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RESEARCH ARTICLE

Susceptibility to peer influence in adolescents with mild-to-borderline intellectual disability: Investigating links with inhibition, Theory of Mind and negative interpretation bias

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ABSTRACT

Background: This preregistered study compares adolescents with mild-to-borderline intellectual disability (MBID) and typically developing (TD) adolescents on their susceptibility to peer influence. To understand why adolescents with MBID are susceptible to peer influence, links with inhibition, Theory of Mind (ToM) and negative interpretation bias are investigated.

Method: We assessed 163 adolescents (111 MBID, 52 TD 14–19 years; 63% boys) using experimental tasks and self- and/or teacher-reports.

Results: Adolescents with MBID and TD adolescents did not differ in their susceptibility to peer influence, inhibition, and negative interpretations. On two ToM instruments, adolescents with MBID performed weaker than TD adolescents. In a structural equation model, tested in the MBID group, inhibition, ToM and negative interpretation bias were not related to susceptibility to peer influence.

Conclusions: This study revealed new insights by strong methods such as the multimethod approach, a full theoretical model testing relations between all constructs simultaneously, and the large sample.

KEYWORDS
Adolescence; peer influence; intellectual disability; inhibition; Theory of Mind; negative interpretation bias

Adolescence has generally been characterised by higher susceptibility to peer influence (see Do et al., 2020 for a review). Adolescents with mild-to-borderline intellectual disability (MBID) may be even more susceptible to the influences of their peers. MBID is highly prevalent: among children and adolescents around 10% meet the criteria of mild problems in conceptual, social and adaptive skills of functioning and an IQ between 50 and 85 (American Psychiatric Association, 2013; Simonoff et al., 2006). Increasing scientific evidence shows that adolescents with MBID are more susceptible to peer influence than typically developing (TD) adolescents (Bexkens et al., 2019; Dekkers et al., 2017; Egger et al., 2021; Wagemaker et al., 2020). However, it is still unknown *why* this may be the case. Therefore, we aim to gain a deeper understanding of susceptibility to peer influence in adolescents with MBID. Here, we compare adolescents with MBID and TD adolescents on their susceptibility to peer influence and link their susceptibility to peer influence to potential underlying factors.

Susceptibility to peer influence in adolescents with MBID

Heightened susceptibility to peer influence in adolescents with MBID has been shown in multiple studies using different measurement methods. Two experimental studies demonstrated that adolescents with MBID took more risks than TD adolescents in a computer

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task with virtual peers encouraging risk taking by different audio fragments (Bexkens et al., 2019; Wagemaker et al., 2020). Another study found that adolescents with MBID more often changed their judgement about popularity of a person based on judgements of their virtual peers than TD adolescents (Egger et al., 2021). Moreover, adolescents with MBID reported less resistance to peer influence than TD adolescents (Dekkers et al., 2017). In the current study we add to these previous findings by administering an experimental task and self-report of susceptibility to peer influence.

Factors linked to susceptibility to peer influence in adolescents with MBID

To understand *why* adolescents with MBID may be susceptible to peer influence, we investigate several potential factors. A recent review on neural biomarkers of susceptibility to peer influence in adolescence indicates that psychological processes that encode regulatory, social-cognitive, and affective cues from the environment contribute to peer influence susceptibility (Do et al., 2020). We operationalise these three processes into three factors: inhibition, Theory of Mind (ToM) and negative interpretation bias.

Inhibition. Inhibition refers to all processes that enable deliberate suppression of dominant responses to serve higher-order or longer-term goals (Nigg, 2000). Stronger inhibition at age 12 in TD adolescents predicts lower susceptibility to peer influence three years later (Meldrum et al., 2013), and a meta-analysis demonstrated that individuals with MBID have a medium to large inhibition deficit compared to TD adolescents (Bexkens et al., 2014a). Therefore, we hypothesise that inhibition problems in adolescents with MBID may lead them to impulsively going along with peers.

ToM. ToM refers to the ability to attribute mental states such as beliefs, desires, emotions, and intentions to oneself and others (Humphrey & Dumontheil, 2016). ToM appears linked to susceptibility to peer influence as adolescents with better ToM demonstrate less risk-taking behaviours such as binge drinking under peer influence (Laghi et al., 2019). Adolescents with MBID perform worse on ToM tasks relative to TD adolescents (Baglio et al., 2016). Therefore, we hypothesise that problems with ToM in adolescents with MBID may lead to unawareness or misunderstanding of peers' intentions, which can result in following advice from peers.

Negative interpretation bias. A negative interpretation bias is the tendency to interpret ambiguous social cues as signs of rejection (Stuijfzand et al., 2018). This bias is often present in TD adolescents with high social anxiety and increases fear of social exclusion (Miers et al., 2008). This fear of social exclusion may increase susceptibility to peer influence by (a) reputation management: avoid rejection by peers (Brechwald & Prinstein, 2011) or by (b) increased stress in peer situations (Gunther Moor et al., 2014). Although never studied before, adolescents with MBID may have a stronger bias than TD adolescents because social anxiety disorder is more common in adolescents with MBID than in TD adolescents (Dekker & Koot, 2003), and higher levels of social anxiety have been linked to higher negative interpretation bias in adolescents with MBID (Klein et al., 2018). Therefore, we hypothesise that a strong negative interpretation bias in adolescents with MBID may increase their susceptibility to peer influence.

The current study

This preregistered study adopted a multimethod approach with experimental tasks, self-reports and/or teacher-reports for all constructs. This strong methodology enhances reliability and validity (Brewer & Hunter, 2006), which is especially important in MBID populations, as correlations between different instruments have been reported to be low for this group (e.g., Bramston & Fogarty, 2000). Our first aim was to investigate group differences between adolescents with and without MBID in their susceptibility to peer influence, inhibition, ToM, and negative interpretation bias on all instruments. Our second aim was to investigate how inhibition, ToM, and a negative interpretation bias are linked to susceptibility to peer influence in adolescents with MBID.

Method

The current study was preregistered in two parts (see https://osf.io/2mu6v/?view_only=44ccdb91d4204a1eab82348efef0ecc4 and https://osf.io/vjb92/?view_only=e52ab9a0f5554ff48e674e4b990f863f). We followed the preregistrations, yet we did not entirely reach planned sample size due to COVID-19 related necessity of ending data collection. The anonymised data and syntax can be found on: https://osf.io/qey3a/?view_only=92148b8c3bec42e687c35aa4c40b1c60.

Participants

Participants were 163 adolescents, ages 14–19, with (N = 111) and without (N = 52) MBID[1] (see Table 1 for group characteristics). The MBID group was sampled from practical vocational track schools. In the

Table 1. Group Characteristics of Adolescents with MBID and TD Adolescents.

	MBID ($n = 111$)	TD ($n = 52$)	Group comparisons
Age	15.91 (.95)	16.83 (1.08)	$t(161) = 5.51$, $p < .001$
Sex (% boys)	55.9%	76.9%	$\chi^2(1) = 6.71$, $p = .01$
IQ	74.75 (6.83)	101.19 (11.50)	$t(68.39^a) = 15.36$, $p < .001$
Country of birth[b] (% Dutch/other)	87.5% / 12.5%	100% / 0%	$\chi^2(1) = 6.92$, $p = .01$
BSA-j[c] (% sufficient/potentially limited/probably limited)	41.4%/13.1%/45.5%	82.1%/10.3%/7.7%	$\chi^2(2) = 20.39$, $p < .001$
SDQ total (% any disorder unlikely/possible/probable)	54.1% / 37.8% / 8.1%	78.8% / 15.4% / 5.8%	$\chi^2(2) = 9.60$, $p = .01$
SES[d]	4.76 (.89)	5.41 (.54)	$t(133) = 4.63$, $p < .001$

[a]The assumption of equal group variances was violated, therefore *df* differs.
[b]Country of birth of 24 adolescents was not reported by parents (23 MBID, 1 TD).
[c]BSA-j of 25 adolescents was not reported by teachers (12 MBID, 13 TD).
[d]SES of 28 parents was not reported (25 MBID, 3 TD).
Abbreviations: BSA-j, Assessment of Social Adaptability – Youth; MBID, Mild-to-Borderline Intellectual Disability group; SDQ, Strengths and Difficulties Questionnaire; TD, Typically Developing control group.

Netherlands, these schools have the following admittance criteria: an IQ between 55 and 80 on a standardised IQ test measured no more than two years prior to admittance and learning delays of 50% or more in at least two educational areas (i.e., mathematics, reading accuracy and fluency, reading comprehension, and spelling). The TD group was recruited at regular schools from the lower and higher general secondary education level and from the intermediate vocational education level.

We used IQ as an inclusion criterion for both groups. In line with the Dutch definition of MBID (De Beer, 2016), we only included adolescents with an IQ between 50 and 85 in the MBID group. Adolescents with an IQ higher than 85 were included in the TD group. Because of time constraints, we did not use the level of adaptive functioning as an inclusion criterion. Our sample was representative as we did not exclude any forms of psychopathology, which are highly prevalent (around 40%) in MBID (Dekker & Koot, 2003). Nevertheless, we administered short screeners for adaptive functioning and psychopathology to obtain more descriptive information and to test whether adolescents with MBID indeed had lower adaptive functioning and more psychopathology than TD adolescents. Parents provided active informed consent and information about country of birth and socio-economic status (SES). Adolescents provided assent. This study was approved by the ethical review board of the University of Amsterdam.

Materials

Descriptive measures

Intelligence. IQ was estimated with the Wechsler Intelligence Scale for Children – V (WISC-V; Na & Burns, 2016) for adolescents from 14 to 16 years and the Wechsler Adult Intelligence Scale – IV (WAIS-IV; Wechsler, 2008) for adolescents older than 16 years. We administered short versions consisting of the subtests Vocabulary and Matrix Reasoning, which are reliable and correlate highly with total intelligence (Pierson et al., 2012; Sattler, 2001). We deviated from the standard testing protocol in two ways: (1) we did not use the age-appropriate entry items for the MBID group to conserve motivation and (2) when an answer was (partly) incorrect during the Vocabulary subtest, research assistants asked for clarification for three times. The shortened WAIS-IV is not able to estimate total IQ's below 55, but none of the adolescents did not answer any item correct.

Socio-Economic Status (SES). SES was measured by averaging the highest level of education of both parents on a scale from 1 to 7 based on the International Standard Classification of Education (UNESCO, 1999).

Adaptive functioning. Problems in adaptive functioning were reported by teachers on the Assessment of Social Adaptability – Youth (BSA-J; Lekkerkerker & Konijn, 2011), which consists of 18 statements focusing on conceptual, social, and practical behaviour. The internal consistency is high ($\alpha = .90$) and the predictive validity for the type of indicated care is good (73% specificity and 81% sensitivity; Lekkerkerker & Konijn, 2011).

Psychopathology. Psychopathology was screened with the Strengths and Difficulties Questionnaire (SDQ; Goodman et al., 2000) self-, parent and teacher report. The SDQ consisted of five subscales, composite scores including all reporters were calculated per subscale. For the Hyperactivity, Emotional Symptoms, Conduct Problems disorder subscales, the likelihood of psychopathology (no / possible / probable disorder), was determined by the SPSS script provided on www.sdqinfo.com For the Peer Problems and Prosocial subscales, total scores for each of the three informants were averaged and standardised. SDQ subscales have sufficient to good internal consistency ($\alpha = .57–.84$), high test-retest reliability ($r = .58–.89$), and correlate well with other measures of psychopathology ($r = .49–.72$; Muris et al., 2003; van Widenfelt et al., 2003).

Table 2. Overview of Instruments, Psychometric Qualities and Earlier Use in the MBID population.

Construct	Instrument type	Instrument name	Psychometric qualities	Earlier use in MBID population
Susceptibility to peer influence	Experimental task	Balloon Analogue Risk Task (BART) peer vs. solo	Significant links to daily-life risk-taking behaviours such as smoking and alcohol use (Lejuez et al., 2002). A similar BART peer manipulation effectively increased the number of adjusted pumps (Dekkers et al., 2020).	Other peer manipulations in the BART were used successfully for adolescents with MBID before (Bexkens et al., 2019; Wagemaker et al., 2020).
	Self-report	Resistance to Peer Influence Scale (RPI)	Good internal consistency (α > .70; Steinberg & Monahan, 2007).	Has been used successfully in adolescents with MBID (Dekkers et al., 2017; α = .62; Wagemaker et al., 2022).
Inhibition	Experimental task	Stop Signal Task (SST)	Construct validity is supported by links with behavioural and impulse control problems, including Attention-Deficit/ Hyperactivity Disorder (ADHD), substance abuse and obsessive-compulsive behaviours (Lipszyc & Schachar, 2010; Smith et al., 2014).	Has been used in adults with MBID before (Van Duijvenbode et al., 2013).
	Self-report	Behavioural Rating Inventory of Executive Functions - Self Report (BRIEF-SR)	High internal consistency (α's > .80; Sullivan & Riccio, 2007)	Has not been used in adolescents with MBID, but was used in adolescents with traumatic brain injury (Byerley & Donders, 2013).
	Teacher report	Behavioural Rating Inventory of Executive Functions - Teacher Report (BRIEF-TR)	High internal consistency (α's > .80) and BRIEF-TR scores predict ADHD symptoms (Sullivan & Riccio, 2007).	Has been used in teachers of adolescents with autism spectrum disorder and intellectual disability (Tsermentseli et al., 2018).
Theory of Mind	Experimental task	Hinting task	Construct validity is shown by predictions of autism (Craig et al., 2004).	Has not been used in adolescents with MBID before. Therefore, we piloted the task on its feasibility in three adolescents with MBID (see Supplement A part V).
	Self-report	Basic Empathy Scale (BES)	The subscales have high internal consistency (α = .85 and .79 respectively) and correlate with self-report on perspective taking (r > .35 Jolliffe & Farrington, 2006).	The Dutch version (Van Langen et al., 2012) has never been used in adolescents with MBID before. Therefore, we piloted the BES in three adolescents with MBID and adapted items with difficult words (1) or negatively formulated items (6; see Supplement A part VI).
	Teacher report	Mindful Conversational Difficulties Scale (MCDS)	Internal consistency is high (α = .87), and scores correlate with a ToM battery (r = .39; De Rosnay et al., 2014).	Has not been used in studies with adolescents with MBID before.
Negative interpretation bias	Experimental task	Recognition task (IREC-T)	The original task demonstrated good internal consistency (α = .71) and correlated with self-reported social anxiety in adolescents with MBID (r = 0.34; Houtkamp et al., 2017).	Has been used in adolescents with MBID (Houtkamp et al., 2017).
	Self-report	Social Anxiety Scale for Children – Revised (SASC-R)	Subscales negatively correlate with social acceptance in TD adolescents (r's = -.23 to -.47; La Greca & Stone, 1993). Internal consistency was excellent in a MBID sample (α = .93; Houtkamp et al., 2017).	Has been used in adolescents with MBID (Houtkamp et al., 2017).

Abbreviations: MBID, Mild-to-Borderline Intellectual Disability.

Multimethod approach. Susceptibility to peer influence, inhibition, ToM, and negative interpretation bias were assessed with an experimental task, self-report and/or teacher report (see Table 2). We selected experimental tasks based on the following criteria: minimal verbal requirements, minimal working memory requirements, minimal ceiling effect in the TD group, highly motivating, norms available, and validated in more than one study. As self-report can be difficult for adolescents with MBID (Emerson et al., 2013), we added comprehension checks to the online questionnaires (see Supplement A part I). We selected teacher reports above parents reports as parents from adolescents with MBID may have difficulty filling out questionnaires. We did not include teacher reports on susceptibility to peer influence and negative interpretation bias, as no instruments were available. More detailed information on the instruments, the psychometric qualities, and earlier use in the MBID population can be found in Table 2 and Supplement A parts II to VII.

Susceptibility to peer influence

Experimental task. In the Balloon Analogue Risk Task (BART; Lejuez et al., 2002 adapted from Dekkers et al., 2020) adolescents were instructed to earn

money by pumping a virtual balloon. Each pump was worth €0,01; but the balloon could explode at each next pump, which meant that the money for that balloon would be lost. Adolescents could "cash" the balloon at any point. This money remained in possession of the adolescent. The BART consisted of 30 test trials divided over two blocks with a break in between. The explosion points were determined randomly ranging between 5 and 128 ($M = 64$ for both blocks), the same array of explosion points was used for every adolescent. We included two practice blocks with three balloons each to practice pumping and cashing. The practice blocks had identical mean explosion points as the experimental blocks.

Adolescents performed the BART twice: in a solo condition as described above and in a peer condition where they received advice from a peer. In the peer condition, before the task started, adolescents were told that a sex- and age-matched peer from another school would try to predict their performance. This peer was watching the adolescent via a camera positioned behind. In fact, the peer was a confederate of the study. We chose to let only one peer encourage risk taking as opposed to multiple peers. In this way, we could increase the credibility of the peer by including a short standardised introduction via WhatsApp on a smartphone that was provided to the adolescent. Also, the peers only encouraged risk taking at the beginning and halfway the task, during a break by sending negative risk encouraging messages (i.e., "you pump very little"). In this way, we ensured that the peer effect was not confounded with distraction from the task.[2] See Supplement A part II for the detailed BART peer condition protocol. The difference in the number of pumps between the BART peer and solo was used as an indication of susceptibility to peer influence.

Self-report. The Resistance to Peer Influence Scale (RPI; Steinberg & Monahan, 2007) consisted of ten questions using a tree-based structure. An example item was: *Some children go along with their friends just to keep their friends happy BUT Other children refuse to go along with what their friends want to do, even though they know it will make their friends unhappy.* Scores on each item were aggregated in a 4-point Likert-type scale score, in which the "Really true" and "Sort of true" options of the less peer-resistant statement were coded as 1 and 2 respectively, and the "Sort of true" and "Really true" options of the more peer-resistant statement were coded as 3 and 4 respectively. The outcome was the total score, higher scores indicated more resistance to peer influence. To obtain an index of susceptibility to peer influence, RPI total scores were multiplied by -1.

Inhibition

Experimental task. In the Stop Signal Task (SST; Logan, 1994) adolescents were instructed to respond to go trials but inhibit their response on stop trials. The outcome was the stop signal reaction time (SSRT), the mean time required to inhibit responses to stop trials. As this time cannot be observed, it is estimated using the so-called integration method (Logan, 1994). The total number of go trials is multiplied by the chance of responding on a go trial, and denoted as n. The finishing time of the stop processes corresponds to the nth reaction time in the go trials reaction time distribution. An estimate of the SSRT was obtained by the finishing time of the stop process minus the average stop-signal delay time (Verbruggen et al., 2019). A shorter SSRT reflects stronger inhibition. See Supplement A part III for more detailed information on the SST design and preregistered deviations for the calculation of the SSRT.

Self-report and teacher report. The Inhibit subscale of the Behavioural Rating Inventory of Executive Functions Self Report and Teacher Report (BRIEF-SR and BRIEF-TR; Gioia et al., 2000) consisted of nine items. An example item of the BRIEF-SR was: *I interrupt others.* An example item of the BRIEF-TR was: *This pupil is impulsive.* The outcome measure was the total score, with higher scores reflecting more problems in inhibition.

Theory of Mind

Experimental task. The Hinting Task (Corcoran et al., 1995) consisted of ten short read aloud stories. All stories ended with a hint about what a character wants the other to do and adolescents were asked what the character really meant when he/she said this. The outcome measure was the total score, with higher total scores reflecting better ToM. See Supplement A part IV for more information on the Hinting Task pilot and an example item.

Self-report. The Basic Empathy Scale (BES; Jolliffe & Farrington, 2006) consisted of 20 items construing a cognitive and an affective empathy subscale. An example item of the cognitive subscale was: *I can usually work out when my friends are scared.* An example item of the affective subscale was: *I get caught up in other peoples' feelings easily.* See Supplement A part V for all final BES items after our pilot. We analysed these subscales separately as cognitive empathy (i.e., understanding of other's emotions) may be more directly related to ToM than affective empathy (i.e., empathising with others' emotions). The outcome measures were mean subscale scores, with higher scores reflecting better ToM.

Teacher report. In the Mindful Conversational Difficulties Scale (MCDS; De Rosnay et al., 2014) teachers answered eight questions about adolescents' ToM behaviour compared to TD adolescents from a similar age. An example item was: *Does the child have difficulty understanding other people's thoughts?* The outcome was the mean score, with higher scores indicating more difficulties with ToM. Therefore, scores were multiplied by −1 to obtain an index of capacity instead of impairment.

Negative interpretation bias

Experimental task. The Interpretation Recognition Task (IREC-T; Houtkamp et al., 2017) consisted of seven selected scenarios focusing on potential social rejection. Adolescents were instructed to indicate the likelihood of a negative interpretation at the end of each ambiguous scenario. The outcome was the mean score, with higher scores reflecting stronger negative interpretations. See Supplement A part VI for the IREC-T procedure, selection of the stories and determination of exclusions.

Self-report. The Social Anxiety Scale for Children – Revised (SASC-R; La Greca & Stone, 1993) consisted of 22 items construing three subscales: Fear of Negative Evaluation (FNE) and two Social Avoidance and Distress (SAD) subscales. An example item of the FNE subscale was: *I worry about what others say about me.* An example item of the SAD subscales was: *I get nervous when I meet new people.* We analysed the FNE subscale separately and combined the SAD subscales as the FNE subscale may be more directly related to negative interpretation bias than the SAD subscales. The outcomes were the sum scores, with higher scores indicating more symptoms.

Procedure

Data collection ran from October 2018 until March 13th, 2020 (it ended at the start of the country's lockdown due to COVID-19 pandemic). After providing consent, one of the parents digitally filled out the parent reports. Adolescents were tested individually in a quiet room at school and were assisted by a research assistant. As the test battery was large, test administration was divided over two sessions of 90 minutes, each with a short break halfway. The BART peer and solo conditions were counterbalanced over the two sessions to control for potential learning effects. This led to an A and B version of the test protocol (see Supplement A part VII). There was a minimum of two days and a maximum of four weeks between the sessions. At the end of the second session, adolescents were paid €8,- plus the money earned in one of the two randomly selected BART conditions (total approximately €16,-). Teachers were approached via email to fill out teacher reports. After completion of the data collection, both adolescents and parents were debriefed about the peer manipulation by phone. To get an indication of the credibility of the BART peer manipulation, we asked adolescents to rate the credibility from 0 to 100.

Data analysis

Most analyses were preregistered, non-preregistered analyses are explicitly mentioned as exploratory. Bonferroni corrected p-values (p^B) were calculated by multiplying p-values of comparisons belonging to the same construct by the number of comparisons.

Group comparisons. To assess differences between adolescents with and without MBID, we performed group comparisons. We deviated slightly from our first preregistration as we performed ANCOVA's instead of ANOVA's. The sudden stop of inclusion due to the COVID-19 lockdown prevented levelling the groups and therefore the TD group was significantly older and included relatively more boys than the MBID group (see Table 1). Therefore, age and sex were added as covariates. The assumption of homogeneous regression lines was met as age and sex did not interact with group (MBID vs. TD) on all outcomes. This indicates that potential group differences were not influenced by age and were not different for boys and girls. We calculated partial eta squared effect sizes (denoted by η_p^2). Although we did not reach the sample size of our preregistered power analysis, a post-hoc power calculation using G*Power (Faul et al., 2007) based on ANCOVA's with a medium effect size ($f = .25$) and $\alpha = .025$, .016 or .0125 ($\alpha = .05$ divided by two, three or four indicators for Bonferroni correction) showed that our power was still .82, .77, or .74 respectively.

Structural Equation Model (SEM). To investigate how inhibition, ToM and negative interpretation bias were linked to susceptibility to peer influence in adolescents with MBID, we fitted a SEM only in this group. In this analysis, we estimated latent factors underlying multiple instruments (e.g., experimental task and self-report), which is beneficial as it corrects for noise and thus has higher reliability compared to the instruments themselves (Schreiber et al., 2006). We also estimated the relationships between these latent factors (i.e., susceptibility to peer influence on the one hand and inhibition, ToM and negative interpretation bias on the other). As opposed to multiple analyses, testing this in

one analysis is beneficial because it considers the influence of all factors.

The indicators were the standardised experimental, self-, and teacher report scores[3] and the latent factors were susceptibility to peer influence, inhibition, ToM and negative interpretation bias. We estimated these latent factors based on multiple indicators measuring the same construct and linked the latent factors among each other. For identification of the model, we fixed the variances of latent factors and the factor loading of the BART difference score to the susceptibility to peer influence factor to equal one. The number of free parameters in the model is 18, meaning we would need 90 adolescents to adhere to the rule of five participants per parameter (Kaplan, 2008). An a-priori power analysis based on medium effect sizes, 4 latent variables, and 12 indicators, showed that 137 participants were sufficient to achieve a power of .80 (Soper, 2021). Our preregistered SEM resulted in model non-identification, potentially due to the current sample size being smaller than intended ($N_{MBID} = 111$). We solved this problem by fixing the residual variances of the indicators to a value of .25, which translates to 75% of the total variance in each standardised indicator being explained by its latent factor. This reflects our expectation that the indicators were good indicators of the latent variable. Analyses were run in Mplus (Version 7.31) (n.d.) using maximum likelihood estimation.

Secondary and exploratory analyses (see Supplement B parts II and III for results, Tables B1-B3). As preregistered secondary analyses, we tested whether psychopathology as indicated on the SDQ moderated the group comparisons and we performed within-construct correlations between experimental tasks, self- and teacher reports in the MBID and TD group separately. As exploratory analyses, we tested group differences on the SDQ subscales, average BART peer manipulation credibility. Moreover, to test the robustness of the group comparison results, we reran the group comparisons with only selections from the MBID group (i.e., adolescents with Borderline Intellectual Functioning ($70 < IQ < 85$) and adolescents with (possible) deficient adaptive functioning).

Results

Preliminary analyses

From the 196 recruited adolescents, 33 adolescents were excluded for several reasons, leaving a total sample of 163 adolescents. Concerning the test scores, 3.5% were missing due to non-administration. Preregistered errors were found in 1.1% of the test scores and 0.8% of the scores were outlying based on Median Absolute Deviation exceeding 2.5 (Leys et al., 2013). Adolescents with missing, erroneous or outlying data were excluded from the corresponding group comparisons (for more details see Supplement B part I). For the SEM, full information maximum likelihood (FIML) was used to handle missing data.[4]

Adolescents with MBID had lower scores on IQ, BSA-j, and SES relative to TD adolescents, while they had more "possible" or "likely" psychopathology as measured with the SDQ total difficulties score (see Table 1). In the total sample, the number of pumps was higher in the BART peer condition ($M = 48.46$, $SD = 11.47$) compared to the BART solo condition ($M = 43.67$, $SD = 11.17$, $t(162) = -6.88$, $p < .001$, $d = .54$; see Figure 1(A)), suggesting an effective peer manipulation.

Group comparisons

Regarding susceptibility to peer influence, adolescents with and without MBID did not differ on the experimental task or the self-report (i.e., BART difference score see Figure 1(A), and RPI). On inhibition, both groups did not differ on the experimental task, self-report and teacher-report (i.e., SST[5], BRIEF-SR, and BRIEF-TR). Regarding ToM, adolescents with MBID had lower scores on the experimental Hinting task[6] and on the BES Affective self-report subscale than TD adolescents[7] (see Figure 1(B and C)). This difference was not found on the BES Cognitive self-report subscale and on the MDCS teacher-report. For negative interpretation bias, groups did not differ on the experimental task and the self-report (i.e., IREC-T and SASC-R subscales[6,7]). In sum, we only observed differences between the MBID and TD group on two ToM instruments on which the MBID group showed decreased performance (see Table 3 for all group means and test results).

SEM

As adolescents with MBID were equally susceptible to peer influence as TD adolescents, and as knowledge about potential underlying mechanisms in MBID is limited, linking their susceptibility to peer influence on their inhibition, ToM and negative interpretation bias remains relevant. In the SEM on the MBID group, most indicators loaded positively on their proposed latent factor, except for the SST on inhibition.[8] This suggests that the latent factors represented the constructs they were intended to (squared multiple correlations per indicator are reported in Supplement B part IV Table B4). The latent factors of inhibition,

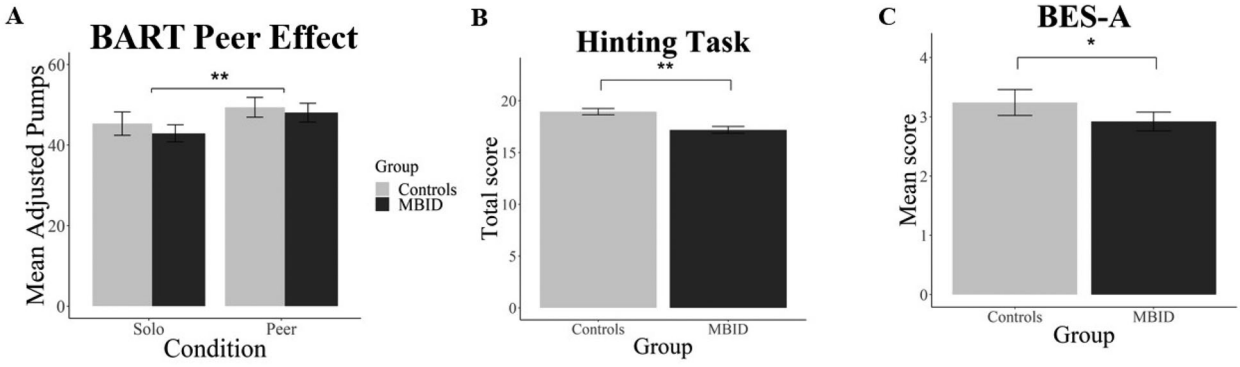

Figure 1. Means and 95% Confidence Intervals in Adolescents with MBID and TD adolescents (Controls) on the BART peer effect, Hinting Task and BES-A. Note: * p^B < .05, ** p^B <.001. Abbreviations: BART, Balloon Analogue Risk Task; BES-A, Basic Empathy Scale –Affective subscale; MBID, Mild-to-Borderline Intellectual Disability group; TD, Typically Developing control group.

ToM and negative interpretation bias were not significantly related to the susceptibility to peer influence factor (see Figure 2(A))[9,10] The fit indices suggest poor model fit (see Table 4).

We checked the robustness of these findings across analytical settings with two alternative models. First, to examine if our findings were affected by the fixation of the indicators' error variances on .25, we fitted a SEM with error variances fixed on .50. Second, to examine if the method of dealing with missing data was of influence, we fitted a SEM with listwise deletion instead of full information maximum likelihood. Both models still had a poor fit and demonstrated the same pattern of results (see Table 4 and Figure 2(B and C)).

Discussion

In this preregistered study, we used experimental tasks, and self- and teacher reports to investigate susceptibility to peer influence in adolescents with and without MBID. We expected higher susceptibility to peer

Table 3. Group Comparisons between Adolescents with MBID and TD Adolescents: Means (M), Standard Deviations (SD's), and Test Results.

Construct	Instrument	MBID *M (SD)*	TD *M (SD)*	MBID main effect	Sex effect	Age effect
Susceptibility to peer influence	BART DIF	5.14 (9.39)	4.07 (7.78)	$F(1,159) = .48$, $p^B = .98$, $\eta_p^2 = .003$	$F(1,159) = .23$, $p^B > 1$, $\eta_p^2 = .001$	$F(1,159) = .14$, $p^B > 1$, $\eta_p^2 = .001$
	RPI	−29.81 (5.69)	−30.13 (4.89)	$F(1,159) = .83$, $p^B = .73$, $\eta_p^2 = .01$	$F(1,159) = .69$, $p^B = .82$, $\eta_p^2 = .004$	$F(1,159) = 1.28$, $p^B = .52$, $\eta_p^2 = .01$
Inhibition	SST	221.09 (47.17)	221.98 (43.90)	$F(1,140) = .08$, $p^B > 1$, $\eta_p^2 = .001$	$F(1,140) = 1.31$, $p^B = .76$, $\eta_p^2 = .01$	$F(1,140) = 2.22$, $p^B = .42$, $\eta_p^2 = .02$
	BRIEF-SR	14.44 (3.45)	15.76 (3.13)	$F(1,158) = 4.08$, $p^B = .14$, $\eta_p^2 = .03$	$F(1,158) = 1.54$, $p^B = .65$, $\eta_p^2 = .01$	$F(1,158) = .16$, $p^B > 1$, $\eta_p^2 = .001$
	BRIEF-TR	16.08 (5.57)	13.92 (4.38)	$F(1,133) = 3.67$, $p^B = .17$, $\eta_p^2 = .03$	$F(1,133) = 1.88$, $p^B = .52$, $\eta_p^2 = .01$	$F(1,133) = .55$, $p^B > 1$, $\eta_p^2 = .004$
ToM	Hinting task	17.18 (1.73)	18.94 (1.12)	$F(1,154) = 37.25$, $p^B <$ .001**, $\eta_p^2 = .20$	$F(1,154) = 2.24$, $p^B = .55$, $\eta_p^2 = .01$	$F(1,154) = .13$, $p^B > 1$, $\eta_p^2 = .001$
	BES – C	3.86 (.58)	4.07 (.51)	$F(1,159) = 3.69$, $p^B = .23$, $\eta_p^2 = .02$	$F(1,159) = 3.39$, $p^B = .27$, $\eta_p^2 = .02$	$F(1,159) = 1.27$, $p^B > 1$, $\eta_p^2 = .01$
	BES – A	2.92 (.85)	3.24 (.80)	$F(1,159) = 8.16$, $p^B = .02$*, $\eta_p^2 = .05$	$F(1,159) = 25.10$, $p^B <$ .001**, $\eta_p^2 = .14$	$F(1,159) = .54$, $p^B > 1$, $\eta_p^2 = .003$
	MDCS	−2.99 (.46)	−2.68 (.43)	$F(1,134) = 5.22$, $p^B = .10$, $\eta_p^2 = .04$	$F(1,134) = .22$, $p^B > 1$, $\eta_p^2 = .002$	$F(1,134) = 2.78$, $p^B = .39$, $\eta_p^2 = .02$
Negative interpretation bias	IREC-T	17.42 (3.98)	18.04 (3.42)	$F(1,147) = 3.07$, $p^B = .25$, $\eta_p^2 = .02$	$F(1,147) = 5.73$, $p^B = .05$, $\eta_p^2 = .04$	$F(1,147) = 1.50$, $p^B = .67$, $\eta_p^2 = .01$
	SASC-R FNE	1.73 (.71)	1.86 (.58)	$F(1,154) = 4.99$, $p^B = .08$, $\eta_p^2 = .03$	$F(1,154) = 19.26$, $p^B <$ .001**, $\eta_p^2 = .11$	$F(1,154) = .83$, $p^B > 1$, $\eta_p^2 = .01$
	SASC-R SAD	2.07 (.77)	2.04 (.58)	$F(1,156) = .34$, $p^B > 1$, $\eta_p^2 = .002$	$F(1,156) = 11.24$, $p^B = .003$**, $\eta_p^2 = .07$	$F(1,156) = .20$, $p^B > 1$, $\eta_p^2 = .001$

Note: * p^B < .05, ** p^B <.01.

Abbreviations: BART, DIF Balloon Analogue Risk Task difference score; BES-C/-A, Basic Empathy Scale – Cognitive and Affective subscale; BRIEF-SR/-TR, Inhibit subscale of the Behavioural Rating Inventory of Executive Functions Self Report and Teacher Report; IREC-T, Interpretation Recognition Task; MBID, Mild-to-Borderline Intellectual Disability group; MDCS, Mindful Conversational Difficulties Scale; RPI, Resistance to Peer Influence Scale; SASC-R FNE / SAD, Social Anxiety Scale for Children – Revised Fear of Negative Evaluation and Social Avoidance and Distress subscales; SST, Stop Signal Task; TD, Typically Developing control group; ToM, Theory of Mind.

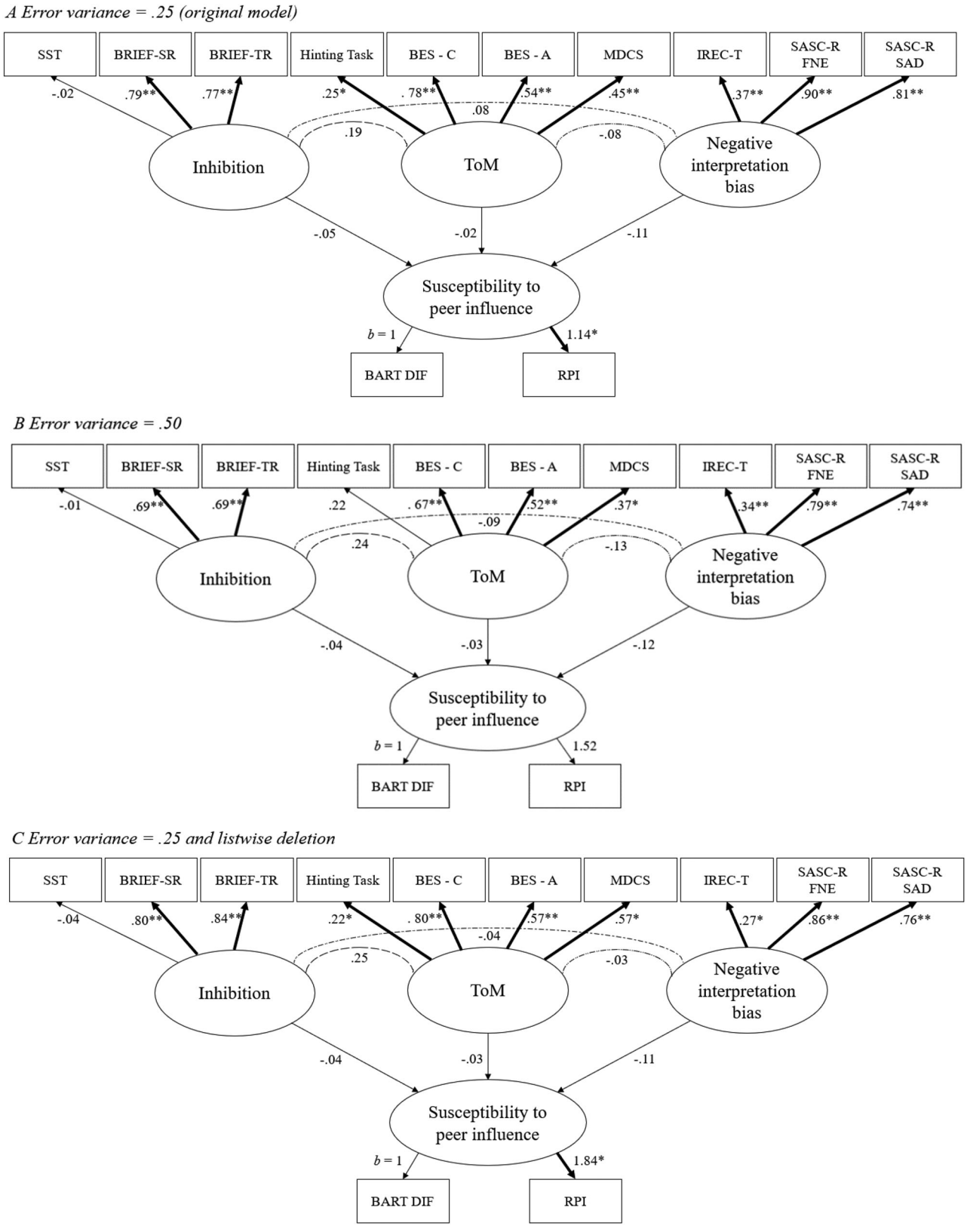

Figure 2. Original and Alternative SEMs in adolescents with MBID. Note: * $p < .05$, ** $p < .001$, squares represent manifest variables, ellipsoids represent latent variables, single arrows indicate a predictive effect, dotted lines indicate covariances, b indicates a fixed coefficient. Abbreviations: BART DIF, Balloon Analogue Risk Task difference score; BES-C/-A, Basic Empathy Scale – Cognitive and Affective subscale; BRIEF-SR/-TR, Inhibit subscale of the Behavioral Rating Inventory of Executive Functions Self Report and Teacher Report; IREC-T, Interpretation Recognition Task; MBID, Mild-to-Borderline Intellectual Disability; MDCS, Mindful Conversational Difficulties Scale; RPI, Resistance to Peer Influence Scale; SASC-R FNE / SAD, Social Anxiety Scale for Children – Revised Fear of Negative Evaluation and Social Avoidance and Distress subscales; SEM, Structural Equation Model; SST, Stop Signal Task; ToM, Theory of Mind.

Table 4. Fit Indices of the Original and Alternative SEM Analyses.

Fit index	Cut-off for good fit	Original model	Alternative models	
		$\sigma^2 = .25$	$\sigma^2 = .50$	$\sigma^2 = .25$ and listwise deletion
X^2	$p > .05$	$p < .0001$	$p < .0001$	$p < .0001$
CFI	≥.90	.000	.000	.000
TLI	≥ 0.95	−3.52	-.05	−2.60
RMSEA	< 0.08	.34	.17	.34
SRMR	< 0.08	.23	.17	.23

Abbreviations: X^2, Chi-square; TLI, Tucker Lewis Index; CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation; SEM, Structural Equation Model; SRMR, Standardised Root Mean Square Residual.

influence in adolescents with MBID relative to TD adolescents. This hypothesis was not supported: groups did not differ in their susceptibility to peer influence on the experimental task and the self-report measure. Furthermore, and again contrary to our hypotheses, adolescents with MBID did not differ from TD adolescents on all measures of inhibition, negative interpretation bias, and on two of the four ToM measures. Group differences on the other two ToM measures were as expected: adolescents with MBID performed worse on the experimental ToM task and reported less affective empathy compared to TD adolescents. In the SEM within adolescents with MBID, all indicators, except the SST, loaded positively on the latent factors. The latent factors of inhibition, ToM and negative interpretation bias were not linked to the latent factor of susceptibility to peer influence.

Comparing adolescents with and without MBID

Susceptibility to peer influence. We found no evidence for heightened susceptibility to peer influence in adolescents with MBID compared to TD adolescents, which is not in line with earlier experimental and self-report research (Bexkens et al., 2019; Dekkers et al., 2017; Egger et al., 2021; Wagemaker et al., 2020). As peer influence situations are highly complex, susceptibility to peer influence of adolescents with MBID may depend on specific conditions such as the relation with the peers, the number of peers, and the exact peer influence used. To illustrate, earlier studies used multiple peers who encouraged risk taking regularly during the task (Bexkens et al., 2019; Wagemaker et al., 2020), while we chose to only let one peer encourage risk taking in two breaks of the task, as adapted from Dekkers et al. (2020). An explanation for the different findings in the self-report could be that the difference in mean IQ between the MBID and TD samples was smaller in our study ($M_{IQdiff} = 26.4$) than in Dekkers et al. (2017; $M_{IQdiff} = 39.3$). As lower IQ scores have been related to higher susceptibility to peer influence (Steinberg & Monahan, 2007), a lower IQ in the MBID group could have led to more susceptibility to peer influence as compared to the TD group. Future experimental research could elucidate whether specific conditions or IQ criteria are crucial to find heightened susceptibility to peer influence in adolescents with MBID.

Inhibition. Adolescents with MBID were not different from TD adolescents with regard to inhibition as assessed by the SST, and the BRIEF self- and teacher reports. Our study was the first to use the SST in adolescents with MBID, providing an indication of behavioural inhibition. A meta-analysis found large behavioural inhibition deficits in individuals with MBID, although two of the five included experimental studies indices showed no significant differences (Bexkens et al., 2014a). The BRIEF questionnaires may tap into several aspects of inhibition (e.g., behavioural/cognitive/motivational inhibition or interference control), which have varying degrees of deficits in individuals with MBID (Bexkens et al., 2014a). The BRIEF-SR has not been administered to adolescents with MBID specifically but a study using the BRIEF-TR in adolescents with and without MBID showed that more problems in behavioural regulation only depended on the presence of a behavioural disorder (Bexkens et al., 2014b). All in all, these findings suggest that inhibition differences found between adolescents with MBID and TD adolescents are variable.

ToM. Adolescents with MBID had weaker ToM compared to TD adolescents on some of our instruments. They had difficulties in interpreting subtle verbal hints, which is in line with earlier studies using ToM tasks (Baglio et al., 2016). They also reported more problems in empathising with others' emotions than TD adolescents. Potentially, the abovementioned ToM aspects can be classified as complex ToM, which continues to develop during adolescence (Humphrey & Dumontheil, 2016) and may be delayed in adolescents with MBID. A potential delay in ToM development in adolescents with MBID may also explain why adolescents with MBID were similar to TD adolescents on more basic forms of ToM such as understanding others' emotions. We would like to acknowledge that adolescents with MBID were less often born in the Netherlands than TD adolescents, which may have increased their difficulty with language-based ToM tasks (Milligan et al., 2007). However, based on a pilot we adapted the experimental ToM task to have minimal verbal requirements.

Negative interpretation bias. The current study was the first to directly compare adolescents with and without MBID on their rejection-related negative interpretation bias, showing no differences. This may indicate

that the higher prevalence of social anxiety disorder in adolescents with MBID compared to TD adolescents (Dekker & Koot, 2003) may not be related to the strength of a negative interpretation bias in adolescents with MBID. As adolescents with MBID have weaker cognitive control than TD adolescents (Bexkens et al., 2014a but cf. the current study), and as cognitive control plays a moderating role between negative interpretation bias and state anxiety (Salemink & Wiers, 2012), a negative interpretation bias may instead have a bigger impact on anxious feelings in adolescents with MBID than in TD adolescents. Future research could elucidate links between negative interpretation bias, (social) anxiety and moderating factors in adolescents with MBID.

Linking susceptibility to peer influence to inhibition, ToM, and negative interpretation bias

This study indicated no link between susceptibility to peer influence of adolescents with MBID to their inhibition, ToM or negative interpretation bias. Future studies could differently operationalise the psychological processes that encode regulatory, social-cognitive, and affective cues from the environment (Do et al., 2020). More specifically, as the SST did not load on the latent factor of inhibition in the SEM, it could be argued that a different experimental task should have been selected with higher correlations with the self- and teacher reports. However, it is known that correlations between task performance and reports of executive functions are usually low (Toplak et al., 2013), this has recently also been proven for cognitive control measures in youth specifically (Snyder et al., 2021).

If these null findings between susceptibility to peer influence and inhibition, ToM, and negative interpretation bias remain replicated, research on susceptibility to peer influence in adolescents with MBID should target different concepts. A relevant target for investigation may be the influence of deviant friends. That is, adolescents with MBID more often have a deviant peer group than TD adolescents (Tipton et al., 2013), which may therefore bring them more often into problematic peer influence situations. Also, if current null findings are replicated, interventions aimed at decreasing susceptibility to peer influence may better not focus on inhibition, ToM or negative interpretation bias, but more attention should be paid to the effectiveness of interventions targeting susceptibility to peer influence directly. As an example, a curriculum for adolescents with developmental disorders may be promising, as it improved decision-making in hypothetical peer influence situations (Khemka et al., 2016).

Strengths

The current study has several strengths. First, the entire study was preregistered, giving confidence in fair treatment of the data (Nosek et al., 2015). We acknowledge that we did not reach our preregistered sample size due to the COVID-19 pandemic. Nevertheless, we still managed to recruit a large sample of adolescents with MBID, a group that is complex and hard to recruit. Second, a strong methodological aspect of this study was the multimethod approach using experimental task, self- and/or teacher-reports, This enabled us to make more reliable claims about the constructs based on multiple instruments. Also, we combined multiple indicators of one construct in a latent factor in the SEM, which increased reliability compared to using single indicators. Third, although instrument selection for research in adolescents with MBID can be challenging, we selected our instruments based on explicit criteria, adapted all self-reports with comprehension checks, and piloted two instruments that we adapted accordingly. Fourth, debriefing credibility questions showed that the peer manipulation was credible.

Limitations

A first limitation is that we may have studied a relatively mild MBID sample. Adolescents with MBID were sampled from practical vocational track schools that only admit students with an IQ between 55 and 80, which we confirmed by a shortened IQ test, and learning delays. However, teachers rated adaptive functioning of 41% of our MBID sample as sufficient. Thus, potentially 41% of our MBID sample did not meet the criteria of MBID. An explanation for this could be that we only used a screener of adaptive functioning. During our study, the Dutch version of the Adaptive Behavior Assessment System became available (i.e., ABAS-3; Harrison & Oakland, 2020). This more extensive instrument may be used in future research to get more detailed information on adaptive functioning.

Second, the validity of some our instruments could be questioned. A first illustration of this point is related to our experimental tasks of inhibition, ToM and negative interpretation bias. It could be that these provided too little emotional load. Situations of peer influence are usually highly emotional for adolescents (Gunther Moor et al., 2014), suggesting that factors involved should also be measured with such an emotional load. First versions of inhibition tasks using emotional faces have been developed (e.g., Pawliczek et al., 2013). These may tap more into hot/emotional aspects of inhibition, which could demonstrate different effects compared to inhibition in

cold/neutral contexts (Aïte et al., 2018). For ToM or negative interpretation bias, virtual reality (e.g., Otkhmezuri et al., 2019) can be used to increase emotional load and hereby validity. A second illustration is our selection of the SASC-R as self-report for negative interpretation bias. Within the currently selected SASC-R, the fear of negative evaluation (FNE) subscale can be conceptualised as assessing a more cognitive aspect of social anxiety. Though the items are formulated from an emotional/affective perspective (i.e., fear of…), they also include rejected-related interpretation of situations. For example: *I am worried that other children may not like me.* In this way, this subscale seems to also tap more interpretation-related processes. Thus, these examples show that our carefully selected instruments suiting the MBID population may have some limitations with regards to their validity.

Third, it might be posited that our SEM was underpowered to observe latent links between susceptibility to peer influence and inhibition, ToM, and negative interpretation bias. This idea could be based on the a-priori power-analysis in our preregistration indicating that 137 adolescents would be necessary to observe medium effects with a power of .8, while we only tested 111 adolescents due to the corona lockdown. However, our SEM demonstrated that the magnitude of the latent links was very small, suggesting that even in larger samples they will not become significant.

Conclusions

Our study showed that adolescents with MBID do not differ from TD adolescents in their susceptibility to peer influence as well as in many other domains and that their inhibition, ToM, and negative interpretation bias were not related to their susceptibility to peer influence. The increased understanding of susceptibility to peer influence in adolescents with MBID offers fruitful areas for future peer influence research and interventions to support this specific group.

Notes

1. The MBID group was larger than the TD group, to allow for SEM within the MBID group.
2. In the BART solo, adolescents watched two short neutral aquarium movies on the research phone at these moments to control for any distractions by the research phone.
3. Standardising the scores has the advantage of knowing the variance of the indicators, namely it being equal to 1. This allows us to easily fix the residual variance in terms of "proportion of total observed variance", which is necessary due to the small sample size relative to the number of free model parameters. We report unstandardised results as a default unstandardised results are only reported if at least one of the hypothesised relations between the latent factors is observed.
4. As some of our missing data are not missing at random (i.e., we removed outliers and preregistered errors), the FIML estimator may be considered inappropriate. Nevertheless, we refrained from excluding cases listwise as this leaves $N = 74$ participants instead of $N = 111$, translating to less than 5 individuals per free parameter.
5. As the equal SSRT obtained by adolescents with MBID compared to TD adolescents may be due to adolescents with MBID responding slower on go trials, we compared the go reaction times (RT) and the number of go-trial errors with similar ANCOVA's as the other group comparisons. The mean go RT and the number of go-trial errors did not differ significantly between the two groups (both p's > .29).
6. The homogeneity of variance assumption was violated for these variables. However, we made no adjustments to the analyses given that our group sample sizes were not deviating more than a ratio of 10 and as we already used a more stringent α level (Tabachnick & Fidell, 2019).
7. Sex was a significant covariate on the BES Affective subscale and both SASC-R subscales with girls reporting higher affective ToM and negative interpretation bias than boys.
8. In general, behavioral tasks such as the SST show low correlations with the BRIEF (see also Bramston & Fogarty, 2000).
9. In our preregistered model, the factor loading of the BART to susceptibility to peer influence was fixed to 1 to allow for identification. Therefore, the latent factor could only be informed by RPI scores, which complicated its interpretation. Exploratively, we fixed the variance of the latent factor to 1 instead. Both the BART and the RPI loaded significantly positive to peer influence factor. The pattern of relationships between the latent variables did not change.
10. As covariances between latent constructs were low, we also fixed these to zero as a sensitivity check. Results were similar.

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Data availability statement

Anonymous data are shared on the Open Science Framework on https://osf.io/qey3a/. The SPSS and M-Plus syntax can be found on https://osf.io/qey3a/

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