


# The Role of Theory of Mind on Social Information Processing in Children With Autism Spectrum Disorders: A Mediation Analysis

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**Abstract** Individuals with autism spectrum disorders (ASD) show significant impairments in social skills and theory of mind (ToM). The aim of this study was to evaluate ToM and social information processing abilities in 52 children with ASD compared to 55 typically developing (TD) children. A mediation analysis evaluated whether social information processing abilities can be mediated by ToM competences. In our results, children with autism showed a deficit in social skills and ToM components. The innovative results of our study applying mediation analysis demonstrate that ToM plays a key role in the development of social abilities, and the lack of ToM competences in children with autism impairs their competent social behavior.

**Keywords** Autism spectrum disorders (ASD) · Mediation analysis · Theory of mind (ToM) · Social cognition · Social information processing

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## Introduction

Children with autism spectrum disorders (ASD) are characterized by a range of deficits in two domains: social communication and social interaction, and repetitive patterns of behavior (American Psychiatric Association 2013; Lai et al. 2014). In addition, children with ASD show deficit in social cognition abilities (Mazza et al. 2014).

Social cognition includes the cognitive mechanisms based on the capacity to process the social world and emerges in early childhood through the development of “theory of mind” (ToM; Astington and Edward 2010). After birth, newborns begin to develop several social competences, such as the capacity for the detection of social agents, mutual affiliation, and preference for social patterns compared to non-social patterns. At around 3 months, there is evidence that newborns develop the social reciprocity related to both contingency recognition between self (i.e. one’s own body) and others (such as his/her mother) and increasing interaction. By the age of 3 to 6 months, early capacities of emotion processing and sensitivity to social signals, chiefly through gaze processing, emerge as highlighted by Happé and Frith (2014). Subsequently, at around 6–18 months, social behavior begins to emerge with the development of strong reciprocity and sharing of mental states with several partners: joint attention, social referencing, attachment, and implicit mental state attribution (Happé and Frith 2014). By the age of 2 years, children clearly show awareness of the difference between thoughts of the mind and things in the world. Pretend play is an example of this ability; that is, toddlers are able to distinguish between objects and their thoughts for objects. At this age, children also understand that people will feel happy if they get what they want, whereas they will feel sad if they do not (Astington and Edward 2010). A crucial

development occurs around 3–4 years of age when children realize that mental states, that is, beliefs or intentions of other people, may not be true. This ability is known as false beliefs attribution (Baron-Cohen et al. 1985). By the age of 4 or 5 years, children realize that people talk and act on the basis of the way they think about the world (Astington and Edward 2010; Happé and Frith 2014). By 5 years, ToM ability is consolidated (Happé and Frith 2014). Thus, social behavior seems to derive from a process of role taking (i.e., ToM ability) that produces altruistically motivated behavior (Eisenberg and Miller 1987).

Most researchers have suggested that the ability to understand another person's cognitive or affective state plays an important role in the development and production of social behavior (Batson 1987; Hoffman 1984; Krebs and Russell 1981). Several studies (Baron-Cohen et al. 2015; Mazza et al. 2014; Pino et al. 2016; Shamay-Tsoory et al. 2009) have suggested that ToM is not a single process but involves two components: cognitive and affective. Specifically, the cognitive component is the ability to understand what others are thinking (i.e., their mental states); whereas affective ToM is the ability to make inferences regarding other people's emotions (Franco et al. 2014; Mazza et al. 2014; Pino et al. 2016; Shamay-Tsoory et al. 2005).

Zaki and Ochsner (2012) proposed a new three-dimensional social cognition model that involves mentalizing, experience sharing, and prosocial behavior components. Compared to previous models (Baron-Cohen et al. 1985; Leslie 1987, 1994), it examines and highlights the importance of the prosocial behavior component (Zaki and Ochsner 2012). This dimension encompasses the motivation of individuals to improve the emotional experiences of other people (e.g., their suffering) and the ability to help them (Zaki and Ochsner 2012). Prosocial behavior is important for the regulation of social behavior (Mariano et al. 2016). According to Happé and Frith (2014), social behavior develops around 5 years of age. Specifically, this competence is evident when children are able to differentiate their own internal states from those of others. Particularly, we know that children with ASD show difficulties in understanding other people's mental states and their views and perspectives. Thus, these difficulties could compromise the development of social behavior in children with ASD (Frith and Frith 2003; Frith and Happé 1994; Happé 1994; Jones et al. 2010; Mazza et al. 2014; Ziv et al. 2014). Few studies involving ToM measures have been conducted with children with ASD between the ages of 5–13.

Ziv and Sorongon (2011) proposed the Social Information Processing Interview (SIPI) to evaluate patterns of social information processing and social behavior of preschool children. The SIPI model suggests that the covert mental mechanisms mediating between an overt (social) stimulus and overt (social) response comprise the

abilities to understand the thoughts of others and to select the appropriate social responses (Ziv and Sorongon 2011). In the study by Ziv and Sorongon (2011), the social information processing mechanism was studied in populations of typically developing (TD) children and was based on the Crick and Dodge (1994) model. According to this model, many mental steps take place before individuals enact a behavioral response to social cues, such as the encoding of social cues, interpretation of the cue, clarification of goals, generation of a behavioral response, response construction, response decision, and enactment of the behavioral response (Crick and Dodge 1994; Ziv and Sorongon 2011; Ziv et al. 2014). The authors suggest that these internal processes include the ability to understand the intentions, feelings, and thoughts of others and to select the appropriate social responses (Crick and Dodge 1994). Therefore, Crick and Dodge's (1994) model provides a substantial theoretical framework for the study of the social cognitive mechanisms that guide social behavior (Ziv et al. 2014).

Subsequently, Ziv and his collaborators (2014) showed a deficit in social information processing abilities in preschool children with ASD compared to TD children using the SIPI. The social deficits that were observed in children with autism were not related to general cognitive abilities but were specific to the social cognition competences (Baron-Cohen et al. 1997; Ziv et al. 2014). The ToM difficulties that characterize children with ASD have been found to be related to inadequate social behavior and poor social communication skills (Lerner et al. 2011; Ziv et al. 2014). On this basis, the first goal of the present study was to evaluate the ToM sub-components, that is, beliefs, emotions, and intentions by using the Comic Strip Task (CST, Cornish et al. 2010; Sivaratnam et al. 2012) and social information processing abilities through the SIPI (Ziv and Sorongon 2011) in children with ASD and to compare them to TD children. In previous studies (Sivaratnam et al. 2012; Ziv and Sorongon 2011), the participants were preschoolers. There is evidence supporting a delay in the development of language in children with ASD (Ambridge et al. 2015; Astington and Jenkins 1999; Colle et al. 2007; Milligan et al. 2007; Sivaratnam et al. 2012). However, a consistent relationship between language development and ToM has been shown. For this reason, our sample of children (both TD and with ASD) covered an age range from 5 to 13 years, because both tasks (CST and SIPI) require well-developed expressive and receptive language skills.

The second goal was to examine the role and effect of ToM on the social information processing patterns using a new analysis approach, that is, a mediation model. Our hypothesis was that a deficit of ToM could adversely affect the ability of social information processing and subsequently compromise the development of adequate social behavior. Therefore, we used the mediation analysis to

examine the impact of different components of ToM on the development of social behavior, first in TD children and then in children with ASD. The mediation analysis is based on the assumption that a third variable (the mediator) can influence the relationship between the other two variables, that is, independent variable (IV, X) and dependent variable (DV, Y). The mediational effect, in which X leads to Y through M, is called the indirect effect, which represents the portion of the relationship between X and Y that is mediated by M (Baron and Kenny 1986; Kenny et al. 2003). In our study, we used the ToM sub-components (intentions, beliefs, and emotions) as mediators and all components of the SIPI (encoding, interpretation, response construction, and response evaluation) both as independent and dependent variables to perform our mediation models.

**Methods**

**Participants**

One-hundred and seven children participated in our study: 52 children (42 male, 10 female) with ASD ranging in age from 5 to 13 years and 55 TD, age-matched children (37 male; 18 female) ranging in age from 5 to 12.25 years. No differences between groups (ASD and TD) emerged for chronologic age ( $F_{1,102} = 3.03; p = 0.095; \eta^2_p = 0.09$ ) and mental age ( $F_{1,102} = 1.85; p = 0.177; \eta^2_p = 0.01$ ).

The TD children were selected from a nursery (for children of 5 years), a primary school (for children from 6 to 10 years), and a lower secondary school (for children from 11 to 13 years) located in Frosinone, central Italy.

Participants with ASD were inpatients of the Reference Regional Centre for Autism of L'Aquila, central Italy. According to the principles established by the Declaration of Helsinki, ethical approval was obtained by the Ethical Committee of the NHS Local Health Unit (Azienda Sanitaria Locale 1). The children’s parents provided informed consent to participate in the study. Diagnosis of ASD was established by experienced clinicians using the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2, Lord et al. 2012), according to the new criteria of the DSM-5 (American Psychiatric Association 2013). Verbal mental age was assessed with the Test for Reception of Grammar, Version 2 (TROG-2, Bishop 2003; Suraniti et al. 2009).

Demographic and clinical information of all the participants are summarized in Table 1.

**Social Cognition Measures**

*Social Information Processing Interview (SIPI, Ziv and Sorongon 2011; Ziv et al. 2014)*

The SIPI is an interview based on a storybook easel depicting a series of vignettes in which a protagonist is either rejected by two other peers or provoked by another peer.

**Table 1** Between-group differences for demographic data, clinical information and social cognition measures

	ASD (N=52) Mean (SD)	TD (N=55) Mean (SD)	F (df=1, 102)	P	Effect Size $\eta^2_p$
<b>Demographic data</b>					
Chronological age (in years)	8.17(2.17)	7.42(2.81)	2.41	0.12	0.23
Verbal Mental age (in years)	6.97(2.30)	7.33(2.42)	0.64	0.43	0.12
<b>Clinical information</b>					
ADOS-social communication and social interaction	9.48 (2.93)	–	–	–	–
ADOS- Repetitive and Stereotyped Behaviours	1.29 (1.2)	–	–	–	–
ADOS Total scores	10.78 (3.11)	–	–	–	–
<b>Social cognition measures</b>					
<i>Social Information Processing Interview</i>					
Encoding	3.15(1.03)	3.92(0.41)	26.96	<b>0.0001</b>	0.26
Interpretation	1.30(0.89)	0.71(0.64)	14.85	<b>0.0001</b>	0.15
Response evaluation	6.56(1.98)	9.64(1.54)	78.80	<b>0.0001</b>	0.46
Response construction	1.93(1.34)	4.15(1.08)	86.80	<b>0.0001</b>	0.47
<i>Comic Strip Task</i>					
Emotions	3.90(0.99)	4.49 (0.66)	13.02	<b>0.0001</b>	0.17
Beliefs	1.67(1.23)	3.40(1.42)	44.84	<b>0.0001</b>	0.27
Intentions	3.84(1.31)	3.72(1.33)	0.214	0.645	0.009

Significant comparison are highlighted in bold

Each type of vignette is combined with each type of peer intent to generate four stories: (1) a non-hostile peer-entry rejection story, (2) an ambiguous peer-entry rejection story, (3) an accidental provocation story, and (4) an ambiguous provocation story (see Ziv and Sorongon 2011; Ziv et al. 2014). According to Ziv and his collaborators (2014), the scores correspond to four of the social information processing mental steps proposed by Crick and Dodge's (1994) model: (1) encoding, (2) interpretation of cues, (3) response construction, and (4) response evaluation. The encoding component evaluates the level of detail that the child recalls across the four stories. A score of 0 is given to a child who recalls no correct details from the stories, and a score of 1 is given to a child who correctly recalls all the details in all stories (see Table 2).

The interpretation component evaluates the hostile attribution to others' behavior. The range for this score is 0–1, with higher scores representing higher levels of hostile attribution bias. The score in the interpretation component is inversely encoded compared to the other SIPI components, that is, a higher score indicates a major tendency to consider the behavior of other children as hostile.

The response construction score is derived from the child's responses to the open-ended question: "What would you say or do if this happened to you?" For each story, the examiner encodes the response as competent or non-competent and assigns a score of 1 if the child's response is classified as competent and score of 0 if the answer is classified as non-competent.

The response evaluation items examine the way the child assesses the behavior of other people as right or wrong. The scores are obtained from a combination of the 12 response decision questions (4 stories  $\times$  3 questions per presented response) for each child's response.

*Comic Strip Task (CST, Cornish et al. 2010; Sivaratnam et al. 2012)*

The CST is a novel 21-item measure developed to assess three aspects of ToM; namely, the understanding of others' beliefs, intentions, and emotional states, and comprises the three sub-components testing belief-understanding (beliefs), intention-understanding (intentions), and emotion-understanding (emotions), respectively. There are 5 items in each sub-component, each comprising a 5-picture comic strip illustrating everyday social scenarios involving interpersonal interactions familiar to young children. For each item, children are shown three pictures that tell a social story, after which the children are presented with two pictures containing alternative endings to the story and asked to select the one that they think best completes the story. One option indicates a lack of understanding of others' mental states and is scored as 0; the other indicates the presence of understanding and is scored as 1. Each sub-component has a maximum score of 5, with a total test score of 15 (i.e., higher scores correspond to better ToM).

Sivaratnam and collaborators (2012) assessed the internal consistency reliability, as measured by Cronbach's alpha: the beliefs sub-component demonstrated low and negative internal consistency (Cronbach's  $\alpha = -0.04$ ); the emotions and intentions sub-components demonstrated moderate internal consistency (Cronbach's  $\alpha = 0.69$  and  $\alpha = 0.70$ , respectively). In their study, Sivaratnam et al. (2012) found a lower internal consistency; for this reason, we calculated the internal consistency of the overall CST and each sub-component (intentions 0.56, beliefs 0.66, emotions 0.23).

**Table 2** Pearson's correlation coefficients for Comic Strip Task (CST) sub-components and Social Information Processing-Interview (SIP-I) sub-components for control and ASDs groups

	Encoding (SIP-I)	Interpretation (SIP-I)	Response construction (SIP-I)	Response evaluation (SIP-I)
Control group				
Emotions (CST)	0.102	<b>-0.388**</b>	<b>0.378**</b>	<b>0.251*</b>
Intentions (CST)	0.177	0.140	-0.077	-0.150
Beliefs (CST)	-0.058	<b>-0.368**</b>	<b>0.514**</b>	<b>0.202</b>
ASDs group				
Emotions (CST)	0.069	-0.120	<b>0.270*</b>	0.064
Intentions (CST)	0.134	<b>-0.223</b>	<b>0.532**</b>	<b>0.253*</b>
Beliefs (CST)	0.011	-0.150	-0.101	0.028

Significant correlations are highlighted in bold with asterisks representing significance levels

\* $p < 0.05$ ; \*\* $p < 0.01$

**Data Analysis**

*ANOVA Analysis*

One-way ANOVA was used to test differences between groups (ASD, TD) regarding demographic parameters and in the component measures of the SIPI (encoding, interpretation, response construction, and response evaluation) and the CST (emotions, beliefs, and intentions).

*Correlations Analysis*

Exploratory Pearson’s correlations were computed to assess the relationships between the components of the SIPI (encoding, interpretation, response construction, and response evaluation) and CST (emotions, beliefs, and intentions), both in the ASD and TD group. On the basis of the correlation results, the mediation models were performed.

*Regression Analysis*

A linear regression analysis was performed in order to evaluate the relations between the dependent variable and one (simple linear regression) or more explanatory variables (multiple linear regression). In this study, the variables for the regression analysis were the components of the SIPI (encoding, interpretation, response construction, and response evaluation) and the sub-components of CST (beliefs, emotions, and intentions).

*Mediation Analysis*

Mediation analysis has stimulated interest among researchers due to its potential to provide answers to a series of important research questions and due to the dissatisfaction with the methods and approaches that have tended to dominate clinical research (Hayes and Preacher 2010). The aim of using this analysis is to develop an increasingly sophisticated hypothesis of the systemic relationships and processes that generate empirical regularities (Cohen et al. 2003; Kenny et al. 2003). In this vein, mediation analysis can inform intervention strategies. The mediation model is important for understanding the mechanism through which the causal variable affects the outcome (Kenny et al. 2003; Preacher and Hayes 2008).

In the mediation process, the relationship between the independent variable (X) and the dependent variable (Y) is hypothesized to be an indirect effect that exists due to the influence of a third variable (M, the mediator). According to Baron and Kenny’s (1986) suggestion, we followed a four-step approach, in which several linear regression analyses are conducted, and the significance of the coefficients is examined at each step:

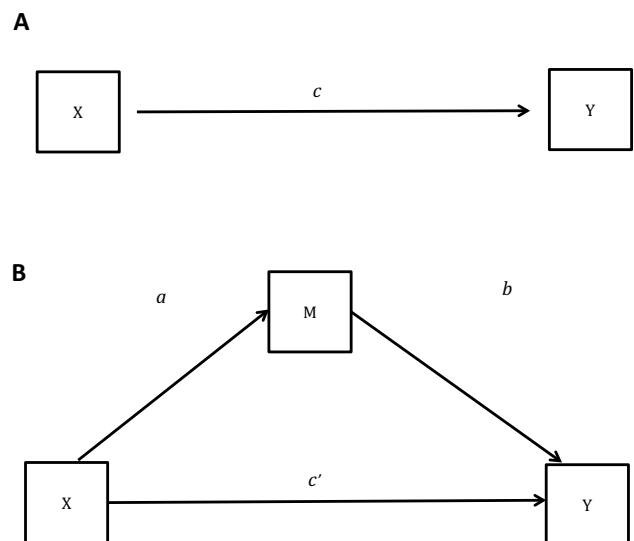
**Step 1:** Show that the causal variable is correlated with the outcome. Conduct a linear regression analysis with X predicting Y to test for path *c* (see Fig. 1a, b). This step establishes that there is an effect that may be mediated.

**Step 2:** Show that the causal variable is correlated with the mediator. Conduct a linear regression analysis with X predicting M to test for path *a* (see Fig. 1a, b). This step essentially involves treating the mediator as if it were an outcome variable.

**Step 3:** Show that the mediator affects the outcome variable. Conduct a linear regression analysis with M predicting Y to test the significance of path *b* (see Fig. 1a, b). It is not sufficient to just correlate the mediator with the outcome; in fact, the mediator and the outcome may be correlated because they are both caused by the causal variable X. Therefore, the causal variable must be controlled when establishing the effect of the mediator on the outcome.

**Step 4:** Establish that M completely mediates the X-Y relationship, the effect of X on Y controlling for M (path *c'*) should be zero (see Fig. 1a, b). The effects in both Steps 3 and 4 are estimated in the same equation.

If the criteria for all four of these steps are met, then the data are consistent with the hypothesis that variable M completely mediates the X-Y relationship, which supports *full mediation*; on the other hand, if the first three steps are met but Step 4 is not, then *partial mediation* is indicated



**Fig. 1** a Illustration of a direct effect. X affects Y. b Illustration of a mediation design. X is hypothesized to exert an indirect effect on Y through M. (Preacher and Hayes 2008)



(Kenny et al. 2003; Mathieu and Taylor 2006). In this study, we found *full mediation* for each mediation model.

Finally, we used the *Sobel test* (Sobel 1982, 1986) to explore the significance of a mediation effect. Particularly, in our study, the Sobel test was performed to evaluate whether the social information processing ability, measured by the SIPI (Ziv and Sorongon 2011; Ziv et al. 2014), was mediated by the ToM abilities measured by the CTS (Cornish et al. 2010; Sivaratnam et al. 2012) in both the ASD and TD group. The indirect effect of X on Y through M can then be quantified as the product of *a* and *b* (i.e., *ab*). The total effect of X on Y is quantified with the unstandardized regression weight *c* (Fig. 1a) (for details see Preacher and Hayes 2008). The Sobel test involves computing the ratio of *ab* to its estimated standard error (SE).

The overall statistical significance of the model was set at the 0.001 level. The Statistical Package for the Social Sciences (SPSS) software (version 22; SPSS Inc., Chicago, IL, USA) was used.

## Results

The ANOVA of the SIPI components showed that the ASD group had lower scores compared to the TD group with regard to social information processing competences. Specifically, children with ASD showed difficulties in all components of the SIPI: encoding ( $F_{1,102} = 26.96$ ;  $p = 0.0001$ ;  $\eta^2_p = 0.26$ ), interpretation ( $F_{1,102} = 14.85$ ;  $p = 0.0001$ ;  $\eta^2_p = 0.15$ ), response evaluation ( $F_{1,102} = 78.80$ ;  $p = 0.0001$ ;  $\eta^2_p = 0.46$ ), and response construction ( $F_{1,102} = 86.80$ ;  $p = 0.0001$ ;  $\eta^2_p = 0.47$ ), compared to the TD children (Table 1).

Furthermore, the ASD group had lower scores in beliefs ( $F_{1,102} = 44.84$ ;  $p = 0.0001$ ;  $\eta^2_p = 0.27$ ) and emotions ( $F_{1,102} = 13.02$ ;  $p = 0.0001$ ;  $\eta^2_p = 0.17$ ), but there were no significant differences in the intentions ( $F_{1,102} = 0.214$ ;  $p = 0.645$ ;  $\eta^2_p = 0.009$ ) sub-component of the CST compared to the TD group.

## Correlational Analysis

### TD Group

Significant correlations were found in the TD group between the emotions CST sub-component (affective ToM) and three components of the SIPI (interpretation, response construction, and response evaluation). Specifically, we found a significant negative correlation between the emotions sub-component of the CST and the interpretation component of the SIPI ( $r = -0.388$ ;  $p = 0.002$ ).

A significant positive correlation was also found between the CST emotions sub-component and both the

response construction ( $r = 0.378$ ;  $p = 0.002$ ) and response evaluation ( $r = 0.251$ ;  $p = 0.032$ ) components of the SIPI. Furthermore, the three SIPI components (interpretation, response construction, and response evaluation) showed significant correlations with the beliefs sub-component of the CST (cognitive ToM). The beliefs sub-component of the CST was negatively correlated with the SIPI interpretation component ( $r = -0.368$ ;  $p = 0.003$ ).

Finally, the beliefs sub-component of the CST was positively correlated with the response construction ( $r = 0.514$ ;  $p = 0.001$ ) and response evaluation ( $r = 0.202$ ;  $p = 0.70$ ) components of the SIPI.

### ASD Group

A significant positive correlation was found in the ASD group between the emotions sub-component of the CST (affective ToM) and the response construction component of the SIPI ( $r = 0.270$ ;  $p = 0.035$ ). Significant correlations were also found between the intentions sub-component of the CST (cognitive ToM) and the three SIPI components (interpretation, response construction, and response evaluation). Specifically, the CST intentions sub-component was negatively correlated with the SIPI interpretation component ( $r = -0.223$ ;  $p = 0.68$ ).

Finally, we found a significant positive correlation between the CST intentions sub-component and both the response construction ( $r = 0.532$ ;  $p = 0.001$ ) and response evaluation ( $r = 0.253$ ;  $p = 0.45$ ) components of the SIPI.

## Regression Analysis

According to the results obtained by the correlation analysis and in order to create the mediation models, a linear regression analysis was performed. The corresponding results allowed us to conduct the Sobel test (Sobel 1982, 1986) to explore the significance of the mediation effects between the different variables.

### TD Group

Firstly, we conducted a first regression analysis using the emotions sub-component of the CST as the dependent variable and the interpretation component of the SIPI as predictor ( $R^2 = -0.39$ ,  $SE = 0.13$ ,  $p = 0.003$ ). This was followed by a second regression analysis where the emotions sub-component of the CST became the predictor together with the interpretation component of the SIPI, while the SIPI response construction component was the dependent variable ( $R^2 = 0.63$ ,  $SE = 0.22$ ,  $p = 0.007$ ).

Secondly, we conducted a first regression analysis using the beliefs sub-component of the CST as the dependent variable and the interpretation component of the SIPI as

predictor ( $R^2 = -0.79, SE=0.28, p=0.006$ ). This was followed by a second regression analysis where the beliefs sub-component of the CST became the predictor together with the interpretation component of the SIPI, while the SIPI response construction component was the dependent variable ( $R^2=0.41, SE=0.09, p=0.001$ ).

Thirdly, we conducted a first regression analysis using the emotions sub-component of the CST as the dependent variable and the interpretation component of the SIPI as predictor ( $R^2 = -0.39, SE=0.13, p=0.003$ ). This was followed by a second regression analysis where the emotions sub-component of the CST became the predictor together with the interpretation component of the SIPI, while the SIPI response evaluation component was the dependent variable ( $R^2=0.64, SE=0.32, p=0.05$ ).

Finally, we conducted a first regression analysis using the beliefs sub-component of the CST as the dependent variable and the interpretation component of the SIPI as predictor ( $R^2 = -0.79, SE=0.28, p=0.006$ ). This was followed by a second regression analysis where the beliefs sub-component of the CST became the predictor together with the interpretation component of the SIPI, while the SIPI response evaluation component was the dependent variable ( $R^2=0.23, SE=0.15, p=0.13$ ).

**ASD Group**

Firstly, we conducted a first regression analysis using the intentions sub-component of the CST as the dependent variable and the interpretation component of the SIPI as predictor ( $R^2 = -0.33, SE=0.22, p=0.13$ ). This was followed by a second regression analysis where the intentions sub-component of the CST became the predictor together with the interpretation component of the SIPI, while the SIPI response construction component was the dependent variable ( $R^2=0.52, SE=0.13, p=0.001$ ).

Secondly, we conducted a first regression analysis using the intentions sub-component of the CST as the dependent variable and the interpretation component of the SIPI as

predictor ( $R^2 = -0.33, SE=0.22, p=0.13$ ). This was followed by a second regression analysis where the intentions sub-component of the CST became the predictor together with the interpretation component of the SIPI, while the SIPI response evaluation component was the dependent variable ( $R^2=0.32, SE=0.22, p=0.16$ ).

**Mediation Analysis**

Mediation models were performed on the basis of the correlation and regression analyses. In order to elucidate whether the interpretation of other people’s social behavior is mediated by the ability to understand intentions, beliefs, and emotions of others, four separate mediation models for the TD group and two for the ASD group were conducted.

**TD Group**

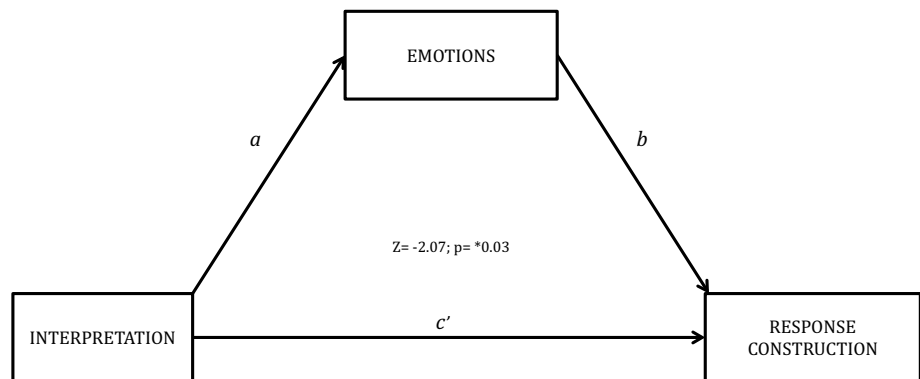
Firstly, the relationship between the interpretation (X) and response construction (Y) components of the SIPI, using the emotions sub-component of the CST (affective ToM) as a mediator, was explored. The Sobel test showed that this model was significant ( $Z = -2.07; SE=0.11; p=0.03$ ; see Fig. 2).

Secondly, the relationship between the interpretation (X) and response construction (Y) components of the SIPI, using the CST beliefs sub-component (cognitive ToM) as a mediator, was examined. The Sobel test showed that this model was significant ( $Z = -2.39; SE=0.13; p=0.01$ ; see Fig. 3).

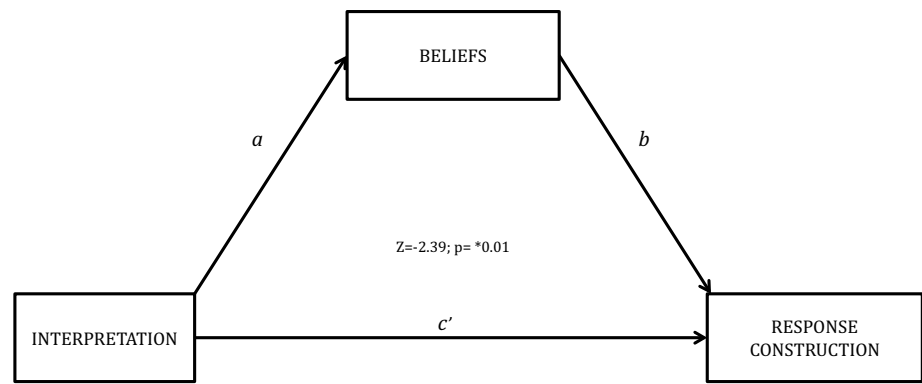
Thirdly, we explored the relationship between the interpretation (X) and response evaluation (Y) components of the SIPI, using the CST emotions sub-component (affective ToM) as a mediator; however, this model did not show any significant indirect effect of mediation.

Finally, we explored the relationship between the interpretation (X) and response evaluation (Y) components of the SIPI, using the CST beliefs sub-component (cognitive

**Fig. 2** TD group: the Sobel test significance levels, for the relationship between interpretation and response construction sub-components of SIP-I as mediated by emotions sub-component (affective TOM) of CST. \* $p < 0.001$



**Fig. 3** TD group: the Sobel test significance levels, for the relationship between interpretation and response construction sub-components of SIP-I as mediated by beliefs sub-component (cognitive TOM) of CST. \* $p < 0.001$



ToM) as a mediator; however, this model did not show any significant indirect effect of mediation.

### ASD Group

Firstly, we explored the relationship between the interpretation (X) and response construction (Y) components of the SIPI, using the CST intentions sub-component (cognitive ToM) as a mediator. Secondly, we explored the relationship between the interpretation (X) and response evaluation (Y) components of the SIPI, using the CST intentions sub-component (cognitive ToM) as a mediator. The Sobel test for both models did not show any significant indirect effect of mediation.

## Discussion

The present study examined differences between the ASD and TD group in ToM and social information processing abilities through two different tasks: the CST (Cornish et al. 2010; Sivaratham et al. 2012) and SIPI (Ziv and Sorongon 2011; Ziv et al. 2014). According to neurodevelopmental research, children's social behavior depends on ToM ability (Astington 1993; Astington and Edward 2010; Flavell and Miller 1998; Happé and Frith 2014). Indeed, ToM represents the core of children's capacity to get along with their peers and other people and to see the world from others' point of view (Astington and Edward 2010; Happé and Frith 2014; Mazza et al. 2014). People use ToM to understand and explain their own or other people's behavior. Thus, the healthy development of ToM is a prerequisite for the processing of social information, that is, we first need to understand and recognize the intentions, beliefs, and emotions of other people to learn to distinguish our own mental states from other people's mental states. Subsequently, we process this social information to interact in adequate ways with other people and the world around us.

The main aims of the present study were to evaluate the differences between the two groups (TD and ASD) in the used tests and to examine the role of ToM abilities in the development of social information processing capacities through mediation analysis, which is an innovative methodology to evaluate the impact of ToM components on social skills. The ANOVA analysis showed that the ASD group had difficulties in social information processes and ToM abilities compared to the TD group.

Specifically, in the SIPI, children with ASD had lower scores in encoding social information efficiently (i.e., encoding component), that is, they showed difficulties in the understanding of the story. In this task, the examiner asked the children to narrate the story that they had heard. The encoding component represents the first step of social information processing because it requires the ability to understand and reproduce what other people say or narrate. According to the Crick and Dodge (1994) model, which was subsequently used by Ziv and his collaborators (2014), another step for correct social information processing is response construction. In this step, the child is asked "to put himself/herself in the shoes" of the main character of the story and try to explain how he/she would act in the same situation. The children with ASD also had difficulties in response construction. In addition, they displayed impairment in response evaluation, particularly in the ability to evaluate whether other people's social behavior was right or wrong (e.g., they evaluated an aggressive behavior as being acceptable). The response evaluation component is crucial for processing social cues and to subsequently guide social behavior. An additional step is represented by the interpretation component of the SIPI. This component evaluates the tendency to attribute hostile intentions to other people in positive social situations and vice versa. The ASD group showed difficulties in this component compared to TD children. This incorrect interpretation of other people's behavior can lead children to exhibit an incorrect social response and compromise the relationship with their peers. These SIPI results are in line with the recent



literature (Happé and Frith 2014; Ziv et al. 2014), which confirmed the impairment in social information processing abilities in children with autism.

Regarding the ToM results measured by the CST (Cornish et al. 2010; Sivaratnam et al. 2012), the ASD group showed an impairment of ToM competences compared to the TD group. Particularly, children with autism scored lower in the beliefs and emotions sub-components of ToM, but there was no significant difference in the ToM intentions sub-component between the two groups. These findings are in contrast with the results of Sivaratnam et al. (2012) who demonstrated a significantly different performance between children with ASD and TD children only for the intentions sub-component of ToM.

In agreement with Happé and Frith (2014), our study supports the hypothesis that the ability to recognize the intentions of other people represents implicit ToM and develops relatively early; it is already present at the age of 3 to 4 months and an important prerequisite for the appropriate development of explicit ToM (Happé and Frith 2014). Moreover, the capacity to understand and recognize the beliefs and emotions of other people is an explicit ability of ToM that develops at 3 to 4 years of age. Thus, this complex competence is based on mentalizing tasks, for example, as assessed by the false beliefs test (Happé 1994; Happé and Frith 2014). On the basis of our results, we hypothesize that children with ASD at an average age of 7 have the ability to recognize the intentions of other people but have not yet developed the capacity to understand the beliefs and emotions of others, because this ability is more complex compared to understanding intentions.

Regarding the second aim, two mediation models for the ASD group and four mediation models for the TD group were performed. For children with ASD, the mediation analysis results showed that the two models using the intentions sub-component of ToM as a mediator were not significant. We used the intentions sub-component of ToM as a sole mediator because it was the only ability that correlated with the SIPI components. In the ASD group, there was no evidence of mediation. Thus, in children with ASD, the ability to recognize the intentions of other people does not reduce their difficulty in social information processing (Pierce 2003). A non-significant mediation model indicates that the association between the IV and DV (i.e., for the first model, the SIPI interpretation and response construction components, respectively; for the second model, the SIPI interpretation and evaluation response components, respectively) was not reduced significantly by the inclusion of the mediator (i.e., CST intentions sub-component) in the model.

Regarding TD children, the results of the mediation analysis revealed two significant models out of four models, using the beliefs and emotions sub-components

as mediators. Specifically, the two significant models showed that the correct interpretation of social cues (interpretation component of the SIPI, IV) and the response construction component of the SIPI (DV) were mediated by both the emotions and beliefs sub-components of the CST (see Figs. 2, 3). It would seem that the ability to recognize emotions (Fig. 2) and beliefs (Fig. 3) of other people improves the relationship between the interpretation of social cues and the generation of an adequate behavioral response in TD children. On the contrary, both ToM components had no mediator role in the relationship between the interpretation and response evaluation components of the SIPI. We hypothesize that the capacity to evaluate other people's social behavior as right or wrong requires a higher level of ToM abilities, such as the knowledge of moral and conventional rules (Blair 1995). If a child does not know the moral or conventional rules, he/she cannot judge the social behavior of his/her peers. According to Blair (1995), moral rules comprise the respect for other people, whereas conventional rules comprise the respect of behavioral rules in specific social contexts such as school, home, and so on. Thus, the response evaluation component does not need ToM abilities, but the knowledge of these rules is laid down by society. In the present study, the knowledge of moral and conventional rules was not examined but may represent a future study.

### Limitations and future directions

Despite these interesting results, the current study is characterized by various important limitations. The first limitation concerns the age range of the sample. The two measures that evaluated ToM abilities and social information processing in the original studies (Cornish et al. 2010; Ziv et al. 2014) were used in preschoolers. However, the children's ages ranged from 5 to 13 years, because the present study considered an age range in which the development of ToM ability in children with TD is consolidated to understand its role in social information processing. The second limitation concerns the lack of direct evaluation of social behavior of all participants. This study evaluated the effect of ToM components on social information processing, and we assume that social behavior is a consequence of how children process social cues. Thus, the difficulties to correctly process social cues hinder children from behaving in the right way in everyday life. Considering that severe difficulties in social interaction are a defining feature of individuals with autism (Fletcher-Watson et al. 2014), our results emphasize the need for intervention strategies based on ToM abilities to improve these social deficits.

## Conclusion

In conclusion, with the innovative approach using mediation analysis, we determined that the ability to understand emotions and beliefs is necessary to implement an adequate social behavior.

Taken together, the results of the present study show that the capabilities to infer other people's emotions (affective ToM) and to understand their beliefs (cognitive ToM) play a key role in determining the appropriate acquisition of social competences (Sebastian et al. 2012) in TD children. On the contrary, the lack of these ToM abilities compromises the appropriate development of social behavior in children with autism.

**Author contribution** MoM and MV designed research; MCP, MeM, and SP collected data; FM analyzed the data; MoM, MCP, SP, and MeM wrote paper.

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