THEORY OF MIND IN NON-AUTISTIC PSYCHIATRIC DISORDERS OF CHILDHOOD AND ADOLESCENCE

Michele Poletti, Mauro Adenzato

Abstract

The presence of Theory of Mind (ToM) deficits in autistic children clearly shows that alterations of neurodevelopment may affect the normal development of ToM abilities. From this perspective, other clinical conditions of childhood and adolescence with less-severe alterations of neurodevelopment in comparison to autism could also be associated with ToM impairment. This hypothesis has been scarcely investigated, considering that apart from studies on autism and other pervasive developmental disorders, empirical research on ToM impairment is mostly focused on adult clinical populations. This paper reviews empirical studies on ToM abilities in non-autistic developmental psychiatric disorders. Preliminary findings derived from this weak empirical evidence suggest that in comparison to typically developing subjects, the following may have altered ToM: (1) patients with disorders with typical onset in childhood or adolescence, such as attention deficit hyperactivity disorder, oppositional defiant disorder, and conduct disorder, and (2) patients with psychiatric disorders typical of adult subjects but with childhood or adolescent onset, such as psychotic disorders, mood disorders, and personality disorders. Findings are discussed, and limitations of these studies as regards sample selection, controls, settings, and ToM assessment are identified. Directions for further studies on this topic are suggested.

Key words: Theory of Mind, developmental disorders, externalizing disorders, childhood and adolescent psychiatric disorders

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1. Introduction

In 1985, Baron-Cohen, Leslie, and Frith identified a Theory of Mind (ToM) deficit in autistic children. ToM refers to the ability to attribute mental states to others and to predict, describe, and explain behaviour on the basis of such mental states (Premack and Woodruff, 1978). Almost 30 years after that seminal paper, empirical studies have investigated and robustly documented ToM impairment not only in autism but also in several other clinical conditions. Neurological studies have shown that brain injuries and neurodegenerative diseases may produce severe ToM deficits (e.g. Adenzato and Poletti 2013, Martin-Rodriguez and Leon-Carron 2010, Poletti et al. 2012), and ToM deficits have been clearly documented in several psychiatric disorders, including schizophrenia (e.g. Brüne 2005, Walter et al. 2009) and mood disorders (e.g. Donohoe et al. 2012, Wang et al. 2008), whereas their presence is more controversial in other psychiatric conditions, such as the anorexia nervosa (Adenzato et al. 2012, Oldershaw et al. 2011).

Apart from studies on autism and other pervasive developmental disorders, empirical research on ToM deficits are focused on adult clinical populations, while developmental disorders are partially neglected. This trend could appear to be paradoxical because ToM deficits of autistic children clearly show that alterations of neurodevelopment may affect the normal development of ToM abilities. From this perspective, one may wonder whether other clinical conditions of childhood and adolescence with less-severe alterations of neurodevelopment in comparison to autism could also be associated with ToM impairment.

Considering the wide and heterogeneous spectrum of developmental neuropsychiatric disorders (e.g. neurological syndromes, genetic syndromes, psychiatric disorders, and cognitive disabilities), the focus of the current paper was limited to ToM abilities in non-autistic developmental psychiatric disorders. This choice permits a narrow focus on a group of more homogeneous disorders to verify whether psychiatric

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manifestations are associated with ToM impairment in developing subjects as well as in many adult psychiatric conditions (e.g. psychotic disorders and mood disorders). Studies were selected and discussed if they investigated (1) disorders with typical onset in childhood or adolescence, such as attention deficit hyperactivity disorder, oppositional defiant disorder, and conduct disorder, and (2) psychiatric disorders typical of adult subjects but with childhood or adolescent onset, such as psychotic disorders, mood disorders, and personality disorders.

The included studies were identified through searches in the Thomson Reuters - Web of Knowledge, Medline, and PsycINFO electronic databases, and only studies in the English language were included. The final search for this review was carried out in May 2013. The keywords used for the search were 'mentalizing', 'mindreading', and 'Theory of Mind' combined with the terms 'attention deficit hyperactivity disorder', 'oppositional defiant disorder', 'conduct disorder', 'developmental disorders', 'psychopathology', 'childhood onset', and 'adolescent onset'. Results of the search were screened, and studies assessing only autistic-spectrum disorders of children and adolescents were excluded.

2. The neural bases of the Theory of Mind

The ability to recognise, manipulate, and behave with respect to socially relevant information requires neural systems that process perception of social signals and connect such perception to motivation, emotion, and adaptive behaviour (Adolphs 2009, Lieberman 2007). Neuroimaging studies have shown the existence of a distributed neural system underlying ToM abilities. This system includes, at least, the complex formed by the posterior superior temporal sulci (pSTS) and by the adjacent temporo-parietal junction (TPJ) areas, precuneus, and prefrontal cortex (PFC) (especially its medial portions) (Carrington and Bailey 2009, Ciaramidaro et al. 2007, Enrici et al. 2011, Van Overwalle 2009, Walter et al. 2004). Furthermore, lesion studies have highlighted the key role of the prefrontal brain areas in ToM abilities (Channon and Crawford 2000, Lee et al. 2010, Roca et al. 2011, Stone et al. 1998, Stuss et al. 2001). In particular, two separate prefrontal systems are probably involved in processing inferences about other people's emotions and feelings (affective ToM) and inferences about others' beliefs and intentions (cognitive ToM), as first proposed by Shamay-Tsoory and colleagues (2006, 2007) on the basis of lesion studies and confirmed by neuroimaging (Sebastian et al. 2012a, Corradi-Dell'Acqua et al. 2013).

The ventromedial PFC is believed to play a unique role in affective ToM reasoning, while the dorsolateral PFC is believed to play a major role in cognitive ToM. Moreover, the posterior regions of the ToM system (i.e. the precuneus, TPJ, and pSTS) do not exhibit preference for processing affective or cognitive mental states, but they play a major role in assigning agency to these mental states (Abu-Akel and Shamay-Tsoory 2011).

3. Developmental psychiatric disorders and Theory of Mind

Ten studies were identified in the search of electronic databases, and the main findings of these studies are reported in the **table 1**. Six studies investigated ToM in externalising disorders; that is, disorders mainly characterised by outward behaviours, and four studies investigated psychiatric conditions that had a childhood or adolescent onset (one on schizophrenia, one on paediatric bipolar disorder, and two on borderline personality traits).

3.1 Externalizing disorders

Most studies assessed ToM in children and adolescents with externalizing disorders characterised by outward behaviours. Two studies compared ToM abilities of children with autism spectrum disorder (ASD) and children with attention deficit/hyperactivity disorder (ADHD). Buitelaar and colleagues (1999) assessed ToM with first-order and second-order false belief tasks and emotion recognition tasks in ASD (20 autistic, 20 autistic not otherwise specified) and 20 psychiatric controls, of whom nine were children with ADHD. ASD children and ADHD children had similar ToM performance that was significantly lower than that of healthy controls and non-ADHD psychiatric controls. Similar findings were reported more recently by Buhler and colleagues (2011), who assessed ToM abilities in a sample of 86 children with autism spectrum disorder (ASD), 84 children with attention deficit/hyperactivity disorder (ADHD), and 52 children with both disorders. ToM abilities were assessed with a facial emotion-recognition task and a social attribution task, which measure the ability to spontaneously attribute social meaning to ambiguous visual stimuli. No difference in ToM performance was found between groups for the entire sample; however, significant differences were found when age-based subgroups were compared. In subjects ≤10 years old, ADHD children performed better than ASD children in facial emotion recognition.

In a clinical study on disruptive behaviours, Donno et al. (2010) assessed 26 primary school children with disruptive behaviours (as indicated by schools) and 22 control children. Diagnostic interviews and the Child Communication Checklist (CCC-2) were administered to parents, and the children underwent a neuropsychological assessment that included performance and verbal IQ, attention and executive functions, and social cognition. Social cognition tasks included emotion recognition, gaze monitoring, and a ToM task involving the attribution of mental states to animated shapes (Castelli et al. 2002, Salter et al. 2008). In this task, eight silent cartoons are shown on a computer screen, and each cartoon features a large red triangle and a smaller blue triangle moving around a framed white background. In the experimental ToM condition, movements of one object are decoupled from those of the other, generating a reactive pattern, and cartoon activities are surprising, mocking, coaxing, and seducing; these types of action patterns are intended to elicit mental-state descriptions. The control condition consisted of goal-directed animations in which the actions of one object show a simple dependency on those of the other; these cartoons involved the joint activities of dancing, fighting, chasing, and leading. The children's verbal responses were scored in terms of intentionality (the degree of intentional attribution to the relative movements of the shapes) and appropriateness (the degree to which the events in the cartoons are understood). Disruptive children were rated by parents as having poor pragmatic language abilities (on the CCC-2), and they performed poorly in comparison to their control peers on the ToM task (as suggested by fewer mentalizing responses) and on the gaze-monitoring task. However, it must be emphasised that

Table 1. *Studies investigating Theory of Mind in children and adolescents with non-autistic psychiatric disorders*

Study	Clinical condition	Study type	Setting	Sample	Mean age*	Task	Function	Main Findings
Buitelaar et al. 1999	ADHD	Behavioral	Clinical	20 ASD 20 ASD-NOS 20 CC 20 HC	12.5 ± 3.2 12.4 ±3.1 12.3 ± 3.2	Emotion recognition	Affective ToM	Lower performances of ADHD and ASD in comparison to CC and HC Similar performances of ADHD and ASD
						False-belief task	Cognitive ToM	
Pilowsky et al. 2000	COS	Behavioral	Clinical	12 COS 12 ASD 12 HC	12.18 ± 1.68 13.02 ±3.90	False-belief task Deception Task	Cognitive ToM	COS and ASD had worse performances in ToM tasks in comparison to controls, particularly in Baron-Cohen's false-belief task; COS children outperformed ASD children in the Deception Task
Schenkel et al. 2008	PBD	Behavioral	Clinical	26 PBD 20 HC	13.19 ± 3.21	Affective Story Task	Affective ToM	Worse performances in the Affective Story Task (in the positive and negative story conditions) and in Hinting Task. Increased symptoms of mania associated with failure to answer the false-belief question correctly in the negative story condition of the Affective Story Task and poorer performance in the Hinting Task
						Hinting Task	Cognitive ToM	
Donno et al. 2010	Disruptive Behavior	Behavioral	School	26 Disruptive 22 HC	9.21 ± 1.81	Emotion recognition Gaze monitoring Animated shapes ToM task	Affective and Cognitive Tom	Worse performances in gaze monitoring and in attributing mental states to animates shapes
Buhler et al. 2011	ADHD	Behavioral	Clinical	84 ADHD 86 ASD 52 ASD + ADHD	9.7 ± 3.3 10.8 ± 2.8 10.1 ± 3.2	Social Attribution Task	Attribution of social meaning	Similar performance of ASD and ADHD
Ha et al. 2011	CD	Behavioral	Community	659 children	9.5 ± 1.2	Distorted Mentalizing Task	Cognitive ToM	Overly positive attributional style with strong self-reference predicts conduct problems at 1 year follow up
Sharp et al. 2011	BPD	Behavioral	Clinical	111 Adolescents	15.49 ±1.44	Movie for the Assessment of social cognition	Cognitive and Affective ToM	Borderline personality traits negatively correlated with total ToM score; in particular strong correlation with hypermentalizing
Sebastian et al. 2012b	CD	fMRI	Clinical	31 CD 16 HC	14.35 ± 1.75	Cartoon ToM task	Cognitive and Affective ToM	More errors in the affective ToM condition; difference approaching to be significant between cognitive ToM vs. affective ToM (p = .08). Lower amygdala and anterior insula activation in affective ToM condition vs. cognitive ToM condition in CD
Dinolfo & Malti 2013	ODD	Behavioral	Community	67 4-year olds 61 8-year olds	4.43 ± 0.27 8.48 ± 0.37	Interpretative understanding task	Cognitive ToM	Interpretative understanding (higher ToM competence) negatively correlated with ODD symptoms
Sharp et al. 2013	BPD	Behavioral	Clinical	68 BPD	15.5 ± 1.44	Movie for the Assessment of social cognition	Cognitive and Affective ToM	Hypermentalizing in BPD adolescents in the MASC

Legend: ADHD = Attention Deficit/Hyperactivity Disorder; ASD = Autistic Spectrum Disorder; BPD = Borderline Personality Disorder; CC = Clinical Controls CD = Conduct Disorder; COS = Child Onset Schizophrenia; fMRI = functional Magnetic Resonance Imaging; HC = age matched Healthy Controls; MASC = Movie for the assessment of social cognition; ODD = Oppositional Defiant Disorder; PBD = Pediatric Bipolar Disorder; SLI: Specific Language Impairment; ToM = Theory of Mind; ASD-NOS = Autistic Spectrum Disorder - Not Otherwise specified
*The mean age is of the clinical groups

nine of the 26 disruptive children presented features of autism spectrum disorder and had the lowest scores on the CCC-2 and ToM task, and this could have biased findings of this study.

In a combined fMRI-behavioural study (Sebastian et al. 2012b), 31 adolescents with conduct disorder (CD) and 16 controls were scanned while performing a cartoon ToM task. CD adolescents made more affective-ToM errors, and a difference approaching to be significant ($p = .08$) emerged between cognitive ToM and affective ToM in the clinical group. Moreover, at the neural level, fewer amygdala and anterior insula activations were detected in the affective-ToM condition than in the cognitive-ToM condition in adolescents with CD but not in controls.

Two community studies investigated the relationship between ToM ability and behavioural problems in children, in particular those with symptoms of CD (Ha et al. 2011) and oppositional defiant disorder (ODD) (Dinolfo and Malti 2013). In the first study, Ha and colleagues (2011) recruited and assessed a community sample of 659 children (age range 7 to 11 years). Of these 659 children, 439 (67%) were assessed again one year later for a follow up. Baseline and follow up CD problems were assessed with the parent and teacher versions of the Strengths and Difficulties Questionnaire. Baseline ToM ability was assessed with the Distorted Mentalizing Task (Sharp et al. 2007). On this task, children are presented with a set of 15 vignettes containing potentially distressing social scenarios that draw from themes that may cause unhappiness or distress by depicting emotional and/or physical pain and social conflict. Themes involve loneliness, ridicule, being singled out, under-achievement in sports, physical size, moving to a new school, physical disability, social embarrassment, experiencing divorce, poverty, and peer rejection. Children were presented with three response options: (1) an unrealistic and positive bias with strong self-reference (e.g. 'They would think I'm cool not to play silly games with the rest of the kids'), (2) a negative bias with strong self-reference ('They would think nobody likes me'), or (3) a neutral/rational/adaptive option devoid of a global, internal, and stable self-attribution ('They would think I'm just sitting down to think and have a rest'). Children's attributional styles were categorised as overly positive with strong self-reference (positive), overly negative with strong self-reference (negative), or neutral/rational without strong self-reference (rational).

With baseline CD problems, IQ, socioeconomic status, and gender controlled, findings showed that children who had an overly positive mentalizing style were more likely to be reported by teachers as having CD problems at the one-year follow-up. These findings suggest that children who mentalize by inflating views of themselves may, in time, feel threatened when confronted with more realistic feedback, which in turn may lead to acting out.

A study by Dinolfo and Malti (2013) recruited a community sample of 128 children (67 four-year-olds and 61 eight year-olds). ODD symptoms were assessed with parents' ratings derived from the Child Behavior Checklist (CBCL) (Achenbach 2000; 2001), and ToM ability was assessed with a task using hand puppets that was developed by Lalonde and Chandler (2002). Findings indicated that interpretative understanding negatively predicted ODD symptoms; better scores on the ToM task predicted lower ODD ratings on the CBCL.

3.2 Psychiatric disorders with childhood onset

Although ToM impairment has been clearly documented in schizophrenia (Brüne 2005, Walter et al. 2009), its investigation in childhood-onset schizophrenia (COS) has been hampered by the low prevalence of this severe psychiatric condition. Only one study (Pilowsky et al. 2000) investigated ToM in 12 children and adolescents with COS as compared to 12 children and adolescents with high-functioning autism and 12 healthy controls. ToM was assessed with false belief tasks (Baron-Cohen et al. 1985, Flavell et al. 1990) and the Deception Task (Hala et al. 1991), in which individuals are encouraged to actively trick the experimenter by hiding a small car in a container while one of the experimenters is outside the room. Both clinical groups performed worse on ToM tasks in comparison to controls, particularly on the false-belief task of Baron-Cohen; autistic children performed more poorly than did COS children on the Deception Task.

A subsequent study (Schenkel et al. 2008) investigated ToM in children and adolescents with bipolar disorder (BD). Twenty-six BD children and adolescents and 20 healthy controls (mean age 13 years) were enrolled. The clinical group included subjects with BD type I, mixed ($n = 9$) or manic ($n = 5$) state, or BD type II, hypomanic ($n = 8$) or depressed ($n = 4$) state, and medication-free for at least one week prior to testing. Subjects were included if they had manifested at least two of the three core symptoms of BD in childhood and adolescence (i.e. elated mood, irritability, and grandiosity) but not if they presented with irritable mood in the absence of elated mood and/or grandiosity. ToM was assessed with a newly developed *ad-hoc* task (affective story task) and the hinting task (Corcoran et al. 1995). The affective story task is a false-belief-understanding task and consists of positive-, neutral-, and negative-valenced stories that elicit a subjective experience characteristic of manic, euthymic, or depressed states, respectively. Subjects were assessed on their ability to recognise that a misleading series of events could lead one of the characters in the story to develop a false belief about another character's mental state. At the end of each story, subjects were asked (1) a false-belief question that assessed whether they understood the potential for misunderstanding (scored dichotomously as correct or incorrect), and (2) a 'control' question to assess story comprehension and understanding. The hinting task assesses the ability to infer the 'real intentions' behind indirect comments. It consists of 10 short passages (adapted for use with children and adolescents for this study), each describing a social interaction between two characters that ends with one character dropping a hint to the other. Subjects were required to infer the actual meaning of the hint; if a subject failed to give a correct answer, a more obvious hint was provided. On the affective story task, BD subjects performed worse in comparison to healthy controls in the positive and negative story conditions, and there was a trend toward poorer performance in the neutral condition. Within BD subjects, performances were worse in the negative story condition than in the positive one, but there was no difference between these conditions in healthy controls. On the hinting task, the BD group scored significantly lower than controls, and among BD patients, poorer performance on the hinting task was correlated significantly with younger age and an earlier age at first diagnosis. In the BD group, increased symptoms of mania on the Youth Mania Rating Scale was associated with failure to answer the false-belief

question correctly in the negative story condition of the affective story task and poorer performance on the hinting task.

Two studies investigated ToM in adolescents with borderline personality traits. Sharp and colleagues (2011) recruited 111 adolescent psychiatric inpatients. Borderline personality traits were assessed with a battery of general (Youth Self Report, Diagnostic Interview Schedule for Children) and specific (Borderline Personality Features Scale for Children, Childhood Interview for DSM-IV Borderline Personality Disorder) neuropsychiatric inventories. ToM was assessed with the movie for the assessment of social cognition (MASC: Dziobek et al. 2006). For the MASC, subjects are asked to watch a 15-minute film about four characters getting together for a dinner party. Themes of each segment cover friendship and dating issues. Each character experiences different situations through the course of the film that elicit emotions and mental states such as anger, affection, gratefulness, jealousy, fear, ambition, embarrassment, or disgust. The relationships between the characters vary in the amount of intimacy (from friends to strangers), and thus represent different social-reference systems on which mental-state inferences have to be made. During administration of the task, the film is stopped at 45 points during the plot, and questions referring to the characters' mental states (feelings, thoughts, and intentions) are asked. Subjects are provided with four response options: (1) hypermentalizing responses, reflecting over-interpretative mental-state reasoning; (2) under-mentalizing responses, involving insufficient mental-state reasoning resulting in incorrect, 'reduced' mental-state attribution; (3) no mentalizing responses, involving a complete failure to use any mental-state term in explaining behaviour; and (4) accurate mentalizing response. Findings showed that borderline traits were negatively correlated with the total ToM score, therefore indicating reduced overall mentalizing capacity associated with increased borderline traits. Moreover, this correlation was clearly driven by a very strong correlation between ToM errors of the hypermentalizing type, while no other ToM error correlated with borderline traits. Similar results were reported in a subsequent study of the same research group (Sharp et al. 2013) that adopted the MASC to evaluate ToM in 164 adolescent inpatients at their admission and at discharge. Sixty-eight patients (about 41% of the sample) met full or intermediate diagnostic criteria for borderline personality disorder. Borderline personality traits negatively correlated with ToM ability, and in particular, an association was reported with hypermentalizing, independently of internalising and externalising symptomatology. Unlike performance on other ToM tasks (Reading the Mind in the Eyes, Mentalizing Stories for Adolescents), MASC performances were enhanced by inpatient treatment, as indicated by reduced hypermentalizing at the discharge assessment.

4. Discussion

This paper was aimed at reviewing empirical data on ToM in non-autistic psychiatric manifestations of childhood and adolescence. This aim was derived from the evidence that severe alterations of neurodevelopment, as in pervasive developmental disorders, are associated with severe alterations of ToM; we therefore hypothesised that less severe neurodevelopmental disorders may also present ToM deficits. Within the very heterogeneous spectrum of neuropsychiatric developmental manifestations, we focused on psychiatric manifestations because (1) they represent a more homogeneous clinical group, and (2) they are associated with ToM impairments in adulthood.

Few empirical studies investigated ToM in developmental psychiatric manifestations. We found six studies that investigated ToM in disorders with typical onset in childhood or adolescence, including externalising disorders (two ADHD and four disruptive behaviours, including oppositional-defiant or conduct problems) and four studies that investigated ToM in psychiatric disorders typical of adulthood but with childhood or adolescent onset (one schizophrenia, one bipolar disorder, and two borderline personality traits). Although we narrowed the focus of the present review to psychiatric manifestations, these studies were heterogeneous as regards subjects (children vs. adolescents), controls (healthy vs. clinical), settings (clinical vs. community), and most of all, ToM tasks, hampering the possibility to draw robust conclusions. Age of subjects is an important factor considering that ToM ability continues to develop until adolescence. For example, a recent fMRI study (Moor et al. 2012) reported that affective ToM ability continues to develop until early adolescence through a progressively increasing recruitment of the medial PFC and of the medial temporal pole, while activity in the posterior temporal sulcus is stable across ages. Another recent fMRI study (Sebastian et al. 2012a) revealed that in adolescence there is a peak in medial PFC activation during a task of affective ToM (cartoon task), while activation progressively decreases towards adulthood.

The selection of controls influences the possibility of establishing degrees of impairment in comparison to healthy subjects, while the selection of clinical vs. community settings influences the severity of the clinical conditions investigated. Finally, although ToM tasks may be roughly distinguished as assessing either cognitive ToM or affective ToM, the adoption of very different tasks hampers a clear comparison of findings in terms of ToM deficits. Moreover, most ToM tasks, such as false-belief tasks, present a dichotomous approach (pass or fail the task) that is probably appropriate when assessing autistic children who present with very severe ToM impairment. ToM tasks that can distinguish degrees and types of impairment are probably more appropriate for the study of developmental clinical populations that present with milder impairment in comparison to autistic subjects.

Keeping in mind these limitations, some general and preliminary conclusions can be drawn from the studies we examined. First, developmental psychiatric manifestations are associated with impairment of ToM abilities in comparison to age-matched healthy controls. This confirms that alterations of neurodevelopment are somehow associated with impairment of ToM ability, which aligns with the severe alterations of neurodevelopment in autistic subjects and the degree of impairment in adults with psychiatric conditions, as schizophrenia and mood disorders. ToM impairment has been detected in disorders with typical developmental onset (externalising disorders) and in psychiatric disorders of adulthood but presenting in children and adolescents (e.g. schizophrenia, bipolar disorder, and borderline personality traits).

As regards the degree of ToM impairment, only a few studies compared different clinical conditions with autistic children as clinical controls. Interestingly, both studies that assessed ToM in ADHD (Buhler et al. 2011, Buitelaar et al. 1999) in comparison to ASD reported

similar impairment, with ADHD children outperforming ASD children on a task of facial emotion recognition only in the subgroup of children < 10 years old (Buhler et al. 2011). Slightly different results were reported in a study on disruptive preschoolers (Donno et al. 2010), in which the subgroup of ASD children performed worse on ToM tasks in comparison to disruptive children without autistic traits. In a study on COS (Pilowsky et al. 2000), both COS and ASD children performed worse than controls on a false-belief task, but ASD children performed worse than COS children on the deception task (in which individuals are encouraged to actively trick the experimenter by hiding a small car in a container while one of the experimenters is outside the room). Therefore, although these studies confirm that ASD children show the most severe ToM impairment, further studies are needed to establish the degree of ToM impairment across distinct psychiatric disorders of childhood and adolescence.

As regards ToM impairment, some studies not only established the existence of impairment in comparison to controls, but they also attempted to establish the nature of the impairment. Studies on adolescents with borderline personality traits (Sharp et al. 2011, 2013) reported an association of these traits with hypermentalizing, or an over-interpretative mentalizing style, as reported in adult patients with schizotipy (Fyfe et al. 2008) and schizophrenia (Bara et al. 2011); therefore, further studies are needed to establish whether specific mentalizing errors or biases are associated with specific psychiatric disorders of childhood and adolescence.

As regards the neural and cognitive correlates of these deficits, few findings emerged from these studies. Only the fMRI study of Sebastian and colleagues (2012b) assessed the neural bases of ToM performance. These authors reported that adolescents with conduct problems had lower amygdala and anterior insula activation in an affective ToM condition than in a cognitive ToM condition. Indeed, children and adolescents with conduct problems have specific aberrant activation of the medial PFC during reward-related tasks (Rubia et al. 2009); therefore, they could have affective ToM impairment due to a primary dysfunction of the neural network involved in this ability (Abu-Akel and Shamay-Tsoory 2011). Moreover, considering that the medial PFC is progressively recruited from childhood to adolescence by affective ToM tasks (Moor et al. 2012), further studies comparing children and adolescents with conduct problems are needed to establish at which point during development the dysfunctional activation of the medial PFC becomes clinically relevant; is it from childhood or only since adolescence that the progressively increasing medial PFC activation typical of healthy adolescents fails?

In order to explain possible ToM impairment in developmental neuropsychiatric disorders, it could be useful to refer to the neuroanatomical and neurochemical ToM model presented by Abu-Akel and Shamay-Tsoory (2011). This model proposed three steps, or levels of analysis, in ToM ability: representation, attribution, and execution/application of mental states. The representational level pertains to the individual's ability to represent cognitive and affective ToM, the attributional or agentive level refers to the individual's ability to attribute mental states to self or other, and the execution/application aspect refers to the manner in which the individual applies mental states. This model predicted that a disruption within the complex neural ToM network is likely to lead to varying degrees of ToM impairment. Damage to posterior regions (particularly the temporo-parietal junction) could lead to a loss of one's ability to globally represent mental states, (i.e. detecting agency). Damage to the ventral and dorsal attentional systems could lead to a malfunction in one's ability to distinguish between self and other mental states. Moreover, a disruption to lateral PFC structures within the mentalizing network that is particularly linked to serotonergic and dopaminergic release could lead to a malfunction in the ability to control the application of represented mental states.

Severe ToM impairment of autistic children can probably be attributed to damage or alterations to all three of these levels and their relative neural bases (Dichter 2012). In particular, the lack of ToM ability of some severely autistic children may suggest primary damage to the representational level, impairing the detection of agency, and milder ToM impairments in non-autistic neuropsychiatric disorders may be attributed to damage to the attributional level and the execution/application level. For example, studies in adolescents with borderline personality traits (Sharp et al. 2011; 2013) that reported hypermentalizing (over-attribution) suggest impairment in the execution-application level in this clinical population. On the other hand, the overly positive attributional style with strong self-reference reported in conduct disorder (Ha et al. 2011) could suggest impairment in the attributional level and the relative distinction between self and others' mental states.

5. Conclusions and future directions

Studies reviewed in this paper preliminarily suggest that different degrees of ToM impairment are present and detectable in non-autistic developmental psychiatric manifestations, confirming that alterations of neurodevelopment are somehow associated with impairment of ToM ability. Further neuroimaging and neuropsychological studies are needed to establish the neural and cognitive correlates of ToM impairment in different neuropsychiatric disorders, to provide clues about which level of ToM is more compromised in each disorder, and to suggest ways to improve weak ToM abilities through rehabilitative interventions, such as those efficiently implemented for adult borderline personality disorder (Bateman and Fonagy 2010, Brüne et al. 2013) and schizophrenia (Cavallo et al. 2013, Subramaniam et al. 2012). As regards future studies, in addition to psychiatric manifestations, other neuropsychiatric disorders such as specific language impairment (Farrant et al. 2006), learning disabilities, especially of the non-verbal type (Galway et al. 2011, Petti et al. 2003), and intellectual disabilities (Baurain and Nader-Grosbois 2013) have been scarcely investigated and deserve further empirical investigation.

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