

SUPPLEMENTARY MATERIALS

Psychometric properties of reviewed clinical measures of empathy in children and adolescents.

1. Bryant's Index of Empathy

The Bryant's Index of Empathy (BIE) is the first validated measure that primarily assessed the construct of empathy in children and adolescents. This self-reported scale was developed after the Mehrabian and Epstein's Measure of Emotional Empathy questionnaire for adults ^[1], and is one of the most widely used worldwide ^[2]. It was constructed as a mono-dimensional measure, composed of 22 items that mainly assess reactions towards sympathy-eliciting scenarios. The questionnaire was originally developed in English by Bryant (1982), and further validated in 1984 ^[4] in three studies on 128 healthy 7-year-old subjects, 163 healthy 10-year-old subjects and 73 healthy 14-year-old subjects.

A Spanish version was validated by del Barrio et al. (2004) on 832 adolescents aged 14.4 years old on average (49% of boys), and its psychometric properties were further studied by Lasa Aristu et al. (2008) and Lucas-Molina et al. (2016). A Dutch version was validated by De Wied et al. (2007) on 1978 children with a further examination of the internal structure.

Bryant's Index of Empathy repeatedly showed a 3-factor internal structure both in exploratory and confirmatory analysis, relating to Feeling of Sadness, Understanding Feelings and Tearful Reaction, with acceptable to good internal consistency for each subscale (Cronbach's alpha ranging from 0.72 to 0.83) ^[2,5,6]. However, the Dutch study by de Wied et al. (2007) failed to confirm the same structure, suggesting two factors with acceptable to poor reliability, and thus questioning the validity of the scale.

2. Interpersonal Reactivity Index

The Interpersonal Reactivity Index (IRI) was originally developed by Davis (1980) as a self-reported questionnaire for adults composed of 28 items equally distributed across four subscales, respectively referring to Fantasy and Perspective-Taking

(combined into the cognitive empathy subscale), Empathic Concern and Personal Distress (combined into the affective empathy subscale). Davis (1980) validated it on 1161 healthy young adults (49.9% of males) recruited from universities in the United States of America (USA).

The original questionnaire was largely based on the definitions of empathy proposed by Smith (1759), who made the initial differentiation between instinctive sympathy (or emotional empathy) and intellectualized sympathy (or cognitive empathy), and by Spencer (1855), who drew the same distinction which has continued to our days. The IRI was the first measure validated on adults to provide separate assessments of the cognitive perspective-taking capabilities and the emotional reactivity. The questionnaire was also designed to be easily administered and scored.

The scale was first adapted as a self-report instrument for children by Litvack-Miller and colleagues (1997) in a sample of 478 children aged 7 to 12 years old. A Spanish version of the scale was validated by Mestre-Escriba et al. (2004) on 1285 adolescents aged 13 to 18 years old (54.3% of boys), recruited from educational centers, and a Dutch version by Hawk et al. (2013) on 501 children.

Results from confirmatory analyses in children and adolescents ^[11-13] corroborated the 4-factor internal structure of the scale originally suggested by Davis ^[8]. Nevertheless, Carrasco-Ortiz and colleagues (2011) identified in the Spanish version a novel 5-factor structure, including Intellectual Empathy, Positive Emotional Empathy, Disorganized Emotional Empathy, Virtual Empathy and Impassiveness, with the former two factors nested in a second-order dimension named Considerate Social Style; this model was also confirmed by Holgado-Tello et al. (2013).

3. *Scale to Measure Empathy*

A Scale to Measure Empathy (SME) was derived from the Empathy subscale of the Prosocial Behavior Questionnaire by Martorell et al. (1995, 1998) as a self-reported questionnaire in Spanish for pre-adolescents and adolescents. Empathy was defined as the trait disposition to understand others' condition, emotions and feelings based on Fuentes (1989). It is composed of 15 items, whose factor structure has not been investigated. However, the scale was evaluated by Rey (2003) in a sample of 318

Colombian male adolescents, aged 11 to 18 years old, including 94 patients affected by conduct disorder (CD), recruited in re-educational centres. CD patients showed significantly higher scores than healthy peers ($p = 0.008$). Internal consistency was acceptable with a Cronbach's alpha of 0.78.

4. *Feeling and Thinking scale*

The Feeling and Thinking scale (F&T) is a self-reported questionnaire for children composed of 12 items equally distributed between two subscales, respectively referring to the affective and cognitive components of empathy. The scale was developed in English as a modified version of the IRI that could be administered to 8- and 9-year-old children by Garton and colleagues (2005), who validated it on 413 healthy subjects aged 8 – 10 years old (53% of boys) recruited from schools in Australia.

The measure is largely based upon the empathy construct proposed by Cotton (2001), who summarized research findings of comprehensive dictionary definitions. Empathy is typically defined as including an affective capacity to share in another's feelings and a cognitive ability to understand another's feelings and perspective; it also includes the ability to communicate one's empathetic feelings and understandings to another by verbal and non-verbal means.

The authors of the scale initially found a 4-factor solution dissimilar to that previously obtained by factor-analysing IRI items in adults [8] and children [11], including General Affective Empathy, Fantasy, Fatalistic (???) and Perspective Taking, with unacceptable to acceptable internal consistencies. Further analyses reduced the structure to a parsimonious 2-factor scale representing the two main components of empathy, i.e. cognitive and affective empathy. Nonetheless, there was no notable improvement of the internal consistency (Cronbach's alpha ranging from 0.54 to 0.69). On the other hand, criterion validity of the measure was corroborated by the evidence of higher scores obtained by females than males.

5. *Basic Empathy Scale*

The Basic Empathy Scale (BES) was originally developed as a self-reported questionnaire for adolescents composed of 20 items nearly equally distributed across

two subscales, respectively referring to the affective and cognitive components of empathy. The scale was developed in English by Jolliffe and Farrington (2006), who validated it on 720 healthy subjects aged 14.8 years old on average (50.8% of boys) recruited from schools in England. The authors performed both exploratory and confirmatory analyses that established good internal consistency for each subscale with Cronbach's α ranging from 0.79 to 0.85. The robustness of the measure was strengthened by criterion-oriented evidence of higher scores obtained by females than males ($p < 0.0001$), by convergent relations with the IRI questionnaires ($r = 0.43$ to 0.53) and by divergence from measures exploring alexithymia (Toronto Alexithymia Scale, $r = -0.20$ to -0.17) and desirability (Social Desirability Scale, $r = -0.11$ to 0).

Since previous scales do not precisely measure cognitive empathy, Jolliffe and Farrington (2006) concluded that having a valid measure of cognitive empathy is essential for understanding the relationship between empathy and offending as both affective and cognitive empathy would be expected to provide a unique contribution. Their new measure of affective and cognitive empathy attempted to overcome the shortcomings of the existing questionnaires, being specifically based on the definition of empathy put forth by Cohen and Strayer (1996) with a focus on both affect congruence (affective empathy) and the understanding of another's emotions (cognitive empathy).

Several translated versions have been validated so far. Hence, the scale is available in French [23], Italian [24,25], Slovak [26], Chinese [27], Spanish [28], Portuguese [29] and Korean [30]. Short versions of the questionnaire are also available in Spanish [31,32] and Portuguese [33]. The measure was also adapted for children both as a self-reported measure in French [34] and, as a parent-reported instrument, in Spanish [35]. Further psychometric properties of the scale have been investigated in the Portuguese version by Anastacio et al. (2016), and Pechorro and colleagues (2017) in a sample of juvenile offenders.

The same internal structure originally proposed by Jolliffe and Farrington (2006) was corroborated with variable levels of internal consistency by the majority of the studies that validated translated versions of the questionnaire [23–26,29,32,33,35]. Good psychometric properties were also repeatedly confirmed by means of test-retest

reliability [23], criterion [23,31,35] and convergent/ divergent validity [23–26,29]. Nonetheless, a three-factor model of empathy (emotional contagion, cognitive empathy, and emotional disconnection) was established by Bensalah and colleagues (2016) in the children self-report version of the scale and by Herrera-Lopez and colleagues (2017).

6. *Griffith Empathy Measure*

The Griffith Empathy Measure (GEM) is a parent-reported questionnaire for children and adolescents composed of 23 items distributed between two subscales, respectively referring to the affective and cognitive components of empathy. The scale was adapted from the Bryant's Index of Empathy, though using a nine-point Likert scale rather than the yes/no format designed for use with children in Bryant's version, and questions were reworded in third person format.

The scale was originally developed in English by Dadds and colleagues (2008), who validated it on 2612 healthy subjects aged 4 – 16 years old (52.8% of boys) recruited from schools in Australia. Both exploratory and confirmatory analyses established a two-factor structure with good internal structure for the entire scale, with Cronbach's α ranging from 0.62 to 0.83. Inter-rater reliability was moderate ($r = 0.38$ to 0.40), while test-retest reliability proved to be higher ($r = 0.69$). Criterion validity was confirmed by higher empathic attitudes in females than in males ($p < 0.001$), while convergence with intellectual functioning (IQ, $r = 0.30$) and interpersonal response ($r = 0.30$ to 0.56) and divergence from the Cruelty to Animals Inventory ($r = -0.12$ to -0.31) were reported.

The GEM is the first parent-reported scale of child empathy, since no previous parental reports of the construct were available. It is a brief measure that can be used in large scale community and clinical studies with young children, largely based upon the Hoffman's developmental theory of empathy.

7. *Children Empathic Attitudes Questionnaire*

The Children Empathic Attitudes Questionnaire (CEAQ) is a self-reported 16-item scale for children. The questionnaire was originally developed in English by Funk and colleagues (2008) who validated it on 213 healthy subjects aged 10 – 13 years old (49.6%

of boys) recruited from schools in the USA.

In reviewing self-report measures of empathy in both children and adults, Funk and colleagues (2008) realized that what is measured is the cognitive component of empathy conceptualized as empathic attitudes. Their questionnaire is largely based upon Hoffman's developmental theory ^[41], which addresses how the individual's emotional reactions interact with their developing cognitive capabilities to produce a specific empathic response.

The questionnaire showed good internal consistency with a Cronbach's alpha of 0.77. To further assess the reliability of this scale, the authors combined Classical Test Theory methods with the more modern Rasch model, which constructs unidimensional measures or "rulers", where subjects and items are placed on the same metric scale. Thus, children can be placed along an "empathy development ruler" to quantify their likelihood of achieving different milestones. Rasch model-based indexes are reported in Table 3. The questionnaire is addressed to 10- to 13-year-old children, since by this age empathic attitudes should be fairly stable, and individuals should have the cognitive capacity needed to respond to a self-report instrument, and because this is a critical age range for interventions to address emerging behavioral problems reflecting empathic deficits.

In its original validation, criterion-oriented evidence was based on the finding of higher scores by females than males ($p < 0.01$). Convergent and divergent relations were reported with the BIE ($r = 0.57$) and two measures assessing respectively social desirability (Crandall Social Desirability Test for Children, $r = 0.39$) and general emotional, behavioral and relational abilities (Strength and Difficulties Questionnaires, $r = -0.17$ to 0.39). A Spanish version was also validated by Vilte et al. (2016) on 297 children aged 9.53 ± 1.2 years old (50% of boys) recruited from communities.

8. *Dispositional Positive Empathy Scale*

The Dispositional Positive Empathy Scale (DPES) is a parent-reported 7-item scale for children. The questionnaire was originally developed in English by Sallquist and colleagues (2009), who validated it on 168 healthy subjects aged 4.5 years old (52.9%

of boys) recruited from maternity hospitals in the USA. The measure demonstrated good internal consistency (Cronbach's $\alpha = 0.81$) and adequate convergent validity with a task of observed positive empathy [43]. Similarly, convergence was reported with two subscales of Infant-Toddler Social and Emotional Assessment questionnaire (ITSEA, $r = 0.35$ to 0.43).

Previous empathy scales have focused on empathic responses to others' negative emotions, while positive empathy, i.e. an expression of happiness or joy that results from comprehending another person's positive emotional state or condition, has not been extensively investigated. However, according to Hoffman's theory [41], 3-year-old children are able to recognize and label positive emotion and show cognitive abilities necessary to empathize in the positive emotion eliciting situations. Measures that quantify positive empathy in children were previously limited to scarcely reliable picture-story tests. The DPES is, thus, the first questionnaire assessing positive empathy in children. The examination of the association between the positive and negative empathy is necessary, since positive affect has been related to benefits in a variety of domains of functioning [43].

9. *Empathy Quotient*

The Empathy Quotient (EQ), together with the Systemizing Quotient (SQ), was originally developed in English by Baron-Cohen and Wheelwright (2004), in order to examine trends in gender-typical behavior in adults. The two questionnaires contain a list of real-life situations, experiences and interests in which empathizing and systemizing (i.e. the drive to analyze, explore and construct a system) skills, respectively, are required. While the formers are usually stronger in females, males score show higher levels of the latter [44]. Interestingly, adults with high-functioning autism spectrum disorders scored extremely higher at the SQ compared to the EQ, thus providing further evidence for the so-called 'Extreme Male Brain' theory of autism.

The Adult EQ was then adapted in English by Auyeung and colleagues (2009) for Children (EQ-C) as a parent-reported questionnaire composed of 27 items and validated on 1256 healthy subjects aged 4 – 11 years old (46.3% of boys) recruited from

schools in the United Kingdom (UK). The measure showed excellent internal consistency (Cronbach's $\alpha = 0.93$). Also, test-retest reliability was examined on 258 participants that were asked to complete a second copy of the questionnaire with high intra-class correlation ($r = 0.86$). The questionnaire is also available for adolescents [46].

In addition, the adapted version of the questionnaire was also administered to parents of a cohort of 265 autistic children (82.6% of boys) recruited from clinical centers. Interestingly, the authors reported strongly significant differences between groups ($p < 0.001$), with typical girls scoring the highest, followed by typical boys and autistic children scoring the lowest [45], which further confirmed the 'Extreme Male Brain' hypothesis. Finally, divergent validity was reported with the Systemizing Quotient for Children ($r = -0.13$).

10. *Empathy Scale – Psychopathic Personality Inventory – Short Version*

The brief empathy scale (ES) proposed by Whitt and Howard (2013) consists of 5 items selected through exploratory factor analysis of the Psychopathic Personality Inventory–Short Version (PPI–SV) [48], a self-report instrument originally intended to assess empathy deficits and personality dimensions associated with psychopathy. Five factors were extracted from the 56 PPI–SV items in a sample of 688 antisocial adolescents (mean age \pm SD in the original sample = 15.5 \pm 1.2 years). Internal consistency was questionable (Cronbach's $\alpha = 0.69$), as also content validity as evidenced by convergent relations with the Brief Symptom Inventory ($r = 0.11$ to 0.30) and the Massachusetts Youth Screening Instrument ($r = 0.08$ to 0.21), and by divergence from the Antisocial Process Screening Device ($r = -0.18$ to -0.08).

Indeed, after a qualitative assessment of the content explored by the questionnaire, all five items could be easily interpreted as related to separation anxiety and interpersonal sensitivity (e.g. "Ending a friendship is (or would be) very painful for me"). To support this hypothesis, among measures assessed to support concurrent validity, the interpersonal sensitivity subscale of the Brief Symptom Inventory [49] showed the highest correlation coefficient ($r = 0.30$), followed by Global Severity Index ($r = 0.26$).

11. *Cognitive and Affective Empathy Scale*

The Cognitive and Affective Empathy Scale (TECA) was originally developed by López-Pérez and Fernandèz (2008) as a self-reported Spanish questionnaire for adults composed of 33 items, distributed across four subscales, namely Perspective taking, Emotional understanding, Personal distress and Empathic joy. While the former two subscales refer to cognitive facets of empathy, distinguishing the comprehension of points of view from that of emotions, the latter assess affective empathy taking into consideration the positive or negative valence of feelings involved.

The scale was first adapted as a self-report instrument for Basque speaking children and adolescents, aged 10 to 18 years old, by Gorostiaga and colleagues (2012) in a sample of 504 students, retaining 31 items. The original Spanish version of the scale was later validated by López-Pérez et al. (2014) in 670 subjects aged 10 to 16 years old, retaining 30 items. Both studies replicated the original four-factor structure in confirmatory analysis and showed adequate to good internal consistency.

12. *Empathy Questionnaire*

The Empathy Questionnaire (EmQue) is a parent-reported questionnaire for children composed of 20 items distributed across three subscales, respectively referring to the first three Hoffman's stages of empathy development ^[41]. While the first three levels of empathy in infants and young children are examined by the EmQue, the fourth level that develops in late childhood is not incorporated in the questionnaire. As extensively discussed in the main text, the first level refers to the Emotion Contagion, manifested by newborns' distress attending to others' emotions. The second level, allowed by the gradual development of self-other differentiation, perspective-taking and emotional regulation, is focused on the Attention to Others' Feelings, or, in other words, the awareness of someone else's emotions with less personal distress. At the third level, concern for others leads the child to react pro-socially and intervene on behalf of others (i.e. Prosocial Actions stage).

The scale was originally developed in Dutch by Rieffe and colleagues (2010), who validated it on 109 healthy subjects aged 1 – 5 years old (47.7% of boys) recruited from schools and day-care centers in the Netherlands. In its original validation, the scale

demonstrated questionable to good internal consistency, with Cronbach's alpha ranging from 0.58 to 0.80. Unfortunately, neither criterion-oriented nor convergent/divergent relations were assessed to further confirm the robustness of this measure.

An Italian version was validated by Grazzani et al. (2017) on 304 children, while a Spanish version was validated by Lucas-Molina et al. (2018) on 103 children. A new version of the Dutch scale, adapted for children and adolescents (EmQue - CA), was validated by Overgaauw and colleagues (2017) on 1250 subjects aged 10 - 15 years old: three subscales were identified a principal component analysis, i.e. affective empathy, cognitive empathy, and intention to comfort.

13. *Adolescent Measure of Empathy and Sympathy*

The Adolescent Measure of Empathy and Sympathy (AMES) is a self-reported questionnaire for adolescents composed of 12 items equally distributed across three subscales, respectively referring to sympathy and the affective and cognitive components of empathy. The scale was originally developed in Dutch by Vossen and colleagues (2015), who validated it on 450 healthy subjects aged 10 - 15 years old (50% of boys) recruited from households in the Netherlands.

The 3-factor structure was confirmed by both exploratory and confirmatory analyses with acceptable to good levels of internal consistency for each subscale (Cronbach's α ranging from 0.75 to 0.86). Test-retest reliability was confirmed on 248 participants of the initial sample ($r = 0.56$ to 0.69). The measure also proved good construct validity, demonstrated by criterion-oriented evidence of higher scores in females than males ($p < 0.01$), convergent relations with the IRI ($r = 0.21$ to 0.63) and with a Prosocial Behavior Scale ($r = 0.14$ to 0.50), and divergence from physical aggression behaviors [57]. A Turkish version was validated on 212 adolescents by Zengin et al. (2018), who confirmed the same internal structure of the questionnaire with questionable to acceptable levels of internal consistency for each subscale (Cronbach's α ranging from 0.63 to 0.75).

14. *Empathy and Theory of Mind Scale*

The Empathy and Theory of Mind Scale (EToMS) is a parent-reported questionnaire for children composed of 16 items nearly equally distributed across three subscales, respectively referring to Empathy, Nice and Nasty Theory of Mind. The scale was originally developed in Chinese by Wang and Wang (2015), who validated it on 189 healthy subjects aged 3 – 6 years old (50.8% of boys) recruited from schools in China. Both exploratory and confirmatory analyses established a 3-factor structure of the measure, with acceptable to good internal consistency for each subscale (Cronbach's α ranging from 0.71 to 0.83). Construct validity was demonstrated by criterion-oriented evidence of higher scores in females than males and convergent relations with experimental conditions aimed at eliciting social responses in children ($r = 0.21$ to 0.33).

Compared to previous child measures of empathy or theory of mind, this questionnaire is the first to provide a tool for simultaneous assessment of both constructs. Theory of minds and empathy are closely related on both psychological and neuronal grounds, and both undergo developmental changes throughout childhood and adolescence ^[59]. Both are perspective-taking capacities that are essential in maintaining a functional social relationship; however, while theory of mind concerns the understanding of the intentionality implied by propositional attitudes (the “cold” cognitive aspect of interpreting other people's intentions, desires and beliefs), empathy originates from emotional connectedness and physiological arousal, and is concerned with what it feels like for another person to experience a certain emotion or sensation (the “hot” affective aspect of prosocial behavior, morality, altruism and cooperation).

15. *Cognitive, Affective and Somatic Empathy Scales*

The Cognitive, Affective and Somatic Empathy Scales (CASES) for Children is a self-reported questionnaire for children composed of 30 items, equally distributed across six subscales, respectively referring to the affective, cognitive and somatic components of empathy, each with their positive and negative facets. The CASES was developed as the first empathy scale to include somatic empathy, according to Blair tripartite model of empathy ^[60], and the first instrument to differentiate cognitive,

affective, and somatic empathy into both positive and negative components.

The scale was originally validated in English by Raine and Chen (2018b) on 428 healthy subjects aged 11 – 12 years old recruited from communities in the USA, and in Chinese by Liu et al. (2018) on 860 children aged 11.54 ± 0.64 years old. Two confirmatory analyses ^[61,62] supported the tripartite structure of the questionnaire, with questionable to excellent internal consistency reported for the main subscales (Cronbach's $\alpha = 0.63$ to 0.91).

Construct validity of the measure was established based on higher scores in females compared with males. Moreover, the scale showed convergent relations with intellectual functioning (IQ) and divergent relations from the Reactive-Proactive Aggression Questionnaire ($r = -0.11$), Externalizing Behaviors of the Child Behavior Checklist and the Antisocial Process Screening Device ($r = -0.12$ to -0.39).

16. *Empathy Questionnaire*

The Empathy Questionnaire (EQ) is a self-reported questionnaire for children composed of 15 items equally distributed across five subscales, respectively referring to Emotional Contagion, Self-Other Awareness, Perspective-Taking, Emotional Regulation and Empathic Action. The scale was originally developed in Spanish by Richaud and colleagues (2017), who validated it on 479 healthy subjects aged 9 – 12 years old (46.3% of boys) recruited from schools in Argentina.

The five-factor structure of the scale was confirmed in both exploratory and confirmatory analysis, with acceptable internal consistency across each subscale (McDonald's ω ranging from 0.70 to 0.76). Convergence was shown with the Prosocial Behavior Scale ($r = 0.21$ to 0.79) and the IRI ($r = 0.32$ to 0.37), while divergence was reported from the Physical and Verbal Aggression Scale ($r = -0.18$ to -0.31) and the Emotional Instability Scale ($r = -0.24$).

The instrument was based on the model proposed by Decety and Jackson (2004), which develops on Hoffman's theory ^[41], and includes five dimensions of empathy in children (i.e. Emotion Contagion, Self-Awareness, Perspective Taking, Emotional Regulation and Empathic Action), integrating affective and cognitive components.

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