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Empathy, sex and fluid intelligence as predictors of theory of mind

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ABSTRACT

Individual differences in theory of mind (ToM) are affected by a variety of factors. We investigated the relationship between empathy, sex and fluid intelligence (FI) as predictors of ToM in a random probabilistic sample of secondary students. First, we explored whether sex, as well as high, average or low levels of empathy and FI affect ToM performance. Furthermore, we assessed the contribution of empathy, sex and FI in predicting ToM by using a path analysis. This method allows testing of causal models of directed dependencies among a set of variables. The causal dependencies of empathy, sex and fluid intelligence were confirmed and identified. In addition, the model confirmed the direct effect of empathy, sex and fluid intelligence on ToM; and the indirect effect of sex mediated by empathy. Thus, individual differences in ToM levels are partially attributable to sex, empathy and fluid intelligence variability, raising important considerations for clinical research as well as ToM's theoretical models of domain specificity.

1. Introduction

Humans are expert interpreters of others' intentions and actions, demonstrating a domain-specific ability to "read others' minds". However, will a more empathetic person therefore have greater capacity to infer others' intentions? Is sex, mediated by empathy, another predictor of this capacity? Additionally, do abilities such as general cognitive skills affect this aptitude? This study investigates the relationship between empathy, sex and fluid intelligence (FI) in the capacity to infer the internal emotional states of others (theory of mind, ToM).

ToM allows us to understand the mental states (intentions, beliefs and emotional states) of ourselves and others and seems to be the core of social cognition (Ibanez & Manes, 2012). ToM is related to individual differences in executive functions (Sabbagh, Xu, Carlson, Moses, & Lee, 2006) and general skills (Pellicano, 2010), among other factors (Amodio & Frith, 2006). ToM is thus dependent on several different processes, which suggests that it is relatively domain nonspecific (Stone & Gerrans, 2006).

ToM evolves early in human development (Miller, 2009). ToM precursors such as joint attention (arising at 3 months; Scaife & Bruner, 1975) appear early in the development. Children at 3 years or earlier provide mentalistic explanations for behavior (Clements, Rustin, & McCallum, 2000). The first order ToM (e.g., inferring the thoughts of another person) is fully achieved at 4–5 years old. The second order ToM [one person's (A's) belief about another person's (B's) mental state] is achieved at 5–6 years old (Korkmaz, 2011; Miller, 2009). Inferring complex emotions and thoughts of other persons from eye regions is considered an equivalent to second order ToM (Miller, 2009). More complex ToM inferences are accomplished at 7–9 and the full ToM achievement is granted during the young adolescence (10–11 years; Brune & Brune-Cohrs, 2006; Korkmaz, 2011; Miller, 2009). More complex interactions of ToM and pragmatic language processes (e.g., figurative language) appear later in the development but the evidence is scarce (Miller, 2009). Most of the research has been performed in children and young adolescence; and differences among children, adolescents and adults are now well known (Brune & Brune-Cohrs, 2006; Korkmaz, 2011). Thus, young adolescence is a good stage to test ToM individual differences due to the full achievement of mentalizing skills. In addition, results can be more generalizable to other reports.

Empathy involves sharing another's feelings (emotions and sensations, Singer, 2006). Although sometimes used synonymously, empathy and ToM are different processes that engage partially shared areas of the brain. For instance, sharing sensations and feelings (empathy without ToM) requires an emotional response to another person's state of mind (Baron-Cohen, 2009) whereas

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mentalizing (ToM without empathy) requires a cognitive inference about mental state (Singer, 2006). Despite a number of studies assessing both empathy and ToM, it is not known whether differing levels of empathy can predict ToM performance.

Social behaviors appear to be strongly influenced by sex differences (Baron-Cohen, 2009). It is assumed that sex differences also affect ToM; the higher levels of ToM observed in females may be explained by the female brain's capacity for empathy (Baron-Cohen, 2009). Note that this implies not only that sex would have a direct effect on levels of ToM, but also an indirect effect, mediated by empathy. Surprisingly few empirical studies have tested whether sex has this effect (Charman, Ruffman, & Clements, 2002; Cutting & Dunn, 1999; Walker, 2005). The widely used Reading the Mind in the Eyes Task (RMET), which involves the emotional inference of mental states, indexes one of the most basic mosaics of ToM (Baron-Cohen, 2009). To our knowledge, only one report has shown evidence of sex differences in RMTE in a small sample (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001).

FI has been defined as the ability to think logically and solve problems in novel situations, independent of acquired knowledge (Duncan, 2005). Although originally associated with "cold" cognitive skills, FI may also relate to social cognition. Psychosocial adaptation is related to FI (Huepe et al., 2011), suggesting the latter as part of a general capacity for adaptation to social contexts. Moreover, indirect reports suggest that intelligence is partially associated with facial processing (Wilhelm et al., 2010) and RMET (Roca et al., 2010). Thus, as in the case of executive functions, FI may be an important modulator of ToM.

In brief, the evidence presented above suggests that empathy, sex and FI could be important predictors of individual differences in ToM. This is the first study exploring the relationship between ToM and empathy, FI and sex in a random-probabilistic sample of secondary school students. First, we explored whether sex, along with high, average or low levels of empathy/FI, differentially affect ToM performance (assessed using the RMET). We hypothesized that females and individuals with higher levels of empathy/FI should present higher levels of ToM. Additionally, this study uses a path analysis to investigate the unique contribution of empathy, sex and FI in predicting ToM. This method allows the causal modeling of directed dependencies among a set of variables (Shipley, 2002). We hypothesized that each of the three factors would predict a significant portion of ToM variance. Additionally, we tested the indirect effect of sex on ToM, mediated by empathy.

2. Materials and methods

2.1. Participants

This sample was composed of 424 secondary school students (age, $M = 12.5$ years, SD = 0.68; range = 12.0–13.2; 47.6% female) recruited from a random-probabilistic sample (maximum variance of 95% confidence with ±5% sample error) from 27 schools ($M = 15.7$ students, SD = 8.44 per institution). All educative institutions in which the study was performed approved the research performed in Chile (Santiago) as part of a national research program on education. All participants and their parents or legal guardians gave signed, voluntary consent in accordance with the Declaration of Helsinki.

2.2. Measures

2.2.1. ToM

The RMET (Baron-Cohen et al., 2001) consists of a set of 25 photographs of the area of the face involving the eyes. Participants are given four options and are asked to choose the one that best describes what the person in the photograph is thinking or feeling based on the expression in his or her eyes.

2.2.2. Fluid intelligence (IF)

A standard version of the Raven progressive matrices (RPM) was used as a measure of FI (or *g* factor; Raven, 2000). RPM included 60 spatial tasks divided into five blocks of 12 trials (from easiest to most difficult). In each trial, participants were asked to complete a series of drawings.

2.2.3. Empathy

The Interpersonal Reactivity Index (IRI; Davis, 1983) is a measure of dispositional facets of empathy (perspective taking, empathic concern, personal distress, and fantasy). In the present study, the global score of the IRI was used as an indicator of empathy.

2.3. Statistical analysis

2.3.1. Exploratory analysis

Groups of high, average, and low scorers on the FI and empathy measures were identified (high = >1 SD; low = <1 SD; average = ±1 SD) to explore the relationship between FI, empathy, and ToM performance. Comparisons between these groups as well as between sexes were made using the Kruskal–Wallis test. z' pairwise comparisons were performed.

2.3.2. Path analysis

To test the relationship between empathy, FI, sex and ToM, we used a path analysis (Shipley, 2002). This method involves developing a theoretical model to specify relationships (usually represented using a path diagram) and testing these hypotheses by comparing the pattern of correlations found in the data with that implied by the model (see S1 in Supplemental material).

3. Results

3.1. Exploratory analysis

Regarding empathy scores, the Kruskal–Wallis test showed significant results (H (2, $N = 424$) = 21.32, $p < 0.001$) in relation to ToM. The resulting z' pairwise comparisons displayed significant differences both between high and average ($z = 4.08$) and high and low ($z = 4.20$) performance levels.

The same set of analyses was carried out for the relation of FI scores with ToM. The results of a Kruskal–Wallis test were also significant (H (2, $N = 424$) = 13.7551, $p < 0.001$), and the z' pairwise comparisons identified differences between high and average ($z = 2.54$) and between high and low ($z = 3.68$) scorings.

In regard to sex differences, the Kruskal–Wallis test H produced significant results ((1, $N = 424$) = 24.0797, $p < 0.001$), and the z' pairwise comparisons also showed significant differences between males and females ($z = 3.42$). See Table 1 and Fig. 1.

Table 1
Descriptive statistics.

	High ($n = 68$)	Average ($n = 292$)	Low ($n = 64$)
FI	20.24 (0.45)	18.14 (0.22)	17.17 (0.47)
Empathy	19.61 (0.51)	18.37 (0.21)	16.88 (0.51)
	Female	*Male*	
Sex	19.24 (0.26)	17.50 (0.25)	

High, average and low levels of empathy and FI, as well as sex differences in ToM.

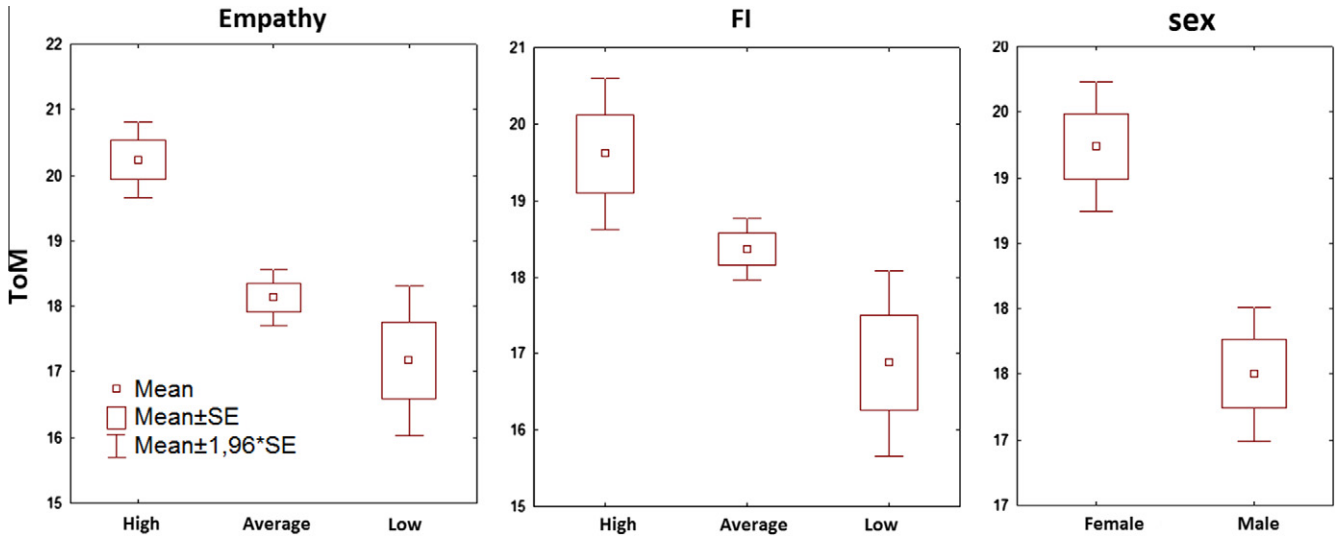

Fig. 1. Exploratory results of FI, empathy and sex on ToM performance. Significant effects for empathy (A), FI (B) and sex (C) on ToM performance. The box-whisker plots (mean + SE and 1.96 × SE) represent a 95% confidence interval.

3.2. Path analysis modeling

The fit of the proposed model (Fig. 2) was successful and we obtained excellent fit indices (GFI = .997; CFI = .992; RMSEA = .030; SRMR = .02). More importantly, the chi-square test was not statistically significant; χ^2 ((2, N = 424) = 2.77, p = 0.25). We emphasize this point because χ^2 is considered a stringent test of model fit in SEM (Barrett, 2007; Bollen, 1989; Hayduk, Cummings, Boadu, Pazderka-Robinson, & Boulianne, 2007).

Even if a model shows a good fit, this does not mean it is necessarily the best possible model to explain the set of observed relationships among variables (Bollen, 1989). For this reason, and given some controversies in SEM models (see S2 in Supplementary data), we compared our model with a set of alternative models. Basically, this approach (Bollen, 1989; McDonald & Ho, 2002; Mueller & Hancock, 2008, 2010) tests the proposed model with other competing models that could also be theoretically plausible. Our model postulates direct effects (empathy, intelligence and sex) on ToM, and sex as an indirect effect mediated by empathy (empathy → sex → ToM). We tested three alternative models, with the same degrees of freedom and direct effects, but varying the indirect effect. Thus, the alternative Model 1 proposes an indirect effect of sex through FI on ToM; alternative Model 2 an indirect effect of FI through empathy on ToM, and alternative Model 3 an indirect effect of empathy through FI on ToM. In other words, the three alternative models propose indirect effects other than those hypothesized in our model. The results of the analyses are presented in Table 2. Comparing the χ^2, conventional fit indices and Akaike and Bayesian information criteria (AIC and BIC) they all show that our proposed model is the best fitted. These results provide strong support for the plausibility of our model.

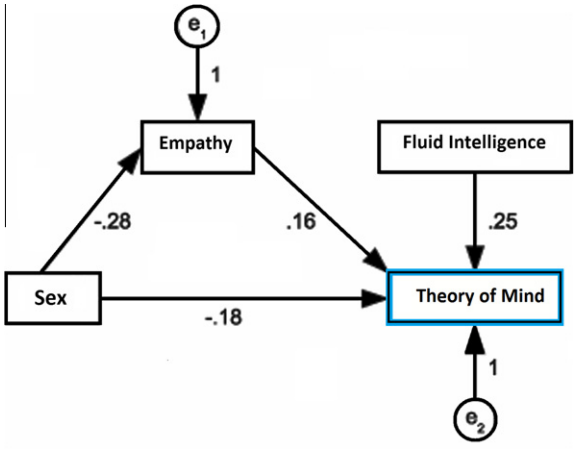

Fig. 2. Path analysis model used to test the effect of sex (1 = male; 0 = female), empathy and FI on ToM. Each standardized coefficient in the diagram was statistically significant (p < 0.01). The "e" in the path represents the error terms of factors outside the model (including measurement error).

An examination of the standardized and non-standardized coefficients (Table 3) of our model shows that sex has a direct negative effect on ToM (−.18) and also on empathy (−.28) such that males demonstrate lower scores than females (female coded as 0, male coded as 1) on ToM and empathy. On the other hand, empathy and FI have positive effects on ToM of .16 and .25, respectively. Additionally, sex also had a small but significant negative indirect effect on ToM, mediated by empathy (−.045; p = 0.003) and a total effect (sum of direct and indirect effects) on ToM of −.18 + −.045 = −.225; p < 0.001.

Finally, in order to provide additional measures of our model, a box-plot of the predicted versus observed ToM extracted from a regression, a discrepancy index, and a bootstrap analysis of the estimated paths are presented as Supplementary data confirming the robustness of the model.

4. Discussion

To our knowledge, this is the first study based on a random probabilistic sample offering a model that includes empathy, FI and sex as predictors of ToM. This model also shows that the relation of sex and ToM is mediated by empathy. Although the effects of these variables (particularly empathy and sex) are frequently assumed in ToM models, no previous study has tested their canonical relationship.

4.1. Sex differences in ToM

According to the empathizing–systemizing theory that contrasts a person's strength of interest in empathy (E) and in systems (S), women predominantly show a stronger E-profile, whereas men

Table 2
Comparison between the model proposed and the alternative models by fit index.

Model	χ^2	*p* value	RMSEA	90%_RMSEA	CFI	SRMR	AIC	BIC
Proposed model	2.78	0.25	0.03	(0.00; 0.10)	0.99	0.02	9135.93	9184.52
Alternative Model 1	37.75	<0.0001	0.21	(0.15; 0.27)	0.43	0.08	9170.89	9219.49
Alternative Model 2	35.21	<0.0001	0.20	(0.14; 0.26)	0.66	0.08	9168.35	9216.95
Alternative Model 3	35.21	<0.0001	0.20	(0.14; 0.26)	0.47	0.08	9168.35	9216.95

Table 3
Path coefficients of the tested model.

Effects	Non standardized		Standardized	
	Coef*	SE	Coef*	SE
FI → ToM	0.123	0.023	0.25	0.044
Empathy → ToM	0.051	0.015	0.16	0.047
Sex → ToM	−1.392	0.360	−0.18	0.046
Sex → empathy	−6.863	1.130	−0.28	0.045
Sex → empathy → ToM	−0.347	0.117	−0.045	0.015
Sex total effect on ToM	−1.739	0.350	−0.225	0.045

* All coefficients are significant at $p < 0.01$.

tend to show more interest in systems (Baron-Cohen, 2009). This particular linkage of sex and RMTE has been examined in only a few studies and with a small sample size (Baron-Cohen et al., 2001). The results of these studies showed female superiority at the trend level but were not always significant (Baron-Cohen et al., 2001). Our findings are consistent with those made in previous studies and confirm the idea of sex differences in ToM and, in particular, in the RMTE.

4.2. ToM and empathy

Sharing another's feelings and emotions is at the core of the concept of empathy (Singer, 2006). ToM must be distinguished from empathy, as it is instead defined as the ability to infer and represent the intentions, beliefs and desires of others. Empathy has an affective component that is not essentially in ToM and, conversely, ToM has an inferential component not necessarily present in empathy (Singer, 2006).

Empathy (as an emotional reaction that is appropriate to other mental states) appears before and is less complex than ToM skills: the last requires a cognitive inference about others' mental states (Blair, 2008; Korkmaz, 2011). Even a basic task of ToM process such as the RMET indexes can be distinguished by empathy since the subject has to make explicit inferences about others' mental states. Thus, empathy is usually considered a necessary component of ToM (Baron-Cohen & Wheelwright, 2004). Consistent with these claims, empathy was a significant predictor of ToM performance.

Neuroscience studies of empathy in which participants view images of a person in pain (Singer, 2006), suggest that empathy and ToM share similar process restricted to common regions of the brain, but belong to different neural networks. Our results, at another level, also support for partially shared but differentiated processes of ToM and empathy, consistent with the psychological models of those functions.

Sex and ToM were mediated by empathy, indicating that female sex alone does not guarantee greater accuracy in RMTE; a high level of empathy is also necessary. Thomas and Maio (2008) manipulated sex traits by persuading male participants to manifest characteristics consistent with the traditional female gender role (e.g., enhanced empathy) while performing a ToM task. In doing so, the men showed improved ToM performance, similar to that obtained by women. This evidence is consistent with the idea that empathy, and not only sex, is directly related to ToM.

4.3. ToM and FI

FI, social cognition and executive functions all engage the frontal lobe (Roca et al., 2010). However, the interaction between so-called 'cold' cognitive skills and 'hot' social functioning has not been extensively studied. A related relationship between FI and psychosocial adaptation was confirmed in a recent study (Huepe et al., 2011). The RMET used to measure ToM in our study requires facial processing, which is also associated with FI (Wilhelm et al., 2010). Thus, FI would not only be related to abstract and logical thinking but may also be required for social cognition.

4.4. Convergence of measures and theoretical considerations about the model

Our report provides convergent evidence for sex, empathy, and FI as predictors of ToM: the group comparison, the path analysis and additional analysis. Regarding the path weights, we have detailed both the adequacy of reporting a path model with the current weights and goodness of fit model with low weights.

Theoretical considerations prevent us from expecting a complete or even strong prediction of ToM based on sex, FI and empathy. What we had expected is that these three factors would predict a *partial* but significant ToM variance. The reason is simple: ToM is a complex process being affected by many other cognitive processes. Executive functions, attention, language, emotion, memory, moral reasoning, and other social cognition domains (Carlson, Mandell, & Williams, 2004; Joseph & Tager-Flusberg, 2004; Korkmaz, 2011; Miller, 2009), affect the individual differences in ToM. The variance of the only three factors assessed in this study cannot explain the influence of all those other possible factors. Nevertheless, our study shows that sex, FI and empathy are important predictors of RMET performance. Future studies should consider, in addition, other factors affecting ToM performance.

4.5. Generalization and future assessment of ToM variability

This is the first report considering empathy, sex and FI as predictors of ToM. Important limitations (to be considered in future studies) are summarized here.

Our empathy scores are based on self-reports. Societal stereotypes could bias the evaluation of self-reports. Further research should include implicit and automatic measures. Nevertheless, we included the most widely used measures of empathy and FI. In our study, we utilized the most common measure of FI, the Raven test, but there are other measures (e.g., WAIS, verbal analogies, number series) that can provide additional assessments.

We selected the RMTE to measure ToM from a pool of more than 30 available paradigms (Doherty, 2008) for several reasons. The RMTE is one of the most widely used ToM tasks in both normal and clinical samples and is easy to apply and to respond. This task indexes one of the most fundamental ToM processes: the explicit report of emotional inference of others' feeling and thoughts. Although other ToM processes are important, this is a core component of mentalizing (Baron-Cohen et al., 2001; Joseph & Tager-Flusberg, 2004). RMTE has received validation with scales of aut-

ism (Baron-Cohen et al., 2001) and do not require explicit verbal report which indirectly affects ToM performance (Vierkant, 2012). The RMET is currently considered an equivalent to second order task and requires similar or higher ToM demands as other post-first-order tests (Miller, 2009). Even RMTE presents a strong correlation with the faux pas (Torralva et al., 2007; Torralva, Roca, Gleichgerrcht, Bekinschtein, & Manes, 2009), a higher level ToM test. Conversely, RMTE, compared to other ToM tasks (strange stories, TOMI, or faux pas), is less affected by language and do not require an explicit verbal report. Moreover, in a non clinical population (and contrary to classic tasks such as strange stories test or faux pas), RMET is also not affected by executive functions (Ahmed & Stephen Miller, 2011). Thus, RMTE is a widely used and validated task correlating with higher order ToM tasks and indexing core basic mentalistic processes instead of other processes (such as executive functions and language). Nevertheless, ToM is a complex construct involving different subcomponents (Korkmaz, 2011) and future research should include a battery of basic (RMET) and more complex tasks (e.g., faux pas).

4.6. Developmental issues

As detailed in Section 1, young adolescence is a representative population for ToM research, since it presents a full achievement of mentalizing, and childhood and adolescence are the most studied periods (thus making the results with this population more generalizable). Nevertheless, more complex ToM processes and their relation with later developments of language and executive functions (e.g., figurative language) are observed together with adolescent brain maturation (Blakemore, 2012). Thus, although our results may be relatively generalizable to a wide-ranging population, our results should be considered with caution. Furthermore, higher order ToM from adulthood to aging are out of the scope of this work and should be considered in further studies.

Several sex differences in the cognitive process (including ToM) are believed to affect adolescence development, especially during puberty (Blakemore, 2012). The relationship among gender, puberty and social cognition development has received little attention (Blakemore, 2012). Our study, as most of ToM studies, did not control for menarche. Nevertheless, given that the skills required in the RMTE are thought to be achieved before puberty, and ToM sex differences have been noted in children (Miller, 2009) it is possible to speculate that our sex results are partially independent of puberty changes. Nevertheless, future studies should compare young adolescent with adult populations and controls for menarche.

5. Conclusions

Several studies have examined ToM in neuropsychiatric conditions (e.g., autism and Asperger syndrome, schizophrenia, mental retardation, brain damage, communicative disabilities, ADHD, bipolar affective disorders, William syndrome, language impairments, and different forms of dementia), but most assess ToM without including FI or empathy as possible modulating variables. A control that combines sex, FI and empathy assessment may be desirable. Individual differences in ToM performance would therefore be explained not only by domain-specific impairments (e.g., the ability to infer mental states) but also by differences in empathy and FI.

It has been debated whether ToM should be considered an isolated modular domain or rather a compound process (Apperly, Samson, & Humphreys, 2005; Stone & Gerrans, 2006). Our data provide indirect support for this by showing that ToM is partially dependent on affective states (empathy) as well as general domain abilities (FI). Thus, although specific to an extent (e.g., inferring the other's mental states), ToM appears to be a cognitive skill coupled and embedded with other cognitive and affective processes.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.paid.2012.11.022.

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