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ABSTRACT

Executive Functions (EFs) have been associated with aggression in children and adolescents. EFs as higher-order cognitive abilities are assumed to affect cognitive functions such as Social Information Processing (SIP). We explored SIP skills as a mediating mechanism linking EFs to aggression in adolescents with mild to borderline intellectual disability (MBID with IQ from 50–84), a high risk group for aggressive behaviors and EF impairments. A total of 153 adolescents (M_{age} = 15.24, SD = 1.35; 54% male) with MBID participated. Focused attention, behavioral inhibition, and working memory were tested with multiple neurocognitive tasks to define latent EF constructs. Participants responded to a video-based SIP task. A latent construct for aggression was defined by caretaker, teacher, and adolescent self-reports of aggression (Child Behavior Check List, Teacher Report Form, and Youth Self Report). Structural equation modeling was performed to test mediation. Results were consistent with mediation of the relation between focused attention and aggression by SIP, namely via hostile interpretations and self-efficacy for aggression. Behavioral inhibition was linked to aggression, but this relation was not mediated by SIP. The relation between working memory and aggression was mediated by SIP, namely via hostile interpretations, aggressive response generation and via self-efficacy for aggressive responses. Bearing the cross-sectional design in mind, support was found for SIP skills as a mechanism linking EFs, in particular focused attention and working memory, to aggression, providing a viable explanation for the high vulnerability of adolescents with MBID for aggression.

Executive Functions (EFs) refer to a set of higher-order cognitive skills including inhibitory control, cognitive flexibility and working memory. Empirical studies and meta-analyses have demonstrated associations between impaired EF performance and aggressive or hyperactive and impulsive behavior in children and adolescents (e.g.,

Granvald & Marciszko, 2016; Ogilvie, Stewart, Chan, & Shum, 2011; Oosterlaan, Logan, & Sergeant, 1998; Schoemaker, Mulder, Deković, & Matthys, 2013). The mechanisms explaining how EFs are linked to behavioral outcomes are, however, less well understood (see systematic review by Van Lieshout, Luman, Buitelaar, Rommelse, & Oosterlaan, 2013). The role of deficient EFs in the etiology of aggressive behavior problems may be elucidated by incorporating other relevant cognitive processes, such as social information processing (SIP; Dodge, 1980).

EFs affect social cognitive processes

Theoretically, EFs as higher-order cognitive abilities affect cognitive processes (Miyake & Friedman, 2012). Among the latter, processing of social information – essential in interactions with other people – may be particularly relevant for children and adolescents with aggressive behavior. There is a long tradition of research on SIP in children and adolescents with aggressive behavior and related psychiatric disorders (e.g., Dodge, 1980; Dodge et al., 2015; Matthys, Cuperus, & Van Engeland, 1999). The SIP model by Crick and Dodge (1994) distinguishes several steps, namely, the encoding of cues, the interpretation of the intent and emotions of self and others, clarification of social goals, generation and evaluation of responses, and finally, a behavioral response is selected and enacted (Crick & Dodge, 1994; Lemerise & Arsenio, 2000). Youth with aggressive behavior tend to encode significantly more hostile cues and generate more aggressive responses than typically developing peers (e.g., Dodge & Frame, 1982; Kupersmidt, Stelter, & Dodge, 2011) and biased SIP skills have been found to relate to aggressive behavior (e.g., Dodge et al., 2015).

Conceptually, intact inhibitory control, including attention control or focused attention (Diamond, 2006, 2013) and behavioral inhibition (Nigg, 2000), and intact working memory are necessary for adequate SIP for several theoretical reasons. First, impaired focused attention may affect the encoding of relevant cues and, as a result, the interpretation of the problem situation. Focused attention may also be required for the decision-making process in difficult social situations, when there is a need to focus on positive and negative aspects of response options (Diamond, 2013). Second, impaired behavioral inhibition may affect problem-solving, including careful interpretation of the problem situation, generation of several possible responses, and reflection on and consideration of self-efficacy for these responses and the possible outcomes from these options (Nigg, 2000). Third, impaired working memory may affect the encoding of cues and their interpretation, as these mechanisms involve assembling multiple pieces of potentially contradicting information. Working memory may also affect response generation as the incorporation of retrieved information from long-term memory into the encoded current circumstances is required (Baddeley, 2003), including recalling various appropriate response options. In addition, impaired working memory may affect cognitions related to enactment, including self-efficacy and decision-making as this process requires retaining various responses and associated outcomes actively in mind (Klingberg, 2010). Using a regression approach, two empirical studies also found first indications for relations between EFs, such as focused attention and inhibition, with SIP skills (Van Nieuwenhuijzen et al., 2017; Van Nieuwenhuijzen & Vriens, 2012).

EFs and SIP in youth with mild to borderline intellectual disability (MBID) and aggression

Examining the possible role of EFs in relation to SIP as factors involved in aggression is relevant in general, and particularly for adolescents with a mild intellectual disability or borderline intellectual functioning (MBID with an IQ 50–84, Schalock et al., 2010) as these youth are at high risk for developing severe aggression and rule-breaking behavior problems, and they are overrepresented in the juvenile justice system (e.g., Douma, Dekker, De Ruiter, Tick, & Koot, 2007; Kaal, Brand, & Van Nieuwenhuijzen, 2012; Sainero, Del Valle, López, & Bravo, 2013). Although variability in EF performance is found within the group of MBID, on average youth with MBID are impaired in EFs compared to typically developing peers. Moreover, relations have been found between impaired EFs and behavior problems in youth with MBID (Bexkens, Van Der Molen, Collot d'Escury-Koenigs, & Huizenga, 2014; Danielsson, Henry, Messer, & Rönnberg, 2012; Schuiringa, Van Nieuwenhuijzen, Orobio De Castro, & Matthys, 2017; Van Nieuwenhuijzen, Orobio De Castro, Van Aken, & Matthys, 2009; Visser, Berger, Van Schrojenstein Lantman-De Valk, Prins, & Teunisse, 2015).

In addition, compared to their typically developing peers, youth with MBID show a number of SIP biases. These include tendencies toward encoding mainly negative social cues, higher hostile interpretations, generation of submissive and aggressive responses, and selection of aggressive responses (Van Nieuwenhuijzen, Orobio De Castro, Wijnroks, Vermeer, & Matthys, 2004; Van Nieuwenhuijzen, Vriens, Scheepmaker, Smit, & Porton, 2011). Moreover, these biased SIP cognitions related to higher aggression scores in youth with MBID (e.g., Van Nieuwenhuijzen, Orobio De Castro, Wijnroks, Vermeer, & Matthys, 2009; Van Rest et al., 2014).

Relations between EFs and aggression may be explained by SIP

In this study, it was hypothesized that the relation between EFs and aggression is statistically mediated by SIP (see Figure 1). Three separate EFs were included, namely, focused attention, behavioral inhibition, and working memory. This choice was based on conceptualizing executive functioning as a combination of separate, yet related, executive cognitive constructs, instead of one unitary construct (Lerner & Lonigan, 2014; Miyake et al., 2000). Four SIP cognitions were selected as possibly linked to these EFs: encoding, hostile interpretations, aggressive response generation, and self-efficacy for aggression. These represented early, mid, and late steps of SIP, based on previous SIP studies investigating relations with aggression and ID (e.g., Lansford et al., 2006).

In line with previous studies (e.g., Ogilvie et al., 2011; Van Nieuwenhuijzen et al., 2017), associations between the EFs and aggression were expected. The main aim was to study the viability of SIP as a linking mechanism by testing indirect effects, consistent with the definition of mediation as proposed by Kenny, Kashy, and Bolger (1998) and Hayes (2009). As EFs are theorized as higher-order cognitive functions that affect other cognitive processes, the direction of relations with SIP was expected from EFs as purely cognitive functions toward SIP as subsequent
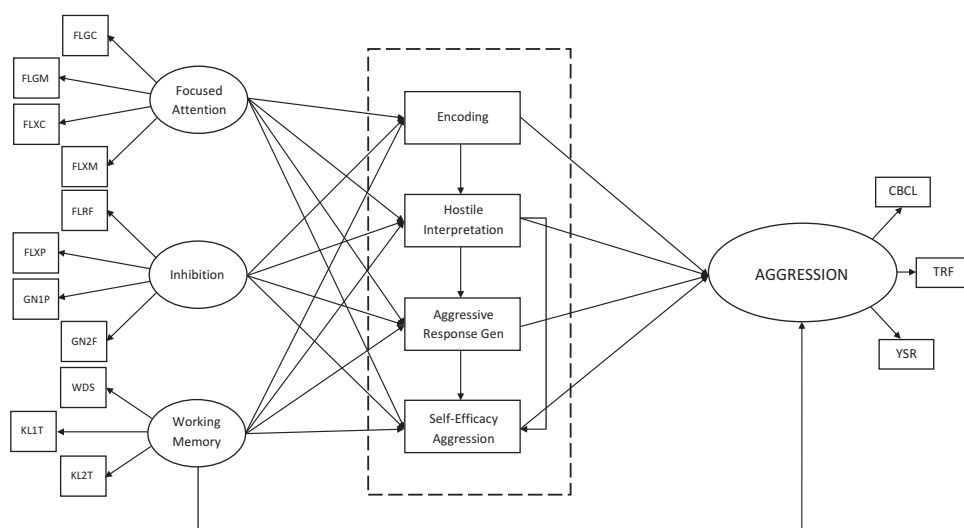
Figure 1. Tested mediation model with latent variables for EFs and Aggression, and observed SIP variables.

Note. All abbreviations are explained in the method and measures section.

social-cognitive processes. Each EF was tested in relation to all four SIP cognitions, and it was hypothesized that focused attention would significantly relate to encoding, interpretation, and self-efficacy; behavioral inhibition was hypothesized to relate to interpretation, response generation, and self-efficacy; and working memory to all four SIP cognitions. The SIP cognitions were expected to represent the direction of the theoretical transitive model with interrelated SIP steps (Crick & Dodge, 1994). The final steps of the model including the generation of aggressive responses and perceiving self-efficacy for those responses were expected to associate with reported aggressive behavior.

Method

Participants

A total of 168 13 to 17-year-old adolescents ($M = 15.24$, $SD = 1.33$; 54% male) participated, originating from urban and rural areas and controlled for their socioeconomic status (SES) and race-ethnicity minority status (see Measures). The adolescents attended special (residential) care institutes for youth with intellectual disability, clinical (residential) youth care institutes, youth psychiatric institutes, special education programs, and two attended mainstream schools. Hence, we included a variety of participants that validly represented the population of MBID within a range of cognitive, social, and behavioral problems. Intellectual ability scores ranged from 50–84, congruent with a mild intellectual disability (MID) and borderline intellectual functioning (BIQ, Schalock et al., 2010). Intellectual ability was based on Wechsler intelligence tests (Wechsler, 1949, 1955; Dutch versions by Kort et al., 2005; Uterwijk, 2000) using an

Table 1. Descriptive statistics and influences of age on study parameters.

	n	M	SD	Min	Max	r Age
Att Correct1	153	29.54	3.96	5.00	32.00	ns
Att Correct2	151	24.99	6.06	12.00	32.00	ns
Att Missings.r	153	−5.10	13.72	−120.00	0.00	ns
Inh Fault1.r	153	−5.33	7.92	−32.00	0.00	ns
Inh Fault2.r	149	−1.62	1.71	−8.00	0.00	ns
Inh Prem1.r	153	−.86	2.22	−16.00	0.00	ns
Inh Prem2.r	149	−1.47	2.00	−9.00	0.00	ns
WM Auditive	146	5.61	2.92	1.00	14.00	ns
WM VisFor	152	10.16	3.82	0.00	19.00	.21*
WM VisBack	152	7.64	3.79	0.00	15.00	ns
Encoding	153	4.69	1.10	1.50	7.00	ns
Hostile interp	153	1.77	.36	1.17	3.00	ns
Resp Gen	153	1.11	1.29	0.00	5.00	ns
Self-Effic	153	2.74	.94	1.00	5.00	ns
CBCL aggr	149	9.62	7.91	0.00	33.00	ns
TRF aggr	138	8.47	8.77	0.00	37.00	ns
YSR aggr	151	7.20	4.83	0.00	23.00	−.17*
FIQ	153	68.00	8.94	50.00	84.00	
Block Design no	146	4.53	2.25	1.00	10.00	
Vocabulary no	144	4.69	1.96	1.00	9.00	

Note. *$p < .05$, **$p < .01$
All reversed EFs variables end with ".r"
Higher numbers equal better EF performance in all variables
Att = Focused Attention. Inh = Behavioral Inhibition.
WM = Working Memory.
Prem = prematures. VisFor = visual forward. VisBack = visual backward.
Interp = interpretation. Resp Gen = aggressive response generation.
Self-Effic = self-efficacy for aggression.
Aggr = aggressive behavior report.
FIQ = full scale IQ score by clinical file or estimate.
No = norm scores from the Wechsler intelligence tests.
Numbers 1 & 2 represent the first and second task for one EF.

estimation of Full scale IQ (FIQ) with the sum of the scaled subtest scores of the subtests "Vocabulary" and "Block Design" (Table 1). In some cases, IQ scores were obtained from the participant's clinical file, if the Wechsler intelligence test had been administered during the 12 months previous to our test administration ($n = 9$). When recent IQ scores were not available in the clinical file, the FIQ was estimated by the subtests ($n = 159$). FIQ estimates are reliable and highly congruent with the FIQ score (Hrabok, Brooks, Fay-McClymont, & Sherman, 2014; Silverstein, 1970), and this procedure has been validly used in previous studies with youth with MBID (e.g., Van Nieuwenhuijzen et al., 2004).

Ten adolescents (5.95%) were excluded from the analyses due to an IQ-score below the lower bound of 50 for MID. We aimed to include youth with MID and BIQ only, and exclude youth with moderate or severe ID who require a different approach in practice and in analyses (Schalock et al., 2010). In addition, five participants were excluded due to missing data on crucial observed variables measuring aggressive behavior or EFs (for specific numbers and explanations see under Measures). In the end, 153 participants ($M_{age} = 15.24$, $SD = 1.35$; 54% male) were eligible for further analyses. Of these participants, 34 (22.2%) belonged to a race-ethnicity minority status, 38 adolescents (24.8%) came from families with low SES of which 8 (5.3%) with parents who had not finished any formal education, 6 (4.0%) with parents who finished only elementary school, and 24 (15.9%) with

middle to high school graduation in the Dutch education system. The remaining adolescents came from families with medium SES (56.6%) or high SES (18.6%).

Procedure

The Science and Ethics Committee of the Faculty of Behavior and Movement Sciences, Vrije Universiteit Amsterdam, and the Ethical Committee of the institute for Health and Care Research at VU medical center approved the study. This study was part of a larger research project in which stratified recruitment was used in order to include children and adolescents with MID, BIQ, and average IQ. We targeted special (residential) care institutes for youth with intellectual disability, clinical (residential) youth care institutes, youth psychiatric institutes, special education programs, and mainstream schools. In addition, in all IQ groups, participants were recruited within a range of externalizing behavior, distributed across groups with and without clinical levels of externalizing behavior (98th percentile). Clinical professionals from several institutions and schools and Master's students were trained on the standardized data collection protocol. Following written informed consent by parents or legal guardians and the adolescents, and school and institution boards provided permission to invite participants, assessments were conducted at clinical institutions or schools. Adolescents received a small monetary incentive to participate.

Measures

Demographic characteristics

The parents or the legal guardian of the adolescent completed a questionnaire providing information about participants' age, sex, race-ethnicity, and family level of SES. SES was defined by a maximum score of highest level of education of the caretakers, answered on a scale ranging from 0 for no formal education to 7 for post-doctoral education. Race-ethnicity minority group status was defined as a combination score based upon the birth country of both parents and the adolescents. In the Netherlands, the most common non-Western minority groups are from Morocco, Turkey, Surinam, and the Dutch Antilles (CBS, Central Bureau for Statistics in The Netherlands, 2018). Some other birth countries from non-Western minority groups were also included in the minority group status, resulting in a dichotomous score for belonging to a race-ethnicity minority group or not.

Aggression

Aggressive behavior was assessed using the syndrome scale "Aggression" of the ASEBA scales (Achenbach & Rescorla, Teacher Report Form: TRF, 2001; Achenbach & Edelbrock, Child Behavior Check List: CBCL, 1991a; and Achenbach & Edelbrock, Youth Self Report: YSR, 1991b). Teachers (TRF), caretakers (CBCL), and adolescents (YSR) completed the 20, 18, and 17 items, respectively, of this syndrome scale of the Dutch ASEBA versions (Verhulst, Van Der Ende, & Koot, 1996, 1997a, 1997b). The YSR is a valid and reliable self-report instrument in youth with MBID (Douma, Dekker, Verhulst, & Koot, 2006). Each item on the scale described aggressive

behaviors to which each informant rated the youth (either as a proxy or as a self-report) on a 3-point Likert scale: 0) not true, 1) sometimes or somewhat true, or 2) often or very true. The total raw sum scores for aggressive behavior on all three questionnaires separately were taken as the three indicators of aggressive behavior. The aggressive behavior scores of these adolescents ranged from clinically aggressive to typically developing (Table 1).

Missing item scores for aggressive behavior problems were replaced by the individual scale mean, with a maximum of two items per scale. In case of completely missing questionnaires, latent aggression variable scores were calculated from the remaining two out of three aggression reports. One participant (0.60%) had missing data on both the CBCL and TRF; therefore, this adolescent was removed from further analyses.

Executive functions

For the measurement of executive functioning, three computer-based games were custom-developed as applications for use on a tablet computer in order to assess (1) Focused Attention, (2) Behavioral Inhibition, and (3) Working Memory. The choice for three "cool" EFs (the more purely cognitive skills that are prompted in abstract thinking and problem-solving) as opposed to "hot" EFs (the affective side of EF skills that are elicited by emotional and motivational situations and problem-solving) was based on findings that so-called cool EFs contribute more to understanding specifically the differences in aggression between children (Poland, Monks, & Tsermentseli, 2016; Zelazo & Carlson, 2012). The development of the tests was based on the principles, technical programming information, and previous experiences with the Amsterdam Neuropsychological Tasks (De Sonneville, 1999), Klingberg's principles for working memory (Klingberg, 2010; Klingberg et al., 2005), studies on computer-based assessment of inhibition in children (e.g., Nigg, 1999, 2000; Nosek & Banaji, 2001; Oosterlaan et al., 1998; Simmonds, Pekar, & Mostofsky, 2008), and attention processes assessed with the Flanker principle (Eriksen & Eriksen, 1974). All tests were adapted to the specific needs of adolescents with MBID (Schalock et al., 2010), by including fewer trials, shorter tests, visual support during test instructions, and attractive stimuli.

In order to validly represent a proxy of each single yet related EF, each function was assessed multiple times with two or three different tests or different tasks within tests, creating three or four observed variables per EF. The EF data from four participants (2.38%) were removed from the analyses. These participants had partially missing or invalid data on multiple tests due to test interruption or invalid test administration. As multiple observed variables were missing, latent variables could not be validly constructed for these four participants. A detailed description of tests and indicators per EF follows.

Focused attention

An attention game was developed based on the Flanker-principle by Eriksen and Eriksen (1974), in which an individual is requested to focus on a stimulus that is accompanied by other distracting objects (the flankers). In the current test, stimuli were presented consisting of five arrows next to one another; the center arrow was the object of focus. The color of the arrows – either green or red – indicated a particular assignment. The test was divided into two tasks, measuring several constructs of attention: (1)

focused attention, with green arrows and (2) focused attention with cognitive flexibility, with alternating green and red arrows. All respondents received an instruction and a practice session for both tasks. For each task, 32 stimuli were presented on the tablet screen for a maximum of 2,500 ms per stimulus, until participants provided an answer. The stimuli were preceded by a fixation symbol that was presented with a random duration of 1,000, 1,500, or 2,000 ms to avoid habituation. In case of non-response, after the stimulus disappeared, there was a 100 ms timeframe before the start of the fixation symbol. The 32 stimuli were presented in random order across all participants.

In task 1, with green arrows, 16 compatible stimuli consisted of pictures with five arrows in similar direction; eight stimuli pointing right and eight pointing left. An additional 16 incompatible stimuli consisted of five arrows with the center arrow pointing in the opposite direction from the other four arrows; eight stimuli pointing right and eight pointing left. Participants were asked to quickly press a left or right button on the tablet screen with their index fingers, congruent with the direction of the center arrow presented. In task 2, half of the stimuli from task 1 were used, and half of the stimuli were colored red. These red stimuli instructed the participant to quickly press a button on the tablet screen incongruent with the direction of the center arrow. These green and red arrows were alternated, resulting in a mix of 16 green and 16 red, of which 16 compatible and 16 incompatible stimuli. Therefore, focused attention on the center arrows was required, combined with a flexibility for alternating assignments.

Each task of this Flanker test had an average duration of two minutes. Responses in both tasks were considered valid from 200 ms after onset of stimulus presentation. The variables used in these tasks for measurement of the latent variable Focused Attention were the total correct responses as a measure of adequate focused attention in the two tasks (see Figure 1, FLGC, for Flanker Green Correct, and FLXC, for Flanker mixed Correct), and total missings or lack of on-time responses in the two tasks, which represented lapses of attention (see Figure 1, FLGM and FLXM for Missings). For the main analyses, the latter two variables were reversed, in order to create four variables in which higher scores represented better focused attention processes.

Behavioral inhibition

The task for measurement of behavioral inhibition was based on the Go/No-go principle (e.g., Nigg, 1999), which assesses the ability to suppress an action and inhibit behavior. A game was developed in which participants had to collect points as quickly as they could. The game consisted of two tasks. All respondents received an instruction and a practice session in both tasks.

The first task was created as a baseline, in order to increase speed and enhance the urge to respond. Fifty-two stimuli were presented on the screen for a maximum of 800 ms per stimulus, until the participant provided an answer. Stimuli were preceded by a fixation symbol for 1,000 ms, and with an interval of 1,000 ms in between end of stimulus and start of fixation symbol. Participants were asked to react as quickly as possible to collect points by pressing the button on the tablet screen with their index finger of the preferred hand. They were also instructed not to press yet during the fixation symbol, but only when a stimulus was presented. This required withholding their behavior. The second task included an additional component of inhibition. The task contained 39 Go stimuli alternated with 13 No-go stimuli with a red cross through

the picture, also presented for 800 ms per stimulus and preceded by the fixation symbol. The No-go stimuli were first randomly distributed across the Go stimuli; it was checked whether there were no more than two successive No-go stimuli in a row. Subsequently, the order was fixed for all respondents in order to prevent possible clusters of No-go stimuli within the task. In this second task the respondents received the same instruction as in the first task; in addition, they were asked to suppress their action when presented with a red cross.

Both tasks had an average duration of 2.5 min. Responses in both tasks were considered valid from 200 ms after onset of stimulus presentation. The parameters used to construct the latent variable Inhibition were the number of premature responses in the first task, and the number of faults in the second task, that is pressing a button while being presented with a red cross (see Figure 1, GN1P, for Go/No-go task 1 Prematures; GN2F, for Go/No-go task 2 Faults). Pressing a button during the presentation of the fixation symbol and before 200 ms after stimulus onset was considered a premature response.

In addition, the Flanker task was used in order to measure the construct of behavioral inhibition. We tested the suppression of initial behavioral responses when confronted with reversed instructions. This was done by using the Flanker tasks with red arrows, as presented earlier, including the instruction to press the opposite direction of the center arrow presented. The variables used from this task were the number of faults in the task with only red arrows, representing the inability to suppress an initial response, and the number of premature responses in the mixed task with alternating green and red arrows, representing the inability to withhold behavior (see Figure 1, FLRF, for Flanker Red Faults; and FLXP, for Flanker mixed Prematures). All four observed inhibition variables were reversed, in order to create variables in which higher scores represent better behavioral inhibition skills.

Working memory

The task for visual working memory was based on the Klingberg principle (Klingberg, 2010; Klingberg et al., 2005). The task assessed both the maintenance of temporal patterns in working memory and the use of the central executive in processing and manipulating stored information (Baddeley, 2003; Hambrick, Kane, & Engle, 2005). A game was developed in which respondents were asked to remember and replicate visual patterns of stimuli (green and red dots).

In this game, a 4 × 4 grid was presented on the screen consisting of 16 units on which patterns of stimuli were presented. One forward and one backward task was conducted and all respondents received an instruction and a practice session in both tasks. Each task started with the presentation of a trial with two adjacent stimuli and increased gradually in length and in difficulty, that is, successive stimuli were first presented on units that were attached and then on detached units further apart. Each stimulus appeared on a unit for 1,000 ms and disappeared for 750 ms in between stimuli of one trial. In the Forward task, respondents were asked to quickly replicate the presented patterns in correct order on the tablet screen with their index finger of the preferred hand. In the Backward task, manipulation of stored information was also required, as the presented patterns had to be replicated in reversed order, starting with the last unit and moving backwards.

The tasks were terminated after two subsequent incorrect trials within the same length and difficulty level. For example, when four stimuli were successively presented on detached units and the adolescent answered in wrong order twice in a row, the task ended, in order to avoid frustration and exhaustion of respondents with low working memory ability. Therefore, task durations varied according to performance level of the participants. Adolescents with a better working memory continued for a longer time, as they achieved to replicate longer trials of stimuli. Responses in both tasks were considered valid with a 10 ms interval after last stimulus presentation of the presented trial. The variables used in this study were total correctly replicated trials forward, and backward (see Figure 1, KL1T, for Klingberg task 1 Trials, and KL2T, for Klingberg task 2 Trials).

Auditive working memory was included using the Digit Span task from the Wechsler intelligence scales (Wechsler, 1949, 1955), using the Dutch versions (Kort et al., 2005; Uterwijk, 2000). In this task, respondents were asked to verbally replicate trials of numbers that were presented verbally by a test leader. These trials increased in length, adding one number after two trials of the same length. A first task requested to replicate the patterns, and a second task requested to replicate the trials in backward order. Answers were rewarded with points for correctly replicated trials. Using Dutch norms, for each participant one norm score was calculated for the combination of the forward and backward digit span tasks, and used as a variable in this study (see Figure 1, WDS, for Wechsler Digit Span).

Social information processing

SIP skills biases and deficits were assessed based upon adolescents' responses to six videos depicting social problem situations. Participants responded to a semi-structured interview and multiple choice questions on a tablet computer in a newly developed mobile SIP app called "SIVT" (SIVT, Sociale InformatieVerwerkingsTest [Social Information Processing Test] [Computer software]). The SIP items were based upon previous SIP research and assessment procedures (e.g., Kupersmidt et al., 2011; Matthys et al., 1999; Schultz et al., 2010; Van Nieuwenhuijzen, Bijman, Lamberix, Wijnroks, & Matthys, 2009; Van Rest et al., 2014; Ziv & Sorongon, 2011). Within the SIVT, videorecorded vignettes depicted scenes involving interpersonal problems within situations that were hostile, ambiguous, and accidental or benign, involving a peer or an adult perpetrator. In all six videos, the outcome of the situation was negative for the victim. The plots for these vignettes were written based upon previous interviews with adolescents about the social situations that they found most difficult or challenging (Van Rest et al., 2014).

Four SIP cognitions were assessed according to separate steps in the SIP model (Crick & Dodge, 1994; Lemerise & Arsenio, 2000), and according to previously reported SIP assessment procedures (e.g., Kupersmidt et al., 2011; Matthys et al., 1999; Van Nieuwenhuijzen et al., 2011; Van Rest et al., 2014). To cover the SIP model from beginning to end, four different SIP cognitions were selected from the early, mid, and late steps of the SIP model (Crick & Dodge, 1994; Lansford et al., 2006) based on pervasive SIP impairments in youth with MID (Van Rest et al., 2017).

Encoding was assessed by responses to the open-ended question "What happened in this video?" The 10 most essential elements of the situation were scored by the test

administrator. For each element mentioned by a respondent, one point was awarded, leading to scores ranging from 0 to 10 correct per video. A mean score for Encoding was calculated. Inter-rater reliability kappas for encoding items were calculated for each of the six videos separately; for video A, $K = .87$; B, $K = .66$; C, $K = .67$; D, $K = .62$; E, $K = .77$; F, $K = .59$, the latter representing one moderate kappa (Landis & Koch, 1977).

Hostile interpretation was examined as the attribution of the perpetrator's level of hostility by asking "What do you think of [this perpetrator]?" Answers on a 3-point Likert-type scale ranged from 1 = normal to 3 = (very) mean. Hostile Interpretation was averaged across the six videos.

Aggressive response generation was assessed with the open-ended question: "If this happened to you, what would you do?" Answers were dichotomized into an aggressive or antisocial response versus a passive, assertive, or prosocial response. A total sum score for Aggressive Response Generation was calculated. Inter-rater reliability kappas for the response generation items were calculated for each of the six videos separately, for video A, $K = .41$; B, $K = .71$; C, $K = .59$; D, $K = .76$; E, $K = .60$; F, $K = .70$. These included two moderate kappas (Landis & Koch, 1977).

Self-efficacy for aggressive responses was measured after presenting videos with an aggressive, assertive, or passive response as possible enactment by the victims in the six situations. Multiple-choice questions assessed the participant's self-efficacy for these responses ("Could you also respond like [the behavior of the victim]?"). The participants answered on a 5-point Likert type scale, ranging from 1 = totally not, to 5 = totally. A mean score for the Self-Efficacy for Aggressive responses was calculated across the six videos.

Results

Overview of the analyses

Means and standard deviations were computed for the main variables EFs, SIP cognitions, and aggression (Table 1). Correlations were computed between all main variables and possible confounding factors of age, SES, and race-ethnicity. Confounding variables that significantly correlated with the predictor variables were taken into account by performing regression analyses on the variables and using the residuals in further analyses.

Variance for one focused attention variable was found much larger than the three other variables, which can lead to estimation problems in the structural equation models. Therefore, this variable was transformed by a multiplication of 10.

For the main analyses, structural equation modeling was performed in Mplus 7. A factor model was constructed for each EF and aggression. A path model was constructed for the four SIP cognitions, as predicted by theory. The fit of these models was examined and was considered acceptable in case of a non-significant chi-square using an alpha of .05, and with the model fit indices Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) indicating values of .90 or higher, and Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean square Residual (SRMR) values of below .08. For the comparison between models the Akaike's Information Criterion (AIC) was used, with a lower AIC indicating a better model fit. Note that factor models

with three observed variables are saturated and demonstrate a perfect fit. In addition to model fit, we examined the factor loadings and proportion of variance explained.

The three types of EF (focused attention, behavioral inhibition, and working memory) were measured by 11 observed EF variables in total. The four inhibition variables with number of faults and premature responses and two focused attention variables for number of missings were reversed to create variables with higher scores representing better EF performance. Factor models were constructed as depicted in Figure 1.

The SIP model represented four observed interrelated SIP cognitions. In this study, SIP was reduced to four cognitions, that were entered in the order implied by the original SIP model by Crick and Dodge (1994) (see Figure 1). Significance of the path coefficients was evaluated in order to find a most parsimonious model describing the interrelations between the SIP cognitions. Model fit indices, variance explained, and the path coefficients between the SIP cognitions are presented.

A factor model for aggression was constructed with caretaker, teacher, and adolescent self-reports on aggression as the three indicators (CBCL, TRF, and YSR respectively; Achenbach et al, 1991a, 2001, 1991b). Model fit indices were presented as well as all separate factor loadings and variance explained.

In the next step, the best fitting models for the EFs, SIP and aggression were combined into a larger mediation model that was tested stepwise (Hayes, 2009; Kenny, 2016; Preacher & Hayes, 2004, 2008). Because executive functioning was conceptualized as a collection of interrelated, yet distinct functions, instead of one unitary construct (Lerner & Lonigan, 2014; Miyake et al., 2000), the relations between each EF factor and SIP or Aggression were analyzed separately. This resulted in three mediation models with either the latent construct of focused attention, behavioral inhibition, or working memory as the independent variable, the SIP model as the mediator, and the latent construct of aggression as the dependent variable (See Figure 2).

Mediation steps were followed (Hayes, 2009; Kenny, 2016; Preacher & Hayes, 2004, 2008). First, the relations between the three latent EF variables and Aggression were analyzed. Second, relations between EFs and the four SIP cognitions were analyzed. Third, relations between the SIP cognitions and Aggression were analyzed. Fourth, a mediation model was tested with the relations between the three latent EF variables and Aggression decomposed into indirect effects (EF-Aggression relations mediated by SIP) and direct effects of EF on aggression. Additionally, in the fourth step it was examined to what extent the relation between EFs and Aggression was explained by SIP by testing the significance of the direct effect. Following Kenny et al. (1998) and Hayes (2009) the first step and testing full mediation in the final step were not required to demonstrate mediation of EF relations with aggression by SIP.

For clarity of presentation of the results, the SIP relations with Aggression were presented first (step 3), as the model of relations between SIP and Aggression remained similar across the three mediation models differing only in terms of the independent EF variable. A model was analyzed to test which SIP variables were related to aggression, while the interrelations between these SIP cognitions according to SIP theory were also investigated.

Subsequently, the mediation analyses were presented per EF separately. For each EF, the relation between the EF and aggression was presented first (step 1), then the associations between the EF with the SIP cognitions (step 2), and finally the test on the effect of SIP on aggression and the mediation of EF via SIP toward aggression were
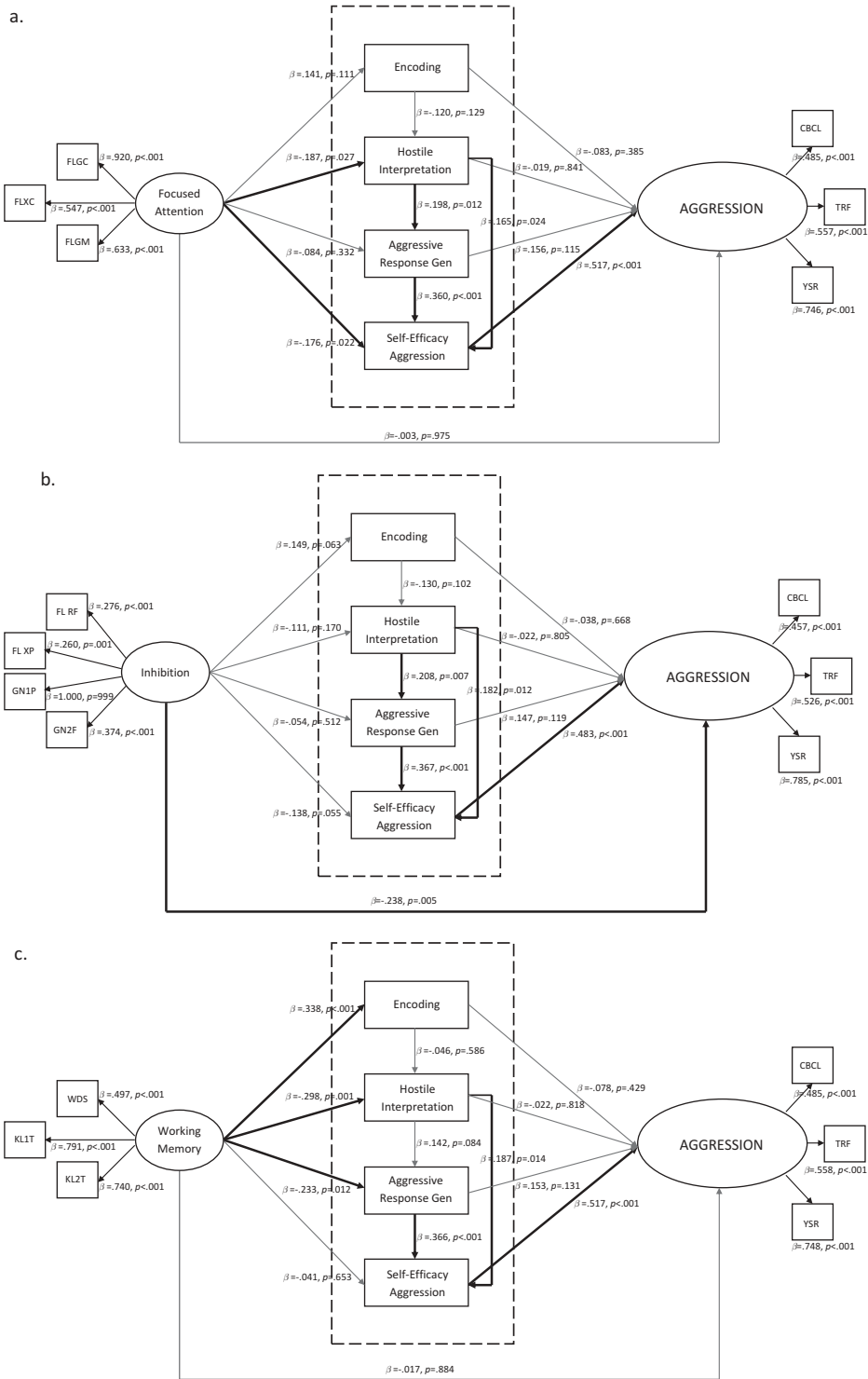
Figure 2. Tested mediation models with direct and indirect effects via SIP between each EF and aggression.

presented (step 4). All pathways from the latent EF variables to the four observed SIP variables were permitted in the model.

Demographic characteristics

Descriptive characteristics for predictor and dependent observed variables are presented in Table 1. A series of correlations between possible confounders and predictor variables showed that SES and race-ethnicity were not related to any predictor variables, except for one correlation between race-ethnicity (minority status) and aggressive response generation in the SIP test ($r = .19$, $p = .02$). As age is generally related to the development of cognitive functions (Casey, Giedd, & Thomas, 2000), for clarity, all correlations between predictor and dependent observed variables with the covariate "age" are presented in Table 1. The age of the participants was associated with visual Working Memory forward ($r = .21$, $p = .01$). For the two other variables within the latent variable of Working Memory, there were no age-related differences. The age-residualized version of visual Working Memory forward was used in further analyses.

The YSR self-report for aggression was also related to age ($r = -.17$, $p < .05$); older participants reported slightly less aggressive behaviors. It was decided not to normalize this YSR variable for age differences, because aggression was not a predictor, but an outcome in the current study.

EF latent variables construction

Focused attention

To construct a latent variable for focused attention a first model was tested with the four observed attention variables. This model demonstrated a poor fit (CFI = .84; TLI = .51; RMSEA = .28; SRMR = .06; $\chi^2(2) = 25.41$, $p < .001$). The variable for number of missings in the mixed task of the Flanker explained only a small proportion of variance ($R^2 = .16$, $p = .03$), and it loaded negatively on the factor ($\beta = -.40$, $p < .001$). This variable was deleted; hence, the model for focused attention with three observed variables was saturated. All three variables contributed strongly and significantly to the factor for focused attention: the number of correct responses in the green task ($\beta = .93$, $p < .001$), the number of correct responses in the mixed task ($\beta = .54$, $p < .001$), and the number of missings in the green task ($\beta = .63$, $p < .001$). This latent variable model with three observed variables was included in the subsequent main analyses.

Behavioral inhibition

For the latent variable of behavioral inhibition a model was tested with the four observed inhibition variables. This model demonstrated an excellent fit (CFI = 1.00; TLI = 1.00; RMSEA = .00; SRMR = .02; $\chi^2(2) = 1.16$, $p = .56$). Factor loadings were significant for the number of faults in the red Flanker task ($\beta = .32$, $p = .001$), for the number of premature responses in the mixed Flanker task ($\beta = .32$, $p = .002$), and for the number of faults in the second Go-Nogo task ($\beta = .45$, $p < .001$). For the number of premature responses in the first Go-Nogo task a strong contribution was found ($\beta = .84$,

$p < .001$). The residual variance for this variable was not significant ($\beta = .30$, $p = .24$), and therefore it was set to zero. The resulting model for behavioral inhibition was included in the subsequent main analyses.

Working memory

For working memory a model was tested with the three observed working memory variables; therefore, this model was saturated. All three variables contributed strongly and significantly to the factor for working memory, namely, the norm score of trials completed in the auditive digit span task ($\beta = .48$, $p < .001$), the number of forward trials completed in the visual task ($\beta = .81$, $p < .001$), and the number of backward trials completed in the visual task ($\beta = .73$, $p < .001$). This latent variable model with three observed variables was included in the subsequent main analyses.

SIP model construction

The four observed SIP variables were first entered into a transitive model that only permitted the relations between the successive SIP steps (Crick & Dodge, 1994). In this model, encoding was entered as a predictor of hostile interpretations, which in turn was a predictor of aggressive response generation, and this response generation was a predictor of the final step of self-efficacy for aggression. This model demonstrated a poor fit (AIC = 1021.84; CFI = .89; TLI = .77; RMSEA = .10; SRMR = .06; $\chi^2(3) = 7.73$, $p = .05$) and was therefore rejected.

A second model was tested including relations between SIP steps with the two previous steps as predictors. Two paths were added to the first model, namely, encoding as a predictor of aggressive response generation and hostile interpretations as a predictor of the self-efficacy for aggression. This model demonstrated an excellent fit (AIC = 1018.12; CFI = 1.00; TLI = 1.00; RMSEA = .00; SRMR = .00; $\chi^2(1) = .01$, $p = .91$). The path coefficient from hostile interpretations to self-efficacy for aggression was significant ($\beta = .20$, $p = .008$). The path coefficient from encoding to aggressive response generation was, however, not significant ($\beta = -.06$, $p = .43$).

Therefore, a third model was tested in which the relation between encoding and response generation was deleted. This model demonstrated an excellent fit (AIC = 1016.74; CFI = 1.00; TLI = 1.00; RMSEA = .00; SRMR = .02; $\chi^2(2) = .63$ $p = .73$). For hostile interpretations, the proportion of variance explained and the path coefficient by encoding were not significant ($\beta = -.15$, $p = .06$; $R^2 = .02$, $p = .35$). For aggressive response generation, the proportion of variance explained was small ($R^2 = .05$, $p = .16$), but the path coefficient of hostile interpretations as a predictor of response generation was significant ($\beta = .22$, $p = .005$). The path coefficients for the association with self-efficacy for aggression were significant (from interpretation, $\beta = .20$, $p = .006$.; from response generation $\beta = .38$, $p < .001$), and the amount of variance explained was acceptable ($R^2 = .21$, $p < .001$). This third model with excellent fit was used as the SIP model in all subsequent mediation analyses.

Aggression latent variable construction

There were three observed variables for aggression, namely the ASEBA reports from caretakers, teachers, and the adolescents themselves. Therefore, the model for the latent aggression variable was saturated. All three observed variables contributed strongly and significantly to the factor for aggression, namely for CBCL (β = .59, p < .001; R^2 = .35, p = .001), for TRF (β = .69, p < .001; R^2 = .48, p < .001), and for YSR (β = .58, p < .001; R^2 = .33, p = .001). This latent variable model with three observed variables was included in subsequent main analyses.

Mediation analyses

Aggression by SIP cognitions

In this model, aggression regressed on the four observed SIP cognitions. The model demonstrated an acceptable to good fit (CFI = .96; TLI = .91; RMSEA = .06; SRMR = .04; χ^2(10) = 15.85, p = .10). The associations with aggression were not significant for the first three SIP cognitions (encoding, β = -.08, p = .37; interpretation β = -.02, p = .84; response generation, β = .16, p = .11), but a strong and significant association was found for self-efficacy for aggressive responses toward aggressive behavior (β = .52, p < .001). Adolescents with a higher self-efficacy for aggression, partly determined by earlier SIP cognitions, behaved more aggressively.

Focused attention mediation models

First, the relation between focused attention and aggression was investigated. This model demonstrated an acceptable fit (CFI = .96; TLI = .92; RMSEA = .07; SRMR = .05; χ^2(8) = 14.67, p = .07). The path coefficient was not significant (β = −.07, p = .51). Subsequently, the relations between focused attention and the four SIP variables were examined. This model demonstrated an excellent fit (CFI = 1.00; TLI = 1.00; RMSEA = .00; SRMR = .03; χ^2(10) = 6.82, p = .74). Impaired focused attention was significantly related to more hostile interpretations (β = -.19, p = .03) and with a higher self-efficacy for aggression (β = -.18, p = .02). Focused attention was not related to encoding skills (β = .14, p = .11) or the generation of aggressive responses (β = -.08, p = .33).

Next, the mediation model for focused attention via SIP toward aggression was tested. This model demonstrated a good fit (CFI = .96; TLI = .94; RMSEA = .05; SRMR = .05; χ^2(26) = 35.34, p = .11). The path coefficients and p values for all paths are presented in Figure 2a. There was no direct effect; the relation between focused attention and aggression was statistically mediated by the SIP steps. Impaired focused attention related to higher hostile interpretations, which related to higher aggressive response generation and self-efficacy for aggression within the SIP model, which related to higher aggressive behavior scores. Significant relations were also found from focused attention toward self-efficacy for aggression, which related to the aggressive behavior of the adolescents. The proportion of variance in aggression explained by the model was significant (R^2 = .37, p < .001).

Behavioral inhibition mediation models

First, the relation between behavioral inhibition and aggression was examined. This model demonstrated a good fit (CFI = .97; TLI = .95; RMSEA = .04; SRMR = .06; χ^2 (14) = 17.22, p = .24). Impaired behavioral inhibition related to aggressive behavior significantly (β = −.31, p = .002). Next, the relations between behavioral inhibition and the four SIP cognitions were examined. This model demonstrated an acceptable fit (CFI = .91; TLI = .85; RMSEA = .06; SRMR = .06; χ^2(17) = 26.31, p = .07). There were, however, no significant path coefficients from inhibition toward any of the four SIP cognitions (encoding, β = .15, p = .07; interpretation, β = −.11, p = .16; response generation, β = −.05, p = .55; and self-efficacy, β = -.14, p = .05).

Next, the mediation model for behavioral inhibition via SIP toward aggression was examined. This model did not demonstrate acceptable to good fit on all fit indices (CFI = .92; TLI = .88; RMSEA = .05; SRMR = .07; χ^2(36) = 51.43, p = .046). The path coefficients and p values for all paths are presented in Figure 2b. The direct effect of behavioral inhibition on aggression was significant (β = −.24, p = .005). Furthermore, despite the significant effect of SIP on aggression, the indirect effect of behavioral inhibition via SIP toward aggression was not significant. There were no significant relations of inhibition with any of the four SIP cognitions, therefore, there was no mediation effect. The amount of variance explained in aggression by this model was substantial (R^2 = .42, p < .001).

Working memory mediation models

First, the relation between working memory and aggression was examined. This model demonstrated a good fit (CFI = 1.00; TLI = .99; RMSEA = .02; SRMR = .04; χ^2(8) = 8.56, p = .38). The path coefficient from working memory to aggression was, however, not significant (β = −.17, p = .15). Subsequently, the relations between working memory and SIP were investigated. This model demonstrated an excellent fit (CFI = 1.00; TLI = 1.00; RMSEA = .00; SRMR = .02; χ^2(10) = 5.78, p = .83). A better working memory was significantly related to the encoding of more cues (β = .34, p < .001), fewer hostile interpretations (β = −.30, p = .001), and fewer aggressive response generations (β = −.23, p = .01). Working memory was not directly related to the self-efficacy for aggression (β = −.04, p = .65).

Next, the mediation model for working memory was examined. This model demonstrated a good fit (CFI = .98; TLI = .96; RMSEA = .04; SRMR = .04; χ^2(26) = 31.15, p = .22). The path coefficients and p values for all paths are presented in Figure 2c. There was no significant direct effect, but there was an indirect relation between working memory and aggression statistically mediated by the SIP model. Impaired working memory related to higher hostile interpretations, which related to higher self-efficacy for aggression within the SIP model, which finally related to higher aggressive behavior scores. In addition, significant relations were found from impaired working memory toward aggressive response generation, relating to a higher self-efficacy for aggression, which related to the aggressive behavior of the adolescents. A better working memory also related to the encoding of more cues; subsequently, this SIP cognition was not related to the other SIP steps or aggression. The amount of variance explained in aggression by this working memory and SIP model was significant (R^2 = .37, p < .001).

Discussion

SIP skills as a mediating mechanism linking EFs to aggression were examined in adolescents with MBID. The patterns of associations found were mostly consistent with a mediational model, where SIP skills linked the relations between the EFs focused attention and working memory with aggressive behavior. Direct effects for these two EFs on aggression were not found while indirect effects via SIP skills were significant (Hayes, 2009; Kenny, 2016). The relation of behavioral inhibition with aggression, however, was not mediated by SIP. There was a direct effect of behavioral inhibition on aggression independent of SIP cognitions.

Indirect effect for focused attention

In adolescents with MBID, there was a mediating role for SIP skills in the relation from impaired focused attention to aggressive behaviors (Hayes, 2009; Kenny, 2016). In line with our hypothesis, low levels of focused attention were associated with high levels of hostile interpretations of the situation. It may be that these adolescents have difficulty paying attention to a variety of cues, including those that could lead to a more positive interpretation, and as a result they are at risk of misinterpreting the intentions of others. This may be explained by relying on social schemas, which are part of the database of the SIP model (Calvete & Orue, 2012; Crick & Dodge, 1994; Lemerise & Arsenio, 2000; Van Nieuwenhuijzen et al., 2006).

Results also show that this biased interpretation subsequently related to the successive SIP steps of aggressive response generation and self-efficacy for aggressive responses. Moreover, focused attention related directly to the self-efficacy for aggressive responses, as a part of the decision-making process of SIP. Similar associations between focused attention and decision-making were found in the study by Van Nieuwenhuijzen et al. (2017). Impaired focused attention may thus result in difficulty considering self-efficacy for other responses than aggressive ones. Only this final step of the tested SIP model associated with aggressive behavior reported for the adolescents, representing an indirect mediation effect of focused attention via SIP toward aggression.

Direct effect for behavioral inhibition

In line with previous studies (e.g., Ogilvie et al., 2011; Oosterlaan et al., 1998; Schoemaker et al., 2013; Van Nieuwenhuijzen et al., 2009), an effect was found for behavioral inhibition on aggression independent of SIP cognitions. There were no significant associations between behavioral inhibition and any of the SIP cognitions, which is inconsistent with statistical mediation of the relation between inhibition and aggression by SIP. The strong relation between inhibition and aggression, as opposed to inhibition and SIP, could be explained by the construct and variables used in this study. The task for measurement of behavioral inhibition was based on the Go/No-go principle (Nigg, 1999), which assesses the ability to suppress an action and inhibit behavior. This included a focus on the behavioral component of inhibition, and there was less focus on cognitive types of inhibition (Nigg, 2000). The behavioral component of

inhibition was measured by the ability to suppress actions, while being stimulated to react, and this measure was directly related to aggression.

A recent meta-analysis by Bexkens et al. (2014) supports the interpretation that different inhibition components differentiate between children with and without MBID. Effects were found for inhibition tasks with a behavioral component and with an interference control component, that is control on attention processes. Conceptually, adequate inhibition is required for SIP, as suppression of the initial behavioral response is a precondition for SIP to occur. This may however be only empirically found for cognitive components of inhibition, such as thought suppression, which were not assessed in the present study.

Indirect effect for working memory

For working memory, there was a mediating role for SIP skills in the relation from impaired working memory to aggressive behaviors (Hayes, 2009; Kenny, 2016). We hypothesized that working memory related to all four SIP cognitions, and found confirmation for our expectations in three SIP cognitions, encoding, hostile interpretations, and aggressive response generation. This demonstrates the important role of impaired working memory in youth with MBID, in line with studies by Alloway (2010) and Van Der Molen, Henry, and Van Luit (2014). Working memory, operationalized as a poor central executive, was shown to be associated with poor overall social competence (McQuade, Murray-Close, Shoulberg, & Hoza, 2013). Present findings give insight into this association specified to SIP skills relating to aggression in youth with MBID. In line with the study by McQuade et al. (2013) youth with poor central executive working memory experience difficulties in considering multiple pieces of information, such as in encoding and interpreting, thinking through response options, and referencing prior social knowledge.

There was no association between working memory and self-efficacy for aggression, in contrast to our hypothesis. It should be noted, however, that working memory indirectly influenced self-efficacy for aggressive responses via the previous SIP steps in the model. Self-efficacy may also be more strongly affected by relying on long-term memory with positive experiences of previously enacting aggressively (Van Nieuwenhuijzen et al., 2006).

Strengths and limitations

Several aspects of the study strengthen confidence in its findings. First, EF constructs were measured with at least two neuropsychological tasks, instead of relying on informants to report on EF performance. Each EF construct was estimated with three or four observed variables using SEM, in order to construct latent variables that alleviate potential task-impurity problems (Miyake & Friedman, 2012). Second, the latent variable of aggression was based on multiple informants. Therefore, the current study provides robust associations between EFs, SIP, and aggression in youth with MBID. Third, the SIP cognitions represented a major part of the theoretical SIP model (Crick & Dodge, 1994; Lemerise & Arsenio, 2000) with interrelated SIP steps, finally associating with aggressive behavior. The direction in

the circular theoretical SIP model was directly modeled as such in the path model. Fourth, the focus on investigating adolescents with MBID specifically provided relevant insight into the most vulnerable youth who are at high risk for developing severe aggression and other externalizing behavior problems (e.g., Douma et al., 2007). By investigating aggression in these youth, we anticipated a thorough understanding of social maladjustment and aggressive behavior at the most problematic level.

The current study also had limitations. First, although the cross-sectional design of the study offered the opportunity to examine SIP skills as a mediating mechanism linking EFs to aggression, longitudinal and experimental studies are required before the indirect effects found may be interpreted as causal mediation. Second, the three moderate interrater kappas should be taken into consideration for the measures of encoding and response generation within the SIP model. These could be due to the content of some videos to which certain responses can be interpreted as assertive or aggressive. Inclusion of these variables for the particular videos may have created a lower score for encoding or for aggressive response generation in some participants. The coding procedure for these videos requires adjustment. Third, as we did not analyze group differences, we have not specified our results according to IQ level. Therefore, it is uncertain whether this model would be similar for MID and BIQ groups separately. We lacked statistical power, however, to investigate the specific moderation of this model by IQ groups. Fourth, the type of measure for encoding was a limitation. In contrast with our hypotheses and the theoretical SIP model, encoding did not relate to subsequent SIP steps, or to focused attention. This could be explained by the choices for the measurement of encoding, namely, as a sum of all cues that were encoded, instead of encoding negative cues specifically. In previous studies, encoding deficits were assessed as a measure of being able to draw conclusions about the situation (Kupersmidt et al., 2011), or the encoding of negative cues was assessed; youth with MBID focused on and encoded more negative cues than typically developing peers (Van Nieuwenhuijzen et al., 2004). Potentially, a certain specific encoding measure would have provided different insight into relations with focused attention and with subsequent SIP cognitions, whereas currently, encoding was used as a more neutral and purely cognitive measure.

This pure cognitive measure of encoding variable was however significantly related to working memory, which is a core problem in MBID (Van Der Molen et al., 2014). Encoding of a situation thus seems a relevant cognitive process in adolescents with MBID, but it could be subsequently related to different behavioral outcomes than aggression specifically. Potentially, as some adolescents do not encode the situation well, they might get confused and fail to generate any problem-solving strategy and as a result, they engage in responding passively or submissively instead of aggressively. This preference for passive responses in youth with MBID was also found by Van Nieuwenhuijzen et al. (2004). This perspective on the encoding variable should be addressed in future studies.

Implications and conclusions

The specific outcomes of this study create valuable insight for interventions for aggressive behavior in youth. The mean effect size of cognitive behavior therapy for these

youth is not large (McCart, Priester, Davies, & Azen, 2006). Improving EFs may increase the effect of cognitive behavioral therapy in which SIP skills are targeted that have been shown to mediate intervention outcomes: interpretation of other people's intentions, generation of possible behavioral responses, and evaluation of the likely positive and negative consequences of the potential responses (Dodge & Godwin, 2013). It should however be noted that it is still unclear how much EFs can be improved through training (Diamond & Ling, 2016).

Results of this cross-sectional study suggest that SIP skills form a mediating mechanism linking the EFs focused attention and working memory to aggression in adolescents with MBID. The possible mediating role of SIP, however, must be further tested in longitudinal studies. In addition, the causal role of EFs, for example WM, could be examined in an experimental study in which EFs are trained. It could then be investigated whether the effect of experimentally enhanced EFs on less aggression would be mediated by ameliorated SIP skills. These longitudinal and experimental studies could be informative in understanding aggression in youth with MBID and in youth with average intelligence levels.

Future research should also investigate distinctions between adolescents with MID and BIQ, because IQ plays an important role in their levels of EFs and SIP (e.g., Van Der Molen et al., 2014; Van Nieuwenhuijzen et al., 2017), and youth with BIQ are understudied in general (Peltopuro, Ahonen, Kaartinen, Seppälä, & Närhi, 2014). The SEM model in the current study could be moderated by IQ, in order to analyze if this model is similar for MID, BIQ, and average intelligence groups. In line with investigating the heterogeneous group of youth with MID and BIQ, in which association with several clinical diagnoses was found, it is also recommended to study EFs and SIP models across groups with different diagnoses, such as Oppositional Defiant Disorder/ Conduct Disorder, Attention-Deficit/Hyperactivity Disorder, and Autism Spectrum Disorder. This could increase insight into (social) cognitive performance profiles of diagnostic groups encountered in clinical work with youth with MID and BIQ.

Finally, from current findings, we propose to investigate several types of inhibition more into detail (Bexkens et al., 2014), in order to examine whether cognitive and behavioral inhibition (Nigg, 2000) show different relations with SIP as a mediator of the relation with aggression. These different types of inhibition, and additional EFs such as cognitive flexibility, cognitive control, and planning (Diamond, 2013), should then be incorporated into a more comprehensive model of EFs.

In sum, the current study shows that a broad spectrum of EFs is involved in explaining aggressive behavior in youth with MBID, when models describe not only direct but also indirect links, in this case through SIP. Including both EFs and SIP in the study of aggression is a new direction in research providing insight into social-cognitive aspects of development that may be relevant for the treatment of aggressive behavior in adolescents with MBID.

Acknowledgments

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References

Achenbach, T. M., & Edelbrock, C. (1991a). *Manual for the child behavior checklist/4-18 and 1991 profiles*. Burlington: University of Vermont, Department of Psychiatry.

Achenbach, T. M., & Edelbrock, C. (1991b). *Manual for the youth self-report and 1991 profiles*. Burlington: University of Vermont, Department of Psychiatry.

Achenbach, T. M., & Rescorla, L. A. (2001). *Manual for the ASEBA school-age forms & profiles*. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families.

Alloway, T. (2010). Working memory and executive function profiles of individuals with borderline intellectual functioning. *Journal of Intellectual Disability Research*, 54, 448–456.

Baddeley, A. (2003). Working memory: Looking back and looking forward. *Nature Reviews Neuroscience*, 4, 829–839.

Bexkens, A., Van der Molen, M. W., Collot d'Escury-Koenigs, A. M. L., & Huizenga, H. M. (2014). Interference control in adolescents with mild-to-borderline intellectual disabilities and/or behavior disorders. *Child Neuropsychology*, 20, 398–414.

Calvete, E., & Orue, I. (2012). Social information processing as a mediator between cognitive schemas and aggressive behavior in adolescents. *Journal of Abnormal Child Psychology*, 40, 105–117.

Casey, B. J., Giedd, J. N., & Thomas, K. M. (2000). Structural and functional brain development and its relation to cognitive development. *Biological Psychology*, 54, 241–257.

CBS, Central Bureau for Statistics in The Netherlands (2018, April 30). Retrieved from https://www.cbs.nl/nl-nl/achtergrond/2016/47/bevolking-naar-migratieachtergrond

Crick, N. R., & Dodge, K. A. (1994). A review and reformulation of social information processing mechanisms in children's social adjustment. *Psychological Bulletin*, 115, 74–101.

Danielsson, H., Henry, L., Messer, D., & Rönnberg, J. (2012). Strengths and weaknesses in executive functioning in children with intellectual disability. *Research in Developmental Disabilities*, 33, 600–607.

De Sonneville, L. (1999). Amsterdam neuropsychological tasks: A computer-aided assessment program. *Computers in Psychology*, 6, 187–203.

Diamond, A. (2006). The early development of executive functions. *In* E. Bialystok & F. I. M. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 70–95). New York: Oxford University Press.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, 64, 135–168.

Diamond, A., & Ling, D. S. (2016). Conclusions about interventions, programs, and approaches for improving executive functions that appear justified and those that, despite much hype, do not. *Developmental Cognitive Neuroscience*, 18, 34–48.

Dodge, K. A. (1980). Social cognition and children's aggressive behavior. *Child Development*, 51, 162–170.

Dodge, K. A, & Frame, C. L. (1982). Social cognitive biases and deficits in aggressive boys. *Child Development*, *53*, 620-635. doi: 10.2307/1129373

Dodge, K. A., Malone, P. S., Lansford, J. E., Sorbring, E., Skinner, A. T., Tapanya, S., . . . Bacchini, D. (2015). Hostile attributional bias and aggressive behavior in global context. *Proceedings of the National Academy of Sciences*, *112*, 9310–9315.

Dodge, K. E., & Godwin, J.; The Conduct Problems Prevention Research Group. (2013). Social-information-processing patterns mediate the impact of preventive intervention on adolescent antisocial behavior. *Psychological Science*, *24*, 456–465.

Douma, J. C. H., Dekker, M. C., De Ruiter, K. P., Tick, N. T., & Koot, H. M. (2007). Antisocial and delinquent behaviors in youths with mild or borderline disabilities. *American Journal on Mental Retardation*, *112*, 207–220.

Douma, J. C. H., Dekker, M. C., Verhulst, F. C., & Koot, H. M. (2006). Self-reports on mental health problems of youth with moderate to borderline intellectual disabilities. *Journal of the American Academy of Child and Adolescent Psychiatry*, *45*, 1224–1231.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Attention, Perception, & Psychophysics*, *16*, 143–149.

Granvald, V., & Marciszko, C. (2016). Relations between key executive functions and aggression in childhood. *Child Neuropsychology*, *22*, 537–555.

Hambrick, D. Z., Kane, M. J., & Engle, R. W. (2005). The role of working memory in higher-level cognition. In R. J. Sternberg & J. E. Pretz (Eds.), *Cognition and Intelligence: Identifying the Mechanisms of the Mind*, (pp. 104–121). Cambridge: Cambridge University Press.

Hayes, A. F. (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. *Communication Monographs*, *76*, 408–420.

Hrabok, M., Brooks, B. L., Fay-McClymont, T. B., & Sherman, E. M. (2014). Wechsler intelligence scale for children-(WISC-IV) short-form validity: A comparison study in pediatric epilepsy. *Child Neuropsychology*, *20*, 49–59.

Kaal, H., Brand, E., & Van Nieuwenhuijzen, M. (2012). Serious juvenile offenders with and without intellectual disabilities. *Journal of Learning Disabilities and Offending Behaviour*, *3*, 66–76.

Kenny, D. A., Kashy, D. A., & Bolger, N. (1998). Data analysis in social psychology. In D. Gilbert, S. Fiske, & G. Lindzey (Eds), *The handbook of social psychology* (pp. 233–265). New York: McGraw-Hill.

Kenny, D. A. (2016, September 13). *Mediation*. Retrieved from http://davidakenny.net/cm/mediate.htm

Klingberg, T. (2010). Training and plasticity of working memory. *Trends in Cognitive Sciences*, *14*, 317–324.

Klingberg, T., Fernell, E., Olesen, P. J., Johnson, M., Gustafsson, P., Dahlström, K., . . . Westerberg, H. (2005). Computerized training of working memory in children with ADHD-a randomized, controlled trial. *Journal of the American Academy of Child & Adolescent Psychiatry*, *44*, 177–186.

Kort, W., Schittekatte, M., Dekker, P. H., Verhaeghe, P., Compaan, E. L., Bosmans, M., & Vermeir, G. (2005). *WISC-III^{NL} Wechsler Intelligence Scale for Children. Manual*. Amsterdam: Harcourt Test Publishers.

Kupersmidt, J. B., Stelter, R., & Dodge, K. A. (2011). Development and validation of the social information processing application: A web-based measure of social information processing patterns in elementary school-age boys. *Psychological Assessment*, *23*, 834–847.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*, 159–174.

Lansford, J. E., Malone, P. S., Dodge, K. A., Crozier, J. C., Pettit, G. S., & Bates, J. E. (2006). A 12-year prospective study of patterns of social information processing problems and externalizing behaviors. *Journal of Abnormal Child Psychology*, *34*, 709–718.

Lemerise, E. A., & Arsenio, W. F. (2000). An integrated model of emotion processes and cognition in social information processing. *Child Development*, *71*, 107–118.

Lerner, M. D., & Lonigan, C. J. (2014). Executive function among preschool children: Unitary versus distinct abilities. *Journal of Psychopathology and Behavioral Assessment*, 36, 626–639.

Matthys, W., Cuperus, J. M., & Van Engeland, M. (1999). Deficient social problem-solving in boys with ODD/CD, with ADHD, and with both disorders. *Journal of the American Academy of Child and Adolescent Psychiatry*, 38, 311–321.

McCart, M. R., Priester, P. E., Davies, W. H., & Azen, R. (2006). Differential effectiveness of behavioral parent-training and cognitive-behavioral therapy for antisocial youth: A meta-analysis. *Journal of Abnormal Child Psychology*, 34, 527–543.

McQuade, J. D., Murray-Close, D., Shoulberg, E. K., & Hoza, B. (2013). Working memory and social functioning in children. *Journal of Experimental Child Psychology*, 115, 422–435.

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions of Psychological Science*, 21, 8–14.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex frontal lobe tasks: A latent variable analysis. *Cognitive Psychology*, 41, 49–100.

Nigg, J. T. (1999). The ADHD response-inhibition deficit as measured by the stop task: Replication with DSM–IV combined type, extension, and qualification. *Journal of Abnormal Child Psychology*, 27, 393–402.

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin*, 126, 220–246.

Nosek, B. A., & Banaji, M. R. (2001). The go/no-go association task. *Social Cognition*, 19, 625–666.

Ogilvie, J. M., Stewart, A. L., Chan, R. C. K., & Shum, D. H. K. (2011). Neuropsychological measures of executive function and antisocial behavior: A meta-analysis. *Criminology; an Interdisciplinary Journal*, 49, 1063–1107.

Oosterlaan, J., Logan, G. D., & Sergeant, J. A. (1998). Response inhibition in AD/HD, CD, comorbid AD/HD+ CD, anxious, and control children: A meta-analysis of studies with the stop task. *Journal of Child Psychology and Psychiatry*, 39, 411–425.

Peltopuro, M., Ahonen, T., Kaartinen, J., Seppälä, H., & Närhi, V. (2014). Borderline intellectual functioning: A systematic literature review. *Intellectual and Developmental Disabilities*, 52, 419–443.

Poland, S. E, Monks, C. P, & Tsermentseli, S. (2016). Cool and hot executive function as predictors of aggression in early childhood: differentiating between the function and form of aggression. *British Journal Of Developmental Psychology*, 34, 181–197. doi:

Preacher, K. J., & Hayes, A. F. (2008). Contemporary approaches to assessing mediation in communication research. In A. F. Hayes, M. D. Slater, & B. L. Snyder (eds), *The Sage sourcebook of advanced data analysis methods for communication research* (pp. 13–54). Thousand Oaks, CA: Sage.

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods*, 36, 717–731.

Sainero, A., Del Valle, J. F., López, M., & Bravo, A. (2013). Exploring the specific needs of an understudied group: Children with intellectual disability in residential child care. *Children and Youth Services Review*, 35, 1393–1399.

Schalock, R. L., Borthwick-Duffy, S. A., Bradley, V. J., Buntinx, W. H. E., Coulter, D. L., Craig, E. M., … Yeager, M. H. (2010). *Intellectual disability: Definition, classification, and systems of supports. Eleventh edition*. Washington, DC: American Association on Intellectual and Developmental Disabilities.

Schoemaker, K., Mulder, H., Deković, M., & Matthys, W. (2013). Executive functions in preschool children with externalizing behavior problems: A meta-analysis. *Journal of Abnormal Child Psychology*, 41, 457–471.

Schuiringa, H., Van Nieuwenhuijzen, M., Orobio de Castro, B., & Matthys, W. (2017). Executive functions and processing speed in children with mild to borderline intellectual disabilities and externalizing behavior problems. *Child Neuropsychology*, 23, 442–462.

Schultz, D., Ambike, A., Logie, S. K., Bohner, K. E., Stapleton, L. M., VanderWalde, H., … Betkowski, J. A. (2010). Assessment of social information processing in early childhood: Development and initial validation of the Schultz Test of Emotion Processing – Preliminary Version. *Journal of Abnormal Child Psychology*, 38, 601–613.

Silverstein, A. B. (1970). Reappraisal of the validity of WAIS, WISC, and WPPSI short forms. *Journal of Consulting and Clinical Psychology*, 34, 12–14.

Simmonds, D. J., Pekar, J. J., & Mostofsky, S. H. (2008). Meta-analysis of Go/No-go tasks demonstrating that fMRI activation associated with response inhibition is task-dependent. *Neuropsychologia*, 46, 224–232.

SIVT, Sociale InformatieVerwerkingsTest [Social Information Processing Test] [Computer software]. Stoof, Wiedemeijer, Roest, & Van de Velde, VU Amsterdam: iOS.

Uterwijk, J. (2000). *WAIS-III Dutch version*. Technical manual Lisse: Swets & Zeitlinger.

Van der Molen, M., Henry, L., & Van Luit, J. (2014). Working memory development in children with mild to borderline intellectual disabilities. *Journal of Intellectual Disability Research*, 58, 637–650.

Van Lieshout, M., Luman, M., Buitelaar, J., Rommelse, N., & Oosterlaan, J. (2013). Does neurocognitive functioning predict future or persistence of ADHD? A systematic review. *Clinical Psychology Review*, 33, 539–560.

Van Nieuwenhuijzen, M., Bijman, E., Lamberix, I., Wijnroks, L., & Matthys, W. (2009). Handleiding voor de SPT-MLK Aangepaste versie. [Manual of the SPT-MLK. Adjusted version]. Utrecht, The Netherlands: Utrecht University, Department of Developmental Psychology.

Van Nieuwenhuijzen, M., Orobio de Castro, B., Valk, I. van der, Wijnroks, L., Vermeer, A., & Matthys, W. (2006). Do social information processing models explain aggressive behaviour by children with mild intellectual disabilities in residential care? *Journal of Intellectual Disability Research*, 50, 801–812.

Van Nieuwenhuijzen, M., Orobio de Castro, B., Van Aken, M. A. G., & Matthys, W. (2009). Impulse control and aggressive response generation as predictors of aggressive behaviour in children with mild intellectual disabilities and borderline intelligence. *Journal of Intellectual Disability Research*, 53, 233–242.

Van Nieuwenhuijzen, M., Orobio de Castro, B., Wijnroks, L., Vermeer, A., & Matthys, W. (2004). The relations between intellectual disabilities, social information processing, and behavior problems. *European Journal of Developmental Psychology*, 1, 215–229.

Van Nieuwenhuijzen, M., Orobio de Castro, B., Wijnroks, L., Vermeer, A., & Matthys, W. (2009). Social problem solving and mild intellectual disabilities: Relations with externalizing behavior and therapeutic context. *American Journal on Intellectual and Developmental Disabilities*, 114, 42–51.

Van Nieuwenhuijzen, M., Van Rest, M. M., Embregts, P. J. C. M., Vriens, A., Oostermeijer, S., Van Bokhoven, I., & Matthys, W. (2017). Executive functions and social information processing in adolescents with severe behavior problems. *Child Neuropsychology*, 23, 228–241.

Van Nieuwenhuijzen, M., & Vriens, A. (2012). (Social) Cognitive skills and social information processing in children with mild to borderline intellectual disabilities. *Research in Developmental Disabilities*, 33, 426–434.

Van Nieuwenhuijzen, M., Vriens, A., Scheepmaker, M., Smit, M., & Porton, E. (2011). The development of a diagnostic instrument to measure social information processing and its precursors in children with mild to borderline intelligence. *Research in Developmental Disabilities*, 32, 358–370.

Van Rest, M. M., Van Bokhoven, I., Van Nieuwenhuijzen, M., Embregts, P. J. C. M., Vriens, A., & Matthys, W. (2014). Developing a new assessment procedure of social information processing in adolescents within secure residential care. *Research in Developmental Disabilities*, 35, 1402–1411.

Van Rest, M. M., Van Nieuwenhuijzen, M., Kupersmidt, J. B., Vriens, A., Schuengel, C., & Matthys, W. (2017). Accidental and ambiguous situations reveal specific maladaptive social information processing skills in adolescents with intellectual disability. (Doctoral Dissertation), M. M. Van Rest, *Social information processing in adolescents with mild to borderline intellectual disability: Executive functions, situational factors, and instrument development*. The Netherlands: Vrije Universiteit Amsterdam, Department of Clinical Child and Family Studies). Retrieved from http://dare.ubvu.vu.nl/handle/1871/55594

Verhulst, F. C., Van der Ende, J., & Koot, H. M. (1996). *Handleiding voor de CBCL/4-18 [Manual for the CBCL/4-18]*. Rotterdam, the Netherlands: Sophia Children's Hospital/Erasmus Medical Centre.

Verhulst, F. C., Van der Ende, J., & Koot, H. M. (1997a). *Handleiding voor de Teacher's Report Form (TRF) [Manual for the TRF]*. Rotterdam, the Netherlands: Sophia Children's Hospital/ Erasmus Medical Centre.

Verhulst, F. C., Van der Ende, J., & Koot, H. M. (1997b). *Handleiding voor de Youth Self-Report (YSR). [Manual for the YSR]*. Rotterdam, the Netherlands: Sophia Children's Hospital/ Erasmus Medical Centre.

Visser, E., Berger, H., Van Schrojenstein Lantman-De Valk, H., Prins, J., & Teunisse, J. (2015). Cognitive shifting and externalising problem behaviour in intellectual disability and autism spectrum disorder. *Journal of Intellectual Disability Research*, 59, 755–766.

Wechsler, D. (1949). *Wechsler Intelligence Scale for Children. San Antonio*. TX, US: Psychological Corporation.

Wechsler, D. (1955). *Manual for the Wechsler Adult Intelligence Scale*. Oxford, England: Psychological Corporation.

Zelazo, P. D., & Carlson, S. M. (2012). Hot and cool executive function in childhood and adolescence: Development and plasticity. *Child Development Perspectives*, 6, 354–360.

Ziv, Y., & Sorongon, A. (2011). Social information processing in preschool children: Relations to sociodemographic risk and problem behavior. *Journal of Experimental Child Psychology*, 109, 412–429.