ORIGINALARBEITEN

Components of Emotion Knowledge in Subtypes of Children with Autism Spectrum Disorders (ASD)

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Summary

Deficits in emotion knowledge can impact children's social-emotional interactions, which are particularly evident in children with autism spectrum disorders (ASD). However, consistent evidence regarding emotion knowledge and its individual components across ASD subtypes, as defined by ICD-10, remained limited. This study investigates emotion knowledge development – both as a whole and in seven specific components – in children with ASD, categorized by subtype, and compares them with a matched group of children without ASD using nearest neighbor matching based on gender, age, and language background. The sample includes 79 children with ASD (68 boys, 11 girls; ages 5–10): Childhood Autism (n = 33), Atypical Autism (n = 15), and Asperger's Syndrome (n = 31). Participants completed the Adaptive Test of Emotion Knowledge for Three- to Nine-year-olds (ATEM 3-9). A control group of 152 children without ASD was drawn from the ATEM 3-9 norming sample. Results reveal significant differences in emotion knowledge development across ASD subtypes. Children with Childhood Autism scored significantly lower than children without ASD, whereas children with Asperger's Syndrome or Atypical Autism showed no significant differences compared to the control group. These findings suggest that emotion knowledge deficits in ASD are subtype specific. Future research should account for these distinctions when examining emotional development in children with ASD.

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Keywords

autism spectrum disorder – emotion knowledge – adaptive test – child-development – ATEM 3-9

Zusammenfassung

Komponenten des Emotionswissens bei Subtypen von Kindern mit Autismus-Spektrum-Störungen (ASS)

Ein umfassendes Emotionswissen gilt als zentrale Voraussetzung für gelingende sozial-emotionale Interaktionen. Insbesondere bei Kindern mit Autismus-Spektrum-Störungen (ASS) können Defizite in diesem Bereich zu erheblichen Beeinträchtigungen führen. Trotz zahlreicher Studien fehlt bislang eine konsistente Evidenz darüber, in welchem Ausmaß Kinder mit ASS Einschränkungen im Emotionswissen und dessen Komponenten aufweisen und ob sich diese in Abhängigkeit von den ICD-10-Subtypen systematisch unterscheiden. Die vorliegen-

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de Studie analysiert die Entwicklung des Emotionswissens – sowohl als übergeordnetes Konstrukt als auch hinsichtlich sieben spezifischen Teilkomponenten – bei Kindern mit ASS differenziert nach den Subtypen Frühkindlicher Autismus (n = 33), Atypischer Autismus (n = 15) und Asperger-Syndrom (n = 31). Die Gesamtstichprobe umfasst 79 Kinder mit ASS im Alter von fünf bis zehn Jahren (68 Jungen, 11 Mädchen). Die Kontrollgruppe bestand aus 152 Kindern ohne ASS aus der Normierungsstichprobe. Die Gruppen wurden mithilfe des Nearest-Neighbor-Matchings basierend auf Geschlecht, Alter und Sprachhintergrund miteinander vergleichbar gemacht. Zur Datenerhebung wurde der Adaptive Test des Emotionswissens für Drei- bis Neunjährige (ATEM 3-9) eingesetzt. Die Ergebnisse zeigen signifikante Unterschiede im Emotionswissen sowohl zwischen den ASS-Subtypen als auch im Vergleich zur Kontrollgruppe. Während Kinder mit Frühkindlichem Autismus signifikant geringere Werte erzielten, unterschieden sich Kinder mit Atypischem Autismus und Asperger-Syndrom nicht signifikant von Kindern ohne ASS. Diese Ergebnisse unterstreichen die Notwendigkeit einer differenzierten Betrachtung von ASS-Subtypen bei der Erforschung und Förderung emotionaler Kompetenzen.

Schlagwörter

Autismus-Spektrum-Störung – Emotionswissen – adaptiver Test – Kindesentwicklung – ATEM 3-9

1 Introduction

The development of emotion knowledge in children with autism spectrum disorders (ASD) has increasingly become the focus of research in recent years. Emotion knowledge refers to the ability to recognize, understand, express, and regulate emotions in oneself and toward others (Denham & Dunn, 1998). The term encompasses a number of different competences that develop rapidly in early and middle childhood (Pons, Harris, Rosnay, 2004). Deficits in this development can lead to difficulties in social-emotional interactions, which constitute one of three core symptoms of ASD (World Health Organization, 2009). In light of this, many studies have examined whether children with ASD show deficits in the development of emotion knowledge and its individual components, yet findings have remained inconsistent (see for an overview: Begeer, Koot, Rieffe, Meerum Terwogt, Stegge, 2008; Uljarevic & Hamilton, 2013).

In children without ASD, emotion knowledge begins to develop in early childhood. Even infants can distinguish between facial expressions (Pons et al., 2004). With age and social interaction, they learn to label emotions verbally (Streubel, Gunzenhauser, Grosse, Saalbach, 2020). By three years of age, most children recognize basic emotions such as joy, sadness, fear, and anger. From the age of four years onwards, they begin to interpret emotions based on situational cues and Theory of Mind, understanding that emotions relate to desires, beliefs, and causes (Ornaghi, Pepe, Grazzani, 2016; Weimer, Sallquist, Bolnick, 2012; Wellman & Banerjee, 1991).

They also become aware that people can feel multiple emotions at once (Zajdel, Bloom, Fireman, Larsen, 2013) and that expressed emotions may differ from internal feelings due to social display rules. Around the age of 6–8, most children can identify this distinction, even when the rules are implicit (Sidera, Amadó, Serrat, 2013; Voltmer & Salisch, 2022). Emotion regulation strategies also begin developing around age four, progressing from behavioral to mental approaches (Cole, Dennis, Smith-Simon, Cohen, 2009). Various instruments have been developed to assess emotion knowledge in children, including the Affect Knowledge Test (AKT; Denham, 1986) and the Test of Emotion Comprehension (TEC; Pons, Harris, Rosnay, 2004). The Adaptive Test of Emotion Knowledge for Three- to Nine-year-olds (ATEM 3-9; Voltmer & Salisch, 2022) integrates seven components of emotion knowledge within a single adaptive assessment.

Table 1 presents the seven components of emotion knowledge assessed in the ATEM 3-9 and their typical development in children without ASD.

Table 1: The components of emotion knowledge and their development in children without ASD (Voltmer & Salisch, 2022)

Component (Beginning age of development)	Description
Facial recognition (2-3 years)	Recognizing and distinguishing emotions based on facial expressions.
Situational recognition (3-5 years)	Recognizing people's emotions from descriptions of typical situations
Desires (3-6 years)	Recognizing emotions based on the fulfillment and non-fulfilment of desires
Mixed emotions (4-8 years)	Knowing and recognizing that people can feel several emotions at the same time
Beliefs (3-6 years)	Recognizing emotions arising from different as well as false beliefs.
Display rules (4-8 years)	Recognizing the difference between the emotions other people express and those they actually feel.
Emotion regulation strategies (4-8 years)	Recognizing functional behavioral and cognitive strategies for regulating emotions

1.1 Autism Spectrum Disorders

Autism spectrum disorders (ASD) are characterized by neurodevelopmental disabilities that usually manifest in (early) childhood. According to the ICD-10, ASD is defined by three core diagnostic features: (1) qualitative impairments in social interaction, (2) qualitative impairments in communication, and (3) restricted, repetitive, and stereotyped patterns of behavior, interests, and activities (World Health Organization, 2009). Children with ASD characteristically exhibit deficits in social-emotional reciprocity, a core symptom of the disorder. Boys are more likely to be

diagnosed with ASD than girls by a ratio of 3–4:1 (Loomes, Hull, Mandy, 2017; Posserud, Skretting Solberg, Engeland, Haavik, Klungsøyr, 2021).

Given that ASD is a multifaceted spectrum disorder and the severity of deficits varies between children, it is essential to distinguish between the subtypes of ASD (Al Shirian & Al Dera, 2015). This distinction facilitates a more nuanced examination of the specific symptoms and characteristics of children with ASD. The *International Classification of Diseases* (World Health Organization, 2009) differentiates among three subtypes Childhood Autism, Atypical Autism, and Asperger's Syndrome.

Childhood Autism manifests before age 3 with impaired development, limited cognitive abilities, and language acquisition delays (World Health Organization, 2009). Atypical Autism emerges after age 3 or presents without all three core ASD symptoms. Asperger's Syndrome is characterized by normal language and cognitive development but difficulties in social-emotional interaction and motor coordination.

1.2 Current evidence on emotion knowledge and ASD

Previous research on the development of emotion knowledge in children with ASD has yielded inconsistent findings, particularly across its components. For facial emotion recognition, some studies found deficits and atypical gaze patterns in ASD children (e.g., reduced eye contact; Nuske, Vivanti, Hudry, Dissanayake, 2014; Uljarevic & Hamilton, 2013), while others reported no significant differences from children without ASD in typical contexts (Castelli, 2005; Rosset et al., 2008). Notably, when facial expressions and situational cues were incongruent, ASD children tended to rely more on facial expressions, whereas children without ASD used contextual information (Tell & Davidson, 2015).

Regarding Theory of Mind and social cognition, many studies reported difficulties in attributing emotions based on intentions, beliefs, and desires (e.g., Baron-Cohen, 1989; Miranda, Berenguer, Roselló, Baixauli, Colomer, 2017; Yang, Zhou, Yao, Su, McWhinnie, 2009), including reduced understanding of complex emotions like pride or jealousy (Davidson, Hilvert, Winning, Giordano, 2022; Golan, Baron-Cohen, Golan, 2008). However, some findings suggested intact understanding of intentional acts in certain contexts (Broekhof et al., 2015; Carpenter, Pennington, Rogers, 2001).

Evidence on other components such as display rules and emotion regulation is similarly mixed. While children with ASD often understood display rules, they appeared to be less aware of their interpersonal function (Barbaro & Dissanayake, 2007). Emotion regulation strategies appeared less adaptive in some studies, with more impulsive reactions and lower frustration tolerance (Jahromi, Meek, Ober-Reynolds, 2012; Mazefsky et al., 2013; Reyes, Factor, Scarpa, 2020), though others reported effective strategies in specific situations, such as preventing depressive symptoms (Pouw, Rieffe, Stockmann, Gadow, 2013; Rieffe, Bruine, Rooij, Stockmann, 2014).

The relationship between ASD's core symptoms and emotion knowledge deficits likely reflects a dynamic developmental process rather than a simple unidirectional pathway (Masoomi et al., 2024). From one perspective, the defining impairments in social interaction and communication directly compromise the social learning mechanisms through which emotion knowledge is typically acquired. Children with ASD encounter reduced opportunities for observational learning in naturalistic social contexts and demonstrate systematic difficulties integrating emotional information across modalities (facial, vocal, contextual) (Nuske, Vivanti, Dissanayake, 2016). Moreover, restricted behavioral patterns limit exposure to diverse emotional situations, thereby constraining the experiential foundation for comprehensive emotion understanding. From another perspective, early deficits in emotion knowledge may themselves contribute to the manifestation and persistence of social-communicative impairments by limiting children's ability to interpret social cues, respond appropriately to others' emotions, and engage in reciprocal exchanges (Bar, Eden, Golan, 2025). The interplay of these mechanisms creates a mutually reinforcing cycle in which emotion knowledge deficits and social impairments shape each other over developmental time (Li, Blijd-Hoogewys, Stockmann, Rieffe, 2023). This developmental perspective suggests that difficulties in emotion knowledge are not merely secondary consequences of ASD but may constitute integral features of its developmental trajectory (Reed et al., 2021).

A major limitation of existing research is the considerable methodological heterogeneity. Studies vary in their operationalization of emotion knowledge, often using different instruments or focusing on isolated components, which complicates cross-study comparisons. Moreover, many studies assessed only a subset of the emotion knowledge construct, rather than examining it as an integrated whole. Sample selection poses another challenge: research often included only high-functioning individuals with ASD, excluding those with cognitive or language impairments. Furthermore, participants were frequently grouped under the general ASD diagnosis without considering subtype-specific characteristics, despite known differences in developmental profiles. This has limited the generalizability of findings and underscores the need for comprehensive, standardized comparisons across ASD subtypes. While previous research has documented emotion knowledge deficits in children with ASD as a general group, systematic comparisons across the three ICD-10 subtypes – Childhood Autism, Atypical Autism, and Asperger's Syndrome – remain scarce. Given that these subtypes differ substantially in cognitive and language development, it remains unclear whether emotion knowledge profiles also vary systematically. Understanding subtype-specific patterns is essential for developing targeted interventions and for clarifying the inconsistent findings in the literature.

1.3 Current study

This study aims to fill these gaps by using the ATEM 3-9 to examine emotion knowledge and its seven components in children with ASD (Voltmer & Salisch, 2022), separated by subtype, in comparison with a group of matched children without ASD. The following hypotheses were examined:

1. Children in the ASD group will achieve significantly lower total ATEM 3-9 scores than the group of matched children without ASD.
2. Children in the ASD group will achieve significantly lower ATEM 3-9 scores in each of the seven components than the group of matched children without ASD.
3. ASD subtype will significantly predict total ATEM 3-9 scores, even after controlling for demographic variables (gender, age, and language background), with children diagnosed with Childhood Autism expected to demonstrate lower scores than children with Atypical Autism and Asperger's Syndrome due to their more pronounced cognitive and language delays
4. Exploratory analyses will examine whether there are significant differences in the ATEM 3-9 component scores between the three ASD subtypes, with particular attention to whether children with Childhood Autism exhibit greater deficits in components requiring advanced cognitive and linguistic abilities (e.g., Beliefs, Display Rules) compared to children with Atypical Autism and Asperger's Syndrome.

2 Methods

2.1 Participants

A total of N = 79 children aged 5-10 years previously diagnosed with ASD participated. The sample consisted of 68 boys and 11 girls, which reflects a slightly higher male-to-female ratio than the commonly reported 3–4:1 among children with ASD (Loomes et al., 2017; Posserud et al., 2021). The children were recruited from 13 therapy centers throughout Germany. There were no inclusion or exclusion criteria regarding children's IQ levels and language skills. N = 48 children grew up speaking only German and *n* = 31 children grew up bilingually. Based on ICD-10 diagnostic criteria assessed through the ADOS-2 (Lord et al., 2012) and ADI-R (Lord, Rutter & Le Couteur, 1994), n = 33 children were identified with Childhood Autism, n = 15 with Atypical Autism, and n = 31 with Asperger's Syndrome. A control group of N = 152 children without ASD, matched on gender, age, and language background, was taken from the ATEM 3-9 norming sample (Voltmer & von Salisch, 2022). These children had been recruited from daycare centers and schools in different regions of Germany. Parental consent was obtained for all children who participated in the study. The mean chronological age of the children following the matching procedure

was 7.48 years for the ASD group (SD = 1.18) and 7.32 years for the group of children without ASD (SD =1.10).

2.2 Instruments

The ATEM 3-9 (Voltmer & von Salisch, 2021, 2022) was used to assess children's emotion knowledge across seven components: 1) *Facial recognition*, 2) *Situational recognition,* 3) *Desires,* 4) *Mixed emotions*, 5) *Beliefs*, 6) *Display rules*, and 7) *Emotion regulation strategies*. The ATEM 3-9 integrates all seven components within an interview format that does not require expressive language competences.

Through an interactive story of two friends visiting the zoo, the participating children were repeatedly asked how the protagonists feel in certain situations. Children answered questions about the characters' emotions in illustrated scenarios, with each component embedded in a different setting. One character has a foreign name and a darker skin tone to reflect a migration background.

The ATEM 3-9 consists of 35 adaptively presented items of increasing difficulty between and within components, with components 1 and 2 including six items each, components 3 to 6 including five items each, and component 7 containing three items. Skip and termination rules are applied to ensure an efficient testing process, thereby preventing frustration for younger or less proficient participants. One point was awarded for each correctly answered item; incorrect or skipped items received zero points.

Children typically complete the test in approximately 20–30 minutes, depending on their age and performance. Three- to four-year-olds typically complete only the early components, while school-aged children usually work through all seven.

Versions with male or female protagonists are available to match participants' gender. Demographic information (age, gender, language background), ICD-10 diagnosis, and therapy start were collected. Upon completion, scores for each component and a total score are generated automatically.

2.3 Procedure

All children participated voluntarily and without any reward. The ATEM 3-9 was administered digitally via tablet or computer in the presence of trained ASD therapists, who had received a 30-minute training session. To ensure standardization, the story and questions were presented via pre-recorded audio.

2.4 Statistical analysis

All analyses were conducted using R (R Core Team, 2020). To test Hypotheses 1 and 2, nearest neighbor matching was applied to compare ATEM 3-9 scores between the ASD and the non-ASD group, ensuring comparability regarding gender, age, and

language background (Caliendo & Kopeinig, 2008). Each ASD participant was matched to up to three children without ASD. Separate matchings were conducted for each ASD subtype, thereby enabling group comparisons on both total and component scores. The sample characteristics of children in the ASD group and children in the non-ASD group after the nearest neighbor matching are shown in Table 2. One-tailed independent samples t-tests were used to compare total ATEM 3-9 scores and component scores between the ASD group and the matched non-ASD group, as well as between each ASD subtype and its respective matched non-ASD subsample.

To test Hypothesis 3, a hierarchical multiple regression analysis was conducted with total ATEM 3-9 score as the dependent variable. In the first step, demographic variables (gender, age, and language background) were entered as control variables. Gender was dummy-coded (0 = male, 1 = female), and language background was dummy-coded (0 = monolingual German, 1 = multilingual). Age was entered as a continuous variable in years. In the second step, ASD subtype was entered as a categorical predictor using dummy coding with Childhood Autism as the reference category (Atypical Autism: 0 = no, 1 = yes; Asperger's Syndrome: 0 = no, 1 = yes).

For the exploratory analyses addressing Hypothesis 4, one-way ANOVAs were conducted to examine differences in component scores across the three ASD subtypes. Post-hoc pairwise comparisons using Tukey's HSD were applied when significant omnibus effects were detected. Effect sizes were calculated using Cohen's d for t-tests and partial eta-squared (η^2) for ANOVAs.

Table 2: Sample characteristics of children in the ASD group and children in the non-ASD group after matching

Baseline characteristic	**ASD group**	**non-ASD group**
	n (%)	**n (%)**
Gender		
Female	8(13)	24(16)
Male	55(87)	128(84)
Language		
German	38(60)	94(62)
Multilingual	25(40)	58(38)
Age Group		
6	18(29)	47(31)
7	14(22)	38(25)
8	14(22)	39(26)
9	17(27)	28(18)

Note. N = 215 (n = 63 for the ASD group; n = 152 for the non-ASD group)

3 Results

Before conducting the main analyses, the data were screened for outliers and multicollinearity. To test Hypothesis 1, it was examined whether children in the ASD group achieved significantly lower total ATEM 3-9 scores than children without ASD. A one-tailed t-test comparing total ATEM 3-9 scores revealed no significant difference between the overall ASD group and the non-ASD group (see Table 3). However, when differentiating among ASD subtypes, an ANOVA showed significant differences, $F(3, 211) = 4.82$, $p = .003$, $\eta^2 = .06$. Table 3 presents the results for the entire sample and the three subtypes.

Post-hoc analyses showed that children with Childhood Autism scored significantly lower than matched children without ASD, while children with Atypical Autism and Asperger's Syndrome did not differ significantly from children without ASD and actually scored slightly higher (see Table 3).

Table 3: Differences between the total ATEM 3-9 scores of children in the ASD group and in the non-ASD group after matching

	ASD group			non-ASD group with matched partner(s)			t	Cohen's d
	N	M	SD	N	M	SD		
Total ASD group	63	21.65	6.20	152	21.39	6.06	-0.28	0.04
Childhood Autism	29	18.59	5.23	83	21.33	5.61	2.38*	0.50
Atypical Autism	12	24.58	5.18	36	22.42	4.46	-1.40	0.50
Asperger's Syndrome	22	24.09	6.25	66	22.58	5.17	-1.13	0.28

Note. * $p < .05$; M = mean; SD = standard deviation

With regard to Hypothesis 2, which examined individual components, no significant differences were found between the overall ASD group and the non-ASD group (see appendix, Table A.1). However, when examining subtypes, children with Childhood Autism scored significantly lower in *Situational Recognition* (diff = -0.69), *Beliefs* (diff = -0.78), and *Display Rules* (diff = -0.66) compared to children without ASD (see Table 4, next page). In contrast, children with Atypical Autism and Asperger's Syndrome showed no significant deficits in any component (see appendix, Table A.2 and Table A.3).

3.1 Differences in ATEM 3-9 scores between the three ASD subtypes

Addressing Hypothesis 3, further analyses confirmed substantial differences in overall emotion knowledge depending on ASD subtype within the ASD sample. A hierarchical regression analysis showed that ASD subtype significantly predicted total ATEM 3-9 scores, even after controlling for gender, age, and language background. Specifically, children diagnosed with Childhood Autism achieved signifi-

cantly lower total ATEM 3-9 scores than children with Atypical Autism (B = 4.49, p < .05) and, even more markedly, children with Asperger's Syndrome (B = 5.05, p < .001), while no significant difference was found between the Atypical Autism and Asperger's Syndrome groups.

Table 4: Differences between the ATEM 3-9 component scores of children diagnosed with Childhood Autism and children of the non-ASD group

	Childhood Autism		**non-ASD group with matched partner(s)**		**t**	**Cohen's d**
ATEM 3-9 components	M	SD	M	SD		
Facial recognition	5.55	0.69	5.58	0.78	0.16	0.03
Situational recognition	4.10	0.98	4.78	0.94	3.23**	0.71
Desires	2.83	1.58	2.81	1.38	-0.05	0.01
Mixed emotions	2.31	1.34	2.80	1.46	1.66	0.34
Beliefs	1.21	1.29	1.95	1.49	2.57*	0.52
Display rules	0.79	0.98	1.43	0.86	3.13**	0.72
Emotion regulation strategies	1.79	0.86	1.95	0.97	0.83	0.17

Notes. * p < .05, ** p < .01; M = mean; SD = standard deviation

These results were further substantiated by group comparisons. Children with Atypical Autism (M = 23.53, SD = 6.06) and those with Asperger's Syndrome (M = 24.39, SD = 5.78) achieved significantly higher total ATEM 3-9 scores than children with Childhood Autism (M = 18.64, SD = 5.17). Post-hoc comparisons revealed significant differences between Childhood Autism and both Atypical Autism (diff = 4.90, t = 2.71, p < .05, d = 0.90) and Asperger's Syndrome (diff = 5.75, t = 4.18, p < .001, d = 1.05), indicating large effect sizes. The difference between Atypical Autism and Asperger's Syndrome was not statistically significant (diff = 0.85, t = 0.45, p > .05, d = 0.15).

Concerning the exploratory analyses in Hypothesis 4, consistent with these overall differences, children with Asperger's Syndrome also outperformed those with Childhood Autism in several individual components of the ATEM 3-9, including *Situational Recognition*, *Mixed Emotions*, *Beliefs*, and *Display Rules* (see Table 5, next page). Moreover, children with Atypical Autism scored significantly higher than children with Childhood Autism in the *Display Rules* component (diff = 1.04, p = .014, η^2 = .24). These findings underscore the relevance of considering ASD subtypes when assessing emotion knowledge and suggest that children with Childhood Autism exhibit pronounced challenges across both general and specific aspects of emotional understanding.

Table 5: Differences between the ATEM 3-9 component scores of children diagnosed with Childhood Autism and with Asperger's Syndrome

	Childhood Autism		Asperger's Syndrome		t	Cohen's d
ATEM 3-9 components	M	SD	M	SD		
Facial recognition	5.48	0.71	5.55	0.89	-0.06	.02
Situational recognition	4.09	1.01	4.97	1.17	-0.88**	.14
Desires	2.91	1.51	3.26	1.15	-0.35	.02
Mixed emotions	2.33	1.36	3.26	1.37	-0.93*	.10
Beliefs	1.21	1.24	3.03	1.62	-1.82***	.23
Display rules	0.76	0.94	2.13	1.23	-1.37***	.24
Emotion regulation strategies	1.85	0.87	2.19	0.87	-0.35	.05

Notes. * p < .05, ** p < .01, *** p < .001; diff = differences between the ATEM 3-9 scores; N = 64 (n = 33 for children diagnosed with Childhood Autism; n = 31 for children diagnosed with Asperger's Syndrome)

4 Discussion

The present study investigated emotion knowledge in children with ASD using the Adaptive Test of Emotion Knowledge for Three- to Nine-Year-Olds (ATEM 3-9), with a focus on differences across the three ASD subtypes Childhood Autism, Atypical Autism, and Asperger's Syndrome. Although group-level differences were absent, subtype analysis revealed meaningful distinctions.

4.1 Main Findings and Interpretation

Children with Childhood Autism exhibited significantly lower total scores on the ATEM 3-9 compared to children without ASD, particularly in the components of *Situational recognition, False Beliefs*, and *Display Rules*. In contrast, children with Atypical Autism and Asperger's Syndrome demonstrated performance comparable to or slightly above that of children without ASD.

These findings underscore that emotional competence in ASD is not globally impaired but instead varies considerably according to developmental profiles. Prior research had reported both emotion knowledge deficits and intact abilities in children with ASD, depending on the sample characteristics and the methods used (e.g., Castelli, 2005; Rosset et al., 2008; Uljarevic & Hamilton, 2013). The present findings support the view that diagnostic subtypes are critical for understanding this variability.

The differences among subtypes may relate to their associated functioning levels. Children with Childhood Autism often exhibit delays in cognitive and language development, which likely hinder their ability to comprehend socially embedded emotional content. This includes difficulties in recognizing emotions based on false beliefs or adhering to culturally influenced display rules. Their lower performance in these areas is consistent with research indicating challenges in using contextual cues

for emotion interpretation (Tell & Davidson, 2015) and in understanding others' mental states, such as beliefs and intentions (e.g., Baron-Cohen, 1989; Broekhof et al., 2015; Yang et al., 2009). Moreover, children in this subgroup struggled with recognizing socially appropriate emotional expressions – skills that depend on a nuanced grasp of social norms and conventions, which are often compromised by delays in language acquisition and Theory of Mind development.

In contrast, children with Asperger's Syndrome typically demonstrate intact verbal and intellectual abilities, which may facilitate more advanced emotional reasoning, particularly in structured and predictable contexts such as those presented in the ATEM 3-9 assessment. This observation aligns with previous findings that higher cognitive and linguistic capacities are associated with more sophisticated emotional competencies (e.g., Hirosawa et al., 2020; Park, Yelland, Taffe, Gray, 2012). Salomone et al. (2019) similarly found that higher IQ levels correlated with improved emotion understanding in children with ASD. These findings suggest that cognitive and language abilities play a critical role in shaping emotion knowledge across the autism spectrum.

The component of emotion regulation showed no significant group differences, which reflects the mixed findings in the literature. While some studies have reported that children with ASD used less adaptive strategies (Jahromi et al., 2012; Mazefsky et al., 2013; Reyes et al., 2020), others have identified intact or compensatory regulation abilities, particularly among higher-functioning individuals (Pouw et al., 2013; Rieffe et al., 2014). The present findings suggest that basic understanding of regulation strategies may be preserved across subgroups, although this does not necessarily reflect real-life emotional behavior.

4.2 Theoretical and Practical Implications

The present data suggest that functional dimensions such as cognitive and linguistic abilities may be more relevant for understanding differences in emotion knowledge than categorical subtype classifications. Emotion knowledge, particularly in complex components, appears to depend more on underlying developmental capacities than on diagnostic category alone. This interpretation aligns conceptually with dimensional approaches to ASD classification, as reflected in the ICD-11 (World Health Organization, 2023). However, the absence of direct cognitive and linguistic assessments in this study limits definitive conclusions. Future research must incorporate standardized measures of IQ and language proficiency to determine whether observed differences reflect subtype-specific characteristics or underlying developmental capacities.

From a practical perspective, the ATEM 3-9 proved useful in identifying both general and specific emotional strengths and weaknesses across ASD subtypes. This

differentiation has significant implications for individualized intervention. Children with Childhood Autism may benefit from targeted support in understanding beliefs, interpreting social situations, and learning to navigate emotional display rules. More broadly, interventions should not only consider ASD subtypes but also actively support each child's individual cognitive, linguistic, and developmental profile to address their specific emotional learning needs.

4.3 Strengths and Limitations

Strengths of this study include its relatively large sample size, which allowed for comparisons between ASD subtypes and a group of matched children without ASD. Another strength is the integrated assessment of components using one instrument, i.e., the ATEM 3-9. The present results thus contribute to a more nuanced view of emotion knowledge in children with ASD by uncovering strengths and deficits in the development of the components of emotion knowledge in each ASD subtype.

However, several important limitations must be acknowledged. First and most critically, the absence of standardized cognitive and linguistic assessments represents a significant constraint. Without measures of IQ and language proficiency, it remains unclear whether the observed differences in emotion knowledge reflect subtype-specific characteristics or the cognitive-linguistic abilities that typically differ across these diagnostic groups. Children with Childhood Autism may have demonstrated lower performance primarily due to associated cognitive and language delays rather than autism-specific factors. This potential confound limits the causal interpretations and underscores the need for cautious conclusions. Future studies must include comprehensive cognitive and linguistic assessments to disentangle these effects and clarify the mechanisms underlying emotion knowledge development in ASD.

Second, the cross-sectional design precludes inferences about developmental trajectories or causal relationships. It remains unclear whether the emotion knowledge deficits observed in children with Childhood Autism persist over time, ameliorate with maturation, or respond to therapeutic intervention. Longitudinal designs are needed to track changes in emotion knowledge over time and identify critical windows for intervention.

Third, a further limitation concerns the inclusion of children with Atypical Autism. This diagnostic category is inherently heterogeneous, encompassing children who either manifest ASD symptoms after age three or who do not fulfill all three core diagnostic criteria. Consequently, the Atypical Autism group in this study likely includes children with diverse developmental profiles, some of whom might not qualify for an ASD diagnosis under current ICD-11 criteria, which no longer recognize this subtype as a distinct category. This heterogeneity may obscure meaningful

patterns within the group and complicates comparisons with the other subtypes. Future research should consider more homogeneous groupings or apply dimensional approaches to characterize symptom profiles more precisely.

4.4 Conclusion and Future Directions

Future research should investigate how cognitive and linguistic variables influence the development of emotion knowledge in ASD subtypes and extend findings through longitudinal designs. Such studies would help to analyze how cognitive functions affect emotion knowledge and would enable conclusions to be drawn regarding whether social-emotional deficits and strengths found in children with ASD persist or change with age – or with treatment. The ATEM 3-9 appears to be an appropriate measurement instrument for both research and clinical practice. Overall, the findings support a nuanced view of emotional development in ASD and suggest that clinical assessments and interventions should consider subtype-specific profiles. The ATEM 3-9 appears well-suited for identifying both strengths and weaknesses in emotion knowledge among children with ASD.

Implications for Practice

- Emotion knowledge in children with ASD is not uniformly impaired but varies significantly according to the specific diagnostic subtype.
- Children diagnosed with Childhood Autism exhibit the greatest difficulties, particularly in interpreting context-dependent emotional cues and applying culturally learned display rules.
- Standardized, one-size-fits-all intervention strategies are unlikely to be effective; individualized and subtype-sensitive approaches are crucial.
- The ATEM 3-9 provides a valuable tool for identifying both emotional strengths and areas of difficulty with a high degree of specificity.

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Appendix

Table A.1: Differences between the ATEM 3-9 component scores of children in the ASD group and in the TD group after matching

	Total ASD group		TD group with matched partners		t	Cohen's d
ATEM 3-9 components	M	SD	M	SD		
Facial recognition	5.62	0.63	5.62	0.7	-0.02	0.01
Situational recognition	4.59	1.19	4.72	1.14	0.76	0.12
Desires	3.11	1.33	2.75	1.44	-1.75	0.25
Mixed emotions	2.7	1.38	2.8	1.56	0.47	0.07
Beliefs	2.03	1.69	2.04	1.53	0.03	0.01
Display rules	1.51	1.35	1.45	0.93	-0.29	0.05
Emotion regulation strategies	2.1	0.84	2.0	0.97	-0.73	0.10

Notes. M = mean; SD = standard deviation; N = 215 (n = 63 for the ASD group; n = 152 for the TD group)

Table A.2: Differences between the ATEM 3-9 component scores of children diagnosed with Atypical Autism and children of the TD group after matching

	Atypical Autism		TD group with matched partners		t	Cohen's d
ATEM 3-9 components	M	SD	M	SD		
Facial recognition	5.83	0.39	5.64	0.8	-1.12	0.27
Situational recognition	5.17	0.83	4.89	1.01	-0.95	0.29
Desires	3.67	0.78	3.25	1.3	-1.34	0.35
Mixed emotions	3.0	1.21	2.94	1.29	-0.14	0.04
Beliefs	2.42	1.73	2.17	1.25	-0.46	0.18
Display rules	2.08	1.38	1.53	0.77	-1.33	0.58
Emotion regulation strategies	2.42	0.67	2.00	0.93	-1.69	0.48

Notes. M = mean; SD = standard deviation; N = 48 (n = 12 for Atypical Autism; n =36 for the TD group)

Table A.3: Differences between the ATEM 3-9 component scores of children diagnosed with Asperger's Syndrome and children of the TD group after matching

	Asperger's Syndrome		TD group with matched partners		t	Cohen's d
ATEM 3-9 components	M	SD	M	SD		
Facial recognition	5.59	0.67	5.62	0.74	0.18	0.04
Situational recognition	4.91	1.38	5.05	0.88	0.44	0.13
Desires	3.18	1.14	2.88	1.4	-1.02	0.23
Mixed emotions	3.05	1.43	3.06	1.33	0.04	0.01
Beliefs	2.91	1.69	2.38	1.49	-1.31	0.34
Display rules	2.14	1.36	1.56	0.81	-1.88	0.59
Emotion regulation strategies	2.32	0.78	2.03	0.99	-1.4	0.3

Notes. M = mean; SD = standard deviation; N = 88 (n = 22 for Asperger's Syndrome; n = 66 for the TD group)