Strengths in Comprehending Grammatical Aspect among Mandarin-Exposed Preschool Children with ASD

Qianqian Xie, Yi (Esther) Su, and Letitia R. Naigles

1. Introduction

Autism spectrum disorder (ASD) is a lifelong neurodevelopmental disorder marked by impaired social interactions and restricted and repetitive behaviors. Although language impairment has not been considered a core component of ASD in the current diagnostic criteria (American Psychiatric Association, 2013), the precise nature of this impairment as well as its status within the diagnosis remain unresolved (Naigles, 2017). The abnormalities in pragmatic use of language attributable to the social-communicative deficits have been well documented in children with ASD (Naigles & Chin, 2015); however, the extent to which the grammatical component is also impaired continues to be a matter of controversy (Eigsti et al., 2007; Tager-Flusberg, 1994).

Utilizing the eye-movement measures of the Intermodal Preferential Looking (IPL; Naigles & Tovar, 2012) paradigm, our recent cross-linguistic studies in English or Mandarin-exposed children with ASD have demonstrated their strengths of understanding grammatical structures such as the Subject-Verb-Object word order, grammatical aspect (e.g., the perfective marker *-le* and the progressive marker *zai-* in Mandarin Chinese) and (object) wh-questions, which suggested that children with ASD's less frequent usage of the relevant grammatical structures in spontaneous or elicited speech may result from their inherent social deficits in conversations rather than represent fundamental grammatical impairments (Tovar et al., 2015; Jyotishi et al., 2017; Su & Naigles, 2021). These findings also yield evidence that core grammatical knowledge may be preserved in children with ASD, even in the face of radical differences in language environment, social-communicative deficits, and neurological organization, supporting the contribution of the language faculty in autistic

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grammatical acquisition across languages (Su & Naigles, 2021). The present study extends this line of research by investigating Mandarin-exposed preschoolers with ASD's comprehension of a minimal pair of grammatical aspect, i.e., the perfective marker *-le* and the durative marker *-zhe*, to further differentiate the social vs. grammatical origins of the well-documented impairment in aspectual production in children with ASD across languages (e.g., Eigsti et al., 2007; Xie & Su, 2018; Zhou et al., 2015). Moreover, we tested children with ASD whose vocabulary production levels were dramatically delayed compared with the TD controls to investigate the extent to which vocabulary and grammar develop jointly versus separately in ASD (Naigles et al., 2011), and to further explore a modular view of the language faculty in children with ASD (Su & Naigles, 2021).

In human languages, grammatical aspect is encoded in morphemes that refer to the temporal structures of events in many languages. For instance, in English, grammatical aspect is realized by linguistic devices such as inflections, which can also combine with tense. The perfective maker *-ed* (e.g., *picked*) or an irregular past tense form (e.g., *drew*) indicates the aspectual meaning of completion with an inherent or observed endpoint, while the progressive marker *-ing* (e.g., *playing*) marks an ongoing event with no endpoint. To acquire grammatical aspect, English-speaking children are expected to segment the grammatical morphemes (e.g., *-ed*, *-ing*) apart from lexical verbs, and then learn about the meanings (e.g., perfective vs. imperfective) encoded in the morphemes. As with English, across languages, aspect/tense morphology includes the representations of a range of forms and meanings, the combinations of forms and meanings in a language-specific mapping, and in some languages (e.g., Mandarin Chinese), even whether the aspect/tense meanings will be mapped onto overt morphology (Wagner et al., 2009).

Despite the wide variation in the aspectual form-meaning mapping, young typically developing (TD) children start to produce grammatical aspect by 2–3 years of age across languages (e.g., Brown, 1973; Weist, 1999). In contrast, pervasive omission of morphosyntactic markers in speech, including aspect/tense markers, has been identified among children with ASD exposed to typologically different languages. To date, particular difficulties in using and/or producing aspect/tense morphology in children with ASD have been reported in English (Wittke et al., 2017), French (Le Normand et al., 2018), and Mandarin (Xie & Su, 2018; Su et al., 2018; Zhou et al., 2015). Based on the data from spontaneous speech, elicited production tasks or parental report, these studies have consistently reported that preschool children with ASD across languages used aspect/tense markers less frequently, exhibited high rates of omission of aspect/tense marking, and/or made more errors in using the aspect/tense morphology, when compared with TD controls and other groups of children such as those with developmental delay or with developmental language disorders.

Does the aspectual production impairment in children with ASD stem from their social deficits in communications inherent to the ASD diagnosis or from their grammatical deficits in using aspect markers to encode aspectual meaning?

Utilizing the IPL paradigm, Tovar et al. (2015) presented 4-year-old English-speaking children with ASD with side-by side completed and ongoing renditions of events, paired with familiar verbs with the perfective morpheme *-ed/*irregular past tense form or the progressive morpheme *-ing* (e.g., 'she picked the flowers' vs. 'she is picking the flowers'). Relative to their baseline preference, children with ASD looked significantly longer at the matching events when hearing both the perfective aspect (regular *-ed*/irregular past form) and progressive aspect (*-ing*). This strength in comprehending grammatical aspect in English-exposed children supported the claim that their difficulties with using aspect/tense morphology might derive from the social/contextual difficulties inherent to the ASD diagnosis. For example, less frequent usage of the perfective aspect/past tense could be partially caused by their overall less frequent reference to non-present events (Eigsti et al., 2007). However, because this study did not include a TD group, it is unclear whether the ASD and TD groups show similar or different acquisition patterns when acquiring grammatical aspect. More experimental findings are warranted to distinguish between the social vs. grammatical origins of the impaired aspectual production in children with ASD across languages.

Mandarin Chinese is an ideal language to investigate aspect acquisition. Unlike the Indo-European languages which often involve the mixture of aspect and tense morphology, Mandarin is an aspect-prominent and tense-less language, with no systematic and overt tense marking. Moreover, Mandarin does employ a set of grammatical markers to indicate aspectual distinctions. The markers of aspect in Mandarin are a special kind of morphology-like device that can be separated from the verb (Huang et al., 2009). Generally, there are four primary grammatical aspects in Mandarin: the perfective marker *-le*, the durative marker *-zhe*, the progressive marker *zai-* and the experiential marker *-guo*. *-Le* and *-guo* mark perfective situations, while *-zhe* and *-zai* encode imperfective situations. In the current study, we focus on a minimal pair of perfective vs. imperfective markers, i.e., *-le* and *-zhe*. In sentence (1), *-le* is attached to the verb *he1* 'drink', indicating that the event of drinking has been completed. Thus, this sentence means that she has drunk the juice. In sentence (2), *-zhe* also follows the verb *he1* 'drink', suggesting that the action of drinking is still ongoing.

(1) Ta1 he1-*le1* guo3zhi1
She drink-PERF juice
'She has drunk juice'
(2) Ta1 he1-*zhe1* guo3zhi1
She drink -DURE juice
'She is drinking juice'

Mandarin-exposed preschoolers with ASD, including those with high functioning autism (HFA), have demonstrated severe deficits in producing grammatical aspect. For example, using the Putonghua Communicative Developmental Inventory (PCDI), 1–6-year-olds with ASD were less likely to use

the perfective marker *-le* and the experiential marker *-guo* than vocabulary-matched TD groups (Su et al., 2018), and children with developmental language disorder and those with developmental delay (Xie & Su, 2018). However, using the IPL paradigm, Su & Naigles (2021) found that 2–6-year-old children with ASD demonstrated similar looking patterns when processing the perfective *-le* and the progressive *zai-* as the 1–3-year-old TD group, even though the former had significantly lower vocabulary production levels. Thus, similar to the Tovar et al. (2005) study among English-exposed children with ASD, Mandarin-exposed children with ASD's comprehension of *-le* and *-zai* provided further evidence for the social origin of the aspectual production deficits in ASD. Moreover, because aspect comprehension is preserved in a diverse sample of Mandarin-acquiring preschoolers with ASD, whose vocabulary production levels were severely delayed compared to their TD peers, these results indicated that lexicon and grammar may develop separately in children with ASD, thus supporting a modular view of the diverse language domains (vocabular vs. grammar) in autistic language acquisition. However, in this study, *-le* is a suffix which follows the verbs, while *zai-* is a prefix which precedes the verbs. Due to this subtle structural difference, the suffix *-le* and the prefix *zai-* do not construct a minimal pair to investigate children's aspect acquisition in Mandarin Chinese.

In the present study, we take advantage of the minimal pair of the perfective *-le* and the durative *-zhe* to explore whether the temporal information encoded in these two aspectual morphemes (e.g., *completed* versus *ongoing*) function to facilitate sentence comprehension in young Mandarin-exposed children with ASD. Using the IPL paradigm, we tested whether 3–6-year-old Mandarin-exposed children with ASD were able to map aspectual morphemes onto their distinct meanings, by looking longer at the completed events when they heard sentences with the perfective marker *-le*, and at the ongoing events when they heard sentences with the durative marker *-zhe*. Positive experimental findings would yield incremental evidence for the social origin of the aspectual production deficits in children with ASD across languages. Additionally, as with the Su & Naigles (2021) study, our participants included a diverse sample of 3-6-year-old Mandarin-exposed children with ASD, whose vocabulary production levels were dramatically delayed compared to the TD group. This diverse sample enables us to explore to which degree vocabulary and grammar develop jointly or separately in ASD group (cf. Bates & Goodman, 1997). If the delayed vocabulary production level does not hamper their successful comprehension of grammatical aspect, this then would render further evidence for the dissociation between the lexical and grammatical language modules in ASD (Su & Naigles, 2021).

2. Method

2.1. Participants

Thirty-four Mandarin-exposed children with ASD (mean age =54.74±9.74 months, 27 males and 7 females) and twenty-six TD children (mean

age=31.19±5.31 months, 11 males and 15 females) participated in this study. The participants in the ASD group were recruited from three formal autism training centers (Aimier, Xingyuan and Aimeng) in Changsha, China. Their diagnoses were ascertained by experienced child psychiatrists according to the Diagnosis and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5; American Psychiatric Association, 2013). To further confirm the diagnoses, we administrated a parent rating scale of autism severity, namely, the Chinese Autism Behavior Checklist (ABC, Yang et al., 1993). All children in the ASD group scored above the cutoff score of 31 on the ABC (mean score=59.10±23.09, range=31-104), while none of children in the TD group had an ABC score above 31 (mean score =9.78±8.98, range=0-28). The participants in the TD group were recruited from the Blue Sky Art Kindergarten. All parents signed the consent forms for participation, which were approved by the Medical Ethics Committee of the Second Xiangya Hospital, CSU.

Table 1 shows the descriptive data of the participants' age in months, the parent rating scores on the ABC, the total vocabulary production scores, mean length of the three longest utterances (MLU3, Fenson et al., 1993) calculated by averaging the total numbers of words of 'the three longest sentences' that the child uttered recently, the percentage of children who 'used perfective -*le* or experiential -*guo* when talking about the past evens' and the percentage of children who 'made reference to the past events or the people met before' on the PCDI. The TD group was comparable in age to 31-month-old Mandarin-speaking TD children showing reliable comprehension of grammatical aspect in Yang et al. (2018), but they were significantly younger than the ASD group, $t(58)=11.11$, $p<0.001$, $d=2.89$. The total vocabulary production level of the ASD group was equivalent to that of 21-month-old TD children in the PCDI normative study (Tardif et al., 2008), 367.06 ±267.92 vs. 372±205, $t(68)=0.85$, $p=0.39$. $d=0.02$, which was significantly lower than that of the TD group, $t(58)=4.33$, $p<0.001$, $d=1.18$. The MLU3 of the children in the ASD group was also significantly lower than that of the TD group, $t(50)=3.55$, $p=0.001$, $d=1.02$. As expected, the ASD group scored significantly higher on the ABC than the TD group did, $t(55)=12.47$, $p<0.001$, $d= 2.97$.

Unsurprisingly, the proportion of children who used -*le* or -*guo* in the ASD group was significantly lower than that in the TD group, $\chi^2=21.75$, $p<0.001$, $V=0.62$. Furthermore, the percent of children with ASD who talked about the past events/people was significantly lower than that in the TD group, $\chi^2=13.36$, $p<0.001$, $V=0.48$. When compared to the total-vocabulary-matched 21-month-old TD group in the PCDI normative study (Tardif et al., 2008), children in the ASD group still produced fewer -*le*/-*guo,* TD vs. ASD: 50% vs. 33%, and talked less about the past, TD vs. ASD: 69% vs. 38%, with the latter comparison reaching significance, $\chi^2=6.86$, $p=0.009$, $V=0.31$. Additionally, children with ASD who used -*le* or -*guo* were more likely to be the ones who talked about the past, $rho=0.80$, $p<0.001$.

Table 1. Mean and SD and Range of Group Scores on Standardized Tests

	TD (N=26)		ASD (n=34)	
	Mean (SD)	Range	Mean (SD)	Range
Age in months	31.19(5.31)	23-38	52.71(10.02)	36-70
ABC scores	9.78(8.98)	0-28	60.27(20.93)	32-104
PCDI				
Total vocabulary production	641.00(173.08)	242-799	367.06(267.92)	0-799
MLU3	5.34(1.83)	2-8	3.39(2.01)	0-7.33
% of children using *-le*/*-guo*	95.7%		33.3%	
% of children talking about the past	87.0%		38.2%	

Note. ABC, Autism Behavior Checklist; PCDI, Putonghua Communicative Development Inventory; MLU3, Mean Length of Three Longest Utterances.

2.2. Materials

Standardized test measures. *PCDI: Words and Sentences* (Tardif et al., 2008) was administrated to measure children's expressive language levels in Mandarin Chinese via parental report. The CDI assessments (e.g., MCDI and PCDI) have been frequently used in evaluating language development of 1 to 7-year-old children with ASD exposed to different languages. In addition, the *ABC* provides a measure of children's autistic behaviors. This parent rating scale is one of the most widely used ASD screening tools in China (Sun et al., 2013).

IPL setup. The IPL paradigm involves showing each participant two videos side by side, while playing child-directed speech from a central speaker that corresponds to only one of the videos. A laptop projected the video stimuli onto a portable 150 cm × 120 cm screen via an LCD projector. The laptop was connected to an external speaker, which was placed out of sight behind the screen. A digital camera for filming the child's face was placed on a small tripod in front of the screen, just below the center. Children's direction and duration of gaze were recorded and coded for indictors of their comprehension.

IPL stimuli. Table 2 shows the sample layout and trial durations for the aspect video (adapted from Tovar et al., 2015). The familiarization trials introduced the ongoing and completed events sequentially on each side of the screen. The audio for these trials only labeled the girl (e.g., '*Look here, look at her now!'*). For the *control trials*, both the ongoing and completed renditions were presented simultaneously, accompanied by a non-directing audio (e.g., '*Now we see her in both*!'). Thus, the control trials demonstrated the child's baseline looking preferences. During the *test trials*, the two renditions appeared side by side, paired with a direct audio, e.g., '*Look! She's drinking the juice.*'. Four familiar verbs (zhai1 '*pick*', xi3 '*wash*', hua4 '*draw*', he1 '*drink*') and actions (i.e., picking vs. having picked flowers, washing vs. having washed a dolly, drawing

vs. having drawn a ball, drinking vs. having drunk juice) were presented. The side of the screen describing the matching scene was counterbalanced across trials.

Table 2. Sample Layout of the Aspect video (adapted from Tovar et al., 2015)

Trial	Left video	Audio	Right video
Familiarization	Girl drinking the juice	Kan4 zher4, kan4 ta1! '*Look here, look at her!*'	Blank
ITI	Blank	Oh1, wa1! '*Oh, wow!*'	Blank
Familiarization	Blank	Kan4 zher4, xian4zai4 kan4 ta1! '*Look here, look at her now*!'	Girl completes drinking juice
ITI	Blank	Oh1, wa1! '*Oh, wow!*'	Blank
Control	Girl drinking the juice	Xian4zai4 liang3bian1 dou1 you3 ta1! *Now we see her in both*!'	Girl completes drinking juice
ITI	Blank	**Kan4! Ta1 he1-*zhe*1 guo3zhi1! '*Look! She's drinking the juice*.'**	Blank
Test 1st & 2nd halves	**Girl drinking the juice**	**Kan4 ya1! Ta1 he1-*zhe*1 guo3zhi1! '*Look! She's drinking the juice*'**	Girl completed drinking juice

Note. ITI = intertrial interval. Bolded text indicates the matching audio and video.

2.3. Procedure

The child sat in a floor mat around 2 ft in front of the camcorder and screen, watching a series of videos (n=3). The aspect video was usually the second video task that the child watched. The child sat either in the caregiver's lap or in a small chair by him/herself. Caregivers in the kindergarten or training center were requested to fill out the ABCs and the PCDIs within one week after the viewing session.

2.4. Coding

The recording of the child's eye movement was digitized and uploaded to a custom coding program. Each child's visual fixations were coded frame by frame. Two trained coders who were blind to the stimuli marked the child's fixation to the right, left, center or away. Trials where the child did not look at either video, combined, for a minimum of 1s were considered missing. Trials following ITIs in which the child did not look at the center spot for a minimum of 0.3s were excluded. The percentage of excluded trails was 6.13 % for the TD group and 6.98% for the ASD group. All excluded trials comprised fewer than 10% of the total, which is typical for IPL studies. The interrater reliability between two coders averaged 0.98.

2.5. Description of Dependent Variables

Two types of IPL measures were calculated. (1) The first *percent looking to match* measures capture children's preference for the matching scene during the test trials compared with the control trials. If children understand the aspect markers, they should look longer at the completed events when hearing verbs with *-le* and longer at the ongoing events when hearing verbs with *-zhe* during the test trials, relative to their basic preferences for these events during the control trials. The *percent looking to match* was analyzed as three measures: The total-percent-looking-to-match measure compares the entire test trial to the control trial. Furthermore, the entire 6s test trials were divided into two equals halves, i.e., the first 3s and the last 3s, to delineate children's sentence processing. Looking preference to the matching scene during the 1st half (after the first presentation of the test audio) may indicate a faster processing speed, while looking preference during the 2nd half (after hearing the test audio for a 2nd time) may indicate a lower speed and/or less facility with aspect markers. (2) The second *percent-looking-to-completed-rendition* measures calculate children's percent looking time to the completed events during both audios. Hearing verbs with *-le* should trigger more eye movement to the completed events, while hearing verbs with *-zhe* should trigger less eye movement to the completed events during the test trials, compared to their base line preferences to the completed events during the control trials. For the comparison of children's performances upon hearing the two audios of *-le* and *-zhe*, difference scores were calculated for the percent looking to completed scenes during the test trial minus the control trial (entire test trial, 1st half or 2nd half of test trial). This allowed us to investigate whether the two different audios of *-le* and *-zhe* reliably led the children to look at different renditions.

3. Results

3.1. Percent looking to match results

Table 3 shows the descriptive data of the *percent looking to match* measures for the TD and ASD groups during control trials and test trials. Three two-way repeated measures analysis of variance (ANOVAs) were conducted with the children's precent looking to the matching scenes when hearing the *-le* and *-zhe* audio, separately. The within-group factor was trial (control, test) and the between-group factor was the diagnostic group (TD, ASD).

Table 3. Intermodal Preferential Looking Results for Aspect Video by Diagnostic Groups

	TD (N=26)		ASD (N=34)	
Percent looking to matching scene	Control M (SD)	Test M (SD	Control M (SD)	Test M (SD)
PERF*: -Le*				
Entire trial	52.88(8.14)	59.68(11.89)**	54.99(13.95)	59.99(11.64)**
First half of test trial		48.34(14.48)		55.92(13.92)
Second half of test trial		69.21(16.00)***		64.88(17.20)**
DURA: *-Zhe*				
Entire trial	42.11(10.76)	43.62(11.45)	44.71(14.73)	50.12(13.57)*
First half of test trial		54.06(18.89)**		51.26(20.09)*
Second half of test trial		37.84(15.53)		49.35(22.57)

Note. TD, typically developing; ASD, autism spectrum disorder. Comparison of test trials vs. control trials. t-tests (one-tailed), *p<0.05; **p<0.01, ***p<0.001.

3.1.1. *le* audio

In the *-le* rendition, there were significant main effects of trial for the percent looking to match measures for the entire test trials, $F(1, 58)=14.48$, $p<0.001$, $\eta^2=0.20$, and the 2nd half of the test trials, $F(1, 58)=41.64$, $p<0.001$, $\eta^2=0.42$, with no other significant effects or interactions. Follow-up t-tests revealed that both the TD and ASD groups looked longer at the matching (i.e., completed) scenes during the entire test trials, TD: $t(25)=2.77$, $p=0.005$, $d=0.65$, ASD: $t(33)=2.55$, $p=0.008$, $d=0.37$, and the 2nd half of the test trials, TD: $t(25)=5.28$, $p<0.001$, $d=1.24$, ASD: $t(33)=3.73$, $p<0.001$, $d=0.62$, relative to the control trails. However, there were no significant effects or interactions for the percent looking to match during the 1st half of the test trials ($ps\geq0.17$).

3.1.2. *zhe* audio

In the *-zhe* rendition, there were no significant effects or interactions for the percent looking to match measures for the entire test trials and the 2nd half of the test trials ($ps\geq0.08$). However, the follow up t-tests showed that the ASD group looked significantly longer at the matching (i.e., ongoing) scenes during the entire test trials than the control trials, $t(33)=1.94$, $p=0.03$, $d=0.42$. For the percent looking to match measure during the 1st half of the test trials, a significant main effect of trial emerged, $F(1, 58)=12.33$, $p=0.001$, $\eta^2=0.18$, with no other significant effects or interactions. Follow-up t-tests revealed that for both groups, hearing sentences with *-zhe* triggered more eye movements to the ongoing scenes during the 1st half of the test trials compared to the control trials, TD: $t(25)=3.45$, $p=0.001$, $d=0.75$, ASD: $t(33)=1.74$, $p=0.03$, $d=0.36$.

3.2. Percent looking to the completed events results

Three two-way repeated measures ANOVAs were performed on the *percent-looking-to-completed-rendition* measures. The dependent measure was the difference scores calculated for the percent looking to completed renditions during the test trials (entire, 1st and 2nd half) minus the control trials (see Table 4). The within-subject factor was audio (*le*, *zhe*) and the between-subject factor was diagnostic group (TD, ASD) for each comparison. Main effects of trial were found for the entire test trial, $F(1, 58)=15.63$, $p<0.001$, $\eta^2=0.21$, and 2nd half of the test trial measures, $F(1, 58)=14.49$, $p<0.001$, $\eta^2=0.20$. No significant effects or interactions were found for the 1st half of the test trials measure. Thus, for both groups, while hearing the two audios, children's looking time to the completed events varied significantly for the entire test trials minus the control trials, TD: $t(25)=2.77$, $p=0.01$, $d=0.65$, ASD: $t(33)=3.02$, $p=0.005$, $d=0.76$, and for the 2nd half of the test trials minus the control trials, TD: $t(25)=2.78$, $p=0.01$, $d=0.44$, ASD: $t(33)=2.83$, $p=0.008$, $d=0.69$. As shown in Fig.1, when the two groups of children heard sentences with *-le*, they looked longer to the completed actions during the entire test trials compared to the control trials, whereas when they heard sentences with *-zhe*, they looked away from the completed actions during the entire test trials compared to the control trials. The two audios, thus, elicited distinct looking patterns for the child participants in both groups.

Table 4. Percent looking to completed events results for the aspect video by diagnostic groups

	TD (N=26)		**ASD (N=34)**	
Difference scores for the percent looking to completed events during test minus control trial	PERF:*le* M (SD)	DURA:*zhe* M (SD)	PERF:*le* M (SD)	DURA:*zhe* M (SD)
Entire test trial	0.07(0.13)	-0.02(0.13)*	0.05(0.11)	-0.05(0.16)**
First half of test trial	-0.05(0.16)	-0.12(0.18)	0.01(0.15)	-0.07(0.22)
Second half of test trial	0.16(0.16)	0.04(0.19)*	0.10(0.15)	-0.05(0.25)**

Note. TD, typically developing; ASD, autism spectrum disorder. t-tests (two-tailed), *p<0.05; **p<0.01, ***p<0.001.

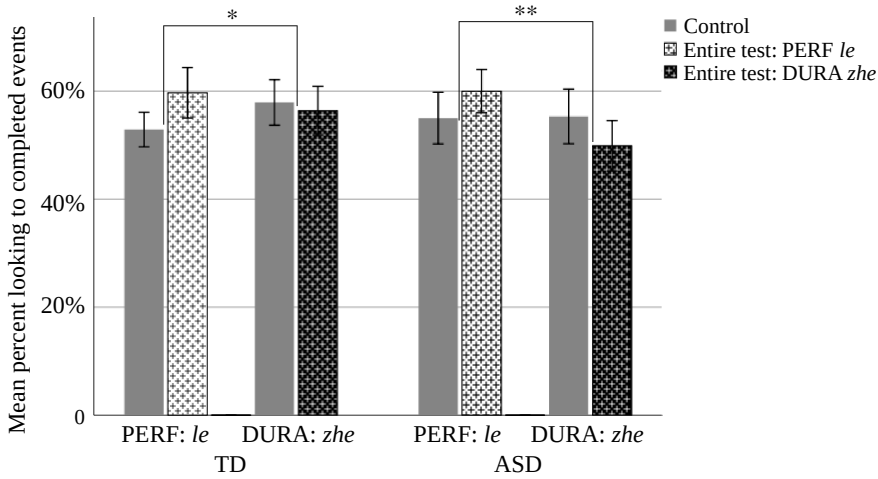

Fig. 1. Percent looking time to the completed events during the entire test trials compared with the control trials by diagnostic groups, *p<0.05; **p<0.01.

4. Discussion

In this study, we found that comprehension of the perfective *-le* and the durative *-zhe* remained a relative strength in a diverse sample of 3–6-year-old children with ASD exposed to Mandarin. Assessed via the IPL paradigm that minimizes social interactions, this group of preschoolers with ASD exhibited understanding of these two grammatical aspect markers, despite their noticeable difficulties with using aspect markers such as the perfective *-le* and the experiential *-guo*. They looked significantly longer at the matching over the nonmatching scenes when hearing both the *-le* and the *-zhe* during the test trials, relative to their baseline preferences during the control trials. For both groups, this effect held most strongly during the second half of the test trials in the *-le* rendition, and during the first half of the test trials in the *-zhe* rendition. In addition, both groups reliably distinguished these two aspect makers during the entire and second half of the test trials, by looking longer towards the completed events when hearing *-le* but away from it when hearing *-zhe* during test trials compared to the control trials. Hence, children with ASD demonstrated comprehension of the *-le* and *-zhe* in a similar fashion to that of 1–3-year-old TD children, though their vocabulary production levels were dramatically delayed.

Together with the findings from Tovar et al. (2015) in English-exposed children with ASD and Su & Naigles (2021) that examined the perfective *-le* and the progressive *zai-* in Mandarin-exposed children with ASD, our results provide incremental evidence that children with ASD have the syntactic and semantic knowledge encoded in grammatical aspect to facilitate sentence comprehension during the preschool period. Specifically in our study, when hearing the perfective *-le*, children with ASD constructed a mental representation of a completed event,

and then moved their eyes towards the scenes that have a temporal structure matched with this mental representation, while when hearing the durative *-zhe*, the children constructed a mental representation of an ongoing event, and then moved eyes towards the scenes matched with this mental representation, even though only a few of them in our study were reported to use the aspect markers *-le* and *-guo* (see also Xie & Su, 2018; Zhou et al., 2015).

Across languages, children with ASD's successful comprehension of perfective vs. imperfective aspect markers suggests that their pervasive impairment in aspectual usage/production may be attributed to a social rather than a grammatical origin. In our data, only a small proportion of children in the ASD group (33.3%) used the aspect markers *-le* and *-guo*, but when we minimized the demands on social and discourse interactions via the IPL paradigm, this diverse sample of children with ASD showed sensitivity to the aspectual contrast between the perfective *-le* and the durative *-zhe*. Such contrast between children with ASD's apparent deficits in aspectual production and their relative strength in aspectual comprehension is also related to the dichotomy between *linguistic performance* and *linguistic competence* (Chomsky, 1957). An individual's language behavior at any moment (*performance*) might not be an accurate index of his/her underlying linguistic knowledge (*competence*). We conjecture that, for example, in an elicitation task, children with ASD could be challenged in interpreting the stimuli in an interactive situation, and thus have difficulties with producing the target structures (Eigsti et al., 2007; Seung, 2007). Moreover, children with ASD may suffer from their inherent social/contextual deficits in making less reference to the past (e.g., 38.2% in this study) or to non-present events overall in spontaneous speech and also in language usage according to parental observations (Su & Naigles, 2021).

Furthermore, although the vocabulary production scores of the ASD group were significantly delayed, our results suggested that Mandarin-exposed children with ASD were able to map the perfective *-le* onto the completed events and the imperfective *-zhe* onto ongoing events in a pattern similar to that of the TD children. Consistent with the similar findings in Su & Naigles (2021), these results indicated that children with ASD's knowledge of grammatical aspect seems not restricted by their vocabulary levels, and thus provided evidence for the modular dissociation between the lexicon vs. grammar domains in ASD. In typical language development, the language faculty is divided into autonomous domains (e.g., phonology, lexicon, syntax, semantics), with linguistic information processed separately in different domains (Crain & Lillo-Martin 1999). Our findings hence underscore some degree of independence in the processes of vocabulary learning vs. grammatical acquisition as well, which supports a modular view of the language faculty in children with ASD (Su & Naigles, 2021).

To conclude, this research reveals the strengths in comprehending a minimal pair of grammatical aspect markers *-le* and *-zhe* in a diverse sample of 3-6-year-old Mandarin-exposed children with ASD. The results showed that the comprehension of aspectual morphemes was preserved in this sample of

preschools with ASD, though their vocabulary production skills were dramatically delayed, which provide incremental evidence that the pervasive impairment in aspectual production in children with ASD across languages may stem from their social difficulties in communications inherent to the ASD diagnosis rather than the fundamental grammatical deficits. Additionally, the ASD group's grammatical knowledge may not be hindered by their limited expressive vocabulary, which renders support for a modular view of the separate language domains (e.g., lexicon vs. grammar) of the language faculty in children with ASD.

Limitations of this study include that first of all, we did not examine verbal/non-verbal IQ, executive function or attention abilities of the participants. Moreover, we only focus on grammatical aspect, without a systematic investigation of lexical aspect. Future research is warranted to explore the acquisition of both grammatical and lexical aspect as well as their interactions in children with ASD.

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