# Understanding, expressing, and interacting: the development of emotional functioning in young children with autism

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# Appendices.

Supplementary materials

Acknowledgements

Curriculum Vitae

**Supplementary Materials Chapter 2**

Table S2.1. Means and standard deviations (SD) of emotion discrimination at four waves.

| | *Autistic* | | | *Non-autistic* | | |
|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** |
| **Positive vs. Negative (0-3)** | | | | | | |
| Time 1 | 1.91 | 1.08 | 61 | 2.19 | .84 | 121 |
| Time 2 | 2.30 | .96 | 45 | 2.63 | .74 | 51 |
| Time 3 | 2.49 | .83 | 43 | 2.86 | .41 | 49 |
| Time 4 | 2.59 | .81 | 41 | 2.89 | .31 | 47 |
| **Sad vs. Angry (0-3)** | | | | | | |
| Time 1 | 1.57 | 1.06 | 61 | 1.87 | .91 | 121 |
| Time 2 | 1.97 | .95 | 45 | 2.17 | .94 | 52 |
| Time 3 | 2.17 | .94 | 43 | 2.56 | .75 | 49 |
| Time 4 | 2.33 | .90 | 40 | 2.73 | .52 | 47 |

Table S2.2. Means and standard deviations (SD) of emotion identification at four waves.

| | *Autistic* | | | *Non-autistic* | | |
|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** |
| **Happy (0-2)** | | | | | | |
| Time 1 | 1.39 | .88 | 62 | 1.75 | .60 | 121 |
| Time 2 | 1.67 | .74 | 45 | 1.98 | .14 | 52 |
| Time 3 | 1.88 | .45 | 43 | 1.94 | .24 | 49 |
| Time 4 | 1.93 | .35 | 41 | 2.00 | .00 | 47 |
| **Angry (0-2)** | | | | | | |
| Time 1 | 1.29 | .91 | 62 | 1.77 | .60 | 121 |
| Time 2 | 1.60 | .75 | 45 | 2.00 | .00 | 52 |
| Time 3 | 1.84 | .53 | 43 | 2.00 | .00 | 49 |
| Time 4 | 1.83 | .54 | 41 | 2.00 | .00 | 47 |
| **Sad (0-2)** | | | | | | |
| Time 1 | 1.03 | .94 | 62 | 1.37 | .83 | 121 |
| Time 2 | 1.38 | .81 | 45 | 1.77 | .47 | 52 |
| Time 3 | 1.70 | .64 | 43 | 1.92 | .28 | 49 |
| Time 4 | 1.83 | .50 | 41 | 1.96 | .20 | 47 |
| **Fear (0-2)** | | | | | | |
| Time 1 | 1.10 | .95 | 62 | 1.36 | .84 | 121 |
| Time 2 | 1.42 | .87 | 45 | 1.79 | .50 | 52 |
| Time 3 | 1.74 | .62 | 43 | 1.94 | .24 | 49 |
| Time 4 | 1.88 | .46 | 41 | 1.94 | .32 | 47 |

Table S2.3. Means and standard deviations (SD) of emotion attribution at four waves.

| | *Autistic* | | | | | | *Non-autistic* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***Verbal*** | | | ***Visual*** | | | ***Verbal*** | | | ***Visual*** | | |
| | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** |
| **Positive emotions (0-2)** | | | | | | | | | | | | |
| Wave 1 | 1.10 | .89 | 62 | 1.11 | .89 | 62 | 1.58 | .69 | 121 | 1.59 | .68 | 121 |
| Wave 2 | 1.58 | .78 | 45 | 1.58 | .78 | 45 | 1.88 | .32 | 52 | 1.88 | .32 | 52 |
| Wave 3 | 1.53 | .74 | 47 | 1.60 | .69 | 43 | 1.79 | .45 | 53 | 1.78 | .47 | 49 |
| Wave 4 | 1.61 | .61 | 47 | 1.63 | .58 | 41 | 1.87 | .34 | 53 | 1.86 | .35 | 43 |
| **Negative emotions (0-2)** | | | | | | | | | | | | |
| Wave 1 | 1.18 | .66 | 62 | .94 | .73 | 62 | 1.11 | .52 | 121 | 1.13 | .49 | 121 |
| Wave 2 | 1.30 | .61 | 45 | 1.34 | .62 | 45 | 1.29 | .31 | 52 | 1.33 | .30 | 52 |
| Wave 3 | 1.45 | .55 | 43 | 1.47 | .57 | 43 | 1.28 | .38 | 49 | 1.27 | .39 | 49 |
| Wave 4 | 1.33 | .55 | 41 | 1.34 | .53 | 41 | 1.30 | .45 | 47 | 1.34 | .45 | 45 |

Table S2.4. Eight vignettes depicting emotion-provoking situations in the emotion attribution task.

| Vignette content |
|---|
| 1. The boy is building a tower; someone knocks it down. |
| 2. The boy receives an ice cream. |
| 3. Someone is pulling at the boy's shirt. |
| 4. The boy falls off from the bicycle. |
| 5. The boy receives a present. |
| 6. The Boya sees a frightening dog. |
| 7. The spade of the boy is broken. |
| 8. The boy sees a crocodile. |

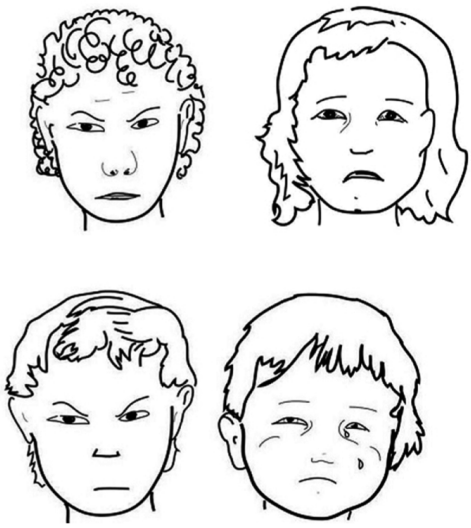

Figure S2.1. Examples of facial emotion expressions used in this study. From left to right: angry facial expressions and sad facial expressions.

Table S2.5. Model fit indices of the best age models for emotion recognition.

| | **Emotion discrimination** | | | |
|---|---|---|---|---|
| | **Positive vs. negative** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 1143.21 | 1155.59 | 1137.21 | - |
| ***Best age model*****:** age (linear; fixed), group | 1033.77 | 1054.28 | 1023.77 | $X^2$ (2)=113.44, $p$<.001 |
| | **Sad vs. Anger** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 1241.63 | 1254.01 | 1235.63 | - |
| ***Best age model:*** age (linear; fixed), group | 1118.13 | 1138.65 | 1108.13 | $X^2$ (2)=127.50, $p$<.001 |

| | | | | |
|---|---|---|---|---|
| | | | | **Emotion identification** |
| | **Happy** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 712.53 | 724.93 | 706.53 | |
| ***Best age model:*** age (linear; fixed & random), group, age x group | 552.65 | 585.50 | 536.65 | $X^2$ (5)=169.88, $p$<.001 |
| | **Angry** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 743.92 | 756.32 | 737.92 | |
| ***Best age model:*** age (linear; fixed & random), group, age x group | 561.89 | 594.73 | 545.89 | $X^2$ (5)=192.04, $p$<.001 |
| | **Sad** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 1003.97 | 1016.37 | 997.97 | |
| ***Best age model:*** age (linear; fixed & random), group | 857.09 | 885.84 | 843.09 | $X^2$ (4)=154.89, $p$<.001 |
| | **Fear** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 1017.72 | 1030.11 | 1011.72 | |
| ***Best age model:*** age (linear; fixed & random), group | 850.26 | 879.01 | 836.26 | $X^2$ (4)=161.71, $p$<.001 |
| | | | | **Emotion attribution** |
| | ***Positive emotions (Verbal)*** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 963.13 | 975.52 | 957.13 | |
| ***Best age model:*** age (linear; fixed & random), group | 832.06 | 860.80 | 818.06 | $X^2$ (4) = 139.07, $p$ < .001 |

| | ***Positive emotions (Visual)*** | | | |
|---|---|---|---|---|
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 892.08 | 904.45 | 886.08 | |
| ***Best age model:*** age (linear; fixed & random), group, age x group | 782.54 | 815.32 | 766.54 | $X^2$ (5) = 119.54, $p < .001$ |
| | ***Negative emotions (Verbal)*** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 541.32 | 553.71 | 535.32 | |
| ***Best age model:*** age (linear; fixed) | 524.59 | 541.02 | 516.59 | $X^2$ (1) = 18.73, $p < .001$ |
| | ***Negative emotions (Visual)*** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 692.32 | 794.71 | 686.32 | |
| ***Best age model:*** age (linear; fixed & random) | 622.05 | 646.67 | 610.05 | $X^2$ (3) = 76.27, $p < .001$ |

NOTE. Models removed during the formal model-fitting procedures were not presented here. The $\chi^2$ statistics present the comparisons of the -2LL values between the best fitting models and the null models.

Table S2.6. Model fit indices of the predicting models with the means score of SRS as the predictor on emotion recognition abilities in autistic children.

| | | | | **Emotion discrimination** |
|---|---|---|---|---|
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Age-only model*** | 425.04 | 437.92 | 417.04 | - |
| ***Model with SRS mean*** | 338.55 | 353.71 | 328.55 | $X^2$ (1) = 88.49, $p$ < .001 |
| | | | | **Emotion identification** |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Age-only model*** | 283.88 | 296.76 | 275.88 | - |
| ***Model with SRS mean*** | 230.16 | 245.31 | 220.16 | $X^2$ (1) = 55.72, $p$ < .001 |
| | | | | **Emotion attribution verbal condition** |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Age-only model*** | 301.82 | 314.71 | 293.82 | - |
| ***Model with SRS mean*** | 243.82 | 258.98 | 233.82 | $X^2$ (1) = 60, $p$ < .001 |
| | | | | **Emotion attribution visual condition** |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Age-only model*** | 310.73 | 323.59 | 302.73 | - |
| ***Model with SRS mean*** | 251.71 | 266.83 | 241.71 | $X^2$ (1) = 61.02, $p$ < .001 |

NOTE. The $\chi^2$ statistics present the comparisons of the -2LL values of the age-only models and the models with SRS mean and change scores as predictors.

**Supplementary Materials Chapter 3**

Table S3.1. Sample size justification.

| Analysis | Explanation |
|---|---|
| Power analysis for the larger project | An a priori power analysis was conducted for the larger research project that embedded this study. It showed that to observe a medium-sized effect (effect size = .35, power = .80, alpha = .05), a total sample size of 216 children would be needed for analyses with four repeated measures and two groups. Note that this analysis was done for the larger project and based on a repeated measure ANOVA design. We opted for mixed models for the current study because it better accounts for the dependency within the data and can handle missing or unbalanced data. |
| Power analysis for the present study | We did not conduct an a priori power analysis specifically for this study because the study was based on the data already collected. Yet, to understand the sample size needed for detecting the effect of diagnosis group in multilevel models, a simulation analysis was conducted via the Optimal Design program (Version 3.01; Raudenbush et al., 2011). It showed that in the case where each participant has two waves of data, an effect of group can be detected with a power ≥ .80 when the total number of participants is ≥ 150; in the case where each participant has three waves of data, a total sample size of ≥ 100 is needed (alpha = .05; effect size = .35). Given that 80% of our participants had three waves of data, we assumed that the power for conducting the analyses is adequate. |

Table S3.2. Internal consistency of measures at three times points.

| | Cronbach's α | | |
|---|---|---|---|
| | **Autistic** | **Non-autistic** | **Total** |
| **Time 1** | | | |
| Shame/guilt | 0.97 | 0.79 | 0.96 |
| Pride | 0.88 | 0.78 | 0.83 |
| EU | 0.91 | 0.74 | 0.91 |
| **Time 2** | | | |
| Shame/guilt | 0.71 | 0.82 | 0.81 |
| Pride | 0.83 | 0.78 | 0.80 |
| EU | 0.92 | 0.76 | 0.92 |
| **Time 3** | | | |
| Shame/guilt | 0.81 | 0.83 | 0.86 |
| Pride | 0.79 | 0.81 | 0.82 |
| EU | 0.88 | 0.79 | 0.89 |

NOTE. EU: emotion understanding.

Table S3.3. Correlation matrix of the predicting variables and moral emotions at three time points.

| | | Pride | | | Age | | | FB[a] | | | EU[b] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | T1 | T2 | T3 | T1 | T2 | T3 | T1 | T2 | T3 | T1 | T2 | T3 |
| **Shame** | **T1** | .29** | | | .06 | | | .45**/.16 | | | -.25/.15 | | |
| | **T2** | | .09 | | | -.21* | | | .03 | | | .10 | |
| | **T3** | | | .42** | | | .12 | | | .30** | | | .36** |
| **Pride** | **T1** | | | | .36*/.05 | | | .40**/-.07 | | | -.03 | | |
| | **T2** | | | | | .15 | | | .45**/-.002 | | | .15 | |
| | **T3** | | | | | | -.10 | | | .39*/-.01 | | | .13 |
| **Age** | **T1** | | | | | | | .45**/.66** | | | .02 | | |
| | **T2** | | | | | | | | .39** | | | -.01 | |
| | **T3** | | | | | | | | | .23* | | | .22 |
| **FB[a]** | **T1** | | | | | | | | | | .16 | | |
| | **T2** | | | | | | | | | | | .45**/.13 | |
| | **T3** | | | | | | | | | | | | .34** |

Note. [a.] false belief; [b.] emotion understanding. *$p < .05$; **$p < .001$.

First, the correlation analyses were conducted for children with and without ASD separately. Next, Fisher *r*-to-*z* transformations were used to compare the correlations of the two groups. Correlations that did not differ between groups were recalculated by collapsing groups. Correlations that differed between groups were both reported in the table, with the correlation of the ASD group on the left and the correlation of the non-ASD group on the right separated by slash.

**Supplementary Materials Chapter 4**

Table S4.1. Mean scores, standard deviations (SD) and reliabilities of parent-reported empathy of autistic and non-autistic group at four time points.

| | *Autistic* | | | | *Non-autistic* | | | |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **$\omega_t$** | **N** | **Mean** | **SD** | **$\omega_t$** | **N** |
| **Affective (0-2)** | | | | | | | | |
| Time 1 | 0.32 | 0.34 | 0.85 | 54 | 0.30 | 0.32 | 0.89 | 118 |
| Time 2 | 0.34 | 0.38 | 0.86 | 50 | 0.30 | 0.31 | 0.88 | 49 |
| Time 3 | 0.38 | 0.42 | 0.91 | 45 | 0.26 | 0.29 | 0.80 | 41 |
| Time 4 | 0.38 | 0.36 | 0.83 | 31 | 0.22 | 0.30 | 0.91 | 33 |
| **Attention (0-2)** | | | | | | | | |
| Time 1 | 0.93 | 0.49 | 0.88 | 54 | 1.38 | 0.35 | 0.82 | 118 |
| Time 2 | 0.97 | 0.49 | 0.89 | 50 | 1.40 | 0.36 | 0.81 | 49 |
| Time 3 | 0.96 | 0.47 | 0.87 | 45 | 1.41 | 0.31 | 0.73 | 41 |
| Time 4 | 1.02 | 0.48 | 0.87 | 31 | 1.36 | 0.42 | 0.88 | 33 |
| **Prosocial (0-2)** | | | | | | | | |
| Time 1 | 0.39 | 0.38 | 0.86 | 54 | 0.98 | 0.39 | 0.89 | 118 |
| Time 2 | 0.41 | 0.42 | 0.91 | 50 | 1.12 | 0.36 | 0.89 | 49 |
| Time 3 | 0.47 | 0.45 | 0.88 | 45 | 1.19 | 0.33 | 0.86 | 41 |
| Time 4 | 0.58 | 0.40 | 0.90 | 31 | 1.26 | 0.42 | 0.94 | 33 |
| **Cognitive (0-5)** | | | | | | | | |
| Time 1 | 2.90 | 0.92 | 0.93 | 55 | 3.87 | 0.54 | 0.84 | 121 |
| Time 2 | 2.94 | 0.91 | 0.94 | 50 | 4.13 | 0.81 | 0.89 | 49 |
| Time 3 | 2.97 | 0.96 | 0.95 | 45 | 4.15 | 0.53 | 0.90 | 41 |
| Time 4 | 3.14 | 0.98 | 0.94 | 31 | 4.04 | 0.55 | 0.90 | 33 |

Table S4.2. Mean scores, standard deviations (SD) and reliabilities of observed empathy of autistic and non-autistic group at four time points.

| | *Autistic* | | | | *Non-autistic* | | | |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **$\omega_t$** | **N** | **Mean** | **SD** | **$\omega_t$** | **N** |
| **Affective (0-2)** | | | | | | | | |
| Time 1 | 0.64 | 0.48 | 0.90 | 61 | 0.83 | 0.47 | 0.84 | 145 |
| Time 2 | 0,63 | 0.53 | 0.83 | 50 | 0.89 | 0.53 | 0.80 | 51 |
| Time 3 | 0.68 | 0.39 | 0.78 | 47 | 0.73 | 0.44 | 0.70 | 48 |
| Time 4 | 0.59 | 0.46 | 0.83 | 43 | 1.13 | 0.43 | 0.74 | 44 |
| **Attention (0-2)** | | | | | | | | |
| Time 1 | 0.99 | 0.62 | 0.93 | 61 | 1.50 | 0.48 | 0.88 | 145 |
| Time 2 | 1.36 | 0.57 | 0.89 | 50 | 1.83 | 0.28 | 0.75 | 51 |
| Time 3 | 1.02 | 0.29 | 0.78 | 47 | 1.25 | 0.25 | 0.72 | 48 |
| Time 4 | 0.95 | 0.38 | 0.85 | 43 | 1.21 | 0.24 | 0.80 | 44 |
| **Prosocial (0-2)** | | | | | | | | |
| Time 1 | 0.22 | 0.28 | 0.87 | 60 | 0.31 | 0.35 | 0.82 | 144 |
| Time 2 | 0.40 | 0.40 | 0.71 | 50 | 0.54 | 0.41 | 0.84 | 51 |
| Time 3 | 0.64 | 0.36 | 0.66 | 47 | 0.41 | 0.33 | 0.55 | 48 |
| Time 4 | 0.49 | 0.29 | 0.64 | 42 | 0.57 | 0.40 | 0.64 | 43 |

Table S4.3. Mean scores, standard deviations (SD) and reliabilities of psychosocial functioning of autistic and non-autistic group at four time points.

| | *Autistic* | | | | *Non-autistic* | | | |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **$\omega_t$** | **N** | **Mean** | **SD** | **$\omega_t$** | **N** |
| **Externalizing (0-3)** | | | | | | | | |
| Time 1 | 0.94 | 0.49 | 0.95 | 55 | 0.43 | 0.25 | 0.89 | 112 |
| Time 2 | 0.50 | 0.34 | 0.94 | 49 | 0.32 | 0.26 | 0.93 | 45 |
| Time 3 | 0.50 | 0.33 | 0.94 | 45 | 0.30 | 0.24 | 0.94 | 34 |
| Time 4 | 0.43 | 0.38 | 0.94 | 30 | 0.22 | 0.22 | 0.93 | 28 |
| **Cooperation (0-2)** | | | | | | | | |
| Time 1 | 1.33 | 0.62 | 0.96 | 60 | 1.74 | 0.35 | 0.92 | 145 |
| Time 2 | 1.44 | 0.46 | 0.95 | 50 | 1.85 | 0.23 | 0.91 | 52 |
| Time 3 | 1.56 | 0.40 | 0.94 | 47 | 1.77 | 0.34 | 0.93 | 47 |
| Time 4 | 1.53 | 0.52 | 0.96 | 44 | 1.85 | 0.16 | 0.82 | 44 |

Table S4.4. Model fit indices of the best age models for empathy.

| | | | | |
|---|---|---|---|---|
| **Parent reports** | | | | |
| | **Affective** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 165.69 | 177.81 | 159.69 | - |
| ***Best age model*:** age (linear) | 155.43 | 171.37 | 147.43 | $X^2$ (1)=9.26, $p$<.001 |
| | **Attention** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 331.38 | 343.51 | 325.38 | - |
| ***Best age model:*** age (linear), group | 292.52 | 312.44 | 282.52 | $X^2$ (2)=51.21, $p$<.001 |
| | **Prosocial** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 386.91 | 399.03 | 380.91 | |
| ***Best age model:*** age (linear), group | 264.66 | 284.58 | 254.66 | $X^2$ (2)=126.25, $p$<.001 |
| | **Cognitive** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 1116.12 | 1124.23 | 1112.12 | |
| ***Best age model:*** age (linear), group, age*group | 881.75 | 901.72 | 871.75 | $X^2$ (2)=240.37, $p$<.001 |
| **Observation** | | | | |
| | **Affective** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 662.43 | 675 | 656.43 | |
| ***Best age model:*** age (linear), group | 636.06 | 656.91 | 626.06 | $X^2$ (2)=30.37, $p$<.001 |
| | **Attention** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 705.34 | 717.92 | 699.34 | |

| | | | | |
|---|---|---|---|---|
| ***Best age model:*** age (linear), group, age*group | 625.30 | 646.16 | 615.30 | $X^2$ (3)=41.43, $p$<.001 |
| | **Prosocial** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 423.79 | 436.34 | 417.79 | |
| ***Best age model:*** age(linear), group, age*group | 379.49 | 404.47 | 367.49 | $X^2$ (3)=50.30, $p$<.001 |

Table S4.5. Model fit indices of the best fitting models for psychosocial functioning with empathy as the predictor.

| | **Externalizing problems** | | | |
|---|---|---|---|---|
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 210.06 | 229.75 | 200.06 | - |
| ***Best predicting model with parent-reported empathy without cognitive empathy:*** age, group, mean, change | 201.77 | 229.10 | 187.77 | $X^2$ (2) = 12.29, $p$ = .002 |
| ***Best predicting model with parent-reported empathy including cognitive empathy:*** age, group, mean, change | 201.46 | 228.87 | 187.46 | $X^2$ (2) = 12.54, $p$ = .002 |
| ***Best predicting model with observed empathy:*** age, group, mean, change | 206.74 | 232.26 | 190.74 | $X^2$ (2) = 9.32, $p$ = .009 |
| | **Social competence** | | | |
| | AIC | BIC | -2LL | $X^2$ statistics |
| ***Null model*** | 384.92 | 405.78 | 374.92 | - |
| ***Best predicting model with parent-reported empathy without cognitive*** | 261.03 | 292.62 | 245.03 | $X^2$ (3) = 129.89, $p$ < .001 |

| | | | | |
|---|---|---|---|---|
| ***empathy:*** age, group, mean, change, mean*group | | | | |
| ***Best predicting model with parent-reported empathy including cognitive empathy:*** age, group, mean, change, mean*group | 300.09 | 268.34 | 252.34 | $X^2$ (3) = 122.58, $p < .001$ |
| ***Best predicting model with observed empathy:*** age, group, mean, change, mean*group, change*group | 299.23 | 336.74 | 281.23 | $X^2$ (4) = 92.69, $p < .001$ |

Notes Supplementary Table 4 and 5. Models removed during the formal model-fitting procedures were not presented here. The $\chi^2$ statistics present the comparisons of the -2LL values between the best fitting models and the null models.

**Supplementary Materials Chapter 5**

Table S5.1. Available data per group per time-point (TP).

| | | TD | ASD | TOTAL |
|---|---|---|---|---|
| *Internalizing* | | n | n | N |
| | 1 TP | 33 | 11 | 44 |
| | 2 TP | 22 | 8 | 30 |
| | 3 TP | 42 | 40 | 82 |
| *Externalizing* | | | | |
| | 1 TP | 33 | 11 | 44 |
| | 2 TP | 23 | 8 | 31 |
| | 3 TP | 41 | 40 | 81 |
| Negative Emotion expression | | | | |
| | 1 TP | 29 | 11 | 40 |
| | 2 TP | 21 | 7 | 28 |
| | 3 TP | 47 | 41 | 88 |
| Emotion recognition | | | | |
| | 1 TP | 29 | 11 | 40 |
| | 2 TP | 20 | 7 | 27 |
| | 3 TP | 48 | 41 | 59 |
| Emotion vocabulary basic | | | | |
| | 1 TP | 29 | 11 | 40 |
| | 2 TP | 21 | 7 | 28 |
| | 3 TP | 47 | 41 | 89 |
| Emotion vocabulary mental states | | | | |
| | 1 TP | 29 | 11 | 40 |
| | 2 TP | 21 | 7 | 28 |
| | 3 TP | 47 | 41 | 89 |

Table S5.2. Internal consistency of measures per time point per group.

| | | Cronbach's α | |
|---|---|---|---|
| | | TD | ASD |
| Time 1 | | | |
| Internalizing | | 0.874 | 0.639 |
| Externalizing | | 0.868 | 0.962 |
| Negative emotion expression | | 0.787 | 0.633 |
| Positive emotion expression | | 0.655 | 0.673 |
| Emotion recognition | | 0.758 | 0.878 |
| Emotion vocabulary | | | |
| | Basic | 0.865 | 0.748 |
| | Mental states | 0.697 | 0.752 |
| Time 2 | | | |
| Internalizing | | 0.874 | 0.882 |
| Externalizing | | 0.889 | 0.895 |
| Negative emotion expression | | 0.802 | 0.817 |
| Positive emotion expression | | 0.398 | 0.705 |
| Emotion recognition | | 0.764 | 0.908 |
| Emotion vocabulary | | | |
| | Basic | 0.749 | 0.831 |
| | Mental states | 0.827 | 0.824 |
| Time 3 | | | |
| Internalizing | | 0.869 | 0.894 |
| Externalizing | | 0.887 | 0.919 |
| Negative emoiton expression | | 0.679 | 0.825 |
| Positive emotion expression | | 0.600 | 0.780 |
| Emotion recognition | | 0.798 | 0.908 |
| Emotion vocabulary | | | |
| | Basic | -0.360 | 0.792 |
| | Mental states | 0.134 | 0.811 |

Table S5.3. Model fit indices per model.

| | Internalizing | | | Externalizing | | |
|---|---|---|---|---|---|---|
| *Best fitting age-model* | AIC | BIC | $X^2$ statistic | AIC | BIC | $X^2$ statistic |
| Null Model | 2055 | 2062 | - | 2391 | 2399 | - |
| Linear Age-model | 1976 | 1983 | $X^2(1) = -79$, $p < .001$ | 2315 | 2323 | $X^2(1) = -67$, $p < .001$ |
| Quadratic Age-model | 1985 | 1993 | $X^2(1) = 10$, $p > .20$ | 2324 | 2332 | $X^2(1) = 9$, $p > .20$ |
| Cubic Age-model | 1995 | 2003 | $X^2(1) = 10$, $p > .20$ | 2333 | 2340 | $X^2(1) = 8$, $p > .20$ |
| **Linear Age x Group** | **1966** | **1974** | $X^2(2) = 29$, $p < .001$ | **2291** | **2299** | $X^2(2) = -41$, $p < .001$ |
| *Best fitting model including all predictors* | | | | | | |
| Full model | **1878** | **1885** | $X^2(5) = 89$, $p < .001$ | 2203 | 2211 | $X^2(5) = -88$, $p < .001$ |
| Full model including interactions with Group | 1868 | 1875 | $X^2(5) = 10$, $p > .10$ | **2179** | **2186** | $X^2(5) = -25$, $p < .001$ |

With $\chi^2$ analyses we tested whether adding extra variables to the model improved model fit. We used the difference between the BIC values of the most parsimonious model with the next model, so null model – linear age-model (i.e., BIC (linear age-model) 1983 - BIC (null model) 2062 = 79). For the full model including all variables of emotion functioning (i.e., emotion expression, emotion recognition, and emotion vocabulary), we compared with the best age-model. We report the $\chi^2$ statistic of model comparison of the BIC values, given that BIC values take the number of added variables into account. Note that BIC and AIC indices resulted in the same selection of best fitting models.

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# CURRICULUM VITAE

Boya Li was born on 27 April 1978, in Yichang, China. From 1996 to 2000, she did her Bachelor study at Beijing Language and Culture University, majoring in teaching Chinese as a foreign language. In 2000, she started her Master program at Peking University, specializing in Chinese linguistics. After one year, she moved to the Netherlands to do her doctoral research on Chinese sentence final particles, under the supervision of prof. dr. Rint Sybesma and prof. dr. Lisa Cheng at Leiden University Center for Linguistics. She obtained her PhD degree in linguistics in 2006. After finishing her PhD project, Boya moved to Warsaw, Poland, to live with her husband. During her stay in Warsaw, she grew a strong interest in psychology. From 2010 to 2013, she did her Bachelor study in psychology at the Faculty of Psychology, the University of Warsaw. She moved back to the Netherlands in 2013 and was admitted to the Research Master program in developmental psychology at Leiden University. After obtaining her Research Master degree in 2015, Boya received the opportunity to work as a researcher and teacher in the unit of Developmental and Educational Psychology at Leiden University. She started her second PhD project in December 2019, under the supervision of prof. Carolien Rieffe, dr. Kirstin Greaves-Lord, and dr. Els Blijd-Hoogewys, to investigate the development of emotional functioning in young children with autism. From January 2021, she joined a new research project as a postdoc researcher, working together with prof. Carolien Rieffe and dr. Els Blijd-Hoogewys, to investigate how to create a more inclusive social environment for pupils with autism.