Is Autism, Attention Deficit Hyperactivity Disorder (ADHD) and Specific Learning Disorder linked to Impaired Emotion Recognition in Primary School Aged Children?

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***Abstract*— Facial expressions are important in decoding meaning and communicating information. Participants were fifty-eight Cypriot and Italian children between 6 and 11 years of age. Comparisons were made between the clinical group, composed of children with ADHD, ASD and learning disorder and the control group, composed of typically developing children. The six primary emotional facial expressions were investigated which were portrayed by contemporary faces of children and adults of both genders. There was a significant main effect for group and a significant main effect for emotion, with happiness being the most accurately decoded emotion followed by anger, surprise, sadness, disgust and fear. Significant interactions were found involving the type of stimuli, emotions and participants' group. The results of the study are discussed considering past research and future directions.**

Keywords—emotion recognition, neurodevelopmental disorders, type of stimuli, basic emotions

I. INTRODUCTION

Facial expressions aid in the communication; any changes in the facial muscles help disentangle meaning, control the conversational flow, provide information as to the speaker/listener's emotional state and inform about intention [1]. Understanding others' emotional facial expressions is a significant social-cognitive skill which helps to modulate one's behavior. Several studies focusing on the developmental aspect of emotion recognition (mainly those focusing on the preschool years) reported improvement with age [2], arguing thus that emotion recognition gradually improves over time [3].

Abnormalities in the recognition of facial expressions have been associated with psychiatric disorders in both adults [4] and children [5] populations. A failure to identify emotional facial expressions can have long-term and wide-reaching detrimental effects upon social behavior [6]. Although different child and adolescent clinical populations have been shown to have deficits in facial expression recognition such as children diagnosed with Down syndrome [7], schizophrenia [8] conduct disorders [9], and depressive disorder [10], autism is perhaps the most widely studied area in terms of developmental psychopathology and emotional deficits.

A. Attention Deficit Hyperactivity Disorder (ADHD)

ADHD is a neurodevelopmental disorder affecting people of all ages and of both genders. The symptoms of ADHD begin in childhood (usually between the ages of 3 to 6), and for about half of the children, the symptoms continue into adolescence and adulthood. The primary symptoms of ADHD are (1) hyperactivity/impulsivity and (2) inattention. The specific presentation of symptoms may vary by age.

School-aged children with ADHD have been reported to suffer from social and emotional deficits, i.e. inability to effectively appraise the emotional state of others and impairments in cognitive functions, i.e. inhibition, sustained attention, and executive planning [11]. Children with ADHD encounter many social problems, are generally less accepted by peers and lack social skills [12]. Reduced social competence has been highly associated with the disorder [13] and the social problems encountered by these children constitute significant predictors of negative outcomes in later life i.e. adolescence and adulthood. Factors related to emotional processing, and specifically deficient emotion recognition, has been discussed to play a key role [14].

In a recent systematic review [15], the authors analyzed the results of 38 studies focusing on face recognition, affect recognition, memory, facial expression recognition and recall of faces in children and adolescents with ADHD. The review concluded that the different profiles found between the ADHD and control groups, could be the result of a different mechanism related to the core deficits in ADHD (i.e. hyperactivity, impulsiveness and inattention), a deficit in the processing of social information, comorbid conditions or specific alterations in brain systems underlying the face processing abilities. Focusing on facial recognition a large amount of studies included in the review showed that children with ADHD performed worse on facial emotion recognition than children in the control group with the social cognitive deficit patterns being probably more similar in

patients with Autism Spectrum Disorder (ASD) and ADHD than in patients with ADHD and typically developing children.

B. Autism Spectrum Disorder (ASD)

The role of emotion in autism has been debated for the past 60 years. The criteria for diagnosis according to DSM-V [16] include persistent deficits in social communication and social interaction across multiple contexts including deficits in social-emotional reciprocity, deficits in nonverbal communicative behavior used for social interaction and deficits in developing, maintaining, and understanding relationships; restricted, repetitive patterns of behavior, interests, or activities and the presentation of symptoms in the early developmental period. These difficulties in using, sharing and responding to emotions correspond to the production of an emotional state and the regulation of that state, namely to two of the three components of emotion processing as defined by [17]. Despite some interventions for autism teaching specific emotion recognition skills, there is lack of consensus if basic emotion recognition is a universal and fundamental difficulty for individuals with ASD or not.

The authors of a meta-analytic review [18] which included 48 studies and 980 participants, found evidence of a general impairment in emotion recognition in individuals with ASD where participant age, IQ and task had no impact on performance. All six emotions (fear, sadness, anger, disgust, surprise, happiness) showed negative effect sizes. For all emotions but happiness (i.e. fear, sadness, anger, disgust, surprise) the 95% confidence intervals were entirely in the negative range, suggesting that adults with ASD have difficulty in the recognition of these individual emotions. There was marginal evidence for differences between emotions, with confidence limits for recognition of happiness spanning zero, and marginally worse recognition of fear than happiness. Results revealed no difference for sadness, surprise, disgust, or anger compared to happiness which was taken as the baseline and recognition of fear was significantly worse than recognition of happiness. Only eight studies nevertheless investigated all six basic emotions.

C. Learning Disorders

In 1980 with the 3rd edition of the DSM (DSM-III) the issue of problems with learning was first addressed. DSM-V (2013) considers specific learning disorders to be a type of Neurodevelopmental Disorder affecting children's abilities to learn or use of one or more specific academic skills such as reading, writing, and mathematics. The learning difficulties appear as 'unexpected' as other aspects of development seem to be fine. Early signs of learning difficulties (i.e. difficulty counting objects or learning names of letters) may appear in the preschool years but they can only be reliably diagnosed after starting formal education.

Learning disorders are among the most frequently diagnosed developmental disorders in childhood. According to DSM-V, epidemiological studies report comparable prevalence rates of 3 -7% for deficits in mathematics and 4-9% for deficits in reading. Research on how well dyslexics can recognize the 6 basic emotions is scarce. Despite most previous studies indicating no links among emotion recognition and dyslexia, recent studies pinpoint to a link between the two.

Sigurdardottir et al. [19] investigated the perceptual performance of dyslexic adults by examining impairment in the recognition of faces and other complex non-word visual objects. The authors found people with dyslexia to be impaired in the recognition of faces and other visually complex objects. As participants' holistic processing of faces appeared to be intact, the authors concluded dyslexics to perhaps be specifically impaired at part-based processing of visual objects. Reference [20] investigated the recognition and discrimination competences in typical and dyslexic readers in three visual categories namely, faces, words and cars as control stimuli. Relative to controls, not only did dyslexic individuals perform more poorly on word recognition, but they also matched faces more slowly, especially when the faces differed in viewpoint, and discriminated more poorly between similar faces (but not cars). Reference [21] sought to examine whether social communication skills and dyslexia share common neurological ground and found dyslexics to be impaired in theory of mind and social communication skills. Reference
[22] examined face naming accuracy and speed in dyslexic university students and found dyslexic and control participants not to differ in their accuracy and overall reaction times to name faces.

The aim of the present research was to examine whether children with ADHD, autism and learning disorder have impaired emotion recognition skills in the six primary emotional facial expressions (happiness, disgust, anger, sadness, surprise, fear) - as identified by Ekman and Friesen [23] - portrayed by contemporary faces of children and adults respectively. Considering the lack of consensus regarding the number and list of primary emotions, the six basic emotions [23] were chosen to serve as the basis of comparison with previous studies in the field.

II. MATERIALS AND PROCEDURES

A. Material

The stimuli consisted of 24 adult and 24 child faces portraying the six primary emotional facial expressions of happiness, sadness, anger, fear, surprise, and disgust. Each emotion was represented by two male and two female faces of children and adults. The stimuli were acquired from two larger sets of stimuli, composed of 84 contemporary children faces and 96 contemporary adult faces respectively [24]. The 48 stimuli selected for the present research work were among those that received the highest percentage of label agreements (between 80% and 100%), meaning that they were the best accurately decoded.

Female Disgust (Adult)	Male Disgust (Adult)
	

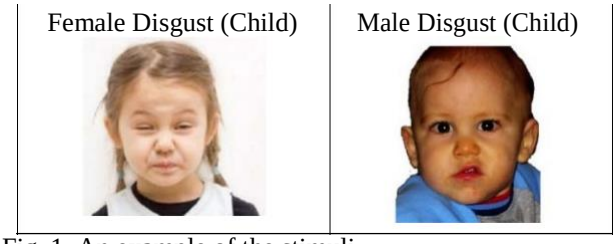

Fig. 1. An example of the stimuli presented *B. Participants*

A total of 58 participants were recruited, 25 in the experimental and 33 in the control group. Participants were between 6.0 and 11.9 years of age, with the mean age being 8 years old (mean age=8.16, SD=1.85). Children in the clinical group (mean age = 8.08, SD = 1.94) did not significantly differ on age from children in the control group (mean age = 8.21, SD = 1.82). All children's guardians voluntarily accepted their children to participate in the study and signed an informed consent form prior to the administration of the study. All children participating gave their verbal consent prior to their participation in the study.

25 children (22 males, 3 females) participated under the experimental/clinical group of which 13 were diagnosed with ADHD, 8 with autism and 4 with a specific learning disorder (dyslexia, dyscalculia and/or dysgraphia) according to the criteria of DSM-V. Of the children in the experimental (clinical) group, 32% were diagnosed with a comorbidity of which 1 with ADHD, 2 with ASD and 5 with a specific learning disorder. Only 2 children were diagnosed with a second comorbidity. Nearly one third (32%) of the children were attending occupational therapy sessions, 16% psychotherapy/psychoeducation, 12% cognitive therapy, and 4% speech therapy and special pedagogy respectively. 20% of the children diagnosed with ADHD were under pharmacotherapy on either Rubifen or Concerta. The control group was composed of 33 children (18 males, 15 females) with no diagnosis of a mental health disorder.

45 children were Cypriots and 13 Italians. Cypriot children were recruited with the collaboration of mental health professionals (i.e. Occupational Therapists, Psychiatrists, Psychologists) as one of the eligibility criteria for participation in the experimental condition was the formal diagnosis by a mental health professional. Children in the control group were recruited from Private Elementary Schools in Cyprus. Italian participants were recruited from the Lab of Cognitive Sciences of Università degli studi della Campania Luigi Vanvitelli in Caserta, Italy.

C. Procedure

An emotional facial recognition test was administered. Prior to the administration of the experiment all children were presented with the six emoticons of happiness, anger, surprise, fear, disgust, sadness and asked to match each emoticon to one of the scenarios presented. Aim of the first task was to ensure that all participants were knowledgeable and confident of the emoticons presented. The following scenarios were presented to children's native language:

1. Imagine it is your birthday, you are surrounded by your friends and family and you have received many beautiful gifts. How are you feeling? (Happiness)
2. Imagine your favorite game is broken or lost. How are you feeling? (Sadness)
3. You have always wanted a puppy, but your parents kept putting it off. One day coming home from school you open the door and a puppy runs towards you, you are very happy. What else do you feel? (Surprise)
4. You must take the cough syrup which has a very bitter taste. How do you feel? (Disgust)
5. Your classmate takes without asking your favorite pen and breaks it. How do feel? (Anger)
6. It is in the middle of the night, you are in bed, and you suddenly hear a thunderstorm. How do feel? (Fear)

Fig. 2. The six emoticons used; surprise, happiness, sadness, fear, disgust, anger

The 48 visual stimuli were subsequently administered individually, through the Superlab software in a quiet room. Each participant saw all 48 adult and children emotional facial expressions, presented on a computer screen, and had to select one of the six emotions (happiness, anger, surprise, fear, disgust, sadness,) that best described the stimulus by selecting the respective emoticon on the keyboard. No feedback on the accuracy of the response, and no time limits were given.

III. DATA ANALYSIS

A series of repeated measure ANOVAs were performed on the correct decoding accuracy obtained by children for the different conditions under examination. The ANOVAs were performed on the accuracy responses provided by children in the clinical and control group. The confidence interval was set to alpha=.05.

A. Condition A: Groups (Between Subjects Variable) – Type of Stimuli (Within Subjects Variable)

The between factor for Condition A was participants' group (experimental and control). The within factors were the emotional categories (happiness, anger, surprise, fear, disgust and sadness), gender of the stimuli (female and male) and age of stimuli (children and adults).

1) Emotion Recognition Skills

There was a significant main effect for group as the between-factor variable ($f(1,56)=11.89$, $p=.001$); children in the control group (mean=6.86, SD=0.18) performed significantly better on overall emotion recognition compared to children in the clinical group (mean=5.93, SD=0.20). A significant main effect for emotion was also found ($f(5,280)=32.67$, $p=.000$). Happiness (mean=1.81, SEM=0.04) was the most well recognized emotion, followed by anger (mean=1.73, SEM=0.05), surprise (mean=1.67, SEM=0.06), sadness (mean=1.66, SEM=0.05), disgust (mean=1.61, SEM=0.05), and fear (mean=1.12, SEM=0.07). Bonferroni's post hoc tests show that disgust was significantly more accurately decoded than fear ($p=.000$), and significantly less accurately decoded than

happiness (p=.001) and anger (p=.001). Sadness was significantly more accurately recognized than fear (p=.000) and significantly less accurately recognized than happiness. Happiness was significantly more accurately decoded for all emotions but anger; disgust (p=.001), sadness (p=0.006), fear, (p=.000), surprise (p=.002). There was no significant group by emotion interaction; f(5,280)=1.27, p=0.279.

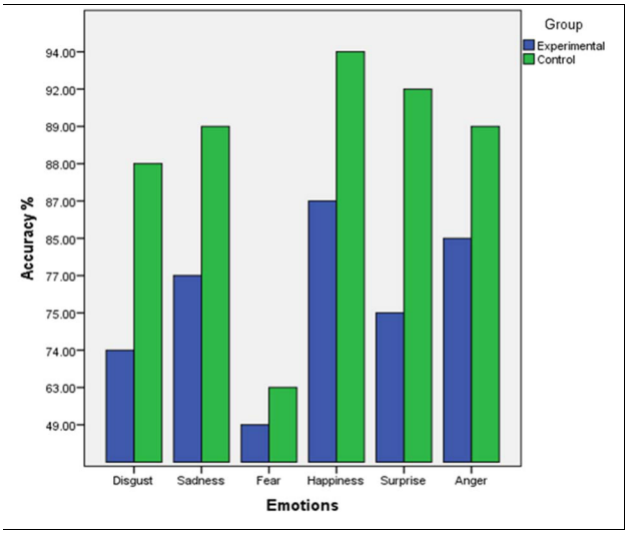

Fig. 3. Accuracy on the emotions of surprise, happiness, sadness, fear, disgust, anger based on participants' group

2) The effect of the Type of Stimuli Presented Focusing on the type of stimuli presented and despite the absence of a significant main effect for stimuli gender (f(1,56)=0.20, p=.660) and stimuli age i.e. whether the stimulus presented was of a male or female (f(1,56)=0.15, p=0.704), a significant strong interaction was found for the emotion presented and the gender of stimuli (f(5,280)=4.67, p=0.000). Bonferroni's post hoc tests show that participants performed significantly worse on the stimuli of sadness when expressed by females than males (p=.002).

A significant interaction was found for the emotion, age of stimuli (children vs. adults) and group (f(5,280)=2.25, p=.05). Bonferroni's post hoc tests show that on the emotions of disgust and happiness the experimental (clinical) group performed worse on the children (but not adult) stimuli compared to the control group; (p=.000) and (p=.019) for disgust and happiness respectively, on the emotion of sadness children in the clinical group performed worse on the adult (but not children) stimuli compared to the control group (p=.003), on the emotion of fear children with a diagnosis of ADHD, ASD, or learning disorder performed worse on the adult stimuli compared to typically developing children (p=.03), on the emotion of surprise children in the experimental group had lower decoding accuracy on children compared to adult stimuli (p=.002), while for anger no significant differences were found among the adult and children stimuli.

A significant interaction was also found with regards to the gender of stimuli, age of stimuli and participant group (f(1,56)=8.71, p=.005). Bonferroni's post hoc tests show that children in the clinical group performed significantly better on the male adult stimuli compared to the female adult stimuli.

A significant interaction was also found for emotion, age of stimuli and gender of stimuli (f(5,280)=5.16, p=.000). Bonferroni's post hoc tests show that for disgust participants performed significantly better when presented with the female children stimuli compared to the male children stimuli (p=.015). Male adult stimuli of disgust were also recognized significantly better than male children stimuli of disgust (p=.008). For sadness there was significantly higher decoding accuracy for the male adult stimuli compared to the female adult stimuli. For fear participants were significantly better in recognizing children of masculine gender than children of feminine gender (p=.013). For surprise there was higher decoding accuracy for female children stimuli than male children stimuli (p=.03). For happiness, the accuracy on emotion recognition differed on both the gender and age of stimuli; (1) female adults were recognized significantly better than male adults (p=.004) and (2) male children stimuli were decoded significantly more accurately than male adult stimuli (p=.004).

A significant interaction was found for the emotion, gender of stimuli, age of stimuli and group (f(5,280)=5.16, p=.009). Table 1 and 2 below show the significant differences following the Bonferroni's post hoc tests conducted.

In Table 1 children diagnosed with ADHD, ASD and learning disorder recognized with significantly lower accuracy the male stimuli of children than the female stimuli of children on the emotion of disgust (p=.0016). In contrast, children in the experimental group decoded with significantly lower accuracy the female adult stimuli on the emotion of sadness compared to the male adult stimuli of the same emotion (p=.001).

TABLE I. Decoding accuracy based on stimuli gender

Group	Emotion	Age ofStimuli	GenderStimuli	GenderStimuli	Mean Diff.	Sig.
Exp.	Disgust	Children	Female	Male	.36	.016
			Male	Female	-.36	.016
	Sadness	Adult	Female	Male	-.44	.001
			Male	Female	.44	.001

In Table 2 the male adult stimuli were more accurately recognized by the experimental group than the male children stimuli with regards to disgust (p=.001). Likewise, for surprise the male adult stimuli where decoded at a significantly higher rate than the male children stimuli (p=.029)

TABLE II. Decoding accuracy based on stimuli age

Group	Emotion	GenderStimuli	AgeStimuli	AgeStimuli	Mean Diff.	Sig.
Exp.	Disgust	Male	Children	Adult	-.44	.001
			Adult	Children	.44	.001
	Surprise	Male	Children	Adult	-.32	.029
			Adult	Children	.32	.029

B. *Condition B: Diagnosis (Between-Subjects Variable) – Type of Stimuli (Within-Subjects Variable)*

A repeated measures ANOVA was performed to assess differences in the emotion recognition skills with children's diagnosis (ADHD, ASD; high functioning autism, learning disorder) as the between-factors variable and type of stimuli (gender and age of stimuli|) as the within-subjects variables.

There was no significant main effect for participants' diagnosis ($f(1,22)=0.55$, $p=.586$); participants did not differ on the decoding accuracy of emotions based on their diagnosis. There was a significant main effect for emotion ($f(5,110)=10.35$, $p=.000$) and a significant interaction for the emotion and gender of stimuli ($f(5,110)=3.75$, $p=.004$).

IV. DISCUSSION

This work is an attempt to systematically investigate the emotion recognition skills of children with ADHD, ASD and learning disorder and to assess whether factors such as gender and age of stimuli (in the case of the study, but of other individuals in real life) influence the decoding accuracy of the emotion under investigation.

An objection made to previous studies is that some did not define the emotions investigated (as in [25]), others did not differentiate among the specific emotion dimensions in their analyses (as in [26]), many did not investigate all six basic emotions and the most did not assess the factors of age and gender of the stimuli under investigation. Furthermore, in many studies (as in [27] and [28]) the stimuli exploited were of non-contemporary faces or the recognition tasks required implicit cognitive efforts (i.e. the recognition of vertical or upside-down faces as in [29]) which increased the difficulty of the task and consequently the recognition of the emotions. As [30] argued, task demands influence the accuracy of emotion recognition; children by 6 years of age were found to have a nearly perfect score when asked to point to which of the two faces was happy, angry, surprised, or sad but a good accuracy level was only achieved by the age of 10 when children were asked to select which of the two faces expressed the same emotion as a third face.

Primary school participants i.e. children between the ages of 6 and 11 years old were chosen as middle childhood brings many emotional and social changes in a child's life in that by this time children go to school hence show more independence from family and parents, friendships increase in significance and children understand more about their place in the world. Children in middle childhood show rapid development in their mental skills and learn better ways to describe their experiences and talk about their thoughts and feelings. Additionally, [31] found children's performance reached the level of adults when children were asked to match an emotional photograph to either surprise, happiness, neutral, or disgust with accuracy increasing between 6 to 8 years of age.

This study found the emotion recognition skills of children in the clinical and control group to differ as children in the experimental group were less accurate to decode the emotional expressions of the stimuli presented than typically developing children. This finding is in line with the systematic reviews conducted on the emotion recognition skill of children with ADHD in [32] and [15] and the meta-analytic review on autism [18] which included 48 studies.

The study found happiness to be the most well recognized emotion, followed by anger, surprise, sadness, disgust and fear. In line with the study's findings happiness is perceived to be the most well recognized emotion, with smiling being an innate expression [33]. The study's results are similar the results of a systematic review on emotion recognition skills in ADHD children (unpublished) which found children with ADHD to show the greatest deficits in the recognition of fear followed by anger, surprise, sadness, disgust and happiness. While in the present study anger was the second most well recognized emotion, in the systematic review conducted anger was at the bottom two.

Likewise, while disgust in the systematic review scored on the top two most well recognized emotions, in the current study the decoding accuracy for disgust was at the bottom two. It is important nevertheless, to mention here that: (a) out of the 25 studies included in the systematic review only two studies examined children's emotion recognition skills on the emotion of disgust and (b) post-hoc tests showed that the recognition accuracy of disgust depended upon the type of stimuli presented; children performed significantly better with female than male stimuli of children, and male stimuli of adults were more accurately decoded than male stimuli of children. Despite, an effect of the gender of stimuli having been also reported in past literature (as in [34]) further investigation should be conducted for more reliable results.

The meta-analytic review [18] also found evidence for worse recognition of fear than of happiness in ASD but no differences between happiness and sadness, surprise or disgust were reported. On the contrary, this study found happiness to be more accurately decoded for all emotions but anger.

Future studies should consider the effect of therapeutic interventions on emotion recognition, the factor of comorbidity, and larger samples of participants.

V. CONCLUSION

The present study is the first to our knowledge to have collectively examined the emotion recognition skills of three of the most common neurodevelopmental disorders in childhood ADHD, ASD and learning disorders. Whereas similarities and differences are evident with past studies, the fact that the emotion recognition skills were not found to differ across the three clinical populations examined while an overall emotion recognition deficit was found, pinpoint to the prospects of a common transdiagnostic intervention for youth psychopathology on emotion recognition.

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