Language development trajectories in young children with developmental disabilities in Taiwan

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Abstract

Background: Language development is critical to various outcomes in young children with developmental disabilities (DD), including autism spectrum disorder (ASD) and non-ASD delays. However, language development trajectories in young children with DD in non-Western populations remain unclear.

Aims: To investigate the language development trajectories of young children with DD in Taiwan. We investigated the relationship between trajectory class assignment and diagnostic outcomes (ASD or non-ASD delays) at 3 years after enrollment in the study and the differences in early abilities among children in different trajectory classes.

Methods and Procedures: The participants were 101 young children with DD (mean age: 21.88 months; follow-up: 1.5 and 3 years after enrollment). Growth mixture modeling analyses were conducted to receptive language developmental quotients (RLDQ) and expressive language developmental quotients (ELDQ) on the basis of the Mullen Scales of Early Learning.

Outcomes and Results: Three RLDQ trajectories were identified, namely age expected, delayed catch-up, and delayed, and two ELDQ trajectories were identified, namely delayed improve and delayed. Trajectory class assignment was related to diagnostic outcomes. Children who demonstrated more proficient skills at the early time point, demonstrated improved language outcomes 3 years later. However, adaptive functioning did not differ between the two ELDQ trajectory classes.

Conclusions and Implications: Language development in young children with DD in Taiwan is heterogeneous. Delayed receptive and expressive language development trajectories relate to later ASD diagnoses.

Keywords: Developmental disability, Language development, Autism spectrum disorder, Developmental trajectory

What this paper adds

Longitudinal studies have revealed that language development in young children with developmental disabilities (DD) is heterogeneous. Some children with DD are later diagnosed as having autism spectrum disorder (ASD) and they were the interest of most studies. Only a few studies have included young children with DD who were not diagnosed as having ASD in their samples. In addition, studies exploring receptive and expressive language development trajectories in young children with DD remain limited, and no such study has involved non-Western populations. This study recruited young children with DD in an Eastern culture to investigate the independent trajectories of receptive and expressive language development. The results demonstrate that both receptive and expressive language development are highly heterogeneous over time in this population.

1. Introduction

Developmental disabilities (DD) are conditions caused by cognitive and/or physical impairment originating in early life that can result in functional or adaptive limitations (Carollo et al., 2021). These conditions include autism spectrum disorder (ASD), language delays and developmental delays. Language delay is usually the primary concern and usually first noticed by the parents or guardians of children with DD; some affected children are later diagnosed as having ASD (Coonrod & Stone, 2004; Hess & Landa, 2012), a neurodevelopmental disorder characterized by deficits in social interaction or communication, restricted interests, and repetitive patterns of behavior (APA, 2013). Language skills in early life can strongly predict cognitive abilities (Mayo et al., 2013), later language skills (Delehanty et al., 2018; Matte-Landry et al., 2020), and adaptive social abilities (Anderson et al., 2009; Matte-Landry et al., 2020). Numerous studies have investigated language development in children with DD and revealed substantial variation in language development among individuals, especially those with ASD (for example, see Anderson et al., 2007). For example, some children with ASD can develop age-expected or even better language skills later in life, but approximately 25%–30% do not develop functional language skills (Tager-Flusberg & Kasari, 2013). This heterogeneity could be an obstacle to the provision of suitable early interventions. Therefore, an in-depth exploration of language development trajectories (e.g., receptive and expressive language abilities) in young children with DD is required to better understand the diverse patterns of language development in this population.

Studies have investigated the phenotypes of language development in children with DD. For example, in an Australian study, Brignell, Williams et al. (2018) independently investigated the phenotypes of receptive and expressive language development in 27 children with ASD and 119 children with language impairment (age: 4 to 7 years). They revealed that both children with ASD and those with language impairment exhibited three patterns (i.e., increasing, stable, and declining) in receptive and expressive language development. However, the researchers only recruited children with an intelligence quotient of over 70, and the subgroups were identified on the basis of individual changes in standard scores; the latent subgroups of the entire population, which assume to allow different growth parameters across unobserved subgroups (i.e., categorical latent variables), were not investigated.

To the best of our knowledge, only two studies have investigated the latent trajectories of language development in children who were suspected of having DD. Using latent growth modeling approaches (e.g., growth mixture modeling [GMM]), Pickles et al. (2014) explored the latent trajectories of joint receptive and expressive language development in a US sample of 192 young children who were referred for possible ASD from the age of 2 years and conducted follow-ups until the age of 19 years. They identified seven developmental trajectories with different improving progression rates. Some children exhibited development similar to that expected of a child without DD (i.e., their age equivalent matched chronological age), whereas some exhibited slow improvement. The results revealed that some children with markedly delayed language abilities at 2 years of age had achieved typical development by the age of 6 years. In addition, their results indicated that language development beyond 6 years of age among children in different trajectory classes progressed in parallel (i.e., exhibited similar improving progression rates). One study conducted on a US sample also investigated the latent trajectories of language development in children with DD and revealed similar developmental patterns to those identified by Pickles et al. Henry et al. (2018) explored the trajectories of language development in 30 young children with language delays and 61 with typical development at 18, 24, and 36 months of age. GMM analyses were conducted to the verbal age equivalent and revealed three trajectory classes: Age-appropriate, delay catch-up, and delayed. These findings help us understand the different trajectories of language development in children with DD. However, these studies have investigated the trajectories of overall language development, while the independent trajectories of receptive and expressive language development still need to be examined.

Several studies have provided information about the independent trajectories of receptive and expressive language development in children with DD through the high-risk sample. For example, Landa et al. (2012) examined the developmental trajectories in 204 siblings of children with ASD from age 6 to 36 months in a US sample. GMM analyses were conducted on each domain of the Mullen Scales of Early Learning (MSEL; Mullen, 1995) and revealed four trajectory classes: Accelerated, normative, language/motor delays, and developmental slowing. Specifically, Longard et al. (2017) examined the independent trajectories of receptive and expressive language development in 371 siblings of children with ASD and 152 low-risk children from age

6 to 36 months in a Canadian sample. They identified three developmental trajectories (i.e., inclining, stable-average, and declining) in receptive and expressive language abilities, respectively. These findings indicate that distinct latent developmental trajectories exist independently in receptive and expressive language abilities in high-risk sample of children with DD. However, it is not clear exactly how the independent trajectories of receptive and expressive language development are presented in clinically referred children with DD.

Given that some children with language delays are later diagnosed as having ASD (Coonrod & Stone, 2004; Hess & Landa, 2012), some studies have explored the relationship between developmental trajectories and diagnostic outcomes. Previous findings revealed that compared with other children, children with ASD had a higher likelihood of having poor language development (Landa et al., 2012; Longard et al., 2017; Pickles et al., 2014). Henry et al. (2018) revealed that developmental trajectories were related to diagnostic outcomes at 36 months of age (i.e., ASD, non-ASD delay, and no delay). In total, 75% of children with ASD were assigned to the delayed trajectory class in Henry et al., and 25% of those with ASD experienced a notable improvement over 1.5 years. These findings suggest that children with ASD could have less favorable language development than children with DD who were not diagnosed as having ASD. Additionally, diverse developmental trajectories were noted in the language abilities of children with ASD.

Studies have indicated that the phenotypes of language development in children with ASD have some similarities to those of children with DD in general for example, they may exhibit a slow improvement (Anderson et al., 2007; Fountain et al., 2012), a stable improvement (Frazier et al., 2021; Landa et al., 2012), a dramatic improvement (Anderson et al., 2007; Fountain et al., 2012), or a decline in progress (Brignell, Morgan et al., 2018; Longard et al., 2017). This high variation in developmental progress was more noticeable in children under 6 years of age (Fountain et al., 2012); this finding is similar to that of a study that recruited children with DD (Pickles et al., 2014). However, although some studies have revealed no noticeable developmental pattern of an age-expected level of language abilities in children with ASD over time (Brignell, Williams et al., 2018; Henry et al., 2018; Pickles et al., 2014), some studies have revealed that a proportion of children with ASD had an age-expected ability level over time in expressive language development (Tek et al., 2014), and both receptive and expressive language development (Frazier et al., 2021; Landa et al., 2012; Longard et al., 2017). Differences in participants and statistical approaches could explain the inconsistency in these findings. Table 1 summarizes the study samples and statistical approaches of these studies.

Table 1

In addition to exploring the trajectories of language development in children with DD and how it related to diagnostic outcomes, some studies gain a deeper understanding of the differences in early abilities among children with DD in different trajectory classes. For example, Pickles et al. (2014) examined the relationships between early abilities and different trajectory classes. Their results revealed that children assigned to trajectories with the slowest development had the lowest cognitive abilities and the highest severity of autism symptoms, whereas those assigned to trajectories of nearly typical development or mild delay had the strongest cognitive abilities and the mildest autism symptom severity. Fountain et al. (2012) and Frazier et al. (2021), who only recruited children with ASD, had similar findings to those of Pickles et al. with regard to the relationships between early abilities and trajectory classes. These findings suggest that individuals in different trajectory classes exhibited different levels of development in different abilities from a young age.

In summary, language development in young children with DD is highly heterogeneous (e.g., Anderson et al., 2007), especially in children aged under 6 years (Fountain et al., 2012; Pickles et al., 2014). Studies that have investigated language development trajectories in children with DD, including those who were later diagnosed as having ASD, have revealed that such children have similar developmental characteristics to children with ASD (Henry et al., 2018; Pickles et al., 2014). However, studies that have included young children with DD who were not diagnosed as having ASD are limited; furthermore, only a few studies have independently explored the trajectories of receptive and expressive language development (Brignell, Williams et al., 2018; Frazier et al., 2021). None of these studies have been conducted in a non-Western society. To obtain a deeper understanding of language development in children with DD in non-Western societies, the current study independently explored the latent trajectories of receptive and expressive language development in young children with DD in Taiwan over three time points within 3 years. We hypothesized that at least two trajectories would independently exist in receptive and expressive language development. To explore the assignment of trajectory classes to children with ASD, we examined the relationship between trajectory class assignment and diagnostic outcomes (ASD or non-ASD delays) made at 3 years after enrollment. We expected that children with ASD would be assigned to trajectories with less favorable developmental outcomes. We also investigated the differences in early abilities, namely nonverbal cognitive ability, overall cognitive ability, social communicative skills, adaptive functioning, and autism symptom severity, among children in different trajectory classes; we expected that children assigned to trajectories with more favorable outcomes would have stronger early abilities.

2. Method

2.1. Participants

Children aged 16–35 months and suspected of having DD (e.g., ASD, language delays, developmental delays) by the child and adolescent psychiatrists were referred from the Interdisciplinary Assessment Center for Children with Suspected Developmental Delay of a teaching hospital in a rural county of Taiwan. Children with genetic disorders, metabolic disorders, or sensory and motor impairment on the basis of medical reports were excluded. In total, 162 Taiwanese children (mean age = 21.5 months, range = 16–35 months) suspected of having DD, including 74 (45.7%) children with ASD and 88 (54.3%) children with non-ASD delays, participated in the initial assessment (Time 1, T1) and met the inclusion criteria for the study, namely speaking Mandarin Chinese as a primary language and having a *T*-score below 35 in any of the four subscales of the MSEL (Mullen, 1995) measured at T1. However, 61 participants (37.6%) did not complete the follow-up assessments for various reasons (e.g., loss of contact). In total, 101 young children (80 males, 21 females) who completed the MSEL at three time points were enrolled in this study; their demographic information is presented in Table 2.

All participants completed the initial assessment (Time 1, T1; mean age = 21.88 months, range = 16–35 months) and two follow-up assessments conducted 1.5 years (Time 2, T2; mean age = 40.36 months, range = 31–52 months) and 3 years (Time 3, T3; mean age = 59.15 months, range = 53–71 months) later. All participants were diagnosed at T3 on the basis of the criteria from the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5; APA, 2013) by a multidisciplinary team comprising two senior clinical psychologists with doctoral degrees who specialized in child psychology and two senior child and adolescent psychiatrists.

According to the DSM-5 criteria for diagnosing ASD, children are required to exhibit at least three domains of social communication or interaction skills and two in restricted or repetitive behavior. These criteria were met, according to the results of the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1999), the Autism Diagnostic Interview-Revised (ADI-R; Le Couteur et al., 2003), cognitive and adaptive functioning tests, clinical observations, children's developmental history, and parental concerns. Some clinicians in Taiwan still use the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR; APA, 2000) for assessments and diagnoses; therefore, eight children who met the DSM-IV criteria for a pervasive developmental disorder not otherwise specified (PDD-NOS) were also diagnosed as having ASD in the current study. On the basis of the clinical diagnoses at T3, we divided participants into groups with ASD and non-ASD delays. According to our results, 53% (*n* = 54) of participants who met the diagnostic criteria for ASD in the DSM-5 or PDD-NOS in the DSM-IV were in the ASD group, and the other 47% (*n* = 47) who did not meet the criteria for ASD were in the non-ASD delays group.

Table 2

2.2. Procedure

All participants were assessed using the MSEL (Mullen, 1995) and the ADOS (Lord et al., 1999) individually, and their primary caregivers completed the Adaptive Behavior Assessment System-II (ABAS-II; Harrison & Oakland, 2003) at each time point. Additionally, the Taiwanese version of the Screening Tool for Autism in Two-Year-Olds (T-STAT; Chiang et al., 2013; Wu et al., 2019) was used for measuring early social communicative skills at T1, and the ADI-R (Le Couteur et al., 2003) was administered to the primary caregivers of the children at T3 to evaluate the severity of autism symptoms and confirm diagnoses. All assessments were administered in Mandarin by qualified and well-trained researchers.

2.3. Measures

The MSEL (Mullen, 1995), conducted at each time point, is a standardized developmental test for young children aged 0–68 months. It includes visual reception, fine motor, receptive language, and expressive language subscales. Specifically, the receptive language subscale evaluates children's vocabulary development, understanding of verbal instructions, and general information; the expressive language subscale evaluates children’s vocabulary development, specific vocal or verbal responses to tasks, and concept formation (Mullen, 1995). The MSEL was recommended as a component of a core assessment battery for ASD (Ozonoff et al., 2005). The average age equivalent in each of the four subscales was calculated to determine an overall mental age (MA). Three participants were older than 68 months (i.e., 69, 70, and 71 months) at T3 and hit the ceiling of some subscales; thus, their chronological ages (CA) were used as the age equivalents for these subscales. Developmental quotients (DQ), calculated by dividing MA by CA and multiplying the result by 100, represent cognitive functioning. Receptive language developmental quotients (RLDQ), expressive language developmental quotients (ELDQ), and nonverbal developmental quotients (NVDQ) were calculated to represent receptive language, expressive language, and nonverbal abilities, respectively. 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 MSEL-Taiwan version 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 ADOS (Lord et al., 1999), conducted at each time point, is a semi-structured, standardized, and play-based assessment. It has excellent internal consistency, test–retest reliability, and interrater reliability (Lord et al., 2000), and it is widely used in empirical research related to ASD (Ozonoff et al., 2005). Four modules are available; which of these modules are selected for use depended on the age and expressive language ability of the child. The ADOS-2 has not been culturally adapted to and validated in Taiwan at the time of writing; thus, the Chinese version of the ADOS authorized by the publisher (WPS) was used in this study. It uses the same cut-off as the ADOS and demonstrates good validity (Wu et al., 2020), and its sensitivity and specificity mapped with clinical diagnosis in this study were 1 and .94. All participants were administered Module 1 of the ADOS at T1. Ten participants with phrase speech were administered Module 2 at T2, and 10 with fluent speech were administered Module 3 at T3. In addition, 17 participants were administered Module 1 at T3 because of their poor expressive ability.

The ABAS-II (Harrison & Oakland, 2003), conducted at each time point, is a parent-reported assessment tool for measuring the adaptive behaviors of young children. The composite scores of three subdomains (i.e., conceptual, social, and practical) and a global adaptive composite score can be obtained from the 10 subscales. The ABAS-II has fair concurrent validity with the Vineland Adaptive Behavior Scale (Sparrow et al., 1984) and exhibits good reliability and validity (Harrison & Oakland, 2003). The Chinese version of the ABAS-II also exhibits good reliability and validity (Lu & Chen, 2008); however, it did not contain the norms of children under two years old, the US norms were used in this study. Two pieces of data on the ABAS-II were missing at T3 because of parental refusal to complete the ABAS-II.

The Taiwanese version of the Screening Tool for Autism in Two-Year-Olds (T-STAT; Chiang et al., 2013; Wu et al., 2019), conducted at T1, is an interactive instrument designed for screening children with ASD from DD and it has good accuracy (Chiang et al., 2013; Wu et al., 2019). The test takes approximately 20 minutes to complete, and the total score ranges from 0 to 4. A higher score represents greater impairment in early social communicative skills. One participant did not complete the T-STAT because of time constraints.

The ADI-R (Le Couteur et al., 2003), conducted at T3 for all participants, is a semi-structured interview administered to one parent or primary caregiver of children suspected of having ASD. It measures the severity of autism symptoms and indicating abnormalities in three subdomains: Reciprocal social interaction; communication; and restricted, repetitive, and stereotyped pattern behaviors. The Chinese version of the ADI-R used in this study was authorized by the publisher (WPS) which utilizes the same cut-off as the ADI-R. It demonstrates a satisfactory concurrent validity to the Chinese version of the Social Communication Questionnaire (Gau et al., 2011), and its sensitivity and specificity mapped with clinical diagnosis in this study were .89 and .94.

2.4. Statistical analysis

GMM analyses were conducted on RLDQ and ELDQ to identify the latent class trajectories of receptive and expressive language development across three time points. Unlike conventional growth modeling, GMM relaxes the assumption that participants are members of a single population and follow the same growth trajectory. Different growth parameters are permitted across unobserved classes (i.e., categorical latent variables) in GMM. According to the level of assumptions and constraints of model parameters, there are several types of GMM. For example, latent class growth analysis (LCGA), the simplest type of GMM, assumes that the intercept and slope are fixed within each class. On the basis of this assumption, the growth trajectories of individuals within a class are homogeneous. Subsequential models of GMM relax the constraints of variance or covariance of the intercept and/or slope accordingly for exploring the complexity of developmental variation.

To investigate the latent class trajectories of receptive and expressive language development across individuals, LCGA, which is considered a starting point for conducting GMM (Jung & Wickrama, 2008), was applied first. Further investigation of variation in the development of receptive and expressive language was conducted through two parameterizations of growth mixture models as follows: (1) relaxing the variance of the intercept (random intercept) within a class (GMM1) and (2) relaxing the variance of the intercept and slope (random intercept and slope) within a class (GMM2). All models were tested on up to four classes, and analyses were performed using the hlme function of the lcmm package (Proust-Lima et al., 2017) in R (R Core Team, 2021). We conducted GMM analyses in accordance with the suggestions of Jung and Wickrama (2008) and Wardenaar (2020), and we applied the codes provided by Wardenaar (2020) for LCGA and growth mixture models in R (R Core Team, 2021).

For optimal model selection, we applied model fit indexes in the following order: The Bayesian Information Criterion (BIC; Schwarz, 1978), Aikake's Information Criterion (AIC; Akaike, 1973), and the loglikelihood ratio. The lower the BIC and AIC values are and the higher the loglikelihood ratio is, the better the model fit to the data is. We used the Lo–Mendell–Rubin likelihood ratio test (LMR-LRT; Lo et al., 2001) to determine whether a model was preferable to others in terms of data fit. A small LMR-LRT p value (i.e., $p < .05$) indicates that a model can describe the data better than another model with a smaller number of classes. Finally, in addition to these formal criteria, we considered classification quality, comprising average posterior probability (i.e., the accuracy with which participants are assigned to a latent class) and model class assignment (i.e., numbers of subjects assigned to each class), for improved interpretation of the data. A model with a higher average posterior probability value and that includes at least 10% of subjects in each class was considered to be more suitable for data interpretation than other models. The latent class trajectories of receptive and expressive language development were determined on the basis of the optimal growth mixture model.

To further explore the characteristics of each trajectory class, we examined the relationship between trajectory class assignment and diagnostic outcomes at T3 using chi-square tests of independence. We also investigated the differences in cognitive abilities, social communication skills, severity of autism symptoms, and adaptive behaviors at T1 among classes using an independent *t* test and one-way analysis of variance. These analyses were conducted in SPSS 22.0 for Windows.

3. Results

3.1. Analysis of RLDQ and ELDQ trajectories

Based on the model fit indexes, three candidate models were independently selected for RLDQ and ELDQ. Table 3 presents the model fit indexes for each candidate model, and Table 4 reveals the classification quality results (i.e., average posterior probability and model assignment). On the basis of the model fit indexes, the GMM2 3-class model better fitted the RLDQ data than the other candidate models; it had the lowest BIC and AIC. The LMR-LRT results indicate that the GMM2 3-class model could fit the data better than the other models (i.e., the LMR-LRT *p* value of GMM2 3-class model was < .001, and the GMM2 4-class model had an LMR-LRT *p* value of > .05). Additionally, the classification quality of the GMM2 3-class model was adequate because of the high average posterior probability value, and over 10% of participants were categorized into each latent class. For expressive language development, the GMM2 2-class model best fitted the ELDQ data, according to the model fit indexes and the results of an LMR-LRT test. Additionally, the classification quality of the GMM2 2-class model was adequate because it had the highest average posterior probability value among the three candidate models and because over 10% of participants were categorized into each latent class. Therefore, the final models were the GMM2 3-class model for the RLDQ and the GMM2 2-class model for the ELDQ.

Table 3

Table 4

The RLDQ and ELDQ trajectories evaluated using the MSEL are presented in Figures 1 and 2, respectively. All trajectory classes were named based on their characteristics of changing patterns over time. The three RLDQ trajectory classes were as follows: Age expected (20.8%), delayed catch-up (33.7%), and delayed (45.5%). According to RLDQ trajectory analyses, the age expected trajectory class exhibited stable development without significant mean differences over 3 years. The delayed catch-up trajectory class had a substantial improvement and no significant mean differences from the age expected trajectory class at T3. The delayed trajectory class had the lowest RLDQ at T1 but significantly improved and had no significant mean differences from the delayed catch-up trajectory class at T2. However, their receptive language development remained delayed at T3. Regarding ELDQ development, the delayed improve (38.6%) and delayed (61.4%) trajectory classes were so named because of their patterns over time. Both trajectory classes had a low ELDQ ($M < 70$) at T1 that significantly improved at T2, but their progress became stable from T2 to T3. The delayed improve trajectory class had improved their mean of ELDQ over 70 at T2, while the delayed trajectory class did not.

Figure 1

Figure 2

3.2. Trajectory class assignment and diagnostic outcomes

The trajectory class assignment of RLDQ was correlated with diagnostic outcomes [X^2 (2, N = 101) = 6.60, $p < .05$]. The majority (57.4%) of children in the ASD group were assigned to the delayed RLDQ trajectory class, and only 16.7% of them were assigned to the age expected RLDQ trajectory class (Table 5). Additionally, most children in the non-ASD delays group were assigned to the age expected and delayed catch-up RLDQ trajectory classes, and 31.9% were assigned to the delayed RLDQ trajectory class. For ELDQ development, trajectory class assignment and diagnostic outcome classification were correlated [X^2 (1, N = 101) = 7.88, $p < .01$]. The majority (74.1%) of children in the ASD group were assigned to the delayed ELDQ trajectory class, and only 25.9% of them were assigned to the delayed improve ELDQ trajectory class (Table 5). By contrast, more children in the non-ASD delays group were assigned to the delayed improve ELDQ trajectory class (53.2%) than to the delayed ELDQ trajectory class (46.8%).

Table 5

3.3. Joint distributions of trajectory classes

The joint distributions of RLDQ and ELDQ trajectory classes are presented in Table 6. RLDQ trajectory class assignment was related to ELDQ trajectory class assignment [X^2 (2, N = 101) = 9.43, $p < .01$]. A large proportion (61.9%) of children assigned to the age expected RLDQ trajectory class were also assigned to the delayed improve ELDQ trajectory class, which had better development outcomes. As expected, the majority (76.1%) of children assigned to the delayed RLDQ trajectory class were in the delayed ELDQ trajectory class. However, no noticeable distribution pattern was observed in participant assignment to the delayed catch-up RLDQ trajectory class. In total, 44.1% of such children assigned to the delayed catch-up RLDQ trajectory class were in the delayed improve ELDQ trajectory class, and all others were in the delayed ELDQ trajectory class.

Table 6

3.4. Early abilities among trajectory classes

For all children in this study, Table 7 demonstrates the differences in the children's early abilities measured at T1 among trajectory classes, namely nonverbal cognitive ability, overall cognitive ability, social communicative skills, adaptive functioning, and autism symptom severity. All variables were significantly different among the three RLDQ trajectory classes. According to a post hoc Scheffe test, among the three RLDQ trajectory classes, children in the age expected RLDQ trajectory class had the best performance in all early abilities. Children in the delayed catch-up RLDQ trajectory class had better nonverbal cognitive ability, overall cognitive ability, and adaptive functioning than those in the delayed trajectory class, and they had similar social communicative skills and autism symptom severity to the age expected RLDQ trajectory class. However, children in the delayed RLDQ trajectory class had the worse development in all abilities measured at T1, and their autism symptoms at T1 were more severe than those children who were in other classes. Between the two ELDQ trajectory classes, all variables were significantly different, except for adaptive functioning. These findings demonstrate that compared with the delayed ELDQ trajectory class, at T1, the delayed improve ELDQ trajectory class had better nonverbal cognitive ability, overall cognitive ability, and social communicative skills in addition to less severe autism symptoms. However, no significant differences were noted in adaptive functioning between the two ELDQ trajectory classes.

Table 7

4. Discussion

Trajectories of language development in non-Western children with DD are under-investigated. We investigated the independent trajectories of receptive and expressive language development in children with DD in Taiwan over three time points within 3 years. On the basis of our findings, we identified three trajectory classes for receptive language development and two for expressive language development. We revealed that trajectory class assignment was related to diagnostic outcomes. Further examination suggested that children who exhibited more proficient skills at an early time point, demonstrated improved language outcomes 3 years later.

We investigated the independent trajectories of receptive and expressive language development in young children with DD over three time points within 3 years. According to our GMM analyses, receptive and expressive language development were heterogeneous. Three RLDQ trajectory classes (i.e., age expected, delayed catch-up, and delayed) and two ELDQ trajectory classes (i.e., delayed improve and delayed) were identified. An age expected trajectory class was not identified in ELDQ development. This is reasonable given that expressive language impairments are the primary concern for parents of children with DD, including ASD and non-ASD delays (Coonrod & Stone, 2004). Pickles et al. (2014) revealed that the receptive language improvement rate was higher than that of expressive language before the age of 5 years, indicating that children with DD might have more difficulty improving expressive language abilities than they would improve receptive language abilities at the age of under 5 years.

Consistent with the findings of Henry et al. (2018) that all participants improved over time, children with DD in the current study improved over time in receptive or expressive language development. However, because we identified the latent class trajectories of receptive and expressive language abilities on the basis of DQs and not MA, we provided a clearer picture of the progress rate compared with normative expectations (i.e., age equivalent matches chronological age). Varying progress rates were revealed among the trajectory classes. For example, the progress rate of children in the age expected RLDQ trajectory class did not differ from normative expectations (i.e., age equivalent matches chronological age) over 3 years. The progress rate of children in the delayed catch-up RLDQ trajectory class exceeded normative expectations; they started with delayed ability levels and reached ability levels similar to normative expectations at T3. We followed up these children to approximately the age of 5 years. On the basis of the findings of Fountain et al. (2012) and Pickles et al. (2014) that language development could be more heterogeneous before the age of 6 years, our findings could supplement those of Henry et al., who only investigated language development from age 1.5 to 3 years.

Henry et al. (2018) examined the relationship between trajectory classes and diagnostic outcomes at T3, and similarly, we divided participants into ASD and non-ASD delays groups on the basis of their diagnostic outcomes at T3; we revealed that trajectory class assignment and diagnostic outcomes were correlated. We assigned 53% of children to the ASD group and 47% of children to the non-ASD delays group. The majority of children in the ASD group were assigned to the delayed RLDQ trajectory class (57.4%) or the delayed ELDQ trajectory class (74.1%), and the majority of children in the non-ASD delays group were assigned to the trajectory classes that achieved better outcomes than other trajectory classes did. These findings support the idea that young children with ASD are more likely to experience challenges in language development than children with DD who do not have ASD diagnoses. However, in the current study, 16.7% of children in the ASD group were in the age expected RLDQ trajectory class, but none of the children with ASD were in the age expected group in the study of Henry et al. This may be because of the different ways we measured language abilities. They measured overall language ability, whereas we measured receptive and expressive language abilities independently. Another possible reason was that the present study included 54 young children with ASD, whereas the study of Henry et al. included only 12 children with ASD.

We observed that a proportion of children with ASD had delayed receptive or expressive language abilities around the age of 2 years but achieved substantial progress over time; this finding is consistent with those of other studies (for example, see Anderson et al., 2007 and Henry et al., 2018). However, we did not identify any trajectory class that had declining progress in receptive and expressive language development which is inconsistent with some of the previous studies (Brignell, Morgan et al., 2018; Brignell, Williams et al., 2018; Landa et al., 2012; Longard et al., 2017). These disparate findings might be due to differences in sample sizes and methodologies used. The study of Brignell, Morgan et al. (2018) was a literature review, and the sample size of Landa et al. (2012) and Longard et al. (2017) were larger than the current study. In addition, Brignell, Williams et al. (2018) investigated developmental trajectories by observing performance over time. We performed GMM analyses, in which model assignment was a consideration for model fit, and the sample size in the current study might have limited our ability to identify latent trajectory classes by using GMM. Nevertheless, we explored whether any children with ASD experienced a declined language development using similar methods to those of Brignell, Williams et al. We revealed that two young children with ASD who had delayed receptive language ability experienced declining progress over 3 years, and three children with ASD had declining progress in expressive language development. These children were assigned to the delayed RLDQ and ELDQ trajectory classes respectively rather than a separate declining trajectory class after GMM analyses because of the small sample size.

However, the proportion of children with ASD who experienced declining progress in receptive or expressive language development in this study was much less than some previous findings (Landa et al., 2012; Longard et al., 2017). These disparate findings might be due to the differences in the diagnosis of the sample and study period. Landa et al. (2012) and Longard et al. (2017) recruited siblings of children with ASD with the first visit at age 6 months, whereas the markedly declining progress showed before age 2. However, we recruited children with clinical referrals and followed them from around age 2.

Heterogeneity of language developmental trajectories in young children with DD is evident from the current study and those of others. Our Taiwanese study population could have similar language development patterns and characteristics to those of Western populations. Although the reasons for the high variation in developmental patterns remains unclear, Pickles et al. (2014) hypothesized that different levels of brain plasticity and sensitivity to environmental stimuli related to early language development could be possible reasons. Different types and intensity levels of early interventions could be another possible factor related to the heterogeneity. However, we did not investigate the intervention history of the participants. Nevertheless, studies have revealed that the intervention histories of children with DD in various trajectory classes were highly diverse (Chu et al., 2017; Pickles et al., 2014), and these differences could not predict their language development progress over time (Chu et al., 2017). Even after the types of intervention were controlled, language development in children with ASD remained heterogeneous (Frazier et al., 2021). On the basis of these findings, language development heterogeneity in young children with DD might be a result of factors other than early intervention history.

We further examined the differences in early abilities among children in different trajectory classes. The results revealed that children with better receptive or expressive language abilities had better nonverbal cognitive ability, overall cognitive ability, and social communication skills and less severe autism symptoms around the age of 2 years. This is consistent with the findings of other studies (Fountain et al., 2012; Frazier et al., 2021; Pickles et al., 2014). We found only children with a strong receptive language ability had high adaptive functioning. It is possible that strong receptive language ability allows more effectively learning through daily experiences which support better adaptive functioning.

This study has some limitations. First, our sample was relatively small, which may have limited our ability to identify other latent class trajectories using GMM. Although children with PDD-NOS were included in the ASD group, they were only a small proportion (7.9%) of all participants. The high rate of sample attrition may have played a role in this limitation. This factor may have limited the generalizability of our results. Therefore, researchers must devote more effort to maintaining good relationships with participants during follow-up intervals. In addition, studies with larger sample sizes are required. Second, we used RLDQ and ELDQ to measure the language abilities of all participants instead of *T*-scores because some participants had poor language abilities rendering it difficult to obtain *T*-scores. This may also have limited the generalizability of our findings. Third, the intervention histories of participants were not collected so whether and how intervention histories would have affected our findings on the heterogeneity of language development remains unclear. In future studies investigating language development trajectories in young children with DD, researchers should use intervention histories as a variable. Fourth, we used subscales from a general test of development as the measurement of language abilities which might need to be more comprehensive. Future studies should consider a more comprehensive assessment of language abilities. We did not recruit children with typical development as a control group. Future studies could include such a control group. Finally, the participants were recruited from a rural area in Taiwan. Future studies could include samples from metropolitan areas to better generalize the findings to this population.

5. Conclusion

Receptive and expressive language development trajectories in young children with DD in Taiwan are heterogeneous; this result is consistent with those of Western populations. On the basis of our results, three trajectory classes were identified for receptive language development, and two were identified for expressive language development. Trajectory class assignment in receptive and expressive language development was related to diagnostic outcomes. In addition, children who exhibited stronger early cognitive abilities and social communication skills and less severe autism symptoms around the age of 2 years had improved language outcomes 3 years later. However, children with a history of delayed language development had less favorable early adaptive functioning. Our results provide us with a deeper understanding of language development in children with DD in non-Western populations.

Compliance with Ethical Standards

Ethical Approval

All procedures involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. This study was approved by the Ditmanson Medical Foundation Chia-Yi Christian Hospital Research Ethics Committee.

Informed Consent

Informed consent was obtained from all participants.

Conflict of Interest

The authors have no conflicts of interest to declare.

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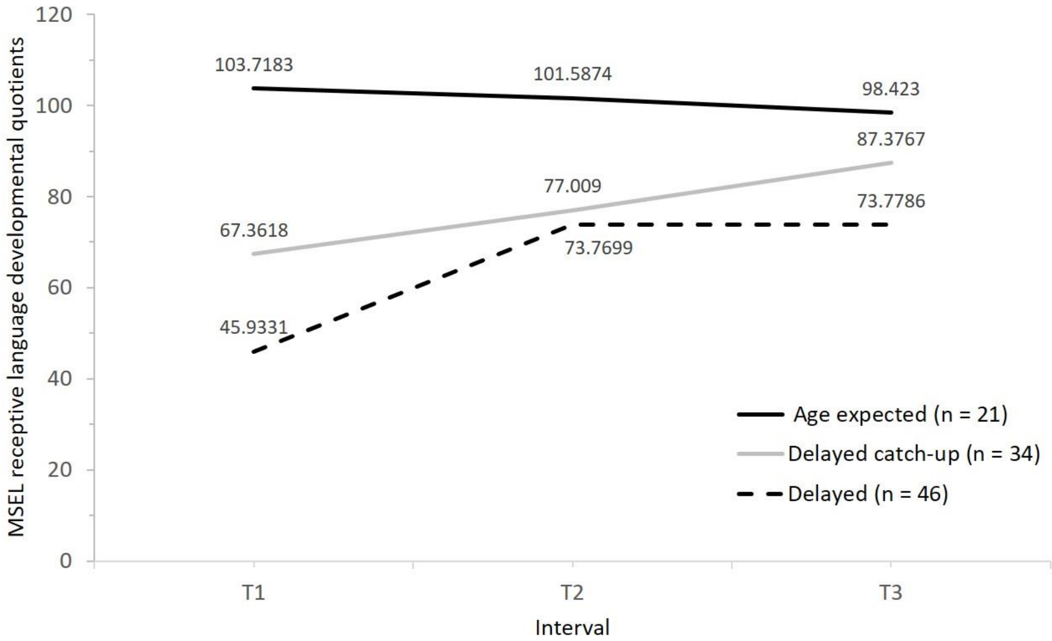

Figure 1. RLDQ trajectories evaluated using the MSEL

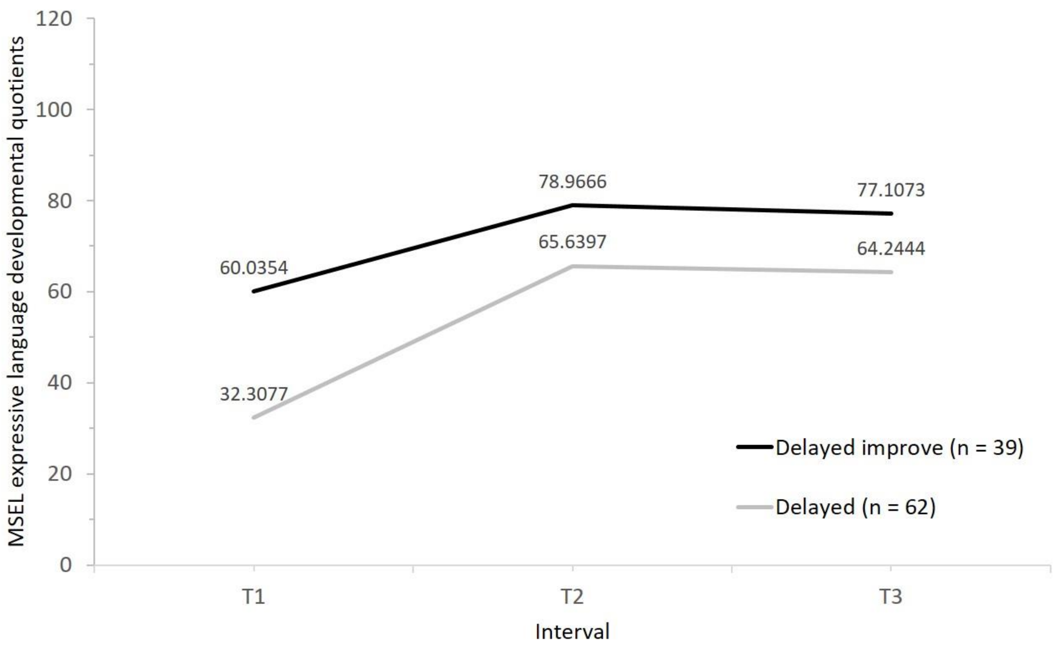

Figure 2. ELDQ trajectories evaluated using the MSEL

Table 1

Summary of the Study Sample and the Statistical Approaches of Other Studies

Study	Diagnosis	Domains of language	Statistical approach
Brignell, Williams et al. (2018)	ASD & LI ($IQ \geq 70$)	Receptive and expressive language	Individual Change in standard score
Landa et al. (2012)	Sibs-A	Receptive and expressive language	Parallel process latent class growth analysis
Longard et al. (2017)	Sibs-A & LR controls	Receptive and expressive language	Semiparametric group-based modeling
Pickles et al. (2014)	possible ASD	Joint receptive and expressive language	Latent class growth analysis
Henry et al. (2018)	LD & TD	Verbal age equivalents	GMM analyses
Brignell, Morgan et al. (2018)	ASD	Overall language	Literature review
Smith et al. (2007)	ASD	Expressive vocabulary	Cluster analyses
Tek et al. (2014)	ASD	Expressive language	Median split on the raw score at T1
Anderson et al. (2007)	ASD	Verbal age equivalents	GMM analyses
Frazier et al. (2021)	ASD received EIBI	Receptive and expressive language	GMM analyses
Fountain et al. (2012)	ASD	Communication functioning	Group-based latent trajectory modeling

Note. ASD = autism spectrum disorder; LI = language impairment; IQ = Intelligence quotient; Sibs-A = Siblings of children with autism; LR = low-risk; LD = language delays; EIBI = early intensive behavioral intervention; GMM = growth mixture modeling.

Table 2

Demographics of Participants

	Whole sample	Diagnostic outcome at Time 3	
		ASD	non-ASD delays
		Mean (*SD*)	Mean (*SD*)
N (%)	101 (100)	54 (53)	47 (47)
Gender (% boys)	79.20	90.70	66.00
CA (months)			
Time 1	21.88 (3.30)	22.56 (3.53)	21.11 (2.85)
Time 2	40.36 (3.27)	40.78 (3.63)	39.87 (2.76)
Time 3	59.15 (3.50)	59.74 (3.81)	58.47 (3.01)
ADOS total score [a]			
Time 1	10.70 (6.80)	15.02 (5.69)	5.74 (4.05)
Time 2	8.90 (6.64)	14.07 (4.33)	2.96 (2.58)
Time 3	9.88 (6.58)	15.22 (3.47)	3.74 (2.86)
ADI-R at Time 3 [a]			
RSI	11.04 (7.65)	16.00 (6.35)	5.34 (4.33)
Com	9.20 (4.89)	12.57 (3.63)	5.32 (2.85)
RRB	3.14 (3.35)	5.19 (3.33)	0.79 (1.04)
Parents' years of education			
Mother	13.94 (2.69)	14.09 (2.34)	13.77 (3.07)
Father	13.53 (2.72)	13.63 (2.68)	13.43 (2.80)

Note. ASD = autism spectrum disorder; CA = chronological age; ADOS = Autism Diagnostic Observation Schedule; ADI-R = Autism Diagnostic Interview-Revised; RSI = Reciprocal Social Interactions; Com = communication; RRB = restricted, repetitive, and stereotyped patterns of behavior.

[a] A higher value indicates a higher severity.

Table 3

Model Fit Indices of Each Candidate Model

Model	Parameters	Loglikelihood	AIC [a]	BIC [a]	Lo–Mendell–Rubin LRT *p* value [b]
RLDQ					
GMM1 4-class	20	-1295	2631	2683	
GMM2 3-class	20	-1288	2615	2668	
GMM2 4-class	25	-1287	2625	2690	.993
ELDQ					
GMM2 2-class	15	-1241	2512	2551	
GMM2 3-class	20	-1238	2515	2568	.304
GMM2 4-class	25	-1235	2520	2585	.394

Note. Loglikelihood ratio is an indicator of a model's goodness of fit; higher values represent better fit. A Lo–Mendell–Rubin LRT *p* value of < 0.05 indicates that a model has a significantly better fit than does one with a smaller number of classes. RLDQ = receptive language developmental quotient; ELDQ = expressive language developmental quotient; GMM = growth mixture modeling; AIC = Aikake's Information Criterion; BIC = Bayesian Information Criterion. LRT = likelihood ratio test.

[a] Smaller values indicate better model fit.

[b] Lo–Mendell–Rubin LRT *p* values were only applied in comparisons of model fit between original and additional classes in the same model.

Table 4

Classification Quality of Each Candidate Model

Model	Average posterior probability				Model assignment			
	1	2	3	4	1	2	3	4
RLDQ								
GMM1 4-class	.97	.93	.89	.90	21	43	27	10
GMM2 3-class	.98	.86	.95		21	34	46	
GMM2 4-class	.93	.97	.98	.70	17	74	4	6
ELDQ								
GMM2 2-class	.91	.96			39	62		
GMM2 3-class	.83	.90	.67		19	38	44	
GMM2 4-class	.84	.90	.63	.78	20	52	13	16

Note. RLDQ = receptive language developmental quotient; ELDQ = expressive language developmental quotient; GMM = growth mixture modeling.

Table 5

Integration of Trajectory Class Assignment and Diagnostic Outcomes

Trajectory class	ASD *n* = 54	non-ASD delays *n* = 47	Total *n* = 101
RLDQ Class			
Age expected, *n* (%)	9 (16.7)	12 (25.5)	21 (20.8)
Delayed catch-up, *n* (%)	14 (25.9)	20 (42.6)	34 (33.7)
Delayed, *n* (%)	31 (57.4)	15 (31.9)	46 (45.5)
ELDQ Class			
Delayed improve, *n* (%)	14 (25.9)	25 (53.2)	39 (38.6)
Delayed, *n* (%)	40 (74.1)	22 (46.8)	62 (61.4)

Note. ASD = autism spectrum disorder; RLDQ = receptive language developmental quotient; ELDQ = expressive language developmental quotient; GMM = growth mixture modeling.

Table 6

Joint Distribution of Trajectory Classes

ELDQ Class	RLDQ Class		
	Age expected *n* = 21	Delayed catch-up *n* = 34	Delayed *n* = 46
Delayed improve, *n* (%)	13 (61.9)	15 (44.1)	11 (23.9)
Delayed, *n* (%)	8 (38.1)	19 (55.9)	35 (76.1)

Note. RLDQ = receptive language developmental quotient; ELDQ = expressive language developmental quotient.

Table 7

Differences in Early Abilities and Symptom Severity among Trajectory Classes Measured at T1

Variable	RLDQ Class					ELDQ Class		
	Age expected (class 1, n = 21) Mean (SD)	Delayed catch-up (class 2, n = 34) Mean (SD)	Delayed (class 3, n = 46) Mean (SD)	F	Post hoc (Scheffe test)	Delayed improve (class 1, n = 39) Mean (SD)	Delayed (class 2, n = 62) Mean (SD)	t
NVDQ	97.96 (7.98)	87.94 (9.89)	76.80 (14.11)	25.15***	1 > 2 > 3	90.05 (11.61)	81.74 (14.94)	2.95**
DQ	87.50 (6.63)	71.98 (7.63)	59.49 (10.56)	72.86***	1 > 2 > 3	79.09 (10.85)	63.50 (12.25)	6.51***
T-STAT score [a]	1.67 (0.87)	2.19 (0.98)	2.93 (0.98) [b]	13.80***	3 > 2 = 1	1.87 (0.87)	2.76 (1.05)	-4.57***
ABAS-II GAC	87.29 (11.95)	75.29 (19.25)	66.00 (13.22)	14.28***	1 > 2 > 3	76.28 (14.11)	71.84 (18.81)	1.27
ADOS score [a]	6.05 (4.39)	8.41 (6.14)	14.52 (6.14)	19.23***	3 > 2 = 1	6.79 (5.00)	13.16 (6.67)	-5.47***

Note. NVDQ = nonverbal developmental quotient; DQ = developmental quotient; T-STAT = Taiwanese version of the Screening Tool for Autism in Two-Year-Olds; ABAS-II = Adaptive Behavior Assessment System-II; GAC = global adaptive composite score; ADOS = Autism Diagnostic Observation Schedule; RLDQ = receptive language developmental quotient; ELDQ = expressive language developmental quotient.

[a] A higher value indicates a higher severity.

[b] Only one piece of data was missing; thus, for the analysis, $n = 45$.

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