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Theory of mind disturbances in borderline personality disorder: A meta-analysis



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ABSTRACT

Impairments of theory of mind (ToM) are widely accepted underlying factors of disturbed relatedness in borderline personality disorder (BPD). The aim of this meta-analysis was to assess the weighted mean effect sizes of ToM performances in BPD compared to healthy controls (HC), and to investigate the effect of demographic variables and comorbidities on the variability of effect sizes across the studies. Seventeen studies involving 585 BPD patients and 501 HC were selected after literature search. Effect sizes for overall ToM, mental state decoding and reasoning, cognitive and affective ToM, and for task types were calculated. BPD patients significantly underperformed HC in overall ToM, mental state reasoning, and cognitive ToM, but had no deficits in mental state decoding. Affective ToM performance was largely task dependent in BPD. Comorbid anxiety disorders had a positive moderating effect on overall and affective ToM in BPD. Our results support the notion that BPD patients' have specific ToM impairments. Further research is necessary to evaluate the role of confounding factors, especially those of clinical comorbidities, neurocognitive functions, and adverse childhood life events. Complex ToM tasks with high contextual demands seem to be the most appropriate tests to assess ToM in patients with BPD.

1. Introduction

Borderline personality disorder (BPD) is a phenomenologically heterogeneous disorder characterized by affective, cognitive, behavioral, and interpersonal (i.e. disturbed relatedness) symptom areas

(APA, 2013). It is widely accepted that BPD patients' unstable relational style is of central importance (Gunderson, 2007), and other symptoms, such as impulsivity, self-harm, anger or emotional instability are consequences of, or triggered by the social, interpersonal context (Hepp et al., 2017; Brodsky et al., 2006; Kehrner and Linehan, 1996). Clinical

Abbreviations: ATT, advanced ToM test; BPD, borderline personality disorder; CAMS, cartoon-based assessment of mentalizing skills; EAT, expression attribution test; FER, facial emotional recognition; FBPST, false-belief picture sequencing task; FPT, faux pas task; HC, healthy controls; JAT, joke-appreciation task; MA, meta-analysis; MASC, movie for the assessment of social cognition; MDD, major depressive disorder; MDE, major depressive episode; MET, multifaceted empathy test; MSAT, mental state attribution tasks; NTT, non-verbal ToM tasks; RMET, reading the mind in the eyes test; TASIT, the awareness of social inference test; ToM, theory of mind

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research paid increasing attention to BPD patients' social dysfunctions during the past decades, and a growing body of data indicates that BPD patients have social cognitive deficits (Daros et al., 2013; reviewed by Roepke et al., 2013; Herpentz and Bertsch, 2014.). Theory of mind (ToM), (or mentalizing) is one of the essential components of social cognition. ToM is the ability to attribute mental states (i.e. beliefs, desires) to self and others, and to understand and predict their behaviors, intentions, and wishes (Baron-Cohen, 1995).

Hence, ToM is a multidimensional construct involving several dimensions. Sabbagh (2004) identified two processes of ToM: (1) detecting and discriminating cues in the immediate social environment, i.e. the ability to *decode* the mental states of others; and (2) making inferences about those cues, i.e. the ability to *reason* about the mental states of others. An additional distinction can be made between components of ToM: one component is involved in understanding others' intentions and beliefs (*cognitive* or 'cold' ToM), whereas the other one processes other people's feelings and emotions (*affective*, or 'hot' ToM). The findings of the functional brain imaging studies sustain the separate neurological underpinnings of ToM decoding and reasoning, as well as those of cognitive and affective ToM (Shamay-Tsoory et al., 2006; Sabbagh 2004). During the past years, increasing attention has been paid to the disassociations of processes and components of ToM in specific clinical populations. Several studies found intact or enhanced mental state decoding abilities together with a dissociation between decoding and reasoning abilities in BPD samples (Preissler et al., 2010; Baez et al., 2015; Zabizadeh et al., 2017). Harari et al. (2010) found a dissociation between cognitive and affective ToM in patients with BPD, but this dissociation was not replicated in later studies (Baez et al., 2015; Petersen et al., 2016). Recently, two studies using different ToM tasks in the same sample reported a decoupling of mental state decoding and reasoning abilities, as well as that of affective and cognitive ToM in BPD (Baez et al., 2015; Zabizadeh et al., 2017).

Clinical studies report common comorbidities in the BPD populations: e.g. 41–83% for major depressive disorder (MDD), 10–20% for bipolarity, 64–66% for substance misuse, 46–56% for post-traumatic stress disorder (PTSD), 23–47% for social phobia, 16–25% for obsessive-compulsive disorder, 31–48% for panic disorder, and 29–53% for any eating disorder (Lieb et al., 2004; Zanarini et al., 1998). Among these, MDD and PTSD have been found to negatively influence ToM performance in BPD patients (e.g. Unoka et al., 2015; Zabizadeh et al. 2017; Nazarov et al., 2014).

Until now, several studies have investigated ToM in BPD, but the results were controversial. Discrepant findings on ToM deficits in BPD might be caused by the low sample sizes, the variability of the ToM processes and components assessed, as well as the heterogeneity of the clinical samples mainly due to the co-morbidities. To resolve controversies, we conducted a quantitative meta-analysis (MA) of the existing data on ToM in BPD. So far, two meta-analyses of social cognition in BPD have been published. Daros et al. (2013) reviewed and meta-analyzed data on facial emotion recognition in BPD – involving 10 primary studies, while Richmann and Unoka (2015) aggregated and meta-analyzed ToM results of 5 studies. However, the latter publication comprised only studies using the Reading the Mind in the Eyes Test (RMET, Baron-Cohen et al., 2001) to assess ToM in BPD.

We outlined the following meta-analysis questions: Can overall ToM deficits be detected in BPD patients compared to healthy control subjects in a large, pooled sample derived from several studies? If so, how can we characterize BPD patients' ToM deficits within the various dimensions and subcomponents of ToM? Do demographic and clinical variables have an impact on ToM capacities of BPD patients? Does task type have an impact on the ToM results? Are there tasks particularly sensitive to assess BPD patients' ToM abnormalities?

2. Methods

2.1. Literature search and study selection

PRISMA guideline (Moher et al., 2009) was followed when conducting this MA. In agreement with other meta-analyses on ToM deficits in psychiatric disorders (recently reviewed by Cotter et al., 2018), electronic, peer-reviewed databases including PubMed, Scopus, PsychINFO, and Web of Science (from January 1990 to November 2017) were searched using keywords {"Theory of mind" OR "mentalizing" OR "social cognition"}, AND {"borderline personality disorder"}. The reference list of papers examined for eligibility criteria, as well as that of reviews on social cognition in BPD, were also reviewed for additional publications.

The initial search strategy yielded 697 studies. After filtering duplicates, 445 studies were screened for eligibility criteria. Studies were selected if they (i) investigated ToM performances of patients with BPD fulfilling DSM-IV criteria confirmed by the Structured Clinical Interview for DSM-IV Axis II Personality Disorders (SCID-II, First et al., 1997) (ii) included healthy comparison groups, (iii) used well-established, valid, and widely used ToM tests, and (iv) presented appropriate data to determine effect sizes and variances. All identified publications were reviewed and data were extracted by two authors (N.N. and M.S.) independently. Inconsistencies of study selection and data extraction were discussed. A discrepancy of data extraction appeared with regard to one publication (5%); nonetheless, it was resolvable: after discussion, there was a 100% agreement on data extraction.

Reasons for exclusion were: participants with no or with not sufficiently established diagnosis of BPD ($n = 4$), no healthy comparison group ($n = 4$), no eligible ToM tasks ($n = 3$), overlapping sample ($n = 1$), mixed clinical sample ($n = 2$). We did not include studies with adolescent samples ($n = 4$), because ToM skills are known to be developing during that age (Sharp et al., 2013; Blackmore 2012); therefore, adding adolescent samples to the MA with adults would have substantially increased the heterogeneity. Regarding the commonly co-occurring psychiatric comorbidities in BPD, samples with typical psychiatric comorbidities (e.g. MDD, PTSD, eating disorders, anxiety disorders, and other personality disorders) were not excluded from the meta-analysis. Fig. 1 presents the flowchart of the study selection process. We also contacted authors for unreported data and missing information.

Seventeen studies involving 585 patients with BPD, as well as 501 healthy controls (HC) passed the inclusion criteria (Table 1). There was no significant between-group difference for age ($d = -0.06$, $CI = -0.18$ to 0.06 , $z = -0.97$, $p = 0.33$). The percentage of males was higher in the HC groups (11.99%) than in the BPD groups (9.2%), and there was a significant difference for gender between BPD and HC across the studies ($RR = 1.18$, 95% $CI = 1.04$ to 1.35 , $z = 2.49$, $p < 0.05$). Therefore, gender was added as a moderator to the analysis.

2.2. ToM measures

The most frequently applied ToM task was the Reading the Mind in the Eyes Test (RMET, Baron-Cohen et al., 2001) that measures the ability of *mental state decoding* ($N = 8$). In RMET, a series of photos presenting only the eye region is shown, and participants are instructed to pick one from four words presented simultaneously with the eyes to best describe the emotional state of the person in the photo. However, partially based on neuroimaging studies, where RMET has been found to be related to amygdala activation (e.g. Russel et al., 2009), it is widely used as a measure of affective ToM as well.

Other tasks assessed the *mental state reasoning* abilities: Faux Pas Task (FPT, Stone et al., 1998) was used in 5 studies; in 2 other studies, ToM was measured with Happé's Advanced theory of mind test (ATT, Happé, 1994). In addition, several ToM cartoons, the Multifaceted Empathy Test (MET), the cognitive empathy subtest of which is

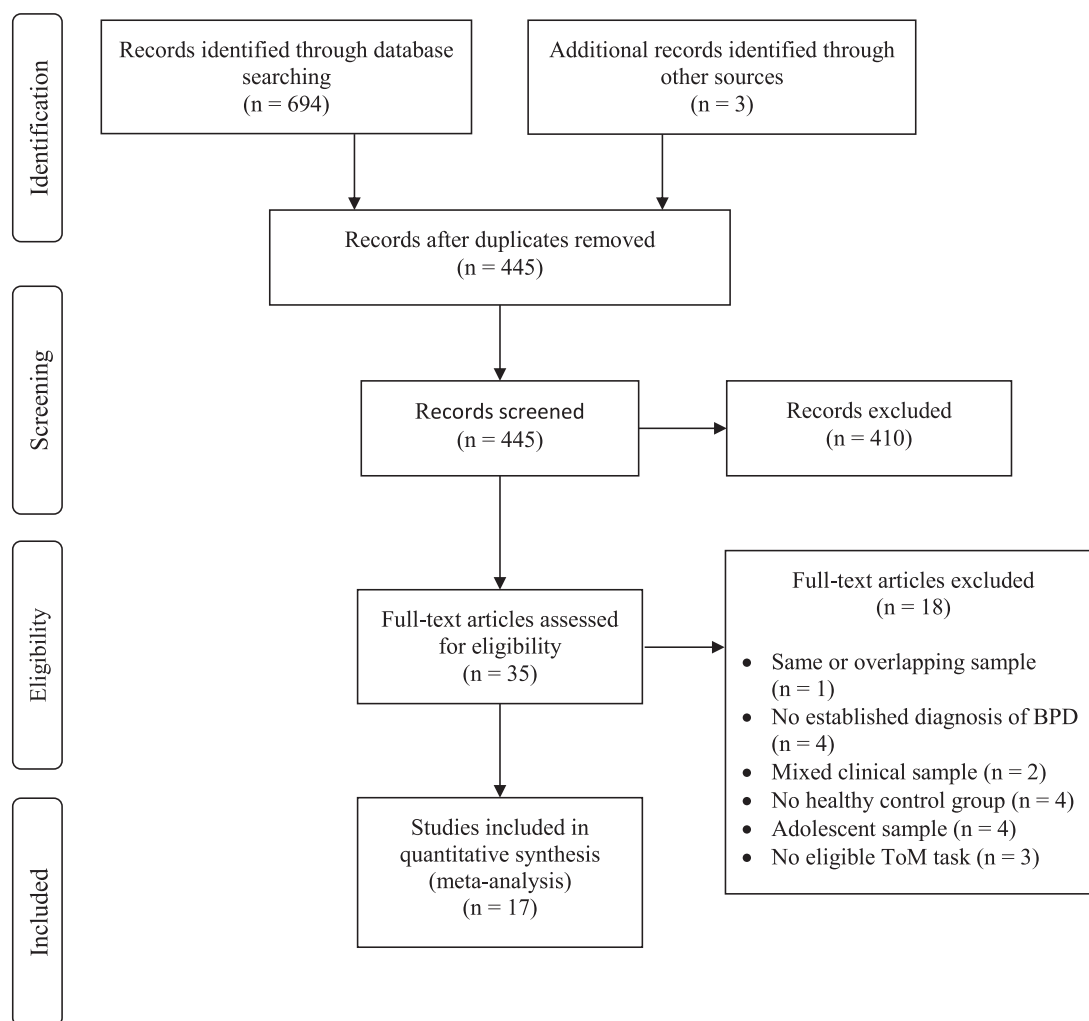


Fig. 1. Flowchart of the study selection process.

considered to measure affective ToM capacities (Dziobek et al., 2008), as well as the Movie for the Assessment of Social Cognition test, which is an ecologically valid, video-based ToM task (MASC, Dziobek et al., 2006) and another video-based ToM test, the Awareness of Social Inference Test (TASIT, McDonald et al., 2003) were applied in the selected studies for measuring mental state reasoning.

For a subsequent analysis, we subgrouped the existing ToM data into cognitive and affective components of ToM. It is widely accepted in ToM research that specific ToM tests (or their subscores) are considered as measures of affective or cognitive ToM. There is agreement that RMET predominantly measures the capacity to understand others' emotions and feelings (e.g. Petersen et al., 2016; Zabizadeh et al. 2017), while false belief tests or ATT assess the capacity to understand others' beliefs and intentions. However, some more complex ToM tests (e.g. FPT, MASC, CAMS) contain questions for both affective and cognitive ToM. In case of the latter tests, if data were available, we calculated with the cognitive and affective scores separately. (Supplementary Table 1 presents the complete list of ToM tests and the subscores that were used for calculating affective and cognitive ToM).

2.3. Data analysis

We conducted a meta-analysis on the results from the different studies using an aggregate data approach. Negative effect sizes indicated poorer performance of the BPD group relative to the healthy group. For studies that reported more than one ToM task, within-study

effect sizes and variances were aggregated by the Gleser and Olkin (1994) procedure. First, a meta-analysis for overall ToM was conducted using aggregated effect sizes across all studies.

Then, we performed separate categorical random-effects meta-analyses for the two main ToM processes: for mental state decoding (i.e. RMET only), and for mental state reasoning (any other ToM task used in the studies). Effect sizes for the different valences of RMET (neutral, positive, negative) were also counted.

Subsequently, meta-analyses of affective and cognitive ToM were performed (Supplementary Table 1). Then, MAs for predominantly verbal, visual, and multimodal ToM tasks were conducted. If there were at least 4 studies reporting data on a particular task, then a separate, task-specific MA was also conducted (Fu et al., 2011). Individual task analysis was possible for FPT ($n = 5$). In addition, effect sizes for RMET ($n = 8$, as mental state decoding), cartoons (contents differ, $n = 4$), as well as for MASC ($n = 4$) were calculated.

All statistical analyses were performed in R environment (R Development Core Team, 2015; Del Re and Hoyt, 2010) with the Metafor (Viechtbauer, 2010) and the MAD packages (Del Re and Hoyt, 2010). Effect sizes were weighted using the inverse variance method. Because studies in the MA are not supposed to share a common effect size, random effects model with DerSimonian–Laird estimate was used to calculate summary effect sizes (DerSimonian and Laird, 1986). The homogeneity of the distribution of the weighted effect sizes was examined with the Q and I^2 tests (Hedges and Olkin, 1985). Between-study heterogeneity in the random effects model was estimated with

Table 1
 Characteristics of included studies.
 BPD = Patients with borderline personality disorder, HC = Healthy controls, ToM = Theory of mind, MDD = Major depressive disorder, PTSD = Posttraumatic stress disorder, Edu = Educational level, ATT = Happé's advanced theory of mind test, RMET = Reading the mind in the eyes test, MSAT = Faux pas test, MSAT = Mental state attribution tasks (Brüne, 2005), MASC = Movie for the assessment of social cognition, MET = Multifaceted empathy test, cognitive empathy score, JAT = "Joke-appreciation" task, EAT = "Shortened version of the expression attribution test (Langdon et al., 2006), FBPST = False-belief picture-sequencing tasks (Langdon and Coltheart, 1999), CAMS = Cartoon-based assessment of mentalizing skills (Dimaggio and Brüne, 2010); NTT: Non-verbal ToM tasks (Happé et al., 1999; Gallagher et al., 2000), TASIT: The awareness of social inference test.

Study	Sample (female)	BPD–HC	Matched for	ToM tasks	Characteristics of BPD group					Outcome
					Mean age	MDD% (lifetime)	PTSD%	Medication status	Medication status	
Arntz et al. (2009)	16(16)–28(28)		Age, gender, IQ	ATT	30.5	–	–	–	–	No difference
Fertuck et al. (2009)	30(26)–25(15)		Age, edu	RMET	29.8	56.7 (76.7)	30	13.3%	–	BPD > HC
Harari et al. (2010)	20(18)–22(19)		Age, edu, gender, IQ	FPT	32.1	0	0	–	–	FP recognition, cognitive FP: BPD < HC, affective FP: no difference
Ghiassi et al. (2010)	50(46)–20(13)		Age	MSAT	26.2	–	–	–	–	No difference
Preissler et al. (2010)	64(64)–38(38)		Age, gender, IQ	MASC, RMET	29.2	12.5 (42.2)	35.9	32.8%	–	MASC: BPD < HC RMET: no difference
Dzibek et al. (2011)	21(21)–21(21)		Age, gender, IQ	MET	31.7	19 (28.6)	38.1	–	–	BPD < HC
Schilling et al. (2012)	31(30)–27 (12)		Age, edu	RMET	27.3	67.7	16.1	80.6%	–	No difference
Frück et al. (2012)	21(21)–20(20)		Age edu, gender	RMET	21.7	23.8 (47.6)	33.3	0%	–	BPD > HC
Wingenfeld et al. (2014)	38(38)–35(35)		Age, gender	MASC, MET	24.3	23.7	13.2	0%	–	No difference
Unoka et al. (2015)	78(74)–76(69)		Age, edu, gender	RMET	29.9	43.6	5.1	majority of the sample	–	BPD < HC
Vaskinn et al. (2015)	25(25)–25(25)		Age, edu, gender	MASC	30.7	52	12	–	–	No difference in overall score (overmentalizing errors: BPD > HC)
Baez et al. (2015)	15(12)–15(13)		Age, edu, gender	FPT, RMET	38.4	26.7	0	–	–	FP: BPD > HC RMET: no difference
Andreou et al. (2015)	44(38)–38(22)		Age	MASC	29	61,4	0	–	–	BPD < HC (overmentalizing errors)
Petersen et al. (2016)	19(18)–20(19)		Age, gender, IQ	RMET, JAT, FPT, EAT, FBPST	32.5	0	52	94.7%	–	BPD < HC only in more complex tasks (FP, JAT)
Brüne et al. (2016)	30(30)–30(30)		Age, edu, gender	CAMS	25.7	–	–	63.3%	–	BPD < HC
Yeh et al. (2017)	40(37)–36(33)		Age, edu, gender	FPT, ATT, NTT, TASIT	30.9	–	–	–	–	NTT, TASIT: BPD < HC ATT, FP: no difference
Zabihzadeh et al. (2017)	44(21)–25(12)		Age, edu, gender, IQ	RMET, FPT	26.2	50	34.1	–	–	RMET: BPD only > BPD + MDD > HC FP: HC > BPD only > BPD + MDD

tau-squared (τ^2), an estimate of the total amount of heterogeneity.

Publication bias was estimated with the Fail-safe N test, and tests for assessing funnel plot asymmetry. Fail-safe N test computes a pooled *p*-value for all studies in the MA and calculates how many further studies with a zero effect would be necessary to generate a non-significant *p*. Egger's test and Begg and Mazumdar's test rely on the assumption that studies with small sample sizes are more often published if they report significant results, while studies with large sample sizes are usually published regardless of significant findings.

Meta-regression analyses were conducted for age, gender (the ratio of females in the BPD group compared to that in the HC group), and education (years), as well as for clinical comorbidities (current MDD, anxiety disorders [=panic disorder + phobias + generalized anxiety disorder], social phobia, PTSD, any eating disorder, and substance use disorder) (Supplementary Table 2). Other personality disorders, symptom severity of current depression, childhood trauma, and neurocognitive functions were also considered, but there were no sufficient data available to add them to the analysis. In the moderator analyses, we used study-level continuous measures only when they were published in at least 7 studies (Fu et al., 2011). Categorical subgroup variables were used only when each subgroup had a minimum of 4 studies (Fu et al., 2011). For continuous moderators, analyses with a linear mixed effects model, for categorical variables, subgroup analyses were conducted. Q_{bet} -test was used to compare the effect sizes of the subgroups (Borenstein et al., 2009).

3. Results

The summary of the main meta-analysis results is presented in Table 2, and Supplementary Fig. 1. (Negative effect sizes indicates poorer performance of the BPD group.)

3.1. Overall ToM

Overall ToM performance ($n = 17$) was significantly impaired in the BPD group compared with the HC group, but the effect size was low ($d = -0.2, p = 0.01$) (Fig. 2, Table 2). Because there was high heterogeneity for the distribution of effect sizes for the total ToM score, further moderator analyses were conducted. No publication bias was found.

Table 2

Mean weighted effect sizes for differences between patients with BPD and healthy controls on ToM.

ToM test	St. N	BPD N	HC N	<i>d</i>	95% CI	<i>z</i>	<i>p</i>	Q-test (<i>p</i>)	τ^2	Egger (<i>p</i>)	Begg (<i>p</i>)	Fail safe N
ToM total	17	585	501	-0.27	-0.48, -0.06	-2.56	0.01	<0.0001	0.13	0.09	0.09	134
ToM process												
Decoding (=RMET)	8	302	246	0.12	-0.28, 0.51	0.59	0.55	<0.0001	0.25	0.31	0.40	N.A.
Positive	7	287	231	-0.008	-0.43, 0.41	-0.04	0.97	0.004	0.26	0.34	0.38	N.A.
Neutral	7	287	231	-0.33	-0.97, 0.31	-1.01	0.91	<0.0001	0.66	0.96	0.77	N.A.
Negative	7	287	231	0.7	-0.06, 1.46	1.8	0.07	<0.0001	0.97	0.1	0.07	N.A.
Reasoning	13	425	353	-0.61	-0.87, -0.35	-4.60	<0.0001	<0.0001	0.16	0.62	0.59	244
ToM content												
Affective ToM	12	410	354	-0.17	-0.48, 0.15	-1.03	0.30	<0.0001	0.24	0.53	1.00	N.A.
Aff. ToM without RMET	7	206	181	-0.62	-0.87, -0.38	-4.95	<0.0001	0.18	0.04	0.09	0.24	57
Cognitive ToM	9	290	244	-0.44	-0.71, -0.17	-3.20	0.001	0.007	0.10	0.88	0.46	57
Task type												
Visual	13	481	388	-0.14	-0.44, 0.16	-0.93	0.36	<0.0001	0.23	0.26	0.25	N.A.
RMET (=decoding)	8	302	246	0.12	-0.28, 0.51	0.59	0.55	<0.0001	0.25	0.31	0.40	N.A.
Cartoons	4	139	106	-0.59	-0.88, -0.31	-4.09	<0.0001	0.24	0.02	0.48	0.75	22
Verbal	6	154	146	-0.81	-1.46, -0.17	-2.48	0.01	<0.0001	0.55	0.49	0.72	55
Faux pas task	5	138	116	-1.07	-1.65, -0.5	-3.68	0.0002	0.0008	0.33	0.33	0.48	69
Videos	5	209	172	-0.52	-0.79, -0.25	-3.74	0.0002	0.09	0.05	0.80	1.00	33
MASC	4	169	136	-0.46	-0.77, -0.15	-2.92	0.0035	0.09	0.05	1.00	1.00	16

ToM = Theory of mind, St. = Studies, BPD = Borderline personality disorder, HC = Healthy controls, *d* = Cohen's *d*, RMET = Reading the mind in the eyes test, MASC = Movie for the assessment of social cognition test.

3.2. Mental state decoding versus reasoning

Mental state decoding (separate analysis of RMET only, $n = 8$): We found no significant effect size for overall accuracy in RMET ($d = 0.12, p = 0.55$). The distribution of the effect sizes was significantly heterogeneous (Fig. 3, Table 2). Data on RMET were further analyzed for valence types (positive, negative, and neutral, $n = 7$). Results showed no significant between-group differences for positive ($d = -0.02$), and for neutral valences ($d = -0.33$); heterogeneities were significant. Nevertheless, there was a trend level significant difference between BPD patients and HCs for the negative valence: $d = 0.7 (p = 0.07, heterogeneity was significant) (Supplementary Fig. 2).$

Mental state reasoning abilities were significantly impaired in BPD ($d = -0.61, p < 0.001, n = 13$) (Fig. 4, Table 2).

BPD patients' mental state reasoning deficits were more robust compared to the mental state decoding abilities ($Q_{bet} = 9.89, p < 0.05, n = 13 + 8$).

3.3. Affective versus cognitive ToM

Affective ToM ($n = 12$): Patients with BPD did not differ in their affective ToM abilities compared to HCs ($d = -0.17$) (Fig. 5). After removing RMET data from data on affective ToM, we calculated an effect size for the 'affective ToM without RMET' subgroup. (Supplementary Fig. 3) Here, we found that BPD patients significantly underperformed HC in affective ToM tests ($n = 7, d = -0.62, p < 0.001$), if RMET data (i.e. data of affective decoding or discrimination) were removed from the subset of affective ToM data.

Cognitive ToM ($n = 9$): Patients with BPD performed significantly worse in cognitive ToM tasks ($d = -0.44, p = 0.01$) (Fig. 6, Table 2).

However, there was no significant difference between BPD patients overall affective and cognitive ToM deficits ($Q_{bet} = 1.54, df = 1, p = 0.21, n = 12 + 9$). Similarly, there was no significant difference between affective ToM without RMET and cognitive ToM ($Q_{bet} = 1.06, p = 0.3, n = 7 + 9$).

3.4. The effect of task types

We reanalysed data by task types, and calculated effect sizes for predominantly visual ($n = 13, d = -0.14, p = 0.36$), verbal ($n = 6, d = -0.81, p = 0.01$), and multimodal (i.e. video-based; $n = 5, d = -0.52, p < 0.001$) ToM tasks. The comparison of performances in

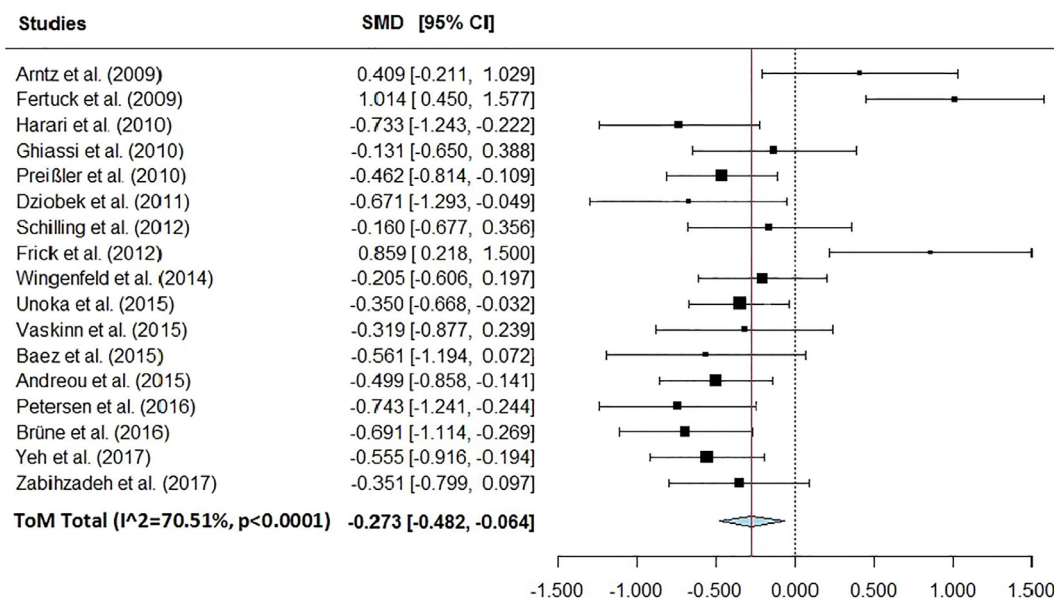


Fig. 2. Forest plot for meta-analysis of overall ToM (theory of mind) in BPD (borderline personality disorder). Negative effect size indicates poorer performance of the BPD group.

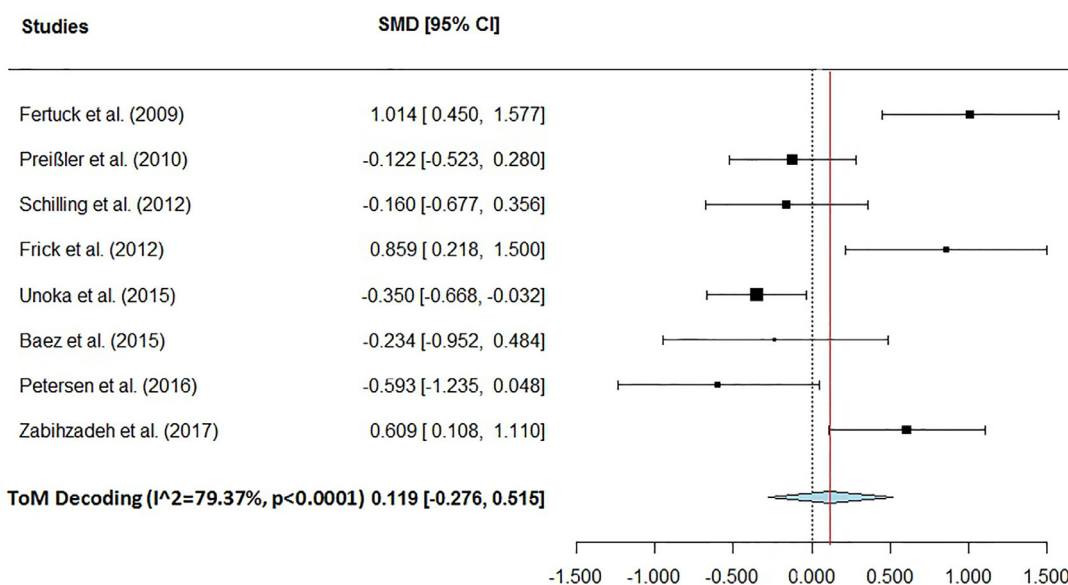


Fig. 3. Forest plot for meta-analysis of mental state decoding in BPD (borderline personality disorder). Negative effect size indicates poorer performance of the BPD group.

the three task types revealed that BPD patients performed significantly worse in verbal than in visual tasks ($Q_{bet} = 4.61, p < 0.05$). (Table 2).

To explore the origin of BPD patients' relatively good performance in visual tasks, we ran a separate MA with data of visual tests without RMET (i.e. cartoons and MET, $n = 6$), and found a significant effect size: $d = -0.54, p < 0.001, 95\% \text{ of CI: } -0.76 \text{ to } -0.33, z = -4.83, I^2 = 16.34\%, \tau^2 = 0.012$. The heterogeneity was substantially reduced compared with the MA of the composite visual tests. BPD patients' ToM deficit in visual tasks without RMET was more robust compared to that in RMET ($Q_{bet} = 6.7, p = 0.01, n = 8 + 6$).

In individual task analyses, there was no significant deficit in BPD patients' accuracy in RMET ($d = 0.12, n = 8$, see above by mental state decoding); however, there were significant impairments of BPD patients in performing the FPT ($d = -1.07, p < 0.001, n = 5$), the ToM cartoons ($d = -0.59, p < 0.001, n = 4$), as well as the MASC

($d = -0.46, p < 0.001, n = 4$). (Table 2) When comparing ToM impairments in the individual task types pairwise with post hoc Holm-modified Tukey procedure, we detected significant difference only between the RMET and FPT ($d = 1.18 \pm 0.29, z = 4.12, p < 0.001$).

3.5. Meta-regression analyses

In the meta-regression analyses, there was no moderating effect of age, education, and gender (the ratio of females in the BPD group compared to that in the HC group). However, the summed rate of panic disorder, generalized anxiety disorder, and phobias ($n = 9$) had a significant positive effect on BPD patients' ToM performance compared to HC ($z = 2.11, p < 0.035$, the proportion of total between-study variance explained by model: $R^2 = 0.32$). Also, the summed prevalence rate of panic, generalized anxiety disorders and any phobias ($n = 9$)

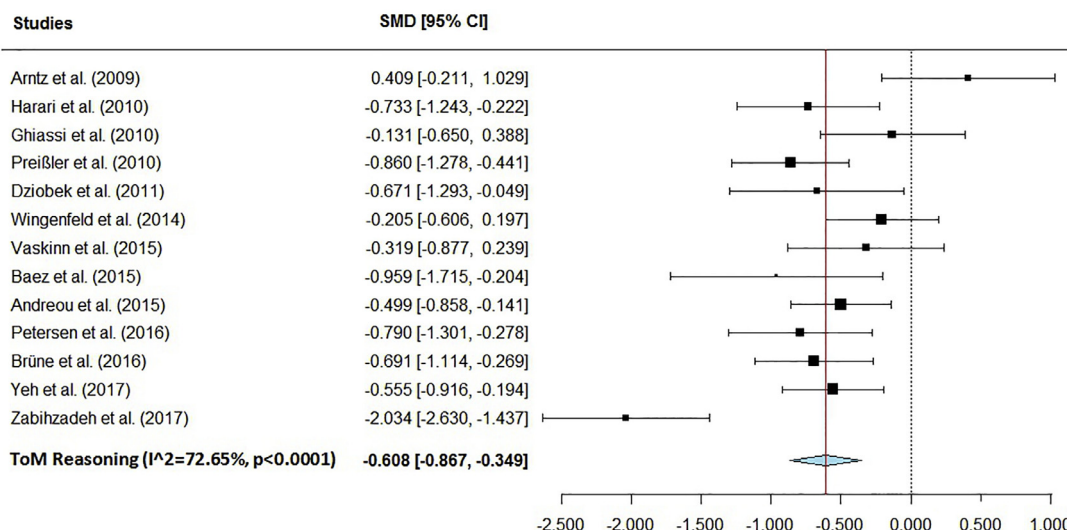


Fig. 4. Forest plot for meta-analysis of mental state reasoning capacities in BPD (borderline personality disorder). Negative effect size indicates poorer performance of the BPD group.

had a significant positive effect on BPD patients’ affective ToM performance compared to HC ($z = 2.06, p < 0.04$, the proportion of total between-study variance explained by model: $R^2 = 0.34$). There was no other significant relationship between any other comorbidity variables and ToM performances.

4. Discussion

4.1. Main results

The main finding of our MA is that BPD patients are significantly impaired in their overall ToM capacities compared to HC; however, the effect size was relatively small.

Another important finding of the present study is that BPD patients’ mental state decoding capacities (measured by RMET) do not significantly differ from those of HCs. In contrast, BPD patients’ mental state reasoning was found to be significantly worse compared to HC subjects. Q_{bet} test revealed that deficits of the mental state reasoning

were significantly poorer than those of mental state decoding in BPD (**Supplementary Fig. 1**).

RMET contains subtle emotional information that taps a wider range of mental states beyond the basic emotions. However, during RMET, participants should put themselves into the situation of the person presented in the photograph, therefore RMET assesses ToM capacities. Requiring no inferences about cognitive and affective mental contents, as well as no contextual processing, RMET is regarded as an appropriate task to measure the initial, decoding (or discriminating) ToM processes, predominantly the decoding of subtle facial affective cues. A recent MA collapsing RMET performances across 5 studies reported significantly impaired RMET accuracy in neutral valences in BPD patients, while co-occurring MDD enhanced their performance in general, and on positive valence scores (Richman and Unoka, 2015). In our more extended MA ($n = 8$), we could not replicate this finding: we found no moderating effect of the current major depressive episode (MDE), and only BPD patients’ slightly enhanced accuracy in negative valences could be detected (significant at the trend level).

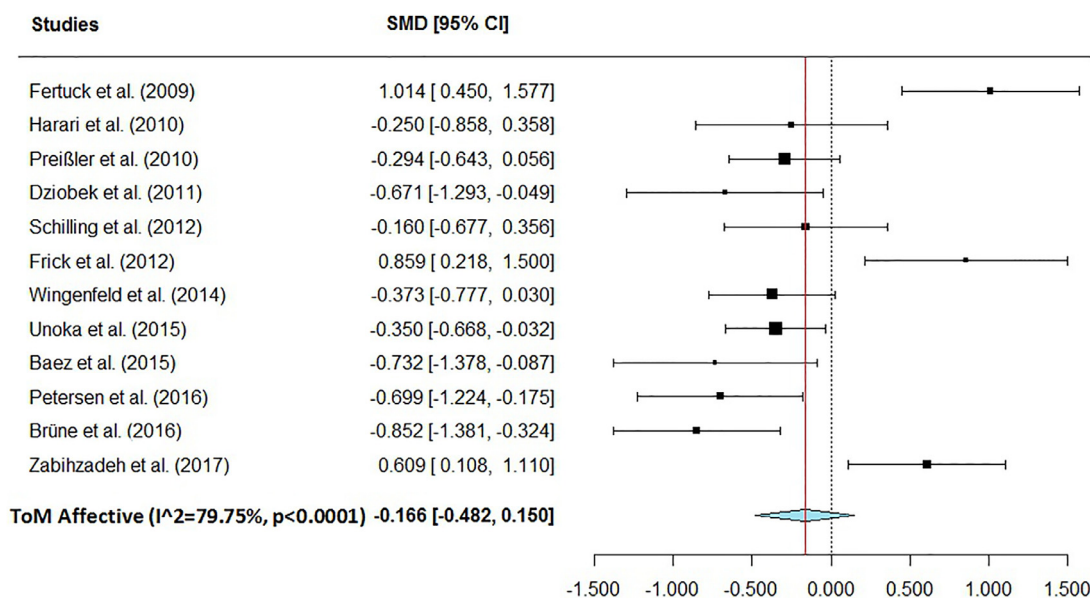


Fig. 5. Forest plot for meta-analysis of affective ToM (theory of mind) in BPD (borderline personality disorder). Negative effect size indicates poorer performance of the BPD group.

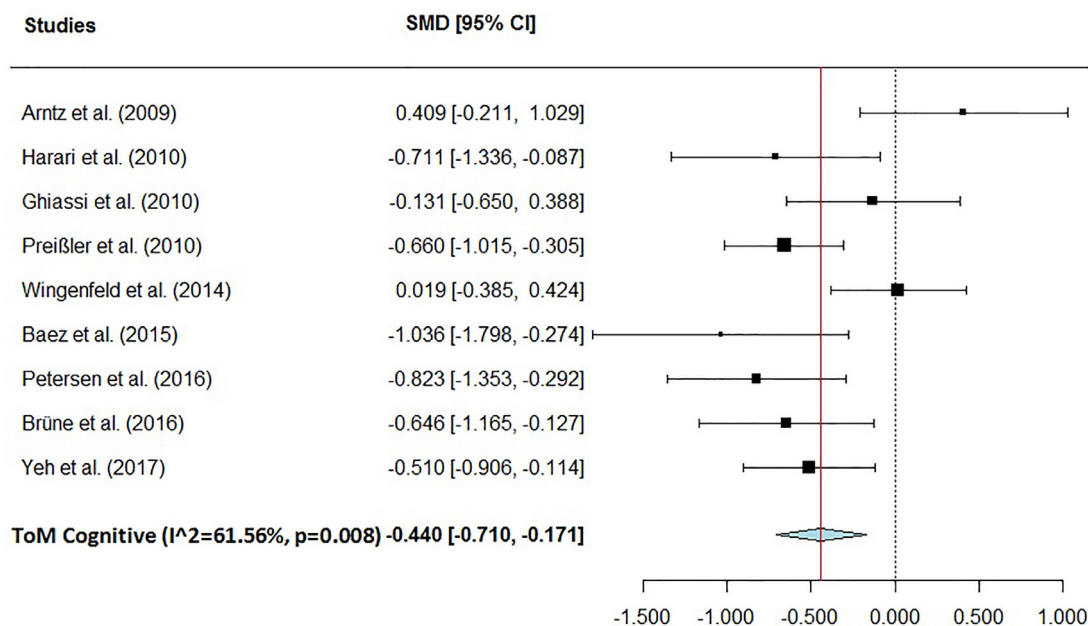


Fig. 6. Forest plot for meta-analysis of cognitive ToM (theory of mind) in BPD (borderline personality disorder). Negative effect size indicates poorer performance of the BPD group.

The latter result is in accord with theories about BPD patients’ sensitivity to negative stimuli, which seems to be characteristic of BPD independently of co-existing depression. BPD patients’ relative sensitivity for other peoples’ negative mental states is in agreement with the amygdalar hyper-reactivity and altered functional connectivity observed in functional neuroimaging studies during RMET and facial emotion recognition tasks (Frick et al., 2012; Donegan et al., 2003; Minzenberg et al., 2007; Cullen et al., 2011). Our results also fit well to the theory of Fonagy and Bateman (2008): BPD patients who grow up in a non-reflecting, non-validating, and often abusing family environment develop an increased emotional vigilance to social stimuli, especially to those with negative emotional content. Nevertheless, BPD patients’ ToM abilities are just partially developed, since their reflexive awareness is low, and their mental state reasoning abilities are significantly impaired.

However, findings with RMET in BPD were rather inconsistent, which was basically due to three studies: in each, BPD patients overperformed normal controls. The first study by Frick et al. (2012) comprised only non-medicated females with a relatively low BDI score and less severe comorbid psychopathology in the BPD group. The second study by Petruck et al. (2009) recruited patients from the acute setting with more severe co-morbid psychopathologies including numerous suicide attempters. Here, the percentage of males was significantly higher in the HC than in the BPD group. In the third study by Zabizadeh et al. (2017), 50% of the BPD patients suffered from clinically relevant MDD, and the patients were recruited mainly from the acute settings. In this study, the proportion of males was exceptionally high but there were no between-group differences in gender ratio. In sum, neither the setting where the patients were recruited, nor the severity of the comorbid psychiatric pathologies, nor the gender ratio of the groups could ultimately explain the relatively good performance of the BPD groups in these studies. Thus, our present MA proposes that the between-study variability of the RMET results seems to be multifactorial, as no consistent reason for the heterogeneous RMET performances could be found. Finally, although no data are available, one cannot exclude the hypothetical role of subtle between-study differences of RMET procedure that could contribute to the extent to which studies implicitly activated a reasoning component to the decoding task.

Furthermore, we detected BPD patients’ impaired cognitive ToM

capacities, while their affective ToM abilities were relatively preserved. Based on that, one can presume that BPD patients’ interpersonal difficulties are mainly due to their deficits in cognitive ToM. This finding can be in agreement with the theoretical framework of the dissociability of affective and cognitive mentalization (Fonagy et al., 2012). Fonagy and Bateman indicate that different forms of psychopathological states are related to the inhibition, deactivation, or simply dysfunction of either the cognitive or the affective or both aspects of mentalization. Patients with BPD are typically overwhelmed by automatic and affect-driven mentalizing, but they have difficulties in integrating the affective experiences with reflective and cognitive knowledge. Nevertheless, the latter clinical observation can be in line with our meta-analysis of affective ToM subgroups. After reanalyzing our affective ToM data without RMET, we found that BPD patients significantly underperformed HC in affective ToM tasks. Accordingly, we can suppose, that BPD patients relatively intact affective ToM capacities are attributable to their affective decoding and discriminating capacities measured by RMET.

However, when we compared BPD patients’ cognitive and overall affective ToM deficits with Q_{bet} test, BPD patients’ cognitive ToM deficits were not significantly worse than that of their overall affective ToM. Notably, we got a similar result when we compared affective ToM without RMET with cognitive ToM. Thus, we should carefully interpret our MA results with affective and cognitive ToM, especially because the number of studies that published affective and cognitive ToM scores separately was low. Future research with simultaneous affective and cognitive ToM measures is needed to understand the exact nature of dissociation of affective and cognitive ToM in BPD.

4.1. The effect of comorbidities on ToM in BPD

The summed rate of DSM-5 anxiety disorders (primarily panic disorder, agoraphobia, specific phobia, social anxiety disorder, and generalized anxiety disorder) has been proofed to have a positive effect on BPD patients’ overall ToM performance and their affective ToM abilities. Among the anxiety disorders, social anxiety disorder presents most typically social dysfunctions and interpersonal difficulties. In a handful of studies that have been published so far, patients with social anxiety disorder were found to have various deficits of ToM decoding and reasoning (Washburn et al., 2016; Buhlmann et al., 2015; Hezel and

McNally, 2014). Interestingly, no significant relationship could be detected between comorbid social anxiety disorder and ToM in our MA. Similarly to the summed prevalence of anxiety disorders, only study-level data (from 9 studies) were available, with no measures of current, individual symptom severity.

A very recent study reported that patients with generalized anxiety disorder displayed more accurate mental state reasoning capacities compared to HC, especially when they suffered from an increased worry (Zainal and Newman, 2017). Although there are no data in the literature about ToM capacities in panic disorder, agoraphobia, or simple phobia, one can assume that worry, concern, and continuous anticipatory anxiety can induce a state of hypervigilance, where people have an increased need for contact with and support from others. These factors might enhance BPD patients' interpersonal sensitivity and ToM capacities if they have comorbid anxiety disorders. Nevertheless, further research is needed to specify the effect of comorbid anxiety disorders in BPD on ToM capacities.

In contrast to previous findings in BPD patients with comorbid depression, our meta-regression analyses did not reveal any effect of comorbid MDD, neither on overall ToM performance nor on any other ToM dimensions or components. There is some evidence for enhanced ToM abilities in non-clinical samples with dysphoria (measured by Beck depression inventory, dysphoria scored > 12) (Harkness et al., 2005; Harkness et al., 2010). Nonetheless, no studies included in our MA measured subthreshold or subclinical depression.

4.2. The effect of task type

Verbal and multimodal task types revealed significantly impaired ToM in BPD. For visual tasks, however, there was no significant difference between BPD patients' and HCs' ToM performance. Presumably, the latter result was due to the effect of RMET. When visual tasks were reanalyzed without RMET, BPD patients were found to be significantly impaired in visual tasks. In addition, BPD patients showed significantly fewer impairments in RMET than in other visual tasks (i.e. cartoons + MET).

Meta-analyses results of individual task types were more consistent than those of subgroups by the predominant modality of stimuli, and revealed, that except RMET, all other test types detected ToM deficits in BPD patients. The largest effect size was found with the FPT, while MA for overall verbal tasks, cartoons with different content, movies, and MASC yielded medium effect sizes.

Accordingly, the FPT seems to be the most demanding ToM task for BPD patients. FPT (Stone et al., 1998) comprises stories describing complex social situations, where a character commits a conversational failure by saying something (s)he should not say or saying something awkward. The FPT encompasses high contextual demands and requires implicit integration of cognitive inferences about mental states. Moreover, the FPT is purely verbal, thus patients with BPD cannot rely on their enhanced sensitivity to non-verbal emotional stimuli while performing the FPT.

Several types of ToM cartoons were used in studies involved in our MA, in which participants needed understand social situations presented in the cartoons and represent the characters' mind, in order to find chronological order, or understand irony, humor, and false beliefs. BPD patients were found to underperform HCs in more complex cartoon tasks (e.g. CAMS, Dimaggio and Brüne, 2010; or JAT, Langdon et al. 2006) where not only cartoon sequencing but a subsequent answering of questions about the cartoon characters' mental states, or integration of multiple perspectives to decipher humour were also required (Brüne et al., 2016; Petersen et al., 2016).

In sum, all tasks with a higher level of complexity detected ToM impairments in BPD patients. In BPD research, several authors emphasize the importance of ToM tasks with high ecological validity (Minzenberg et al., 2006; Dyck et al., 2009; Baez et al., 2015; Roepke et al., 2013). Displaying real-life situations, the multifaceted empathy

test (MET), as well as the video-based ToM tasks (MASC, TASIT), are regarded as ecologically valid. Especially, video-based tasks entail the integration of several cues from faces, gestures, and prosody, along with those of the social context. Of note, MASC is unique, because it measures several forms of mentalizing errors (i.e. hypomentalizing, hypermentalizing). So far, only 4 studies have used MASC in ToM research in adults with BPD. Further research is recommended using MASC in BPD patients to evaluate how sensitively MASC detects specific hypermentalizing tendencies in BPD.

4.3. Limitations

Unexpectedly, meta-regression analyses revealed no moderating effect of the comorbid MDE and PTSD. Since no sufficient data on the individual symptom severity of depression were available, we conducted the analyses with study-level data. Hence, it was not possible to disentangle or weight the effect of mild and severe comorbid depression on ToM. Neither, we detected the moderating effect of comorbid PTSD. Similarly to MDE, only the percentage of comorbid PTSD in the samples, but no other clinical variables (such as symptom severity, chronicity or acuteness, co-occurrence with dissociative symptoms, time and nature of the traumatic event, etc.) were available. There is increasing evidence that adverse childhood life events and insecure attachment play a crucial role in BPD patients' mentalizing deficits (Fonagy et al., 2003). Unfortunately, only a few studies included in the MA quantified the quality of parental care or the severity of adverse childhood life events in BPD patients (e.g. Ghiassi et al., 2010; Brüne et al., 2016, Petersen et al., 2016).

The missing data on medications made it impossible to analyze and reveal any medication effect on ToM impairments. Furthermore, only one study in our MA assessed BPD patients' neurocognitive functions, and their correlation with ToM performances (Baez et al., 2015), therefore the impact of neurocognitive functions on ToM could not be evaluated.

Only 4 studies measured mental state decoding and reasoning in the same sample simultaneously, therefore it was not possible to compare data only from studies with simultaneous measures. So we performed the Q_{bet} test with all studies for mental state decoding ($n = 8$), and reasoning ($n = 13$). Although samples partially overlap, we present this result, because the 95%CI of effect sizes showed no overlap. Nevertheless, this is an obvious limitation and requires revision in the future, when more simultaneous measures are available.

4.4. Conclusion

We demonstrate here that BPD patients have overall ToM deficits compared to HC. We also found that BPD patients have cognitive ToM impairments and deficits of mental state reasoning. This is in line with empiric clinical data on psychotherapeutic interventions in BPD: psychotherapeutic interventions are most effective if they target BPD patients' mental state reasoning and cognitive ToM.

Conflict of interest

There is no conflict of interest concerning the authors in conducting this study and preparing the manuscript.

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Supplementary materials

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