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Short report: Longitudinal study on emotion understanding in children with and without developmental language disorder

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ABSTRACT

Background: Children with Developmental Language Disorder (DLD) have difficult access to social interactions, which could in turn limit their opportunities to learn about others' emotions.
Aims: This study aimed to investigate the developmental trajectories of emotion understanding in young children with and without DLD.
Methods and procedures: 95 DLD children and 149 non-DLD children were tested twice, with an approximately two-year interval (M_{age} = 3.58 years at Time 1), on three indices for emotion understanding (discrimination, identification, and attribution in emotion-evoking situations).
Outcomes and results: At Time 2, DLD children fell behind their non-DLD peers on the non-verbal task for emotion discrimination, while catching up on the verbal tasks for emotion identification and attribution. The two groups developed most of these skills with a similar improvement over time, but DLD children showed a greater increase in positive emotion identification and attribution with age than non-DLD children.
Conclusions and implications: The findings showed the potential of DLD children to understand others' emotions in verbal tasks to a similar extent as their non-DLD peers. However, DLD children may still face difficulties understanding more implicit emotional messages in real-life situations, and longitudinal follow-ups are required to reveal these challenges.

What this paper adds?

Children with Developmental Language Disorder (DLD) have difficult access to daily social interactions, which in turn limits their

Abbreviations: DLD, Developmental Language Disorder.

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opportunities to learn the nuances in other people's emotional expressions. Previous research has shown that school-aged DLD children still face difficulties understanding the basic emotions in others' expressions or those in emotion-provoking situations. However, studies on early childhood remain scarce, despite this stage being a crucial period for developing emotion understanding, and knowledge about how DLD children develop this skill is lacking. The current study is the first to longitudinally examine emotion understanding in DLD children over early childhood, by following up on a previous study two years later. Results highlight the potential of DLD children to catch up with their non-DLD peers on emotion understanding in verbal tasks. Meanwhile, the longitudinal findings reveal difficulties in understanding real-life, more implicit emotional information, suggesting the importance of providing an environment more suitable for incidental learning for DLD children.

1. Introduction

Emotion understanding is an integral part of daily social life. To develop this ability, children need the opportunity to observe, overhear, or participate in social interactions, in which emotions are displayed and used to communicate with one another. For children with a Developmental Language Disorder (DLD), these opportunities do not come easily. DLD is characterized by persistent difficulties with acquiring language, including the acquisition of vocabulary, sentence structure, and discourse (DSM-5; American Psychiatric Association, 2013), with a high prevalence of 3–7 % in (early) childhood (Calder et al., 2022; Law et al., 1998; Norbury et al., 2016). DLD children may miss words in conversation, have difficulties processing sentences spoken by others, or have difficulties socializing with other people and talking about their thoughts and feelings, which in turn hinders their social participation and the learning of emotions (Blaskova & Gibson, 2021; Rieffe et al., 2016). However, the extent to which DLD affects children's emotion understanding has been limitedly studied, and it remains unexplored how DLD children develop this ability in early childhood. This study was the first to longitudinally examine emotion understanding in young children with and without DLD.

Emotion understanding involves at least three levels of skills, which develop gradually with age, from knowing two emotions are different (*discrimination*), to understanding which specific emotion is shown in an expression (*identification*), and finally to linking an emotion to a social context (*attribution*). At an age of four months, most infants can already discriminate between positive and negative facial expressions (e.g., Barrera & Maurer, 1981; Hunnius et al., 2011). This ability continues to develop over early childhood, from a valence-based differentiation (e.g., happy and unhappy) to distinguishing discrete emotions within the same valence (e.g., anger and sadness). At eight years of age, children's performance to discriminate basic emotions reaches the adult level (Mondloch et al., 2003). The ability to identify emotions starts later as it requires the understanding of emotional words, yet it can be seen in children before their third birthday (Dunn et al., 1987; Ensor & Hughes, 2005; Pons et al., 2004). By the age of six years, most children are able to associate emotional labels with corresponding facial expressions (Bruce et al., 2000). The ability to attribute emotions to a social context starts to develop around the age of two years, as children show a greater sensitivity towards actions incongruent with the displayed facial expressions (Hepach & Westermann, 2013). Around this age, children can also be observed to attribute emotions to their toy dolls or to their siblings during pretend play (Dunn et al., 1987). Depending on the complexity of the emotion involved, children keep refining their ability to make affect-event links into adulthood (e.g., Theurel et al., 2016).

Previous studies showed that at school age, DLD children have acquired the ability to discriminate between basic emotions (i.e., happy, anger, sadness, and fear) when asked to match facial expressions (Delaunay-El Allam et al., 2011; Loukusa et al., 2014), and to identify emotions by verbally labelling facial expressions of basic emotions (e.g., Delaunay-El Allam et al., 2011; McCabe & Meller, 2004), to a similar extent as non-DLD children. Yet, DLD children were consistently reported to be less accurate than non-DLD children in attributing a basic emotion to a prototypical social situation (i.e., a situation expected to trigger a similar emotion in most people, such as anger when being put a lollipop in the hair by someone intentionally; e.g., McCabe & Meller, 2004; Spackman, Fujiki, Brinton, 2006).

However, these studies were based on school-aged children and a cross-sectional design. It remains unknown how DLD children develop these skills over early childhood, i.e., a critical period for developing emotion understanding (Denham et al., 2003). To our knowledge, only two cross-sectional studies from the same research team explicitly examined the effect of age on emotion understanding in DLD children, by comparing a younger group (aged 5–8 years) and an older group (9–12 years) with and without DLD (Spackman, Fujiki, Brinton, 2006; Spackman, Fujiki, Brinton, Nelson et al., 2006). They found no clear age effect on emotion identification, whereas the older children performed more accurately on emotion attribution than the younger children, regardless of the DLD diagnosis. Taken together, the available body of evidence suggests that children with and without DLD may have acquired the skills to discriminate and identify basic emotions by the time they enter primary schools, while their ability to attribute emotions to social situations may continue to develop into adolescence.

1.1. Present study

This study was a follow-up of an earlier cross-sectional study in which children with and without DLD were tested on emotion understanding (i.e., discrimination, identification, and attribution), at a mean age of 3.5 years (Rieffe & Wiefferink, 2017). This earlier study showed that DLD children scored lower on tasks with language demands, i.e., identifying a facial expression with an emotion word, and attributing an emotion to a situational context, but not on emotion discrimination, compared to non-DLD children.

For the present study, the same children were tested again approximately two years later, with the same emotion understanding tasks. The question was to what extent DLD children caught up with their non-DLD peers, whether the gap between the two groups remained stable over time, or increased. Regarding the discrimination of basic emotions, we expected that DLD children would keep on performing similarly as their non-DLD peers two years later at Time 2 (i.e., at an average age of 5.5 years), with a similar

Table 1
Characteristics of the participants.

	DLD	Non-DLD
Age at Time 1 (years)	$n = 95$	$n = 149$
Mean	3.52	3.63
SD	0.43	0.90
Range	2.33 – 4.75	2.00 – 5.00
Age at Time 2 (years)	$n = 71$	$n = 85$
Mean	5.60	5.68
SD	0.40	0.93
Range	4.42 – 6.83	4.00 – 7.50
Gender		
Boys	77 (81.1 %)	71 (49.7 %)
Girls	18 (18.9 %)	72 (50.3 %)
Non-verbal IQ (SD)[a]	104 (16)	113 (15)

[a] Nonverbal IQ was assessed by the Snijders-Oomen Nonverbal Intelligence Test 2.5–7-Revised (Tellegen et al., 2005) in 60 DLD children and 91 non-DLD children. Although all children had nonverbal IQ scores within the normal range, the nonverbal IQ of DLD children was lower than that of non-DLD children ($t(149) = 3.69$, $p < .001$).

developmental trajectory (Delaunay-El Allam et al., 2011; Loukusa et al., 2014). For emotion identification, DLD children were expected to catch up with their non-DLD peers when they entered primary schools, and thus no group differences were expected at Time 2 (Delaunay-El Allam et al., 2011; McCabe & Meller, 2004). A catch-up may result from stronger increases with age in the ability of DLD children. Alternatively, non-DLD children may have reached the adult level of performance at school age (i.e., Time 2) on identifying basic emotions (Bruce et al., 2000), and thus a catch-up in DLD children may be accomplished by a similar or lower rate of increase with age, compared to non-DLD children. Lastly, for emotion attribution, DLD children were hypothesized to still score lower than non-DLD children at Time 2 (McCabe & Meller, 2004; Spackman, Fujiki, Brinton, 2006). Therefore, DLD children were expected to develop this skill at a similar or lower rate of increase with age, compared to non-DLD children (Spackman, Fujiki, Brinton, 2006). Given a lack of longitudinal evidence, our hypotheses for the pace of development in DLD children were explorative in nature.

2. Methods

2.1. Participants

Ninety-five DLD children and 149 non-DLD children were tested twice, with an interval of approximately two years (range = 1.25–2.58 years; $M_{interval} = 2.05$). They aged 2–5 years at the first assessment (Time 1) and 4–7.5 years at the second assessment (Time 2). DLD children were recruited from special treatment groups for DLD children over the Netherlands. Children visiting these groups were diagnosed with language impairment (1.5 standard deviation below average on standardized language tests) without additional conditions such as hearing loss, autism, or general developmental delay. Most participants with DLD were boys (i.e., 81.1 %), in accordance with prevalence rates of DLD (Law et al., 1998). Non-DLD children were recruited through childcare facilities in the Netherlands. See Table 1 for more information about the participants.

This study is part of a large research project on social-emotional development of children with communication difficulties, including deaf and hard-of-hearing children, autistic children, and DLD children (Broekhof et al., 2015; Ketelaar et al., 2010, 2012, 2013, 2015, 2017; Li et al., 2020, 2021, 2022; Netten et al., 2018; Rieffe & Wiefferink, 2017; Tsou et al., 2021; Wiefferink et al., 2012, 2013). Informed consent was obtained from all parents and the study was approved by the university's medical ethical committee.

2.2. Materials and procedure

Children were administered an *Emotion Discrimination Task*, an *Emotion Identification Task*, and an *Emotion Attribution Task*. At Time 1, DLD children were tested individually in a quiet room in the treatment group, and at home at Time 2. Non-DLD children were tested in a quiet room at the childcare facilities at Time 1 and a quiet room at school at Time 2. Tasks requiring language (*Emotion Identification* and *Emotion Attribution*) were not administered if the language comprehension of the children was deemed insufficient, i.e., not understanding the word "why" (indicated by parents), or misidentifying more than four objects (among 13 objects, e.g., bike, carrot) in a passive vocabulary test. These tests were developed for the purpose of this study and the other studies in the larger research project, to assess if children's language comprehension was sufficient to understand the tasks presented to them. All sessions were recorded on video and made into transcripts, and the written transcripts were then coded by two researchers. The three emotion understanding tasks have been published in Rieffe and Wiefferink (2017) and Wiefferink et al. (2013). Also see Table A.1 for details about these tasks.

2.3. Statistical analysis

Children unable to perform a task (including those who did not pass the language comprehension test) received a score of 0 for that task. Statistical analyses were performed using SPSS 23.0 (SPSS Inc., Chicago). Graphs were made using R (R Core Team, 2014;

Table 2
Mean scores (standard deviation) for Emotion Discrimination task, Emotion Identification task, and Emotion Attribution tasks.

	Scale	DLD		Non-DLD	
		Time 1	Time 2	Time 1	Time 2
		$n = 92$	$n = 71$	$n = 143$	$n = 85$
Emotion Discrimination[a]	0–3	1.56 (.67)	2.20 (.66)	1.64 (.84)	2.52 (.64)
Emotion Identification	0–2	$n = 94$	$n = 71$	$n = 134$	$n = 85$
Positive Emotion[b]		1.17 (.88)	1.97 (.17)	1.61 (.73)	1.98 (.15)
Negative Emotions[b]		1.02 (.78)	1.83 (.29)	1.25 (.69)	1.89 (.24)
Emotion Attribution	0–1	$n = 91$	$n = 70$	$n = 134$	$n = 85$
Positive emotion prediction[b]		0.34 (.36)	0.91 (.18)	0.62 (.41)	0.89 (.24)
		$n = 93$	$n = 70$	$n = 134$	$n = 85$
Negative emotion prediction[b]		0.41 (.36)	0.87 (.20)	0.63 (.38)	0.84 (.21)

[a] $p < .05$ at Time 2 based on *t*-tests.
[b] $p < .05$ at Time 1 based on *t*-tests.

GGplot2 package).

Group differences at Time 1 and 2 were examined by independent *t*-tests. Longitudinal analyses were conducted using Linear Mixed Models (LMM) to assess the developmental trajectory of emotion discrimination, identification, and attribution in children with and without DLD. We used LMM because it allows for hierarchy within longitudinal data, and can handle missing follow-up data.

Following a formal model-fitting procedure for LMM, we started with an unconditional means model that only includes a fixed and random intercept, to allow for individual differences at starting points. Second, to test the grand mean trajectory of age, two polynomial terms (linear and quadratic) for age (centered around 24 months [age of the youngest child]) were added. Additionally, we included a random-slope effect of age, but this did not improve model fit. Third, group (i.e., non-DLD, DLD) and the interaction between group and age were included, to examine whether the developmental trajectory differed between children with and without DLD. The model fits were evaluated by Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Preferred models have significantly lower AIC and BIC values.

3. Results

Table 2 presents means and standard deviations of all tasks at two timepoints. The LMMs for the longitudinal results are shown in Table A.2.

3.1. Group differences

Regarding Emotion Discrimination, no differences were found between children with and without DLD at Time 1, $t(233) = .73$, $p = .469$. At Time 2, DLD children scored lower than non-DLD children, $t(154) = 3.04$, $p = .003$.

As to Emotion Identification, DLD children had more difficulties recognizing both Positive ($t(226) = 4.13$, $p < .001$) and Negative Emotions ($t(226) = 2.32$, $p = .022$) at Time 1, compared to non-DLD children. At Time 2 no group differences were observed.

On the Emotion Attribution task, DLD children had more difficulties attributing both Positive ($t(223) = 5.29$, $p < .001$) and Negative emotions ($t(225) = 4.45$, $p < .001$) to hypothetical situations at Time 1, compared to non-DLD children. At Time 2 no differences were observed.

3.2. Developmental patterns

The longitudinal analyses indicated an increase with Age on the performance of all the three indices for emotion understanding in both group (see Table A.2 and Fig. 1 for the best-fitting models).

However, the increase in Positive Emotion Identification with Age was stronger in DLD children than in non-DLD children (Group x Age: $b = .01$, $p = .012$; Fig. 1A). Similarly, the increase in Positive Emotion Attribution with Age was stronger in DLD children compared to non-DLD children (Group x Age: $b = .01$, $p = .001$; Fig. 1C).

No other group differences in the developmental trajectories were noted in the best-fitting models. While the interaction of Group x Age was significant when added to the models for Emotion Discrimination and for Negative Emotion Attribution, the addition did not improve the fits of these models.

4. Discussion

This study addressed the development of emotion understanding in young children with and without DLD, by following up on an earlier study (Rieffe & Wiefferink, 2017) two years later. Compared to non-DLD children, DLD children at the follow-up (Time 2) only scored lower on the non-verbal task (emotion discrimination), while performing similarly on all the other tasks, which required language (emotion identification and attribution), a pattern opposite to what was observed at Time 1 in the earlier study. Moreover,

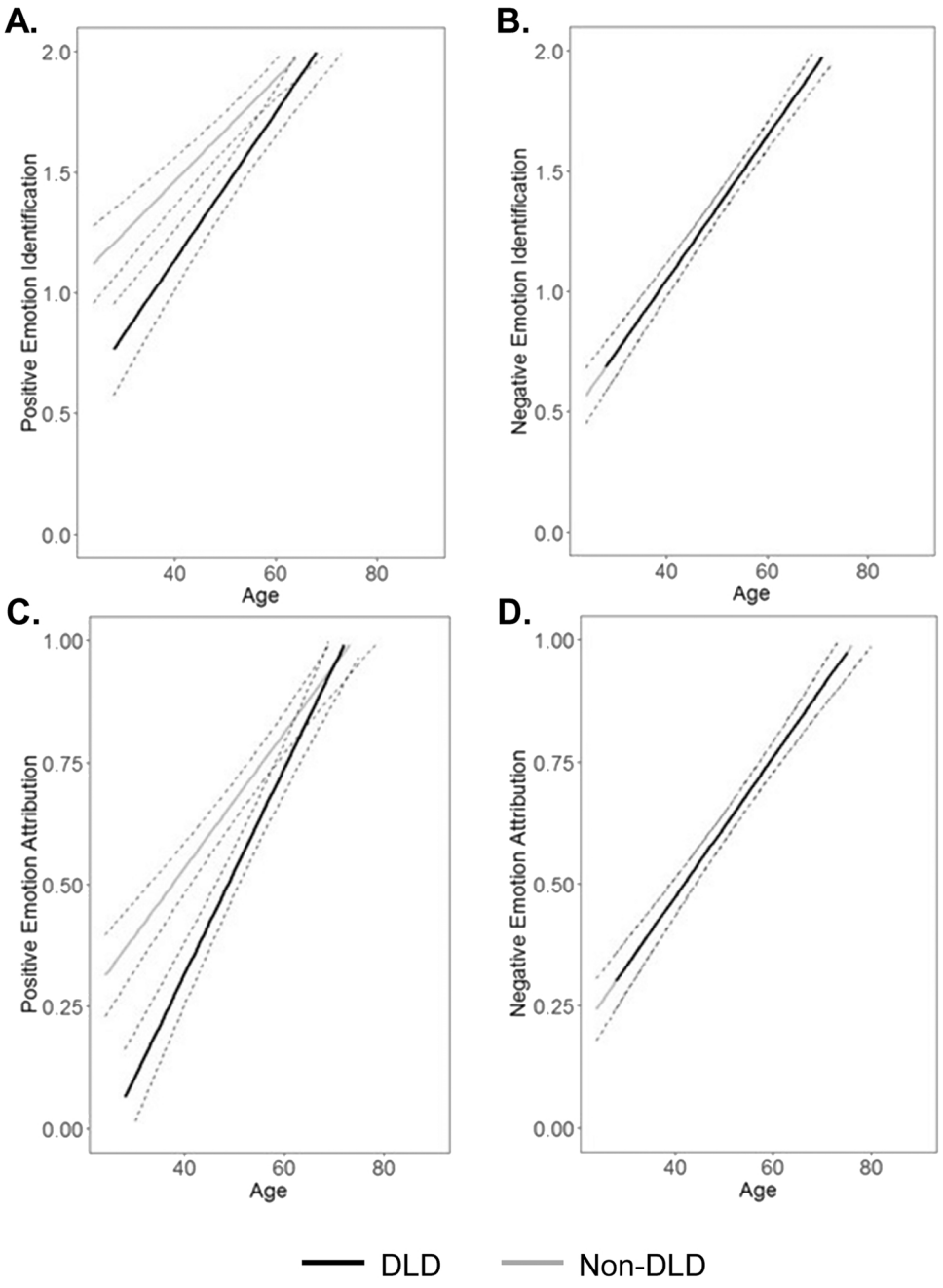

Fig. 1. Longitudinal representations of Age (months) with Positive (**A.**) and Negative (**B.**) Emotion Identification, and Positive (**C.**) and Negative (**D.**) Emotion Attribution based on the predicted values of the best fitting model. *Note.* Black lines represent DLD children and grey represent non-DLD children. When only one line is visible (i.e., in B & D), models for DLD and non-DLD children overlap. Dotted lines represent 95 % confidence intervals.

children with and without DLD developed these skills with a largely similar increase over time. The only exception was that DLD children showed a greater improvement in positive emotion identification and attribution than non-DLD children.

These outcomes are rather positive and encouraging for the DLD group. The DLD children showed their potential to catch up with their non-DLD peers with a similar or even stronger growth with age, on the emotion understanding skills that involved language. Note that between Time 1 and 2, DLD children attended intensive early childhood treatments and entered preschools. The increased access to emotional-social events during this period may at least partially explain the positive results. Nevertheless, many non-DLD children had already reached the (near-)ceiling level at Time 1 for identifying and attributing positive emotions (see Table A.3 for the distribution of scores), thus also leaving a smaller room for improvement. Future studies might examine emotion understanding at more

Table A1
Detailed description of the emotion understanding tasks.

Task	Description	Scale
Emotion Discrimination	This task tested children's ability to differentiate facial emotion expressions with different valences (block 1: happy versus sad), and within the same valence (block 2: angry versus sad;). In both blocks, children had to place six pictures of facial expressions, three for each emotion, under the sample picture on a sheet of paper. Each emotion in each block was scored based on the number of correctly placed cards. Before the emotion discrimination blocks, children were first given two control questions for testing their ability to discriminate between cars versus flowers, and faces with hats versus faces with glasses. Children only continued to the emotion discrimination blocks if they passed the control questions. The pictures of facial emotion expressions used in this task were all computer-generated drawings, in black and white, based on real-life photos of different 3- and 4-year-old boys randomly selected from a large database.	0–3 per block
Emotion Identification	This task assessed children's ability to point at the facial expressions corresponding to the emotion words they hear. The researcher presented eight drawings of faces, two for each of the four basic emotions (i.e., happiness, sadness, fear, and anger), all at once to the children, and asked for each emotion twice: "Who looks <emotion word>?".	0–2 per emotion
Emotion Attribution	In this task, eight vignettes with emotion-evoking events, two for each basic emotion, were shown to children accompanied by a simple explanation. After each vignette, children first named the emotion that the protagonist would feel (verbal condition), and chose a drawing out of four drawings of facial expressions of basic emotions that matched with the feeling (nonverbal condition). Children might experience different emotions in a situation based on where they focus; e.g., when someone pulls at the protagonist's shirt, some children may feel angry if they think this wrongdoing should be addressed, while others may feel sad if they focus on the protagonist's experience of being disrespected or the shirt that was torn. Therefore, an answer was considered correct when a child predicted an emotion within the intended valence (i.e., 1 = correct valence; 0 = incorrect valence). The scores of the two conditions were averaged. The eight situations are: 1. Boy is building a tower; someone knocks it down (angry) 2. Boy receives an ice cream (happy) 3. Someone is pulling at the boy's shirt (angry) 4. Boy falls from bicycle (sad) 5. Boy receives a present (happy) 6. Boy sees a frightening dog (fear) 7. The spade of the boy is broken (sad) 8. Boy sees a crocodile (fear) Example story: (Step 1) The test leader describes what is shown on the drawing: "Look, boy falls from his bicycle." (Step 2) "How does he feel?" (child names or signs emotion). (Step 3) "How does he look?" (child points to drawing of emotional faces).	0–1 per situation

difficult levels in children with and without DLD. For example, in Spackman, Fujiki, Brinton (2006) school-aged DLD children had to predict an emotion from more complex situations that comprised multiple scenes, and scored lower than their non-DLD peers.

Although DLD children performed better on emotion discrimination at Time 2 compared to Time 1, their scores were lower at Time 2 compared to their non-DLD peers. So the question is why DLD children improved less well on this task than their non-DLD peers. This emotion discrimination task was based on facial expressions generated from real-life photos of preschool children expressing genuine emotions, whereas the other tasks used symbolic drawings depicting clear facial features that enabled children to identify the four basic emotions, i.e., happiness, anger, sadness, and fear. Most likely, the four basic emotions and their characteristic facial features have been explicitly taught and discussed with children in classes, as part of the curriculum. Interpreting real-life facial emotional expressions, however, is something that children have to learn implicitly during their daily social interactions and own observations. Implicit learning could be more demanding for DLD children; as part of their diagnosis, they have more difficulties accessing the social world around them. Moreover, real-life facial expressions can be more subtle, and give more information beyond the emotion expression, unlike the more symbolic drawings used in the other tasks. Also other studies found that more diffuse information is more challenging for children with communication difficulties (e.g., Tsou et al., 2021).

Future studies are suggested to examine the plausibility of these assumptions, given that in real-life social interactions, emotional signals are often subtle, which can be a challenge for DLD children. This might also partially explain why adolescents with DLD still report difficulties recognizing basic emotions in daily life (e.g., Van den Bedem et al., 2020). Further research using more naturalistic settings, along with techniques like eye-tracking and psychophysiological measures, is required to understand the underlying emotion processing patterns among individual DLD children. Moreover, an inclusive, more easily accessible daily social environment is needed to better support DLD children for their acquisition of emotional knowledge and prevent them from feeling exhaustion in the learning process.

Conflict of Interest

We have no known conflict of interest to disclose.

Table A2
Linear mixed models on the developmental pattern of Emotion Discrimination, Emotion Identification and Emotion Attribution.

	Emotion Discrimination	Emotion Identification		Emotion Attribution	
		Positive	Negative	Positive	Negative
Model 1					
Intercept	1.91***	1.65***	1.44***	0.67***	0.66***
AIC/BIC	966.81/974.74	818.65/826.55	808.68/816.58	376.75/384.62	310.09/317.97
df	3	3	3	3	3
Model 2					
Intercept	**1.01*** **	0.91***	**0.55*** **	0.18***	**0.24*** **
Age	**0.03*** **	0.03***	**0.03*** **	0.02***	**0.01*** **
AIC/BIC	**819.49/827.42**	699.90/707.79	**607.96/615.85**	202.51/210.38	**157.12/165.00**
df	**4**	4	**4**	4	**4**
Model 3					
Intercept	0.94***	**1.12*** **	0.67***	**0.31*** **	0.35***
Age	0.04***	**0.02*** **	0.03***	**0.01*** **	0.01***
Group	0.22	**-0.53*** **	-0.30*	**-0.34*** **	-0.27***
Age*Group	-.01**	**0.01***	0.01	**0.01*** **	0.01**
AIC/BIC	821.39/829.30	**693.12/701.00**	614.36/622.24	**190.63/198.49**	154.05/161.92
df	6	**6**	6	**6**	6

Note. Values for the best fitting model are displayed in bold.
* $p \leq .05$,
** $p \leq .01$,
*** $p \leq .001$.

Table A3
Emotion understanding scores at the 5th, 25th, 50th, 75th, and 95th percentile in children with and without Developmental Language Disorder (DLD).

		DLD					Non-DLD				
	Scale	5th	25th	50th	75th	95th	5th	25th	50th	75th	95th
Time 1											
Emotion discrimination	0–3	0.25	1.25	1.50	2	2.50	0	1.25	1.75	2.25	3
Emotion identification											
Positive emotion	0–2	0	0	1	2	2	0	2	2	2	2
Negative emotions	0–2	0	0	1	1.67	2	0	0.67	1.33	2	2
Emotion attribution											
Positive emotion	0–1	0	0	0.25	0.50	1	0	0.25	0.75	1	1
Negative emotions	0–1	0	0	0.33	0.67	1	0	0.33	0.75	1	1
Time 2											
Emotion discrimination	0–3	1	1.75	2.25	3	3	1.50	2.25	2.75	3	3
Emotion identification											
Positive emotion	0–2	2	2	2	2	2	2	2	2	2	2
Negative emotions	0–2	1.33	1.67	2	2	2	1.33	2	2	2	2
Emotion attribution											
Positive emotion	0–1	0.50	1	1	1	1	0.50	1	1	1	1
Negative emotions	0–1	0.42	0.83	1	1	1	0.50	0.83	0.83	1	1

Data availability

The data used in this study will be shared with open access at DataverseNL upon the acceptance of the manuscript.

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Appendices.

See Table A1, Table A2, Table A3.

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