A Longitudinal Study of Joint Attention, Motor Imitation and Language Development in Young Children with Autism Spectrum Disorder in Taiwan

Abstract

This longitudinal study examined early predictors of language development in 74 young children with Autism Spectrum Disorder (ASD) in Taiwan. Participants were assessed twice (initial age between 17 to 35 months) on responding to joint attention (RJA), initiating joint attention (IJA), motor imitation with objects (object imitation; OI) and without objects (manual imitation; MI), and receptive and expressive language. The two assessments were 18 months apart. Results showed that both RJA and MI concurrently and longitudinally predicted receptive and expressive language across the two assessments. These findings were not entirely consistent with the limited and mixed findings of Western longitudinal studies. However, they have implications for early interventions aiming to facilitate language development in children with ASD internationally.

Keywords: autism spectrum disorder, joint attention, motor imitation, language development, longitudinal study

Introduction

Language development has long been a cause for concern in children with Autism Spectrum Disorder (ASD) which is a neurodevelopmental disorder characterized by impairments in social interaction and communication, as well as repetitive patterns of behaviors and restricted interests (American Psychiatric Association [APA], 2013). It is a highly heterogeneous condition, in that some children with ASD can be fluent with large vocabularies while others can have minimal language comprehension and production (Saul & Norbury, 2020; Tager-Flusberg et al., 2005). More recent reports suggested that there are as many as 50-74% of preschool children with ASD who use less than 20 functional words (Rose et al., 2016; Thurm et al., 2015). This heterogeneity in the preschool years predicts later social, vocational, and psychiatric outcomes (e.g., Howlin et al., 2000). For example, some aspects of expressive language, such as phrase speech at age 6, were positively associated with better adult outcome (Billstedt et al., 2005). Therefore, identifying the early factors that predict language development in young children with ASD has significant implications for clinical practice in developing effective early interventions and promoting better long-term outcomes for individuals with ASD. These early factors include social, cognitive, and motor abilities such as joint attention (e.g., Siller & Sigman, 2008; Yoder et al., 2015) and imitation (e.g., McDuffie et al. 2005; Young et al., 2011).

Joint attention is an ability to share and coordinate attention with other people in relation to external objects or events that typically emerges between 9 to 12 months of age (e.g., Brooks & Meltzoff, 2002; Carpenter et al., 1998). For example, following the mother's gaze and pointing to determine her attentional focus (namely, responding to joint attention; RJA), and pointing and showing objects to capture the mother's attention (namely, initiating joint attention; IJA) are two forms of joint attention. These behaviors serve as a basis for sharing information, understanding intentions, and learning vocabulary (e.g., Baldwin, 1991; Morales et al., 2000).

However, RJA and IJA may reflect different processes during development (e.g., Mundy et al., 2000, 2007). RJA emphasizes information processing of others' signals and increases linearly between the ages of 9 to 18 months, whereas IJA relates to volitional generation of goal-related behavior and increases in a cubic pattern (Mundy et al., 2007, 2009). Moreover, Mundy et al. (2007) indicated that RJA and IJA predicted different 24-month language outcomes at different ages after controlling for general cognitive development. That is, RJA at 9 months predicted receptive language whereas IJA at 18 months predicted both receptive and expressive language. Although joint attention in general is a commonly observed deficit in ASD (e.g., Chiang et al., 2008; Mundy et al., 1990), RJA may be less impaired than IJA in more developmentally advanced children with ASD (e.g., those with a non-verbal mental age of 30 months or above; Hurwitz & Watson, 2016; Leekam & Ramsden, 2006). Reduced rates of IJA but not RJA were also observed in infants aged 10-18 months who were later diagnosed with ASD compared to those without the condition (Nyström et al., 2019). RJA was also found to be a superior predictor of language development including both receptive and expressive language in children with ASD compared to IJA (e.g., Bono et al., 2004; Pickard & Ingersoll, 2015; Schietecatte et al., 2012; Sigman & McGovern, 2005; for a review, see Bottema-Beutel, 2016).

Imitation is another early ability evident at 9 weeks of age (Oostenbroek et al., 2016; Suddendorf et al., 2013). It increases dramatically and develops progressively over the first 2 years of life from imitating simple sounds, gestures, and actions to complicated, meaningless and sequential gestures and actions on objects (e.g., Abravanel et al., 1976; for a review, see Jones, 2007). Imitation serves similar functions as joint attention, such as sharing information (Meltzoff & Gopnik, 1993) and understanding intentions (Meltzoff, 1995). In particular, motor imitation is positively related to both joint attention (e.g., Carpenter et al., 1998; Carpenter & Tomasello, 1995) and language development, particularly later expressive language (e.g., Charman et al., 2000; Laakso et al., 1999). In children with ASD, imitation of facial, hand, and body movements as well as actions on objects were found to be delayed (e.g., Stone et al., 1997; Young et al., 2011). Longitudinal studies showed that motor imitation (with and without objects) was correlated with later expressive or receptive language and it predicted later expressive language even after controlling for initial language level in children with ASD aged 20 months to 4 years (Charman, 2003; Stone et al., 1997; Stone & Yoder, 2001). Training on motor imitation without objects was, however, reported to be more likely to elicit verbal imitation than training on motor imitation with objects in all 4 children with ASD aged 35 to 47 months in Ingersoll and Lalonde (2010). Moreover, motor imitation without objects was concurrently and longitudinally associated with expressive language over 1 year while motor imitation with objects was concurrently associated with play in children with ASD initially aged 23 to 35 months (Stone et al., 1997). These findings suggest that motor imitation without objects may be more important for language development in children with ASD. As such, motor imitation is similar to joint attention in various aspects, e.g., they both involve at least two types, each of which may differentially associate with language outcomes in children with ASD.

Although it is known that joint attention and motor imitation are interrelated and their relative contribution to different aspects of language development in ASD should be simultaneously examined (e.g., Toth et al., 2006), longitudinal studies investigating both joint attention and motor imitation as predictors of language outcomes in young children with ASD are limited. To our knowledge, there are five, only one of which assesses both measures of joint attention (i.e., IJA and RJA), both measures of motor imitation (with and without objects), and both measures of language outcomes (i.e., receptive and expressive language; McDuffie et al., 2005). It examined a shorter term (6-month) prediction between joint attention, motor imitation and language outcomes in 29 children with ASD aged 2 to 3 years in the United States. They found that both IJA (but not RJA) and motor imitation without objects predicted later expressive language while only IJA predicted later receptive language when cognitive level was controlled.

The other four studies reported inconsistent findings probably because of the different measures of joint attention, motor imitation and language outcomes that were included in the studies and other methodological differences including different participant samples. For example, Bal et al. (2020) studied predictors of long-term expressive language growth only in two large samples of language-delayed children with ASD, one in the United States (n = 86) and the other in Canada (n = 181). Results of the first sample indicated that IJA but not RJA nor motor imitation without objects at age 3 predicted expressive language at age 19 even when controlling for initial visual receptive abilities. For the other sample, neither joint attention nor motor imitation without objects at age 3 were significant predictors of expressive language at age 10.5. Table 1 presents a summary of the mixed findings across the five studies. It is essential to note that all six measures of interest (i.e., IJA, RJA, motor imitation with and without objects, and receptive and expressive language) are usually intercorrelated, so including or excluding any of these measures in a study would lead to different findings and reflecting the interdependency and complexity of social-communicative and language development in children with ASD (Bal et al., 2020; Yoder et al., 2015).

[Table 1]

Another issue is that none of these studies were conducted in non-Western cultures. A lack of understanding of the relationships between joint attention, motor imitation and language development in non-Western populations with ASD may lead to ineffective interventions, targeting factors that may not facilitate their language development and increasing long-term costs of further support across the world. Therefore, the current study sought to address this by investigating both measures of joint attention (i.e., IJA and RJA) and both measures of motor imitation (with and without objects) as concurrent and longitudinal predictors of both receptive and expressive language development over a period of 18 months in a modestly sized sample of young children with ASD in Taiwan. Given previous findings in Western children with ASD, we expected concurrent and longitudinal associations between joint attention, motor imitation and language outcomes in children with ASD in Taiwan. However, which measure(s) of joint attention and motor imitation would uniquely predict concurrent and longitudinal language outcomes in children with ASD in Taiwan over and above the other measure(s) was unpredictable based on previous findings. Current findings would provide practitioners and service providers across the world with a crucial piece of empirical evidence to determine and prioritize early intervention targets for non-Western children with ASD in facilitating their language development.

Method

Participants

Ninety children aged 17 to 35 months were referred from the department of psychiatry of a teaching hospital in Southwest area of Taiwan. Ethics approval was obtained from the Research Ethics Committee of the Ditmanson Medical Foundation Chia-Yi Christian Hospital in Taiwan and informed consent was obtained from all parents prior to their first assessment (Time 1, T1). Of these 90 children, 16 children dropped out after their first assessment due to reasons such as loss of contact. As a result, 74 children (64 males) were assessed 18 months after their first assessment when they were between 35 to 54 months. All children had a clinical diagnosis of ASD confirmed by a multidisciplinary team that included senior child psychologists with Ph.D. degree and child psychiatrists at the second assessment (Time 2, T2). This diagnosis was based on the results of the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1999) and Frazier et al.'s (2012) suggestion for the DSM-5 criteria for ASD. Frazier et al.'s suggestion was adopted because the original DSM-5 criteria was shown to have lower sensitivity for ASD and a relaxed algorithm that required one less deficit in either social communication/interaction or restricted/repetitive behaviors than the DSM-5 was suggested to increase the sensitivity (Frazier et al., 2012; Young & Rodi, 2014). Children with a severe delay in motor development and children who had not yet started walking were excluded from the study. The sample was from a rural and agricultural area of Southern Taiwan. Participant characteristics are presented in Table 2.

[Table 2]

Materials and Procedure

Participants were first assessed between September 2011 to April 2016 and re-assessed 18 months later, which was between March 2013 to September 2017. Each of the two assessments included the Mullen Scales of Early Learning (MSEL; Mullen, 1995), the Taiwan version of the Screening Tool for Autism in Two-Year-Olds (T-STAT; Chiang et al., 2013) and the ADOS (Lord et al., 1999). All three instruments were administered by qualified and trained researchers, taking approximately 2 hours to complete.

The MSEL is a standardized developmental test for assessing cognitive and language skills in children from birth to 68 months. It has four cognitive scales: Visual Reception, Fine Motor, Receptive Language, and Expressive Language. The age equivalent scores obtained from the Expressive Language and Receptive Language subscales were the indexes of a child's expressive and receptive language ability respectively. The average of the age equivalents of the two language subscales was conceived as a child's overall language age and the average age equivalents of all four cognitive scales was determined as a child's overall mental age. The MSEL has good concurrent validity with the Bayley Scales of Infant Development (Bayley, 1969) and acceptable internal consistency, test-retest reliability, and interrater reliability (Mullen, 1995). The Taiwanese version of the MSEL used in this study also exhibits moderate to strong correlation with the Vineland Adaptive Behavior Scale-Chinese version and excellent internal consistency and interrater reliability (Cheong et al., 2022).

The T-STAT is an interactive measure that was adapted from the Screening Tool for Autism in Two-Year-Olds (STAT; Stone et al., 2000, 2004). It is used for detecting ASD in children aged 16 to 35 months and has been validated in Taiwan (Chiang et al., 2013; Wu et al., 2021). It consists of 12 items, measuring four early social-communicative skills: Play (two items), Requesting (two items), Joint Attention (four items: one tests RJA and three test IJA), and Imitation (four items: two test motor imitation with objects and two test motor imitation without objects). Given that the number of items were not equivalent across RJA, IJA, motor imitation with objects (henceforth referred to as object imitation; OI) and motor imitation without objects (henceforth referred to as manual imitation; MI), new items were added and the scoring system was revised to make the scores for these measures more comparable for this study. All participants were tested with two RJA items, two of the three IJA items, three OI items and three MI items in approximately 15 minutes which was shorter than the completion time required by other Western standardized measures of joint attention and motor imitation (e.g., the Early Social Communication Scales and the Motor Imitation Scale; Mundy et al., 2003, Stone et al., 1997). Moreover, McDuffie et al. (2005) also used STAT to measure joint attention and pilot studies replicated previous findings for joint attention and motor imitation in Western children with ASD, indicating the suitability and validity of T-STAT in assessing joint attention and motor imitation in children with ASD in Taiwan. Although joint attention was frequently tested during face-to-face interaction at a table (e.g., the Early Social Communication Scales), the RJA and IJA items in this study were administered on the floor because our pilot studies suggested that face-to-face interaction at a table may easily cause eye contact between the participant and the examiner when the participant incidentally looked up from the table, leading to an overestimation of joint attention. All administrations were videotaped and coded to obtain scores for the following measures.

Each of the two RJA items used two distal objects which were placed by the two sides of the participant at an angle of 30-60 degrees. There were two trials for the first RJA item. Each trial involved the examiner calling the participant by name three times and then directing his/her attention to one of the two distal objects (e.g., a poster) by pointing or eye gaze. For the second RJA item, there were four trials: The participant's attention was directed to each of the two distal objects (e.g., a toy) by pointing for one trial and eye gaze for the other trial. Each trial was scored 1 if the participant followed the examiner's direction and looked at the distal object within three seconds. The score for RJA thus ranged from 0 to 6.

Full-initiating joint attention (F-IJA) and partial-initiating joint attention (P-IJA) were coded from the two IJA items. Each item had three trials. Each trial involved an object being shown to the participant by the examiner. For F-IJA, the participant scored 1 for each trial if s/he (1) showed back-and-forth eye contact between the object and the examiner with expression changes or verbalization; or (2) demonstrated gestures such as pointing or showing eye contact to the examiner. These criteria were equivalent to the descriptions of higher level IJA in Mundy et al. (2003). For P-IJA, the participant scored 1 for each trial if the participant showed one or some of the behavioral elements in the above criteria (e.g., showed back-and-forth eye contact between the object and the examiner without expression changes or verbalization; looked at the object and the examiner with expression changes but then did not look back at the object; pointing/showing without eye contact). These criteria were adapted from the scoring of the ADOS for IJA to avoid the floor effect that was likely to occur for F-IJA based on pilot studies. Both F-IJA and P-IJA had a score range of 0 to 6.

Each of the three OI items had a maximum of three trials. Each trial involved the examiner demonstrating an action with speech sounds on an object for three times and then inviting the participant to imitate by saying, "It's your turn." The participant was given 20 seconds to imitate the action. If the participant imitated the exact action with or without speech sounds, s/he would score 2 and the next item would be administered. If s/he imitated the action partially (e.g., rolling a toy car in one direction rather than rolling it back-and-forth) or inexactly (e.g., using both hands rather than one hand), s/he would temporarily score 1 and had two more trials to attempt a score of 2 instead. In other words, only the best response for the three trials would be scored. If s/he did not succeed for all three trials, she would score 0 for that item. The three MI items had the same structure and scoring system as the OI items, except that actions were performed manually without objects (e.g., turning an open hand into a fist and back to an open hand again). The scores for both OI and MI hence also ranged from 0 to 6.

A random sample of 29 administrations from T1 and 30 administrations from T2 (40% of all administrations) were coded by an independent observer. Kappa was calculated as reliability for each measure obtained from both time points. T1 yielded .91 for F-IJA, .90 for P-IJA, .92 for RJA, .91 for OI, and .88 for MI. T2 yielded .82 for F-IJA, .80 for P-IJA, .86 for RJA, .93 for OI, and .91 for MI.

The ADOS is a semi-structured, play-based and standardized instrument for observing and scoring language and communication, social and stereotyped behaviors, and restricted interests in individuals who are suspected of having ASD. It consists of four modules, each was designed for individuals of different levels of expressive language and took 30 to 45 minutes to complete. All participants were administered with Module 1 at T1. Eighteen of the participants were later administered with Module 2 at T2 because they showed some flexible phrase speech by then. Each module provides an algorithm with cutoffs corresponding to one of the following three categories: autism, autism spectrum (i.e., pervasive developmental disorder-not otherwise specified), or non-ASD. The Chinese version of the ADOS authorized by the publisher (WPS) has demonstrated good validity (Wu et al., 2020). The participants scored 14.36 (SD = 3.70) on the ADOS total score, and its sensitivity mapped with clinical diagnosis in this study were 1.

Results

Means and standard deviations of age equivalent scores on MSEL and scores for joint attention measures (i.e., F-IJA, P-IJA, and RJA), and motor imitation measures (i.e., OI and MI) for both time points are shown in Table 2. There was a floor effect for F-IJA at T1 as expected. No ceiling effects were observed. All T2 scores were significantly higher than all T1 scores using paired t-tests. None of the joint attention or motor imitation measures were distributed normally, and a log(X+1) transformation was therefore conducted. Pearson's correlations of language, joint attention, and motor imitation measures across the two time points are presented in Table 3. At T1, P-IJA, RJA, OI and MI were correlated with all language measures while F-IJA was correlated with none. At T2, all joint attention and motor imitation measures were correlated with all language measures. RJA, OI and MI but not F-IJA and P-IJA at T1 were correlated with all language measures at T2.

[Table 3]

Hierarchical regression analyses were conducted to examine whether certain measures of joint attention and motor imitation (i.e., the predictors) accounted for variance above and beyond the others when all of them were considered simultaneously in predicting language outcomes (i.e., the outcome variables) concurrently at T1 (Table 4) and T2 (Table 5) as well as longitudinally across T1 and T2 (Table 6). Due to the stricter scoring criteria of F-IJA, 78% of the participants had a score of zero for F-IJA at T1. Moreover, F-IJA has a hierarchical relation to P-IJA which contained information in F-IJA as well as information that was lost by the stricter scoring criteria of F-IJA. Therefore, F-IJA was not included in the regression analysis. Chronological age was controlled for by entering them in the first step of the analyses and P-IJA, RJA, OI, and MI were entered in the second step of the analyses. Residual plots and variance inflation factors (VIF) were examined to ensure that the assumptions of hierarchical multiple linear regression were met for each model. The model residuals were normally distributed. There was also no evidence of multicollinearity based on all VIF values being less than 2.09.

[Table 4, 5 & 6]

At T1 (Table 4), chronological age accounted for a substantial amount of variance for all language measures. When P-IJA, RJA, OI, and MI were entered in Step 2, the increments in the amounts of variance accounted for were also significant for all language measures. RJA concurrently predicted receptive and overall language while MI concurrently predicted all language measures. At T2 (Table 5), chronological age did not account for a substantial amount of variance for all language measures. When P-IJA, RJA, OI, and MI were entered in Step 2, the increments in the amounts of variance accounted for were significant for all language measures. RJA concurrently predicted expressive and overall language. Table 6 shows that chronological age at T1 did not account for a substantial amount of variance for all language measures at T2. When P-IJA, RJA, OI, and MI at T1 were entered in Step 2, the increments in the amounts of variance accounted for were significant for all language measures at T2. RJA at T1 longitudinally predicted receptive and overall language at T2 while MI at T1 longitudinally predicted all language measures at T2.

Discussion

Non-Western children with ASD are understudied in the literature on joint attention and motor imitation as early predictors of language development. We aimed to identify specific measures of joint attention and motor imitation that concurrently and longitudinally predicted language outcomes in young children with ASD in Taiwan over 18 months. Findings supported our hypothesis that joint attention and motor imitation were concurrently and longitudinally associated with language outcomes across T1 and T2. After controlling for chronological age, MI was the most pervasive predictor of all language measures whereas P-IJA (henceforth referred to as IJA) did not predict any of the language measures across T1 and T2. This was not entirely consistent with the limited and mixed findings of previous longitudinal studies that examined both joint attention and motor imitation as early predictors of language outcomes in Western children with ASD. Consistencies and inconsistencies between findings are discussed below.

Our findings replicated previous findings that RJA was related to language development in children with ASD (e.g., Bottema-Beutel, 2016; Sigman & McGovern, 2005; Yoder et al., 2015). RJA is a child's propensity to attend and respond to others' social bids as important sources of information about the world, including language. If RJA was not displayed, linguistic input may not be received with context, missing the opportunities to understand reference to objects and use the linguistic input for objective reference. This corresponds with previous findings that RJA concurrently predicted both receptive and expressive language in children with ASD (e.g., Pickard & Ingersoll, 2015) and our findings that RJA concurrently predicted receptive and overall language at T1 and expressive and overall language at T2. However, RJA at T1 longitudinally predicted receptive and overall but not expressive language at T2. This could be because both RJA and receptive language involve information processing of others' signals so their associations may be more stable over time compared to the association between RJA and expressive language. Mundy and Jarrold (2010) also suggested that children with ASD may remain nonverbal while making gains in RJA over time. On the other hand, IJA deficits were consistently observed in infants who were later diagnosed with ASD, preschoolers and adolescents with ASD (e.g., Charman, 2003; Hobson & Hobson, 2007; Nyström et al., 2019) and were less robustly predictive of language development compared to RJA (e.g., Bono et al., 2004; Bottema-Beutel, 2016). This is consistent with our findings that IJA did not predict any language measures while RJA predicted two of the three language measures across T1 and T2. However, three previous longitudinal studies showed that IJA was associated with later receptive and expressive language in children with ASD (Bal et al., 2020; Charman, 2003;

McDuffie et al., 2005; see Table 1). This inconsistency may be explained by methodological differences which provided a context that made interpretation more complicated and tenuous.

First, Bal et al. (2020) and Charman (2003) did not include all four measures of joint attention and motor imitation (i.e., RJA, IJA, OI, and MI) as the current study. Bal et al. (2020) did not measure MI whereas Charman (2003) did not measure both RJA and MI. Given that these measures are intercorrelated in this study (see Table 2) as well as previous studies (e.g., Pickard & Ingersoll, 2015; Toth et al., 2006), including or excluding any of them in predicting language development in ASD would lead to different findings. For example, in this study, RJA and OI at T1 were correlated. They had approximately the same variability and similar strength of correlation with language outcomes at T2 (Table 3). However, they performed differently in accounting for variance in language outcomes in the hierarchical regression model presented in Table 6, with RJA accounting for significant unique variance in receptive but not expressive language, whereas OI accounted for nonsignificant unique variance in both language outcomes. If a study measured OI but not RJA (e.g., Charman, 2003), it may find that OI uniquely and longitudinally predicted both language outcomes (however, Charman only conducted correlation but not regression analysis). By simultaneously examining the relative contribution of these intercorrelated measures to language development in ASD, McDuffie et al. (2005), compared to the other two studies, was more comparable to the current study. Moreover, both McDuffie et al.'s study and the current study used STAT to measure joint attention. However, McDuffie et al. reported that IJA longitudinally predicted both receptive and expressive language whereas the current study found that IJA did not predict any language measures. This inconsistency could be due to sample characteristics, e.g., age.

It is possible that IJA at older but not younger ages longitudinally predicts both receptive and expressive language in children with ASD given that the mean age of McDuffie et al.'s (2005) sample at T1 (i.e., 32.40 months) was 8.22 months older than that of the current sample (i.e., 24.18 months). Bal et al. (2020) also reported that IJA at an older mean age of 41.57 months predicted expressive language at age 19 in their first sample. However, they did not measure receptive language and MI so it is unknown whether it would replicate McDuffie et al.'s finding that IJA at an older mean age also predicted later receptive language over and above other joint attention and motor imitation measures in children with ASD. One may also argue against this possibility regarding IJA based on Charman's (2003) finding that IJA at a younger mean age of 20.6 months was longitudinally associated with both language outcomes in children with ASD. However, it was not examined as a longitudinal predictor of both language outcomes while controlling for other joint attention and motor imitation measures. Thus, further investigation is required to verify whether IJA predicts later receptive and expressive language over and above other joint attention and motor imitation measures in children with ASD.

The current study also found that RJA longitudinally predicted receptive language whereas McDuffie et al. (2005) did not. Could it be possible that RJA at younger but not older ages longitudinally predicts receptive language in children with ASD? It is less likely because Yoder et al. (2015) reported that RJA at an older mean age of 34.7 months longitudinally predicted receptive language in children with ASD. Other studies also indicated that RJA when assessed at older ages concurrently predicted both receptive and expressive language in children with ASD (e.g., Bottema-Beutel, 2016; Pickard & Ingersoll, 2015). Hence, initial age of the participants may not explain the different findings regarding RJA between McDuffie et al.'s study and the current study. It may rather be explained by the very small variability of RJA in McDuffie et al.'s study. This may be related to small sample size and trials being eliminated from analysis due to faulty camera angles that precluded accurate coding of eye gaze. In this sense, our findings regarding RJA may be more reliable.

The current study and McDuffie et al. (2005) were however consistent in the findings that

MI predicted later expressive language while OI did not predict later expressive and receptive language in children with ASD, despite the two studies using different measures of motor imitation. This suggests a replication and generalization across measures of motor imitation and populations of children with ASD from different cultures. Although MI and OI were significantly correlated and they had similar strengths of first order correlations with receptive and expressive language across T1 and T2 (Table 3), they performed differently in accounting for variance in language outcomes in the hierarchical regression models presented in Table 4 and 6, with MI but not OI accounting for significant unique variance in all language measures. These findings correspond with previous findings that MI was more likely to be concurrently and longitudinally associated with language than OI in children with ASD (Ingersoll & Lalonde, 2010; Stone et al., 1997). It could be because MI is a form of gesture which may be more communicative than OI. It is also possible that children with ASD who managed to perform MI had advanced skills to support language development given than MI is more difficult than OI (DeMyer et al., 1972; Stone et al., 1997). However, other previous studies either combined OI and MI as a composite measure of motor imitation (Stone & Yoder, 2001; Yoder et al., 2015) or assessed only one of the two (Bal et al., 2020; Charman, 2003). Future studies should include both OI and MI as separate measures of motor imitation to further clarify the relative contribution of MI versus OI to language development in children with ASD.

Our findings suggest that MI was a pervasive predictor of all language outcomes across two time points in children with ASD in Taiwan. This is new to the literature, extending the motor-oriented theories of language development in ASD from explaining variations in expressive language (e.g., Gernsbacher et al., 2008; Stone et al., 1997; Stone & Yoder, 2001) to receptive and overall language development in children with ASD. However, replication is needed to verify this new evidence and extension. It is also not clear whether extrinsic factors such as culture played a role in the finding. In Chinese culture, learning, including language learning, has a strong emphasis on imitation (Cortazzi & Jin, 1996). For example, a Chinese kindergarten teacher would model a dialogue with exaggerated gestures and intonation and then Chinese 4-year-olds would mimic the pronunciation, intonation and gestures exactly. The same strategy of pairing verbal and gesture imitation is used in training and interventions for children with ASD in Western cultures (e.g., Ingersoll & Lalonde, 2010). Therefore, extrinsic factors such as learning culture and training strategy may contribute to the concurrent and longitudinal associations between MI and language development in children with ASD. Examinations of more comprehensive models that include both intrinsic and extrinsic predictors for language development in ASD, such as the one in Yoder et al. (2015), and investigating moderation/mediation effects on the associations across different populations may further improve our understanding on language development in ASD. However, the more factors a study includes the larger the sample size is needed which is a long-standing challenge to this area of longitudinal research (Bal et al., 2020).

Overall, the current findings suggested that both MI and RJA may be important potential intervention targets for young children with ASD in Taiwan to acquire and develop language. For example, directive statements and attentional devices such as “Do this” or “Look over here” may promote MI and RJA both of which increase effective linguistic mapping. Bono et al.’s (2004) non-systematic observations suggested that Western practitioners tended to direct a child’s focus of attention to objects, events, or symbols that are important to intervention goals. They also indicated that the relationship between amount of intervention and language gain depended on RJA. In this sense, a directive approach may be universally practical for practitioners and service providers across the world to facilitate RJA, MI and social interactions in young children with ASD, contributing to their overall language development.

To conclude, the current study suggested that both MI and RJA concurrently and longitudinally predicted language development over 18 months in young children with ASD in

Taiwan. Although the current findings were not entirely consistent with the limited and mixed findings of previous Western longitudinal studies, the inconsistencies could be explained by the different measures of joint attention, motor imitation and language outcomes that were included in the studies and other methodological differences including different participant samples and their sizes. These inconsistencies also highlighted that more longitudinal studies are needed to further clarify the relationships between joint attention, motor imitation and language development in different populations with ASD. Moreover, the contributions of extrinsic factors in these relationships should be considered in future studies with larger sample sizes. Despite this limitation, the current findings have crucial implications for early intervention and long-term care across the world, providing an important piece of empirical evidence for practitioners and service providers to determine and prioritize early intervention targets for children with ASD in facilitating their language development.

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Table 1

Associations and predictions found between joint attention, motor imitation and later language outcomes in previous longitudinal studies

	Language	
	Receptive	Expressive
Joint attention		
IJA	Charman (2003)	Bal et al. (2020)
	McDuffie et al. (2005)	Charman (2003)
		McDuffie et al. (2005)
RJA	Yoder et al. (2015)	Yoder et al. (2015)
Motor imitation		
OI	Charman (2003)	Stone and Yoder (2001)
MI		McDuffie et al. (2005)
		Stone and Yoder (2001)

Note. IJA = Initiating Joint Attention; RJA = Responding Joint Attention; OI = Object Imitation; MI = Motor Imitation

Table 2

Mean and standard deviation of participants' age, age equivalent scores on MSEL and scores for joint attention and imitation items on T-STAT at both time points

	Time							
	One			Two				
Characteristic	Mean	*SD*	Range	Mean	*SD*	Range	*t*	*p*
Age (months)	24.18	4.44	17-35	42.74	4.64	35-54	-130.02	<.001
MSEL (months)								
Overall mental age	15.20	4.91	7-33	32.11	10.66	10-58	-18.51	<.001
Visual reception	17.74	5.71	7-41	36.12	13.04	11-69	-14.61	<.001
Fine motor	19.96	4.38	9-33	33.92	9.07	17-62	-18.14	<.001
Receptive language	13.03	6.57	5-36	31.07	12.62	5-59	-15.78	<.001
Expressive language	10.07	5.95	4-33	27.32	11.07	4-53	-15.94	<.001
Overall language	11.55	5.77	5-35	29.20	11.42	6-56	-17.16	<.001
T-STAT								
F-IJA	.35	.78	0-4	1.01	1.21	0-5	-4.33	<.001
P-IJA	.96	1.36	0-6	1.95	1.70	0-6	-4.09	<.001
RJA	1.92	2.09	0-6	4.05	2.02	0-6	-7.28	<.001
OI	3.59	2.01	0-6	4.68	1.58	0-6	-4.50	<.001
MI	.95	1.35	0-5	3.39	2.25	0-6	-9.12	<.001

Note. Paired t-test was performed by comparing Time One and Two. MSEL = Mullen Scales of Early Learning; T-STAT = Taiwan Version of the Screening Tool for Autism in Two-Year-Olds; F-IJA = Full-Initiating Joint Attention; P-IJA = Partial-Initiating Joint Attention; RJA = Responding Joint Attention; OI = Object Imitation; MI = Motor Imitation

Table 3

Correlations among language, joint attention, and imitation measures across both time points

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Time 1																
1. Receptive language	—	$.70^{***}$	$.93^{***}$	.22	$.35^{**}$	$.63^{***}$	$.35^{**}$	$.50^{***}$								
2. Expressive language		—	$.91^{***}$	.12	$.23^{*}$	$.39^{***}$	$.31^{**}$	$.54^{***}$								
3. Overall language			—	.19	$.32^{**}$	$.56^{***}$	$.35^{**}$	$.57^{***}$								
4. F-IJA				—	$.72^{***}$	.16	.20	-.06	.06	.14	.10	.16	.09	.22	.10	.04
5. P-IJA					—	$.36^{**}$	$.38^{***}$	.14	.16	.21	.19	.20	.22	$.29^{*}$	.22	.09
6. RJA						—	$.34^{**}$	$.42^{***}$	$.49^{***}$	$.40^{***}$	$.46^{***}$	.11	$.31^{**}$	$.27^{*}$	$.23^{*}$	.08
7. OI							—	$.41^{***}$	$.36^{**}$	$.36^{**}$	$.37^{**}$	.07	.20	.22	$.36^{**}$	.18
8. MI								—	$.45^{***}$	$.45^{***}$	$.46^{***}$	.04	.21	.05	.17	.14
Time 2																
9. Receptive language									—	$.86^{***}$	$.97^{***}$	$.24^{*}$	$.37^{**}$	$.49^{***}$	$.55^{***}$	$.55^{***}$
10. Expressive language										—	$.96^{***}$	$.30^{**}$	$.38^{***}$	$.54^{***}$	$.58^{***}$	$.59^{***}$
11. Overall language											—	$.28^{*}$	$.39^{***}$	$.53^{***}$	$.58^{***}$	$.59^{***}$
12. F-IJA												—	$.76^{***}$	$.26^{*}$	$.35^{**}$	$.44^{***}$
13. P-IJA													—	$.32^{**}$	$.44^{***}$	$.37^{**}$
14. RJA														—	$.52^{***}$	$.54^{***}$
15. OI															—	$.64^{***}$
16. MI																—

Note. F-IJA = Full-Initiating Joint Attention; P-IJA = Partial-Initiating Joint Attention; RJA = Responding Joint Attention; OI = Object Imitation; MI = Motor Imitation

$^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$ (two-tailed)

Table 4

Hierarchical regression analyses of the concurrent contribution of joint attention, and imitation to language outcomes at T1

	Language outcomes					
	Receptive language		Expressive language		Overall language	
	B	ΔR^2	*B*	ΔR^2	*B*	ΔR^2
Step 1:		.07*		.31***		.19***
Age	.38*		.74**		.56***	
Step 2:		.46***		.26***		.40***
Age	.28*		.66***		.47***	
P-IJA	4.08		3.36		3.72	
RJA	9.21***		3.18		6.19***	
OI	-.49		-1.66		-1.08	
MI	6.87**		9.32***		8.09***	

Note. P-IJA = Partial-Initiating Joint Attention; RJA = Responding Joint Attention; OI = Object Imitation; MI = Motor Imitation

*p < .05 **p < .01***p < .001

Table 5

Hierarchical regression analyses of the concurrent contribution of joint attention, and imitation to language outcomes at T2

	Language outcomes					
	Receptive language		Expressive language		Overall language	
	B	ΔR^2	*B*	ΔR^2	*B*	ΔR^2
Step 1:		.02		.03		.02
Age	.35		.38		.36	
Step 2:		.40***		.46***		.46***
Age	.33		.35		.34	
P-IJA	6.91		5.56		6.24	
RJA	10.63		11.38*		11.00*	
OI	15.75		13.70		14.73	
MI	8.13		7.67		7.90	

Note. P-IJA = Partial-Initiating Joint Attention; RJA = Responding Joint Attention; OI = Object Imitation; MI = Motor Imitation

$^*p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 6

Hierarchical regression analyses of the longitudinal contribution of joint attention, and imitation at T1 to language outcomes at T2

	Language outcomes					
	Receptive language		Expressive language		Overall language	
	B	ΔR^2	*B*	ΔR^2	*B*	ΔR^2
Step 1:		.02		.03		.02
Age	.39		.40		.40	
Step 2:		.31***		.26***		.30***
Age	.11		.17		.14	
P-IJA	-3.03		1.60		-.71	
RJA	13.53**		7.47		10.50*	
OI	7.10		5.41		6.25	
MI	11.81*		12.25*		12.03*	

Note. P-IJA = Partial-Initiating Joint Attention; RJA = Responding Joint Attention; OI = Object Imitation; MI = Motor Imitation

*$p < .05$ **$p < .01$ ***$p < .001$