ASD, a substantial number of studies have investigated socio-cognitive abilities and their association with physical, emotional, and intellectual development in this population (Bedford et al., 2014; Bedford, Pickles, & Lord, 2016; Charman et al., 2003; Iverson, 2018; Leonard, Bedford,

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Pickles, & Hill, 2015; Leonard & Hill, 2014). Such approaches reflect a research paradigm shift from a conservative view that conceives each skill as a discrete entity to a new perspective that considers fundamental skill sets as interactive traits. The association between motor and language skills development is no exception.

Emerging evidence suggests a close relationship between motor and language skills in children with ASD. From socio-cognitive perspectives, the cascading effects of each skill impairment on other developmental areas have been actively investigated (Bedford et al., 2016; Bhat, Galloway, & Landa, 2012; Gernsbacher, Morson, & Grace, 2016; Iverson, 2018; Iverson & Thelen, 2005; Lebarton & Iverson, 2013). Studies have examined this association with regard to age, corresponding developmental milestones for specific disorders, and target skills for investigation. Specifically, studies on infants and toddlers have focused on early motor skills such as imitation, crawling, and walking in relation to verbal initiation while also investigating impaired behavioural manifestations as potential autistic attributes (Bhat et al., 2012; Lebarton & Iverson, 2013; LeBarton & Landa, 2019; Luyster, R. J. et al., 2008). Several autism studies particularly evolved around the heritability of the condition. Infants who have siblings with ASD face increasing possibilities of recurrence risks, which has led to a substantial number of studies on familial risks for ASD (Bailey, Landa & Garrett-Mayer, 2006; Le Couteur et al., 1995). Bhat et al. (2012) examined infants at high familial risks for ASD and concluded that both motor and communication delays are prevalent in potentially affected children. This study also links the predictive attributes of their early motor delays to later developmental challenges in social communication skills.

The onset age of motor functioning in young children with ASD has also received much attention as a predictor of later language development (Bedford et al., 2016; Bhat, Galloway, & Landa, 2012). A longitudinal study conducted by Bedford et al. (2016), for example, proposed that the onset of walking may predict the subsequent rate of language development in young children with ASD and their early motor abilities may contribute to linguistic difficulties. A recent study examined developmental trajectories of fine motor skills in infants with high-risk ASD in order to identify their expressive language outcomes. Choi, Leech, Tager-Flusberg, and Nelson (2018), for example, used a standardised assessment of early childhood development (i.e. Mullen Scales of Early Learning; Mullen, 1995) and found a significant relationship between fine motor and expressive language development. Findings highlighted that early fine motor skills of high-risk infants who were later diagnosed with ASD predicted expressive language outcomes at later age.

According to the existing literature, the associative patterns of motor and language skills development have been designed and investigated with varying methodological approaches and aims. Only few studies have identified a connection between motor and language skills based on subject groups and their diagnostic status, such as infants at high and low risk for ASD (Iverson, 2018), as well as autistic and typically developing children as a comparison group (Leonard & Hill, 2014) and based on other methodological distinctions (Ohara, Kanejima, Kitamura, & Izawa, 2020). Still, evidence has emerged that early motor skills may be a key predictive cue for not only diagnosis of ASD but also language skill development in later years (Bedford et al., 2016; Choi et al., 2018). Thus, the aim of this scoping review was to examine empirical studies published in the past 20 years on the associative nature of motor and language skills among children with ASD according to different age

groups and ancillary attributes. This study focuses on categorising the associative features between motor and language development: (1) correlation, (2) prediction in line with diagnosis, (3) prediction for intervention, and (4) intervention-driven causation. By prioritising the functional significance of social cognition, this study is limited to the scope of developmental research investigated from a socio-cognitive perspective and excludes neurological interpretations that underpin brain abnormalities as neurological characteristics of ASD.

Methods

The present study focused on analysing cross-sectional research on the association between motor and language skills development in children with ASD. The primary inquiry is centred on the associative features of two skills in line with research aim and characteristics of subject group(s). We employed the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018) to provide descriptive narratives as well as quantitative theme categorisations. This method enabled us to identify research gaps and practical implications on future research trajectories addressed in the discussion section.

Search and Selection of Sources

We searched peer-reviewed articles published between January 2000 and December 2020 using three search engines, PsycINFO, PubMed, and ERIC. The key terms used for the search included a mixture of key and close variants such as motor AND language AND autism or movement AND literacy AND autism spectrum disorder. The terms indicating the associative nature of two skills such as associate, predict, or relate were deliberately excluded to allow for the wide array of references otherwise represented. We focused on socio-cognitive perspectives that place emphasis on continuity instead of permanence of skills development in nature; thus, we excluded neurological studies that underlie genetic heredity of ASD and dysfunctional brain as its causal impairments.

Data Charting Process

After screening with the key referential terms for the primary search, we followed a selection process through several exclusionary criteria as shown in Figure 1. We excluded (1) duplicates found in each database; (2) sources that focused on neurological aspects (e.g. functions in the cerebellum, cerebellar abnormality, brain networks); (3) studies that did not count all of the primary terms indicated above; and (4) studies that deviated from the research focus of our interest. For instance, we excluded studies that encompass all three components (i.e. motor, language skills, ASD) but focus on either motor or language impairments of children as a discrete predictor of later autism diagnosis (Landa & Garrett-Mayer, 2006). The articles were reviewed through a course of screening processes with titles and abstracts, followed by full-text reviews as a final stage.

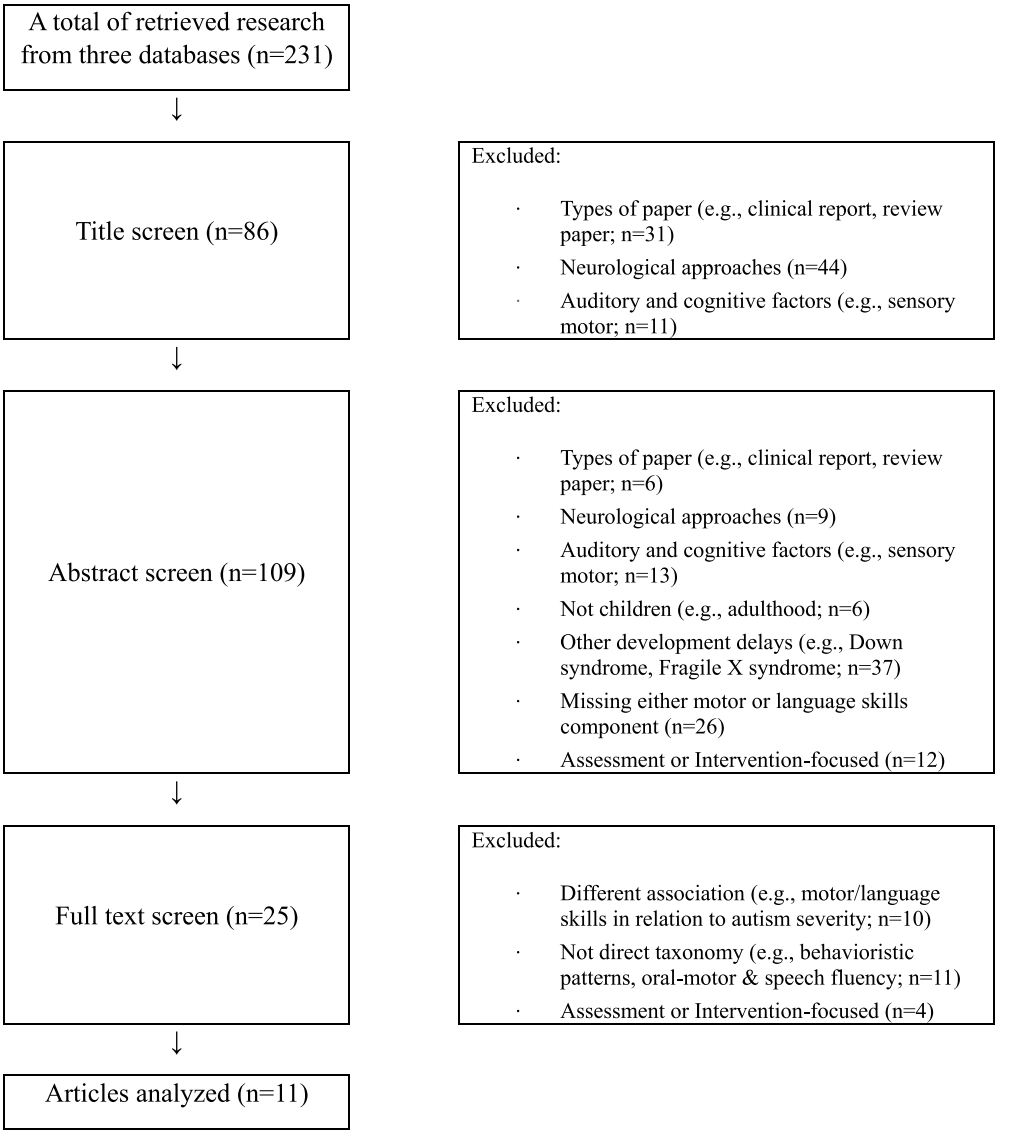

Figure 1. Flowchart of article selection process.

Results

We selected and analysed 11 studies on the association between motor and language skills development in children with ASD explored from multifaceted perspectives. The included articles were then categorised into four types of associative patterns: correlation, prediction in line with diagnosis, prediction for intervention, and intervention-driven causation. In this section, we address each type of associative pattern by identifying key attributes in each study as shown in Table 1

Table 1. Types of Associative Patterns and Key Attributes of Corresponding Studies.

Type	Author (Year)	Subject	Motor Assessment	Language Assessment	Key Findings
Correlation	Hellendoorn et al. (2015)	63 children with ASD at 1st test (Mean age = 27.10 months) and 46 children at 2nd test (Mean age = 45.85 months) 269 children with developmental delays (DD) at 1st test (Mean age = 17.99 months) and 121 children at 2nd test (Mean age = 43.51 months)	Fine motor functioning: The Mullen Scales of Early Learning (MSEL)	Receptive & Expressive language: MSEL	Early fine motor functioning was a predictor of later receptive and expressive language development in both children with ASD and children with DD. Exploration and visuospatial cognition were mediators of the relationships between fine motor functioning and language skills in both groups.
	Hannant (2018)	18 children with autism spectrum conditions (ASC) (aged 7-16; Mean = 9.9 years) 18 typically developing children (aged 6–12; Mean=9.2 years)	Movement (manual dexterity, ball skills, static and dynamic balance): Movement-ABC 2 Visual motor integration, visual perception and fine motor coordination: BEERY VMI	Receptive language: BPVS-III	Low score on language, coordination, and visual motor integration in children with ASC. Correlation between receptive language and balance (sensorimotor skills).
	Kim (2008)	32 children with ASD, including 6 girls (aged 35-65 months)	Fine and Gross motor: VABS	Receptive & Expressive language: VABS	Correlation between the onset of babbling and first words while no linkage between babbling onset to later language, nor to gross and fine motor ages. No correlation between the onset of crawling and later language ages.

(*Continued*)

Table 1. (Continued).

Type	Author (Year)	Subject	Motor Assessment	Language Assessment	Key Findings
Prediction in line with diagnosis	Choi et al. (2018)	30 high-risk infants later diagnosed with ASD 71 high-risk infants without ASD 69 low-risk infants without ASD	Fine motor skills: MSEL (at 6, 12, 18, and 24 months of age)	Expressive language: MSEL (at 36 months)	Significantly slower growth in fine motor skills of high-risk infants later diagnosed with ASD compared to their typically developing peers. Early fine motor skills (at 6 months) were a predictor of later language outcomes (at 3 years).
	Manelis et al. (2020)	36 children with ASD reported to show language regression by their parents 104 children with ASD reported to show no concern of language regression	Early motor skills: Parent intake questionnaire (on the loss of language skills, nonverbal communication skills, and motor skills, and the patterns of word use)	Language skills and assessment of language regression: Parent intake questionnaire and initial clinical record to validate the parents' report.	Children with ASD and language regression showed significant delay in key developmental milestones (i.e., crawling, walking, and use of first words). Children with ASD and language regression showed more severe symptoms of ASD compared to ones without language regression.
Prediction for intervention	Mody et al. (2017)	1781 children with ASD who completed diagnostic, physical, cognitive, and behavioral assessments (aged 2-17 years)	Gross motor skills: VABS-II Fine motor skills: MSEL	Receptive & Expressive language: MSEL	Positive associations between fine motor skills and both expressive and receptive language skills in children with impaired fine motor skills. Negative association between gross motor skills and receptive language skills in children with impaired gross motor skills.
	Bal et al. (2020)	86 children with ASD and language delay	Age of walking: ADI-R (at age 3)	Language abilities and expressive language: ADOS (at age 3) and VABS	Fine motor deficits were a marker to identify persistent language impairment in children with ASD.
	Stone & Yoder (2001)	35 children with ASD (24 with autism and 11 with PDD-NOS)	Motor imitation: MIS Play ability: PAS Joint attention: PIA	Expressive language: MCDI, SICD-R, PLS-3	Motor imitation and number of hours of speech/language therapy can be a predictor to spoken language development in children with ASD.
Prediction for intervention	Sandbank et al. (2017)	61 preschoolers with ASD (aged of 24 and 48 months old), as well as longitudinal data	Object play: CSBS and DPA	Intentional communication (words, conventional signs, un/conventional gestures, nonword vocalizations): UCS and CSBS	Early motor imitation was the only predictor of the later intentional communication ability.

(*Continued*)

Table 1. (Continued).

Type	Author (Year)	Subject	Motor Assessment	Language Assessment	Key Findings
Intervention-driven causation	Ketcheson et al. (2020)	11 children with ASD with intervention and 9 children with ASD without intervention (aged 4-6 years)	Cognitive functioning including visual reception and fine motor: MSEL Motor skills competence (locomotor skills and object control skills): TGMD-2	Cognitive functioning including receptive and expressive language: MSEL	Correlation between locomotor skills and receptive and expressive language skills. Correlation between object control skills and receptive and expressive language skills. Language skills played an important role to improve motor skills through guided intervention in children with ASD.
	Studenka et al. (2017)	5 children with ASD with intervention and 5 verbally matched children as a control group (aged 8-11 years)	Motor perspective considered: ability to facilitate the action of an experimenter hammering with a tool or putting it away (14-18 sessions)	Verbal perspective considered: narrative training through SKILL (19-33 sessions). Improvement in knowledge of story structure and in perspective taking: MISL	Narrative intervention increased motor facilitation as well as use of mental state and causal language in children with ASD.

Correlation

Much research has examined motor and language skills development in children with an emphasis on the intersection of socio-cognitive awareness and communicative interaction (Bedford et al., 2014, 2016; Charman et al., 2003; Iverson, 2018; Leonard et al., 2015; Leonard & Hill, 2014). Two selected studies posited sensorimotor and visuospatial perception as basic components of social cognition that enable children to perceive, explore, and interact with the outside world as windows of opportunities (Hannant, 2018; Hellendoorn et al., 2015). Hannant (2018) particularly focused on visual perception and motor coordination that correlate with receptive language in different subject groups; school-aged children with ASD (Mage = 9.9 years) and typically developing children (Mage = 9.2 years). The research identified a correlation between receptive language and sensorimotor skills in children with ASD as well as low scores on their language, coordination, and visual integration. With an emphasis on the theory of embodied cognition, Hellendoorn et al. (2015) also foregrounded visuospatial cognition and exploration as mediators between motor functioning and language skills in preschoolers with ASD (Mage = 27.10, 45.85 per test). Their findings suggested not only a correlation between early fine motor functioning and later receptive and expressive language development but also a mediatory role of visuospatial cognition and exploration for early motor skills and language skills development in young children with ASD.

On the other hand, an earlier study did not recognise these outcomes. Kim (2008) explored a similar aspect of the relationship that focuses on the onset of developmental milestones such as crawling and babbling observed in preschoolers with ASD (35–65 months). He hypothesised the onset of crawling as a predictor of the age of receptive/expressive language development and similarly the onset of babbling in correlation with the gross/fine motor development. Although the findings revealed a correlation between the language skills, there was no significant relationship found between early language and motor skills. It is important to note that his attempts to identify relational patterns of various developmental skills as key variables were noticeable, but the lack of a detailed assessment process and its validity led to insignificance in findings (Leonard et al., 2015).

Prediction in Line with Diagnosis

The association between motor and language skills development in young children has been actively investigated for preventive purposes in the context of a diagnosis of autism and the severity of its symptoms. Two of the selected studies particularly targeted young children at familial risk for ASD, proposing that the specific time at which the early motor impairment or delay initially emerges can predict the later language ability as well as an autism diagnosis (Choi et al., 2018; Manelis et al., 2020). Through a prospective, longitudinal study, Choi et al. (2018) focused not only on the association between motor and language skills but also the types of infants at risk for ASD (i.e. high-risk infants later diagnosed with ASD, high-risk infants without ASD, and low-risk infants without ASD). They concluded that high-risk infants later diagnosed with ASD showed a slow growth of fine motor skills assessed at 6 months, which also predicted later expressive language outcomes assessed at 3 years of age. Manelis et al. (2020) examined language regression (LR) as a key variable of children with ASD, defining it as the loss of previously acquired skills. They explored a potential association between LR and early motor development in children with ASD through parent reports that document a loss

of language skills such as the patterns of word use, nonverbal communication skills, and motor skills. They particularly focused on the age at which the children achieved key developmental skills, which revealed a significant correlation between the onset age of speaking the first words and the onset age of crawling and walking. These studies conceived the onset or progress of key developmental skills as pivotal to predict both diagnostic symptoms of ASD and other skill developments, all of which necessitates practical applications of timely interventions.

Prediction for Intervention

Available evidence has identified a relationship between motor and language skills as predictors of one another, implying a need for focused interventions with specific skill candidacy (Mody et al., 2017). Much research has explored children with ASD who present diagnostic features of autism and other types of impairment or delay for the purpose of targeted intervention. Mody et al. (2017) investigated the association between two key developmental skills in children with ASD aged from 2 to 17 years old in the context of their specific impairments in motor (gross and fine) or language (receptive and expressive) skills. They emphasised a need for categorising such associations according to subject groups as a way to determine targeted skills for intervention developments. Their findings revealed different degrees of contribution of gross/fine motor skills to not only later language development but also socio-communication skills on a broad level.

Similar to other developmental studies that presupposed motor skills as the primary indicative factors of later language development, Bal et al. (2020) investigated multiple variables in motor functioning (i.e. onset of walking, joint attention, imitation, and developmental progress) to identify language delays of children with ASD. They aimed to identify predictors of expressive language development among preschoolers with ASD whose language delay particularly persisted in later school years via a longitudinal study with retrospective data. They proposed that marked deficits of fine motor at age 3 served as a predictor of an expressive language delay in both school-aged children and young adults, implying a need for effective interventions with specific skill treatment. Stone and Yoder (2001) identified predictive factors of spoken language development of young children with ASD (autism and Pervasive Developmental Disorder-Not Otherwise Specified). Among many variables, motor imitations, learning environments, and hours of language/speech therapy sessions were found to be the most influential predictors of their vocabulary and expressive language development. They concluded that imitation impairments of young children with ASD contribute to language delays in their preschool years and suggested targeted skill interventions.

Early motor delay has been conceived as a predictor of deficits in language abilities, which in turn can hinder subsequent social communication skill development. Sandbank et al. (2017) emphasised communicative language and explored theoretically supported predictors of intentional communication in autistic preschoolers, including tendency to respond, motor imitation, object play, parent linguistic responses, and parent responsive physical play. They hypothesised that early motor impairments in preschool and school-aged children lead to later developmental challenges in gestural and verbal

communicative interactions, which are common characteristics of ASD. Findings indicated that early motor imitation is the only predictor, proposing imitation as a target skill for focused intervention in autistic preschool children.

Intervention-Driven Causation

As shown above, the primary purpose of research on developmental skills in children with ASD converges on identifying the key variables that correlate with other skill impairments in order to offer timely diagnosis and intervention. Some studies further investigated the effects of intervention that focus on a key variable, either motor (Baranek, 2002; Bremer & Lloyd, 2016; Ketcheson, Hauck, & Ulrich, 2017) or language intervention (Bellon, Ogletree, & Harn, 2000; Koegel, Koegel, & Surratt, 1992). The selected studies examined not only the effects of the intervention per se but also the relationships between motor and language skills as a means of drawing causal inference for intervention (Ketcheson, Felzer-Kim, & Hauck, 2020; Studenka, Gillam, Hartzheim, & Gillam, 2017).

Ketcheson et al. (2020) examined the correlation between motor (i.e. locomotor and object-control) and language (i.e. receptive and expressive) skills at baseline. They explored the effect of a motor intervention on young children with ASD aged 4 to 6 and identified the important role of language skills to improve motor skills regardless of children's pre-measured language abilities. A study by Studenka et al. (2017) focused on motor and verbal attributes in school-aged children with ASD (8–11 years old) by positing their interrelatedness from socio-cognitive perspectives. Their findings revealed that narrative interventions increased motor facilitation as well as the use of mental state and causal language. They also proposed motor attributes as not only predictive cues to assess children's communication but also a valuable approach to diagnosing children with ASD. Two studies emphasised the importance of research on the association between motor and language skills as a means of early identification and timely intervention. In these studies, the subjects' age groups particularly range from preschool to school-aged children, and findings commonly imply that the impact of fundamental skill development may persist into adolescence and young adulthood.

Discussion

This scoping review highlighted an array of research on motor and language skills in children with ASD as building blocks for healthy development. Findings support early link between the two skills, as early motor difficulties may forecast subsequent language delays in children with ASD. Some studies demonstrated a correlation between motor and language skills in line with socio-cognitive abilities as key mediators (Hannant, 2018; Hellendoorn et al., 2015; Kim, 2008). Others noted a predictive role of these variables in identifying subsequent skill impairments as well as diagnostic features of autism (Choi et al., 2018; Manelis et al., 2020). A few studies proposed practical implications for focused intervention in autistic children with other skill impairments or delays (Bal et al., 2020; Mody et al., 2017; Sandbank et al., 2017; Stone & Yoder, 2001). Finally, limited research investigated the effect of motor or language intervention (Ketcheson et al., 2020; Studenka et al., 2017). As such, all of these studies reiterate previous findings on a close association between motor and language skills development.

The associative patterns categorised in this study provide not only thematic reviews of each research purpose and design but also several implications for future research on skills development in children with ASD. First, much research has foregrounded multifaceted interactions among motor-language subskills, implying that deficits in early skill development have a cascading effect on other skills impairments (Bedford et al., 2016; Bhat et al., 2012; Gernsbacher et al., 2016; Iverson, 2018; Iverson & Thelen, 2005; Lebarton & Iverson, 2013; Toth, Munson, Meltzoff, & Dawson, 2006). Three selected studies particularly undergird socio-cognitive skills as a bridge for early motor functioning and later language development in such relationships. Their conclusions reiterate previous findings in which early motor deficits can serve as critical candidacy that predicts social and communication impairments prevalent in children with ASD (Bhat et al., 2012; Mody et al., 2017). The primary purpose of such approaches, therefore, converges on identifying critical treatment targets for the focused interventions that other selected studies have pursued (Bal et al., 2020; Mody et al., 2017).

The selected studies also foreground the continuous nature of developmental patterns of the disorder that change over time and intersect with other skill domains. Although most studies presupposed that target skills advance in a linear direction, some proposed the possibility of losing previously acquired skills (i.e. regression), which is revealed later in a developmental phase. A study by Manelis et al. (2020) exemplified that the initial use of language in children with developmental delays does not guarantee a progressive development in later years. Consequently, most studies adopted a longitudinal approach and called for a need to identify long-term relationships between motor and language skills to provide timely interventions in emergent developmental challenges (Bal et al., 2020; Choi et al., 2018; Hellendoorn et al., 2015; Mody et al., 2017). As shown in Bal et al. (2020) and Choi et al. (2018), a longitudinal study often involves multiple visits with children for follow-up assessments to monitor developmental progress for each skill set. This prospective approach enabled them to identify critical points that reveal autistic manifestations (Choi et al., 2018) and impairments of certain skills (Bal et al., 2020). The authors proposed a less direct association between the two skill sets, particularly long term, yet they imply a need for timely interventions that may have been neglected or undiscovered.

It is also prominent that most selected studies have examined various subject groups including children with a variety of developmental conditions (Hannant, 2018). Much developmental research has paid attention to other co-occurring conditions such as general developmental delay (Macdonald, Lord, & Ulrich, 2013), speech/language delay (Bal et al., 2020), intellectual disability, and learning disorder in relation to ASD (Kim, Carlson, Curby, & Winsler, 2016). The studies include exploring associations between two skills specific to only autistic features or identifying target skills for focused intervention. Hellendoorn et al. (2015), for example, purposely included children with other developmental delays to compare and identify associative features of motor and language skills specific to those with ASD. As shown in Manelis et al. (2020), the age at diagnosis as well as the severity of ASD symptoms also serve as primary means for identifying a correlation between key developmental skills. They highlighted that early detection of ASD, and timely interventions may help decelerate language regression in autistic children with language delay. Similarly, Bal et al. (2020) paid attention to the language delay in relation to autism diagnosis in children. Their findings strengthen the predictive relationship

between early motor deficits and persistent language delay in school years of children with ASD and imply a critical need of directly targeted and focused skill intervention development.

The results of this review displayed a research propensity for infants and preschoolers (n = 8) compared to the scant attention to school-aged children (e.g. 7–12 years old; n = 3). The thematic analysis of this review highlights the significance of predictive purposes on infants and young children, yet it also calls for studies on school-aged children to provide practical suggestions for the different modes of communicative interactions emerging in school contexts. One reason for such needs is tied to the nature of children's skills development as a continuous instead of permanent skills acquisition (Helen Tager-Flusberg, Paul & Lord, 2005; White et al., 2006). This perspective necessitates detailed skills assessment of school-aged children with ASD. We propose to consider basic literacy skills that are part of communicative language abilities as another window for children with ASD to connect to the outside world in a broader sense. Most of the selected studies focused on language skills for pragmatic purposes; thus, future studies should pay more attention to the diverse modes of communication beyond verbal interactions. Literature has overlooked basic literacy components such as vocabulary recognition and comprehension via decoding skills in school-aged children despite their marked features in autism (Helen Tager-Flusberg, Paul & Lord, 2005). It is important to note that the separate notion of language skill sets–communicative performance used in real social contexts (i.e. language use) and linguistic knowledge (i.e. vocabulary and grammar)–is a prerequisite for the corresponding assessment of such extended skill classifications (Szatmari, Bryson, Boyle, Streiner, & Duku, 2003).

Importantly, school contexts can offer such extended motor-language skill integration in a sustained manner and therefore play a critical role in assisting children in developmental challenges. Moreover, instructional designs that involve computer-based interventions (CBI) and augmentative and alternative communication (AAC) can serve as alternatives for skills development of school-aged children with ASD. Future research on such advanced and integrated skill sets in tandem with motor and language/literacy skills may offer practical assistance for these individuals to achieve successful transitions to academic, social, and community participation in young adulthood in the long run (Dawn & Wehman, 2009; Liptak et al., 2011).

To summarise, much research posits motor and language abilities in children with ASD, not as permanent but as developing, with room for improvement through timely interventions and support. As Hannant (2018) purposely chose the term 'children with ASC' to refer to autism spectrum 'condition' rather than 'disorder', we welcome the current research paradigm shift that embraces the associative nature of developmental skills and their continuous improvement. The selected research papers proposed that identifying and understanding the associative patterns of core motor or language deficits can lead to developing social and other life skill practices for children with ASD. This perspective also aligns with a recent report released by the Centers for Disease Control and Prevention; autism should be conceived as a 'life-long disability' that requires continuous support for individuals of all ages throughout their life (Dietz, Rose, McArthur, & Maenner, 2020). These implications warrant future research with longitudinal and progressive approaches.

Conclusion

The major limitation of this review study is associated with the scope of the research disciplines. We purposefully selected studies that examined both motor and language/literacy skills developments from socio-cognitive perspectives; however, it is also imperative to consider neurological correlation and socio-environmental factors in developmental studies of children with ASD. In that regard, Lanter, Watson, Erickson, and Freeman (2012) emphasised not only the inheritable characteristics of autism but also the contextual environment as another key contributing factor to interaction and communication challenges. Nonetheless, this study provided critical insights into the relationship between developmental motor and language skills in young children with ASD that may persist into their adulthood, which necessitates future research with more rigorous and longitudinal approaches and interventions.

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