Recognition of emotions in facial expressions – implications and limitations during antisocial development

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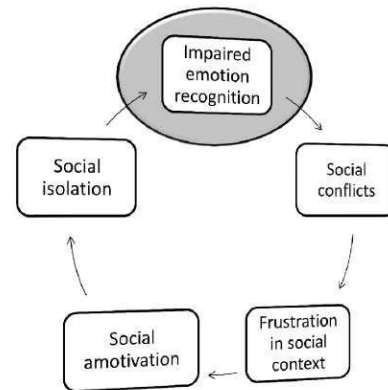*Alba Regia University Centre, Óbuda University, Székesfehérvár, Hungary **Vadaskert Child Psychiatry Hospital, Budapest, Hungary

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Abstract— **Recognition of emotions in facial expressions is crucial for proper social functioning. In adults with antisocial personality disorder, impairment of facial emotion recognition profile is noticed. Across studies, impaired recognition of fear and sadness was described in antisocial individuals, and this impairment might have underestimated importance during development. In the present study, we focus on two things: (i) describing literature data of alterations in facial emotion recognition during antisocial pathway, (ii) analyzing the possible usage of technical developments on facial emotion recognition in children with vulnerability towards antisocial problems. The applications used in the recognition of facial emotions can be described as (i) diagnostic, (ii) method-driven, (iii) therapeutic, (iv) advanced recognition systems. These applications have marked importance for prevention and treatment of conditions associated with impaired recognition of emotions.**

Figure 1. The importance of facial emotion recognition in social context.

I. INTRODUCTION

Proper recognition of emotions in facial expressions is important for "reading the mind" of others, development of empathy and moral decisions. In wider perspective, politics, economy, education and everyday life requires social contacts, and adaptive social communication. Recognition of facial emotions is crucial for proper social functioning [1], and impairment might result severe isolation, changes in social relations and associated behavioral problems (Fig. 1). Not surprisingly, factors that considered important in the formation of certain child psychiatric disorders, like social environment, early development, maltreatment, are also important determinants of normal or pathological development of the facial emotion recognition profile [2].

Children and adults with autism spectrum disorder have marked difficulties in recognizing basic facial emotion patterns [3]. Difficulties also occur in the recognition of facial emotions in individuals with antisocial personality disorder. During antisocial pathway, it is hypothesized that severe alterations of emotion recognition have functional relevance in the formation of adult antisocial behavior [4].

For example, the recognition of fear on the face of the other person has major importance to understand the feelings and motivation of the other individual. The lack of fear recognition might result for the observer that a given situation is neutral, or even positive for the other person, and there is no reason to stop or change a certain behavior or procedure. For certain individuals, even the consequences of physical aggressive behavior might be interpreted as neutral or beneficial for the other person (victim), who has a marked facial expression of fear. During development, some individuals need help in the proper interpretation of social situations, and might need assistance in the recognition of expressed emotions. Thus, aiming better performance in the recognition of emotions might be an important step for prevention of later antisocial behavior [4].

In the present study, we focus on two things: (i) describing literature data of alterations in facial emotion recognition during antisocial pathway, (ii) analyzing the possible usage of technical developments on facial emotion recognition in children with vulnerability towards antisocial problems.

II. THE ANTISOCIAL PATHWAY

A. Clinical appearance and development

According to literature data, the childhood antecedent of adult antisocial personality disorder is conduct disorder (Fig. 2.). Among adolescents with externalization
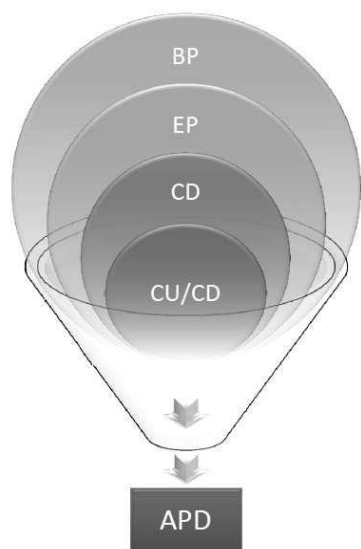
Figure 2. The antisocial pathway. BP, behavioral problems, EP, externalization problems, CD, conduct disorder, CU, callousunemotional trait, APD, antisocial personality disorder.

problems (where regularly aggression related problems are present), especially adolescents with conduct disorder and the so called callous / unemotional traits are vulnerable for later expression of antisocial personality disorder [5].

In the DSM-IV diagnostic criteria established by the American Psychiatric Association, antisocial personality disorder is described as "a pervasive pattern of disregard for and violation of the rights of others" [6]. The diagnosis is based on several positive symptoms, as at least three from the followings: failure to conform to social norms, deceitfulness, impulsivity, irritability and/or aggressiveness, reckless disregard for safety, consistent irresponsibility, lack of remorse. Additionally, the individual has to be above 18 years of age. According to the NICE Guideline, the prevalence of the disorder is 12% in the general population, but in the case of incarceration the prevalence goes up to 50-60% [7]. The distinguished group of authors of the NICE Guideline did not find "A" evidence for the success of neither pharmacological nor psychotherapeutic intervention at this point of the antisocial pathway [7].

DSM-IV describes conduct disorder as "a repetitive and persistent pattern of behavior in which the basic rights of others or major age- appropriate societal norms or rules are violated, as manifested by the presence of three (or more) of the following criteria in the past 12 months, with at least one criterion present in the past 6 months". The criteria are grouped as (i) aggression to people and animals (1, bullied others, 2, initiated physical fights, 3, used weapons, 4, was physically cruel to people, 5, was physically cruel to animals, 6, stole from intimidated victims, 7, forced someone into sexual activity), (ii) destruction of property, (iii) deceitfulness or theft, (iv) serious violation of rules. The disturbance in behavior must cause clinically significant impairment in social, academic or occupational functioning [6]. Altogether, the prevalence of conduct disorder by the age of 16 is around 10% in boys and 4% in girls [8]. At present, the diagnostic criteria distinguish between early onset (before the age of 10) and late onset behavior [6]. The Avon Longitudinal Study described the so called life-long persistent state of aggression, when early aggressive behavior since the beginning of nursery continues till adulthood. According to this study, where

more than 13,000 individuals were screened, approximately 64% of the children and adolescents had no problem with aggressive behavior, 15% had childhood limited aggressive behavior, 12% had adolescent limited aggressive behavior, and the remaining 9% had persistent aggressive behavior during childhood and adolescence [9]. Longitudinal studies suggest a strong relationship between conduct disorder in adolescence and antisocial disorder in adults [10]. The future prognostic changes in relation to conduct disorder (DSM-V) so far involve the presence of callous/unemotional trait, as a grouping variable for children and adolescents with conduct disorder. The trait is part of the psychopathic traits, and seems specific for the antisocial development [5]. The presence of the trait indicate lack of empathy, lack of remorse, insensitiveness to the physical and psychological pain of others [11], and creates a vulnerability towards adult antisocial personality disorder.

The prevalence of conduct disorder and callous/unemotional traits is around 1% among children and adolescents in the general population [11], and the number highly resembles to the prevalence of adults with antisocial personality disorder.

The etiology of conduct disorder involves both genetic and environmental factors. Aggressive behavior related to conduct disorder became a classical example of the geneenvironment interaction. Additional to genetic vulnerability, maternal drug usage during pregnancy, low birth weight, low socioeconomic status of the family, maltreatment (physical, emotional abuse or neglect) have been demonstrated to increase the rate of conduct disorder, and similar risk factors were associated with adult antisocial personality disorder [12].

In individuals diagnosed with conduct disorder and/or antisocial personality disorder, compared to healthy controls, marked alterations were described in the working of the prefrontal cortex and the amygdala, induced by genetic and environmental factors [13, 14]. Laboratory models of antisocial behavior also outlined changes in the prefrontal cortex [15] and the amygdala [16]. The present paper has limitations to describe these profound changes, but the balanced working of the above brain structures is responsible for emotion recognition, decision making, morality and social behavior [17].

B. Recognition of emotions in facial expressions in individuals with antisocial personality disorder

A meta-analysis of Marsh and Blair (reviewing 20 studies with high standards of methodology addressing recognition of facial emotions in antisocial individuals) showed a robust link between antisocial behavior and specific deficits in recognizing fearful expressions [4]. The result had a powerful message onto social psychology: these antisocial people involved in violent interactions can't properly interpret "fear signals" of others (including their victims). In principle, the recognition of fear among basic emotions seems the most difficult even for healthy individuals, and this natural bias seems consecutively enlarged in individuals with antisocial personality disorder [4]. Additionally, difficulties were noticed in the recognition of sadness, albeit the differences were less pronounced and not replicated throughout studies. No alterations in the recognition of other emotions, like happiness, anger, surprise and disgust were consecutively

replicated. According to Marsh and Blair, these results suggest dysfunctions among antisocial individuals in specified neural substrates (amygdala), involved in processing fearful facial effect [4].

C. Recognition of emotions in facial expressions in children and adolescents with conduct disorder and / or psychopathic traits

In children and adolescents with conduct disorder, the possible impairment in facial emotion recognition seems less established. In boys, relative to controls, recognition of emotions on faces expressing anger, disgust and happiness were impaired in participants with early-onset conduct disorder [18]. In contrast, relative to controls, recognition of fear was impaired in boys with adolescentonset conduct disorder, and no difference was reported between the facial emotion recognition of early-onset and adolescent-onset group [18]. In this study, psychopathic trait was associated with impaired fear, sadness and surprise recognition. In girls, compared with control subjects, participants with conduct disorder showed somewhat impaired recognition of anger and disgust, and impaired sadness recognition was present in participants with high psychopathic traits relative to those with low psychopathic features [19]. Psychopathic features were associated with impaired performance on overall emotion recognition, and the recognition of emotions on faces expressing sadness and fear was lower in individuals with high psychopathic tendencies compared with adolescents with low psychopathic scores [20]. Similar result was obtained by Blair and colleagues, as children with psychopathic tendencies needed significantly more steps in identifying sadness and fear on facial expressions [21]. In the latter studies, no gender effect was described, and no measures on conduct disorder were performed. Blair suggested that in psychopathy, the response to fearful and sad expressions was attenuated, and this interferes with socialization resulting in an individual who failed to learn to avoid actions that resulted in harm to others [22]. Data from our own research indicate that conduct disorder symptoms are inversely correlated with the recognition of fear and sadness recognition in boys with externalization problems [23].

III.   ADVANCES IN FACIAL EMOTION RECOGNITION

Evidently, the majority of the studies dealing with the recognition of facial expressions do not contain measures on psychopathology. Social implications without pronounced changes in psychopathology have major influence on the progress of the field. In the Web of Science database, the research on topic words for "emotion" and "recognition" matched 6785 papers, and the publication rate showed a 10 fold increase in the last 20 years (Fig. 3). Similarly, topic words for "facial" and "emotion" and "recognition" found 3602 papers, with a similar increase rate, and over 14.000 citations just in the year 2011 (Fig. 4). The specific research in this area is developing quickly.
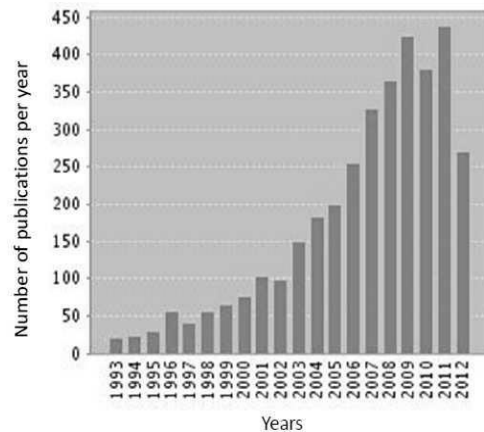

Figure 3. Number of publications per year for topic words "facial" and "emotion" and "recognition" in the Web of Science.

Studies with psychiatric patients have special requirements and distinct features. These constraints disable the (unmodified) usage of certain technologies. New methodologies are applied on healthy individuals, but certain methodologies just get skipped because of general motivational difficulties in people with psychiatric conditions, and especially with antisocial tendencies. In spite of these difficulties, the technological development between the field of computer sciences and behavioral sciences resulted in wider research and clinical potential. Applying sophisticated methodologies based on novel procedures might have potential in breaking the circularity between impaired emotion recognition, social conflicts, social isolation, and decreasing motivation towards beneficial peer relations [24, 25]. So far, therapeutic procedures were mainly targeting autism spectrum disorders. There are ethical questions hidden in the application process: individuals with autism spectrum disorder have at least a minimal insight of their social dysfunction, while most of individuals with antisocial tendencies have difficulties accepting therapeutic help for their "functioning life style" [7]. We hypothesize that at certain period of development, before the individual pruning period ends, children with callous unemotional traits have a higher potential to decrease their bias in the recognition of facial emotions than adults with antisocial personality disorder.
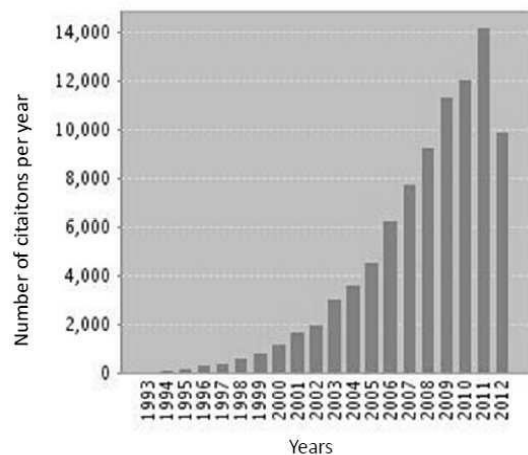
In psychiatry, therapeutic procedures act like major

Figure 4. Number of citations per year for topic words "facial" and "emotion" and "recognition" in the Web of Science.

goals or end points, however, prominent therapeutic procedures can only be achieved by detailed descriptions of pathological functions. At present, the technological implications used or can be used in the near future were divided into four major categories. Fig. 5. summarizes the four major psychiatric usage of applications in the recognition of emotions in facial expressions.

A. Diagnostic application

At present, there are no valid instrument for diagnosis within psychiatry, as no psychiatric disorder contains officially accepted criteria in relation with recognition of facial emotions [6]. In spite of the above argument, setups for analyzing deficits in the recognition of facial emotions can be used in establishing the functional impairment in psychiatric conditions involving social impairment in general and antisocial development in particular [23]. These applications are based on the recognition of emotion within static or dynamic appearances. The majority of studies targeting psychopathology apply the basic recognition of static images. In the basic format, photos representing faces with six basic emotions are shown for a limited period (regularly 3-5 seconds), and the subject is asked for identifying the emotion. The regularly used procedure is the "Facial expressions of emotion- stimuli and tests (FEEST)", based on the original research of Ekman and colleagues [26]. In the basic format, the number of good responses, the number of errors and the shift between responses is recognized. For children with lower age, easier format is possible: they choose for the given emotion from two or three photos or pictures. Our data with the "Emotion" subtest of the "Facial expressions of emotion- stimuli and tests" indicate that adolescents with conduct symptoms have an impaired recognition of fear, while the unrecognized fear responses are declared as surprise [23]. The test last approximately 15 minutes, and can easily be performed above 11 years of age.

The "Hexagon" or similar tests use different proportion of different emotions that are mixed and presented (for example 30% anger and 70% fear), and measure the threshold for the appearance of the given emotion. These tests indicate a finer proportion of impairment, but require more acceptance and attention, and can't get easily applied in children [26]. The test requires significantly more time than the basic "Emotion" test, and can be reliably applied only in motivated children above 14 years of age. Albeit some studies apply the finer measure of the sensitivity, newer studies apply method-driven setups like usage of functional magnetic resonance imaging (fMRI) or eye-tracking [13].

Dynamic representations are also used, but these situations regularly involve full body postures and related emotions. In these types of context, facial emotion recognition is strongly associated with additional factors, like postures, amplitude and speed of movements of limbs, and interaction between subjects or objects. Similar to the applications described in the "Hexagon" test, method-driven applications are widely associated with dynamic representations. To our best knowledge, unlike innovative usage of these tests in autism spectrum disorder [27], no regular usage of these tests were present in the studies dealing with antisocial development.
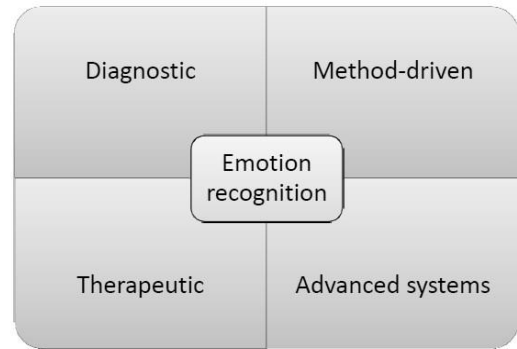

Figure 5. Classification of systems used in facial emotion recognition.

B. Method-driven application

In these setups, a known phenomenon (like bias in the recognition of fear expression in antisocial development) is tested in combination with modern technologies. Two of these technologies, gaze control and the application of fMRI made a significant increase in our understanding of the mechanisms responsible for the development of antisocial behavior.

The combination and usage of eye-tracking systems made a remarkable progress in the research of communication of adolescents with autism spectrum disorder. Unfortunately, only a limited number of studies used gaze control setups in the research of antisocial development. Dadds and colleagues studied adolescents with psychopathic traits, and described the phenomenon "fear blindness": lower fear recognition was associated with lower gaze indices towards the eye region of faces with the expression of fear. In this study, children with psychopathic tendencies had a significantly better performance on recognition of fear after a directed instruction of studying the eye region of the target pictures [28]. Gaze control setups have a marked teaching potential, as instruction-driven gaze might help in the learning of social rules and communicative signals.

Other favored application of method-driven emotion recognition is the combination of visual stimuli with brain activation patterns. Processing pictures with the expression of fear is inducing a marked activation of amygdala in healthy adolescents and adolescents with attention deficit hyperactivity disorder, while adolescents with conduct disorder and callous/unemotional traits does not show similar pattern [13]. Moreover, coupling between prefrontal and amygdalar areas was decreased within subjects of callous/unemotional traits. Similar results were obtained by the group of Jones and colleagues [29]. It seems improbable that combination of emotion recognition and fMRI might be used in the therapeutic process, but so far the combination of fMRI with the application of advanced systems for emotion recognition enables the highest research potential.

C. Therapeutic application

The main goal of training setups is to increase the capacity of emotion recognition. The basic idea and training surface is similar in both children and adolescents, irrespective from the psychopathology, but evidently subjects with autism spectrum disorder are considered the prime target [24, 25].

Basic programs are easily available for even low income families. For example, LinguiSystems released a training program for children between ages 4-12 years, isolating key elements of facial expression and progresses to recognition of basic emotions in social contexts [30]. To our best knowledge, no specific training program of decreasing emotion recognition bias has been developed specifically to individuals with antisocial properties. In the near future, the application of gaze-control setups into training programs is expected. The study of Dadds and colleagues indicated a huge training (or even therapeutic) potential of gaze-control setups in antisocial individuals. But first, specific training programs are needed for children with callous / unemotional tendencies. Frick suggested a higher reward dependency in children with psychopathic traits [5], thus the planning of specific features of therapeutic approaches is necessary for fulfilling motivational goals in this population.

D. Application of advanced systems

The original description of the emotional content of facial expressions was made by Ekman and colleagues [31]. Advanced recognition systems are based on estimating changes in the distances of the reference points on the "face mask", detecting tonic and phasic changes in the muscles of the face. Two major possibilities are within the scope of the advanced systems. First, real-time application might work as "social prosthetic". Second, the individual might get feedback about his/her behavior and facial expressions. Some of the systems were directly developed for "social blindness", while other applications were implemented for market research. To our best knowledge, no study was published applying these setups in individuals with antisocial features.

Emotional-Social Intelligence Prosthetic (later described as Social Emotional Sensing Toolkit) was developed at the Massachussetts Institute of Technology, with the goal of creating "mental state inference engine". Affdex (Affectiva, US) and FaceReader (Noldus, The Netherlands) are similar applications with automatic coding of emotional context of a given face, based on capturing emotion units on the "face mask". A unique combination of gaze control and automated analysis (facial emotion recognition) of the individual watching emotional content is applied by the company ThirdSight [32]. These systems might used for market and clinical research. The combination of automated analysis with training software has a major therapeutic potential, and a high research impact is expected by the combination of fMRI setups and automated coding systems.

IV. CONCLUSIONS

During different levels of antisocial development, alterations in the recognition of facial affect are described, and have a major impact in the formation of antisocial behavior. At present, "diagnostic" application of facial emotion recognition is used widely, but "method-driven research" and the occurrence of advanced automated coding systems created a so far unparalleled research potential. The development of

therapeutic interventions targeting the bias in the recognition of fear is suggested.

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