

**EMOTION RECOGNITION IN CHILDREN WITH AUTISM SPECTRUM
DISORDER, ATTENTION-DEFICIT/HYPERACTIVITY DISORDER AND
TYPICAL DEVELOPMENT WITH EXPLORATORY OBSERVATION ON
COMORBID CASE**

By

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ABSTRACT

Children with Autism Spectrum Disorder (ASD), Attention Deficit/Hyperactivity Disorder (ADHD), and comorbid ASD + ADHD often exhibit challenges in emotion recognition, which can impact social functioning. This study aimed to investigate the unique and shared emotion recognition profiles of children with ASD, ADHD, ASD + ADHD, and typically developing (TD) peers. A total of 17 children (15 males, 2 females; mean age = 9 years) participated, including 5 with ASD, 6 with ADHD, 1 with comorbid ASD + ADHD, and 5 TD children. Using a two-phase methodology, Phase 1 involved translation, cultural adaptation, and pilot testing of a screening questionnaire - selected modules from the Autism-Tics, ADHD, and other Comorbidities Inventory (A-TAC) used in phase 2 to categorize participants into diagnostic groups. Phase 2 utilized computerized experimental tasks, including a Facial Emotion Recognition (FER) task and Affective Prosody (AP) task, to assess and compare visual and auditory emotion recognition abilities across the groups. Given recruitment constraints, the initial 4×2 factorial design was adapted, and analyses were conducted using ANOVA, ANCOVA, and regression to examine group and modality effects while accounting for age and FSIQ. Findings revealed no significant group-level differences in overall emotion recognition accuracy. However, across conditions, children performed significantly better in visual than in auditory emotion recognition, highlighting a consistent modality effect. This suggests that visual cues, particularly facial expressions, may represent a relative strength, whereas auditory prosody presents greater challenges across groups. These results imply that interventions may be more effective when they build on visual strengths while providing targeted support for auditory processing difficulties. The absence of strong diagnostic or cognitive predictors further underscores the potential value of shared, transdiagnostic approaches to intervention, rather than disorder-specific models. Future research should prioritize larger and more

balanced samples to clarify the impact of comorbidity and individual variability on emotion recognition profiles.

Keywords: visual emotion recognition, auditory emotion recognition, ASD, ADHD, comorbid ASD and ADHD

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LIST OF ABBREVIATIONS

ADDM	Autism and Developmental Disabilities Monitoring
ADHD	Attention-Deficit Hyperactivity Disorder
AP	Affective Prosody
ASD	Autism Spectrum Disorder
ASDI	Asperger Syndrome Diagnostic Interview
ASSQ	Autism Spectrum Screening Questionnaire
A-TAC	Autism-Tics, ADHD, and other Comorbidities inventory
BET	Basic Emotions Theory
CDC	Centers for Disease Control and Prevention
CVI	Content Validity Index
CVR	Content Validity Ratio
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
FER	Facial Emotion Recognition
FTF	Five-to-Fifteen Questionnaire
I-CVI	Item-Level Content Validity Index
ICD-11	International Classification of Diseases, Eleventh Edition
NDD	Neurodevelopmental Disorder
RAVDESS	Ryerson Audio-Visual Database of Emotional Speech and Song
S-CVI	Scale-Level Content Validity Index
SLD	Specific Learning Disorder
TCE	Theory of Constructed Emotions
TD	Typically Developing
WNV	Wechsler® Nonverbal Scale of Ability

Chapter I: Introduction

Emotion recognition is a fundamental aspect of social interaction among humans, enabling individuals to navigate complex social landscapes by interpreting and responding in appropriate manners towards the emotions of others. This capacity is not merely a social convenience, but a fundamental skill that underpins effective communication, fosters social cohesion and social adaptation. Emotion recognition contributes to the development of empathy (Hunnikin, Wells, Ash & van Goozen, 2020), emotional regulation (Duville, Pérez, Hugues-Gudiño, Naal-Ruiz, Alonso-Valerdi & Ibarra-Zarate, 2023) and prosocial behaviours (Richard, Baud-Bovy, Clerc-Georgy & Gentaz, 2020), which play a critical role in building relationships, maintaining interpersonal harmony and achieving personal and societal goals. These abilities are particularly vital during childhood, as the developmental trajectory of emotion recognition lays the groundwork for broader social and emotional competencies (Cooper, Hobson & van Goozen, 2020; Riddell, Nikolić, Dusseldorp & Kret, 2024).

The process of emotion recognition encompasses the interpretation of nonverbal cues, including facial expressions, vocal intonations, gestures, and body language (Knapp & Hall, 2010; Visser, 2020). These signals are integral to understanding the emotional states of others and navigating social interactions effectively. For example, decoding facial expressions is essential for determining whether a person is happy, angry, or sad, while vocal intonation provides context that can alter the interpretation of spoken words. Emotional intelligence, a construct encompassing emotion recognition, regulation, and application, has been shown to predict successful interpersonal relationships (Parker, Summerfeldt, Walmsley, O'Byrne, Dave & Crane, 2021), academic performance (Quílez-Robres, Usán, Lozano-Blasco & Salavera, 2023) and career achievement (Poliak, Sabie & Nica, 2020).

Additionally, emotion recognition plays a pivotal role in fostering prosocial behavior, such as helping and cooperating with others, as well as in facilitating empathy, which allows

individuals to connect with and understand the experiences of others (Schlegel, 2021). Deficits in this skill, however, are associated with significant challenges, including social withdrawal, emotional dysregulation, and an increased risk of mental health disorders (de la Torre-Luque, Viera-Campos, Bilderbeck, Carreras, Vivancos, Diaz-Caneja, Aghajani, Saris, Raslescu, Malik, Clark, Penninx, van der Wee, Winter-van Rossum, Sommer, Marston, Dawson, Kas, Ayuso-Mateos & Arango, 2022; Staff, Luman, van der Oord, Bergwerff, van den Hoofdakker & Oosterlaan, 2022; Lee, Ortiz, Glenn, Kleiman & Liu, 2024). For instance, individuals who struggle with emotion recognition may experience difficulties forming and maintaining relationships, leading to feelings of isolation and increased vulnerability to emotional problems. Moreover, such deficits have also been found to link to specific conditions, including alexithymia — a difficulty in identifying and describing emotions — and psychiatric disorders such as anxiety, depression, and conduct disorders across different age groups (Farhoumandi, Mollaey, Heysieattalab, Zarean & Eyvazpour, 2021; Krause, Linardatos, Fresco & Moore, 2021; Wells, Hunnikin, Ash & van Goozen, 2021; Baez, Tangarife, Davila-Mejia, Trujillo-Güiza & Forero, 2023).

Emotion recognition involves the integration of sensory information from multiple modalities, including visual and auditory channels, to process emotional cues from facial expressions, vocal tone, body language and contextual information (Fuxe & Molholm, 2009). Among these modalities, visual emotion recognition – often termed as facial affect or facial expression recognition – has garnered significant research attention due to its pivotal role in effective social functioning, including social interaction and participation. Visual emotion recognition directly impacts social functioning, peer relationships, and behavior (Hunnikin, Wells, Ash & van Goozen, 2022), highlighting its importance for adaptive functioning in both typical and atypical developmental trajectories. Research in visual emotion recognition has identified universal facial cues for emotions (Hwang & Matsumoto, 2015). Specific facial

features contribute differentially to emotion identification. For instance, fear, anger, and sadness are often discerned through the eyes, whereas happiness and disgust are associated with the mouth. Surprise can be identified through either feature (Guarnera, Hichy, Cascio & Carrubba, 2015; Wegrzyn, Vogt, Kireclioglu, Schneider & Kissler, 2017; Proverbio & Cerri, 2022). Recent research has shifted from focusing solely on the universality of facial expressions to exploring strategies for enhancing emotion recognition skills, emphasizing the potential for intervention and improvement (Sollár, Turzákóvá, Romanová & Solgajová, 2016).

Equally significant is the role of auditory emotion recognition, which involves interpreting emotional cues from vocal intonation, pitch, rhythm, and speech prosody. Auditory emotion recognition complements visual cues and is particularly critical in contexts where visual information is unavailable or limited, such as phone conversations or interactions with individuals who have visual impairments. The ability to discern emotions through auditory channels develops alongside language acquisition during childhood, with prosodic features—such as variations in tone and stress—playing a crucial role in conveying emotional states (Akçay & Oğuz, 2020). Research indicates that distinct acoustic patterns are associated with specific emotions: happiness is characterized by higher pitch and faster speech rate, sadness by lower pitch and slower tempo, and anger by increased loudness and pitch variability (Friedman, Neill, Seror & Keinsmith, 2018; Kamiloğlu, Fischer & Sauter, 2020). These auditory features enable listeners to infer not only the speaker's emotional state but also the intensity and valence of the emotion being expressed. However, within the Malaysian context, research on children's auditory emotion recognition remains scarce, underscoring the need to investigate how prosody-based cues are interpreted across diverse linguistic and cultural backgrounds. Beyond its developmental significance, auditory emotion recognition has profound implications for social communication, particularly in educational and therapeutic settings. Interventions targeting auditory emotion recognition—such as prosody training and the use of speech

analysis tools—have shown promise in improving social and emotional outcomes (Lado- Codesido, Pérez, Mateos, Olivares, Caballero, 2019; Pedregal & Heaton, 2021). Moreover, recent advancements in neuroimaging and machine learning techniques offer new insights into the neural mechanisms underlying auditory emotion recognition (Cunningham, Ridley, Weinel & Picking, 2021; Sayar, Cakaar, Bozkan & Ertuğrul, 2023), opening new avenues for innovative approaches to diagnosis and intervention.

Research on emotion recognition, which explores both visual and auditory modalities, offers a comprehensive understanding of the multifaceted nature of emotional communication, underscoring the critical role of sensory integration in promoting social and emotional competence across diverse populations. This dissertation seeks to address existing gaps in the literature by examining the emotion recognition profiles of children with Autism Spectrum Disorder (ASD), Attention-Deficit Hyperactivity Disorder (ADHD), and their typically developing peers. The findings are anticipated to yield practical insights for clinicians and educators, informing the refinement of diagnostic tools and the design of targeted interventions to enhance emotion recognition abilities, thereby improving social functioning.

Emotion Recognition in Children

Children typically acquire abilities of emotion recognition progressively, beginning with basic emotions such as happiness, sadness, anger, and fear, and eventually extending to more complex emotions like embarrassment, guilt and pride (Widen & Russell, 2008; Wang, Hawk, Tang, Schlegel & Zou, 2019). These competencies are shaped by a combination of multiple factors including biological, social and environmental, highlighting the interplay between innate neural mechanisms and experiential learning. For instance, the maturation of neural pathways involved in emotion processing supports children's growing ability to

recognize and interpret emotional cues, while repeated exposure to social interactions enhances their understanding of emotional contexts.

Research suggested that typically developing children tend to follow a relatively consistent trajectory in the development of emotion recognition skills. By the age of four or five, most children can accurately identify basic emotions, such as happiness and anger, across multiple modalities. During middle childhood, they begin to recognize the nuances of complex emotional states and by late childhood, they demonstrate an increasingly sophisticated ability to differentiate emotions with subtle variations, such as distinguishing between sadness and disappointment (Chronaki, Hadwin, Garner, Maurage & Sonuga-Barke, 2014; Covic, von Steinbüchel & Kiese-Himmel, 2020; Witkower, Tracy, Pun & Baron, 2021).

These developmental milestones in acquisition of emotion recognition ability are influenced by various factors. High-quality interactions with caregivers, for example, play a critical role in fostering emotional development. Parents and caregivers who provide emotionally supportive environments and actively engage in labeling and discussing emotions help children build a rich emotional vocabulary and improve their ability to recognize emotional states in others (Hunnikin & van Goozen, 2019; Raval & Walker, 2019; Burley, Hobson, Adegboye, Shelton & van Goozen, 2021). Similarly, peer interactions and social play contribute to these skills by offering opportunities to practice interpreting and responding to a wide range of emotional expressions (Huang, Wang, Ma, Qin & Wang, 2024). Children who experience frequent, meaningful social interactions tend to exhibit greater accuracy and confidence in identifying emotions compared to those who have fewer opportunities for such engagement.

The importance of environmental factors is further underscored by research on the role of emotional scaffolding. Caregivers who model appropriate emotional responses and encourage children to reflect on their own and others' feelings help to refine their emotion

recognition abilities. Conversely, children who grow up in less supportive environments, where emotional expression and discussion are limited, may take longer to develop these skills. This highlights the dynamic interplay between a child's developmental context and their emerging capacity to interpret emotions accurately and effectively (Berzenski & Yates, 2017; Burley et al., 2021). Beyond the immediate caregiving environment, broader cultural norms also share how children learn to decode emotional cues. In Malaysia, for example, emotional expression is often guided by collectivist values and social harmony, where emotions such as anger or disapproval may be conveyed indirectly or in a more subdued manner compared to Western contexts (Abd Hadi, Midin, Tong, Chan, Mohd Salleh Sahimi, Ahmad Badayai & Adilun, 2023; Lee, Matthew & Torres, 2025). This suggests that Malaysian children may need to attend more closely to subtle non-verbal and contextual cues when interpreting others' emotions. Given the country's multicultural composition, children are also exposed to diverse cultural display rules across Malay, Chinese, Indian, and indigenous communities, further enriching but also complicating their emotion recognition experiences. Taken together, these dynamics underscore the importance of studying emotion recognition in Malaysian populations, both to capture culturally specific developmental patterns and to avoid overgeneralizing from Western-derived models of emotional development.

Neurodevelopmental Disorders: ASD & ADHD

Neurodevelopmental disorders (NDDs) encompass a heterogeneous group of conditions that manifest during the developmental period of an individual's life, often resulting in pervasive deficits across multiple domains such as cognition, language, motor skills, and social interaction. These impairments can lead to significant hinderance to an individual's ability to perform effectively in daily functioning including personal, academic, occupational, and social contexts. Although the exact etiology of NDDs is yet to be fully elucidated, current

evidence suggests that their onset is influenced by a complex interplay of genetic predispositions, environmental exposures, and prenatal factors, highlighting the multifactorial nature of these disorders (Hannigan & Havdahl, 2021).

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), defines NDDs as conditions that emerge in early developmental stages, typically presenting with persistent deficits that disrupt functioning across various life domains. The DSM-5 categorizes NDDs into several subtypes, including Intellectual Disability (ID), Communication Disorders (CD), Autism Spectrum Disorder (ASD), Attention-Deficit Hyperactivity Disorder (ADHD), Specific Learning Disorder (SLD), and Motor Disorders, which also encompass tic Disorders. Similarly, the International Classification of Diseases, Eleventh Edition (ICD-11), aligns closely with the DSM-5 in its classification framework, emphasizing the shared global understanding and standardization of these conditions in clinical practice (American Psychiatric Association, 2013; World Health Organization, 2022).

Among the spectrum of NDDs, ASD and ADHD stand out as the two most commonly diagnosed conditions worldwide. Both disorders have far-reaching implications, not only for the affected individuals but also for their families, caregivers, and society at large. ASD is a multifaceted condition primarily characterized by deficits in social communication and interaction, alongside restricted and repetitive behaviors, interests, and activities. Conversely, ADHD is marked by pervasive patterns of hyperactivity, impulsivity, and inattention that significantly interfere with daily functioning and developmental progress (APA, 2013). These core features of ASD and ADHD contribute to substantial challenges in various life domains, including cognitive functioning (Hours, Recasens & Baleyte, 2022), academic performance (Dardani, Riglin, Leppert, Sandereson, Rai, Howe, Smith, Tilling, Thapar, Davies, Anderson & Stergiakouli, 2021), social relationships (Harkins, Handen & Mazurek, 2022), and occupational success (Högstedt, Igelström, Korhonen, Käckér, Marteinsdottir & Björk, 2022).

Such challenges underscore the critical need for early identification and intervention, as evidence consistently demonstrates that timely, tailored treatments can yield significant improvements in long-term outcomes (Green, Pickles, Pasco, Bedford, Wan, Elsabbagh, Slonims, Gliga, Jones, Cheung, Charman, Johnson & The British Autism Study of Infant Siblings Team, 2017; Döpfner, Ise, Breuer, Rademacher, Metternich-Kaizman & Schürmann, 2020).

Global prevalence rates of ASD and ADHD have been exhibiting a pattern of upward trajectory over the past few decades, which could be driven by enhanced clinical awareness, advancements in diagnostic tools, and broader societal recognition of neurodevelopmental conditions. Data from the Centers for Disease Control and Prevention's (CDC) Autism and Developmental Disabilities Monitoring (ADDM) Network highlights this trend, revealing a dramatic increase in ASD diagnoses. Specifically, the prevalence rose from 6.7 per 1000 children in the year 2000 to 16.8 per 1000 children by 2014, reflecting an overall increase exceeding 150% within a 14-year span (Christensen & Zubler, 2020). On the other hand, a recent systematic review and meta-analysis conducted on a total of 53 studies involving a sample size of 96,904 participants revealed that the prevalence rate of ADHD in children under age of 12 is 7.6% (95% confidence interval: 6.1–9.4%)(Salari, Ghasemi, Abdoli, Rahmani, Shiri, Hashemian, Akbari & Mohammadi, 2023). The current study focuses on ASD and ADHD – the two most prevalent and widely researched NDDs. Their high prevalence rates and profound impacts on various aspects of one's daily functioning make them particularly relevant for this research aimed at understanding emotion recognition abilities in children.

Emotion Recognition in Children with ASD & ADHD

Skill of emotion recognition develops through a dynamic interplay of biological, environmental, and cultural influences. Deficits in this ability have been consistently observed

in children with NDDs, particularly ASD and ADHD, which are among the most prevalent and widely studied NDDs. Understanding emotion recognition in children with ASD and ADHD is critical because it provides insight into the social and communication difficulties that characterize these disorders.

Children with ASD frequently experience difficulties in recognizing and interpreting emotional cues, such as facial expressions, tone of voice, and body language. These deficits are often linked to atypical functioning in brain regions responsible for processing emotional and social stimuli, such as the amygdala and fusiform gyrus (Gibbard, Ren, Skuse, Clayden & Clark, 2017; Chen, Chen, Martínez, Fan, Liu, Chen & Cheng, 2021). Most children with ASD, even in those with high-functioning ASD (previously known as Asperger's Syndrome) were found to exhibit challenges in global processing of emotional stimuli — a phenomenon described as "weak central coherence" (Happé, 2021). Rather than perceiving facial expressions holistically, individuals with ASD often display tendency to fixate on specific features, processing these elements in a fragmented manner (Tsang, 2016). Additionally, emotion recognition impairments appear to extend beyond diagnosed individuals, with unaffected relatives of individuals with ASD also demonstrating subtle deficits, suggesting that these impairments may represent an endophenotype of ASD (Neves, Tremeau, Nicolato, Lauar, Romano-Silva & Correa, 2011; Oerlemans, van der Meer, van Steijn, de Ruiter, de Bruijn, de Sonnevile, Buitelaar & Rommelse, 2014).

While research on ADHD and emotion recognition is relatively limited as compared to ASD, some available evidence indicates that children with ADHD also experience deficits in this domain. These deficits are often attributed to impairments in executive functioning and attentional control, which hinder the ability to focus on and process emotional cues effectively. One of the studies conducted revealed that inattention significantly impacted the recognition of angry and sad faces, whereas hyperactivity-impulsivity affected the recognition of angry

faces (Tehrani-Doost, Noorazar, Shahrivar, Banaraki, Beigi & Noorian, 2017). In addition to that, it was also found that children with ADHD frequently struggle with nonverbal communication, particularly in decoding emotional expressions, which may contribute to difficulties in interpersonal relationships with parents, peers, and teachers. These challenges are so pervasive that some researchers argue impaired interpersonal relationships as central to the psychopathologic behavior of children with ADHD (Morgan, Dvorsky, Meza, Schumacher & Pfiffner, 2022). Moreover, given the high rates of comorbidity between ASD and ADHD - estimated at 50% - 70% (Rong, Yang, Jin & Wang, 2021) - emotion recognition deficits in these conditions may reflect overlapping etiological factors. The gradient overarching disorder hypothesis suggests that ASD and ADHD represent different manifestations of a broader neurodevelopmental continuum, with ADHD often regarded as a milder form of ASD. Under this framework, shared impairments in social cognition, including emotion recognition, are to be expected across both conditions (Hours et al., 2022).

Problem Statement and Study Rationale

Given that accurate recognition of emotional cues is foundational for successful interpersonal interactions, deficits in this domain are considered central to the social communication challenges experienced by children with ASD and, to a lesser extent, ADHD. These deficits, particularly in recognition of facial expression and prosody, can significantly impair one's social development, peer relationships, and overall quality of life. Despite the clinical relevance of emotion recognition difficulties, they are often overlooked in the process of clinical assessment. This omission may result in missed opportunities for accurate diagnosis and appropriate interventions, a concern made more pressing in this context given the frequent diagnostic overlap between ASD and ADHD. For example, a research indicated that approximately 20% of children diagnosed with ASD were initially misdiagnosed with ADHD

(Miodovnik, Harstad, Sideridis & Huntington, 2015), highlighting the overlap and complexity between these conditions as well as the cruciality for improvised clinical practice looking into more aspects to aid in accuracy of diagnosis, as such diagnostic inaccuracies not only delay appropriate support but may also exacerbate developmental challenges, underscoring the need for more comprehensive approaches in clinical practice.

Most research on emotion recognition has primarily focused on children with ASD, particularly in relation to visual modalities, such as facial expression recognition. These studies have consistently identified emotion recognition deficits as a hallmark feature of ASD (Harms, Martin & Wallace, 2010; Black, Chen, Iyer, Lipp, Bölte, Falkmer, Tan & Girdler, 2017). In contrast, far fewer investigations have explored the role of prosody—the emotional content conveyed through vocal intonation, rhythm, and stress—despite its critical role in everyday communication. Research on auditory emotion recognition is especially sparse in both ASD and ADHD populations. This gap is concerning, given that prosodic cues are integral to understanding others' emotional states, and may be particularly salient in multilingual and multicultural contexts such as Malaysia, where subtle intonational differences can carry significant meaning. The lack of attention to auditory emotion recognition in ASD and ADHD populations in existing literature therefore represents a major gap that this study seeks to address.

In ADHD, research on emotion recognition remains limited, though emerging evidence links impaired emotional decoding, particularly for anger and sadness, to attentional control and executive functioning deficits (Tehrani-Doost et al., 2017). Given the substantial comorbidity between ASD and ADHD, further exploration of emotion recognition deficits across these groups is warranted to disentangle both shared and distinct impairments. Importantly, a direct comparison across ASD, ADHD, and TD groups is theoretically and clinically justified. Theoretically, such comparisons can clarify whether observed deficits are

condition specific (e.g., social cognition in ASD versus attentional control in ADHD) or reflect overlapping vulnerabilities (e.g., processing speed and working memory limitations). Empirically, inclusion of a TD group provides an essential baseline against which atypical performance can be interpreted. This three-group design therefore enables a clearer understanding of both unique and overlapping difficulties in emotion recognition across neurodevelopmental profiles.

The current study seeks to address these limitations by investigating emotion recognition across visual (facial expression) and auditory (prosody) modalities in children with ASD, children with ADHD, children with comorbidity of both ASD and ADHD, and also typically developing (TD) children. By delineating unique and overlapping emotion recognition profiles, this research aims to bridge critical gaps in clinical assessment and contribute to more comprehensive diagnostic practices, yielding more accurate results. These insights have the potential to improve diagnostic clarity and guide interventions tailored to the specific needs of children with ASD and ADHD, ultimately enhancing their social functioning and overall quality of life.

Within the Malaysian context, little is known about how children with ASD and ADHD experience emotion recognition challenges. While cross-cultural studies have begun to examine how culture shapes emotion recognition in typical development, there is limited empirical data on Malaysian children with ASD and ADHD. Studies have demonstrated that emotion recognition is influenced by cultural display rules and norms (Mohan, Mukhtar & Jobson, 2021; Ji, Son & Kim, 2022), and even that facial expressions may not be universally interpreted the same way (Brooks, Kim, Opara, Keltner, Fang, Monroy, Corona, Tzirakis, Baird, Metrick, Tadesse, Zegeye & Cowen, 2024). This study therefore addresses both an international gap in auditory emotion recognition research and a local gap in understanding how ASD and ADHD manifest within the Malaysian socio-cultural setting.

The Current Study

Emotion recognition is a multidimensional skill involving the ability to interpret emotional states from facial expressions, vocal cues, and situational contexts. While TD children naturally acquire these skills throughout the course of growth and development, children with neurodevelopmental disorders like ASD and ADHD often exhibit distinct challenges. These challenges not only affect their social interactions but also contribute to broader difficulties in emotional and behavioral regulation. Despite substantial research, many existing studies focus narrowly on either ASD or ADHD, leaving comparative analyses underexplored.

In addition to that, research on emotion recognition frequently involves screening tools developed and validated in Western contexts. The lack of culturally adapted and validated instruments affects the generalizability of findings and their relevance in the context of our country as an Asian setting.

To address these challenges, the current study adopts a two-phase approach. Phase 1 involves translation, cultural adaptation, and pilot testing of a screening questionnaire used to categorize the research participants into respective groups, ensuring that it was contextually appropriate and psychometrically sound for the target population. Moving forward, phase 2 involved computerized experimental tasks to investigate and compare the emotion recognition abilities of children with ASD, ADHD, comorbid of both disorders, and TD peers. This study was conducted with the main general objective aimed to provide novel insights into the distinct and shared emotion recognition profiles across these groups. This also led to the following specific objectives hoping to achieve through this study:

1. To evaluate the visual emotional recognition ability of children with ASD, ADHD, ASD comorbid ADHD and TD children.

2. To evaluate the auditory emotional recognition ability of children with ASD, ADHD, ASD comorbid ADHD and TD children.
3. To compare the emotional recognition profile across different modalities (visual and auditory) between children with ASD, ADHD, ASD comorbid ADHD and TD children.

In the effort of achieving these objectives, the current research was guided by the following research questions:

1. How is the visual emotion recognition ability of children with ASD, ADHD, ASD comorbid ADHD and TD children?
2. How is the auditory emotion recognition ability of children with ASD, ADHD, ASD comorbid ADHD and TD children?
3. Is there a significant difference in emotion recognition profiles between children with ASD, ADHD, ASD comorbid ADHD and TD children?

Based on the research objectives and questions listed above, five hypotheses were proposed based on past literature. The first hypothesis (H_1) hypothesized that children with ASD, ADHD, and comorbidity of both will exhibit significant weakness in visual emotion recognition compared to TD children. This hypothesis was based on past literature indicating that individuals with ASD struggle to recognize facial expressions due to deficits in social cognition and atypical gaze patterns (Ma, Gu & Zhao, 2021). Similarly, children with ADHD also face challenges in visual emotion recognition, though to a lesser extent, likely due to attention regulation difficulties and impulsivity, which affect their ability to process facial cues effectively (Tehrani-Doost et al., 2017). The co-occurrence of ASD and ADHD may further amplify these challenges, as both conditions contribute overlapping yet distinct impairments in social attention and facial information processing (Hours et al., 2022).

The second hypothesis (H_2) hypothesized that children with ASD, ADHD, and comorbidity of both will demonstrate deficits in auditory emotion recognition compared to TD

children. Research shows that children with ASD frequently experience difficulties in interpreting emotions from vocal tones and prosody, often attributed to impaired integration of auditory information and reduced sensitivity to affective auditory cues (Gonçalves & Monteiro, 2023). On the other hand, children with ADHD exhibit challenges in auditory emotion recognition due to distractibility and difficulties in sustaining attention during tasks requiring interpretation of vocal tone (Demopoulos et al., 2013).

Other than that, it was also hypothesized that emotional recognition profiles will differ across modalities (visual versus auditory) for children with ASD, ADHD, and ASD comorbid ADHD. Specifically, children with ASD are expected to exhibit greater impairments in auditory emotion recognition than visual emotion recognition (H_3) due to significant difficulties in auditory processing and integration (Gonçalves & Monteiro, 2023), and also children with ADHD will face more pronounced challenges in visual emotion recognition compared to auditory emotion recognition (H_4) owing to attentional biases and regulatory issues (Tehrani-Doost et al., 2017). These hypotheses highlighted potential modality-specific vulnerabilities which guide in recognizing the differences in emotion recognition profiles across children of different conditions.

Finally, it is hypothesized that children with ASD comorbid ADHD will show more severe deficits in both visual and auditory emotion recognition compared to children with ASD or ADHD alone (H_5). This hypothesis is based on evidence suggesting that the co-occurrence of ASD and ADHD exacerbates deficits in cognitive and emotional domains, including emotion recognition (Leitner, 2014). The combined impact of impairments associated with both conditions may result in additive challenges, leading to more pronounced deficits in recognizing emotions across modalities.

Significance of Study

This study holds significant potential to advance both theoretical understanding and practical applications in the fields of clinical and developmental psychology. Despite emotion recognition playing a pivotal role in social communication, yet its development and manifestation in children with NDDs of high prevalence – ASD and ADHD – remain insufficiently understood. By exploring on the unique emotion recognition profiles of children diagnosed with these disorders comparing to their TD peers, the current research contributes insights into how these conditions impact social cognition and emotional processing. The comparative approach adopted in this study allows for an understanding of both similarities and differences across these groups of children, shedding light on the underlying mechanisms that shape their social experiences.

Beyond its theoretical contributions, this study also has practical implications for clinicians, educators and intervention providers working with children with the diagnosis of ASD and/or ADHD. Understanding the specific challenges these children face in recognizing emotions can guide the development of targeted interventions that improve social skills and emotional regulation. The culturally adapted tool utilized in this study can also serve as a valuable resource functioning as a quick screening tool for professionals in the local context (i.e., Malaysia), enabling more early detection of potential ASD and/or ADHD diagnoses, facilitating early interventions.

Finally, the findings yielded from the current study have the potential to inform policy and advocacy efforts aimed at improving mental health care and educational support for neurodiverse children. By emphasizing the need for culturally adapted tools and practices particularly as demonstrated in Phase 1, the current research can help bridge gaps in psychological services, particularly in underserved populations. It also highlights the importance of fostering inclusive environments that address the unique needs of children with

ASD and ADHD of different cultural contexts, promoting better social, emotional, and academic outcomes.

In summary, this study bridges critical gaps in theory, methodology, and practice by addressing emotion recognition in neurodevelopmental disorders within a culturally relevant framework. Its contributions span multiple domains, from advancing academic knowledge to informing clinical practices and policy decisions, ultimately promoting a more inclusive, comprehensive understanding of emotion recognition in children.

Chapter II: Literature Review

In response to the gaps identified in the problem statement and study rationale, this chapter critically reviews and elaborates on the existing literature on emotion recognition, focusing on its development in children and its distinct manifestations in NDDs such as ASD and ADHD. This chapter is structured to first outline theoretical and developmental perspectives, then review empirical evidence across ASD, ADHD, and typically developing (TD) groups, followed by a synthesis of multimodal research and identification of key gaps.

Research on emotion recognition has evolved significantly over the years. At the early years of examining the topic of emotions, studies concentrated on the universality of facial expressions, particularly basic emotions like fear, sadness, happiness, anger, disgust, and surprise (Ekman, 1999). As studies in this field progressed, later research emphasized the importance of specific facial regions in decoding emotional cues (e.g., Sullivan, Ruffman & Hutton, 2007; Rani & Muneeswaran, 2016; Guarnera, Magnano, Pellerone, Cascio, Squatrio & Buccheri, 2018). For instance, the eyes for fear and anger (Sacco & Hugenberg, 2009; Eisenbarth & Alpers, 2011), and the mouth for happiness (Eisenbarth & Alpers, 2011; Beaudry, Roy-Charland, Perron, Cormier & Tapp, 2014). These foundational studies set the stage for exploring emotion recognition deficits in children, especially those with neurodevelopmental disorders who were found to have atypical face perception and processing styles along with varying degree of deficits in decoding facial cues.

Emotion recognition has been a research focus in children with psychiatric and NDDs since the early 1980s. Among these conditions, ASD has been the most extensively studied NDD, with numerous studies establishing emotion recognition deficits as one of the core features of this disorder (see meta-analysis conducted by Yeung, 2022). More recent systematic reviews and meta-analysis (Leung, Sin, Dawson, Ong, Zhao, Veić & Liu, 2022; Masoomi, Saeidi, Cedeno, Shahrivar, Tehrani-Doost, Ramirez, Gandi & Gunturu, 2025) continue to

confirm emotion recognition as a consistent challenge for individuals with ASD across modalities. Individuals with ASD, including those with high-functioning profiles, previously known as Aspergers Syndrome, exhibit significant impairments in recognizing and interpreting emotional facial expressions. These difficulties are typically attributed to atypical visual processing strategies, whereby the individual fixates on specific facial features instead of perceiving the face as a whole (Gauthier, Klaiman & Schultz, 2009). This fragmented processing aligns with the weak central coherence theory, which posits that individuals with ASD struggle to integrate details into a coherent global image (Delli, Varveris & Geronta, 2017; Happé, 2021). Additionally, research has shown that atypical neural functioning in brain regions such as the amygdala and fusiform gyrus, which are responsible for processing emotional and social stimuli, contributes to the emotion recognition deficits experienced by many individuals with ASD (Dziobek, Bahnemann, Convit & Heekeren, 2010; Gibbard et al., 2017; Chen et al., 2021).

Emotion recognition deficits in ASD are not limited to visual cues; auditory emotion recognition, such as interpreting emotional prosody, has also been studied, with mixed findings. Some studies revealed significant impairment (e.g., Schelinski & von Kriegstein, 2019) while others reported no marked deficits (e.g., Baker, Montgomery & Abramson, 2009). Recent cross-linguistic work (Saksida, Flo, Guedes, Nespor & Garay, 2021; Xiao & Liu, 2024) suggests that variability may be partly explained by language background and cultural differences, an issue particularly relevant to multilingual contexts such as Malaysia.

In contrast to ASD, research on emotion recognition deficits in ADHD is comparatively limited. However, there has been emerging evidence suggesting that children with ADHD also exhibit difficulties in recognizing emotional expressions, particularly for negative emotions like anger and sadness (Tehrani-Doost et al., 2017; Maire, Galera, Roux, Bioulac, Bouvard & Michel, 2019). These deficits are often attributed to impairments in executive functioning and

attentional control, which hinder the ability to focus on relevant emotional cues and integrate them into a coherent interpretation effectively. Children with ADHD frequently experience interpersonal difficulties, which some researchers argue are central to the disorder's pathology. Impaired emotion recognition, particularly in nonverbal communication, may exacerbate these social challenges and contribute to strained relationships with parents, peers, and teachers.

However, when looking at research on emotion recognition ability of individuals with ADHD, the findings remain sparse and inconsistent. While some studies report deficits in this area for children with ADHD (e.g., Demopoulos, Hopkins & Davis, 2013), a recent systematic review (see Shepard, Ruben & Weyandt, 2024) found that in spite of 58% of retrieved articles reported significantly lower emotion recognition accuracy among individuals with ADHD in comparison to their neurotypical peers, many of the studies with significant findings were rated as lower in methodological quality according to a quality review checklist. They further pointed out that when studies involved use of control conditions and multiple measures of emotion recognition accuracy, no significant differences in emotion recognition were found between individuals with ADHD and TD participants. This highlights the importance of methodological rigor, a gap which the current study addresses by employing both visual and auditory modalities with a typically developing control group.

One of the factors complicating the understanding of emotion recognition deficits in these two conditions is the high rate of comorbidity between both ASD and ADHD. A recent meta-analysis conducted revealed that as high as 50% - 70% of individuals with ASD also meet the diagnostic criteria for ADHD (Rong et al., 2021). Despite challenges in emotion recognition not being described as a main symptom of ADHD as in ASD, the gradient overarching disorder hypothesis proposed the theoretical understanding that ASD and ADHD are part of a broader neurodevelopmental spectrum, with ADHD representing a milder expression of the impairment observed in ASD (Hours et al., 2022). Under the framework of this hypothesis, shared deficits

in social cognition, including emotion recognition, are anticipated across both disorders. However, research has shown that emotion recognition deficits tend to be more severe in children with ASD than those with ADHD. For instance, children with ASD were found to struggle with both basic and complex emotions through visual emotion recognition, whereas children with ADHD are more likely to misinterpret ambiguous cues as negative (Bora & Pantelis, 2016). Moreover, the developmental trajectory of social cognition in these two groups differs, with age potentially mitigating emotion recognition deficits in ADHD, but not in ASD (Bora & Pantelis, 2016).

Though significant attention has been given to emotion recognition through the visual modality (i.e., facial emotion recognition) from a developmental perspective, the development of auditory emotion recognition – the role of prosody, encompassing vocal intonation, rhythm and stress - has been less investigated (Kilford, Garrett & Blakemore, 2016). Yet, prosody functions as an essential channel for conveying emotional information and plays a critical role in both linguistic and emotional communication. However, both visual and auditory modalities are equally crucial in early development of emotion recognition, as supported by the framework of early multimodal recognition of emotions (Bänziger, Grandjean & Scherer, 2009).

It is evident from infancy that the ability to recognize the face of a close caregiver such as mother is likely influenced by the newborn's prior exposure to her voice, with auditory familiarity beginning during pregnancy. The mother's voice serves as a prominent and easily recognizable stimulus for the developing fetus (Saito, Nishimura, Morimoto, Otsuka, Uratani, Matsunaga, Hosoi & Kitahara, 2019). As infants and children grow, their senses work hand-in-hand to both convey and interpret emotional cues. The interplay between different sensory modalities enhances their ability to understand and respond to emotions. This cross-modal expression, where similar emotional signals are expressed and perceived through multiple senses, plays a vital role in shaping their emotional development and social understanding (Gil,

Hattouti & Laval, 2016). A recent systematic review also further showed that an individual's ability to detect emotions in linguistic stimuli starts developing very early and it continues to improve with age throughout childhood (see Morningstar, Nelson & Dirks, 2018).

Hence, the investigation of auditory modality in emotion recognition abilities of children is as pivotal as visual emotion recognition to gain a fairer yet more comprehensive understanding towards emotion recognition in children, including those with ASD and ADHD.

Despite decades of investigation and advances in the field, there are notable gaps in the literature. Key limitations include inconsistent methodologies, particularly regarding age-specific developmental trajectories, as well as the measurement of emotion recognition. Along with the lack of emphasis on the auditory modality of emotion recognition, the current study aims to gain a more comprehensive understanding of emotion recognition through a multimodal investigation among children in the age range where the abilities of emotion recognition are typically developing. Importantly, while cross-cultural research has highlighted differences in emotional display rules (Matsumoto, 2020), there remains a lack of empirical work specifically examining Malaysian children with ASD or ADHD. Addressing this local gap strengthens the relevance of the present study and its potential to inform culturally sensitive interventions.

Chapter III: Methodology

The present study was conducted in two phases to ensure methodological rigor and adaptability to the study area and target population. In the first phase, the primary objective was to translate, validate, and conduct preliminary reliability testing of the ASD and ADHD domains of the Autism-Tics, ADHD, and other Comorbidities inventory (A-TAC), which served as the main screening tool for subsequent stage of the study. Given the limited English proficiency of part of the study population, it was essential to develop a Malay language version of the A-TAC to facilitate comprehension and ensure accurate responses. Subsequently, the second phase encompassed screening of potential participants, which included brief IQ assessment using the brief, 2-subtest version of Wechsler Nonverbal Scale of Ability (WNV) and clinical group categorization using the ASD and ADHD domains of A-TAC. The items in the selected domains of A-TAC were presented in bilingual – English and Malay language version validated during the first phase of the study. Following this, eligible participants who met the inclusion criteria proceeded to the experiment phase, where they engaged in two computerized tasks – Facial Emotion Recognition (FER) and Affective Prosody (AP) tasks. A detailed methodology for each phase is illustrated below:

Phase 1: Translation, Cross-Cultural Adaptation and Preliminary Reliability Testing of ASD and ADHD Domains in A-TAC

Research Design

The first phase of the study was primarily dedicated to translating, culturally adapting, and pilot testing the ASD and ADHD domains of the A-TAC questionnaire, laying the groundwork for its application in the subsequent phase. A mixed-methods approach was adopted to ensure that the adaptation process preserved the questionnaire's cultural and linguistic appropriateness while retaining the psychometric integrity of the original instrument.

The translation and adaptation followed the forward-backward translation methodology outlined by Ozolins, Hale, Cheng, Hyatt, and Schofield (2020), followed by pilot testing of the finalized translated version.

To safeguard the validity and reliability of the translated instrument, the adaptation process adhered to a structured six-stage protocol established by Beaton, Bombardier, Guillemin and Ferraz (2002) and the World Health Organization (WHO) (2017): (1) forward translation, (2) synthesis of forward translations, (3) backward translation, (4) synthesis of backward translations, (5) expert committee review, and (6) finalization. These sequential steps ensured that the translated items remained accurate and culturally relevant while retaining their original intent. Expert reviews were integrated throughout the process, providing qualitative insights into translation accuracy and cultural adaptation. Furthermore, the quantitative assessment of content validity was conducted by calculating the Content Validity Ratio (CVR) and the Content Validity Index (CVI).

The pilot testing phase focused on evaluating the questionnaire's feasibility, preliminary reliability, and logistical considerations, rather than aiming for statistical generalizability. To assess reliability, Cronbach's alpha was computed for both the Malay translated ASD and ADHD domains of the A-TAC. As a widely used statistical measure, Cronbach's alpha evaluates the internal consistency of a set of items, indicating the extent to which they reliably measure the same underlying construct. This measure provided preliminary evidence of the questionnaire's reliability and informed adjustments necessary for its refinement. This systematic process laid the groundwork for the application of the adapted instrument in Phase 2.