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PAPER

A meta-analytic approach to the association between inhibitory control and parent-reported behavioral adjustment in typically-developing children: Differentiating externalizing and internalizing behavior problems

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Abstract

Impairments in inhibitory control (IC) are traditionally seen as a vital aspect in the emergence and course of maladaptive behavior across early childhood. However, it is currently unclear whether this view applies to both the externalizing and internalizing domain of parent-reported behavioral adjustment. Furthermore, past (meta-analytic) developmental research and theory characterizing this association have largely neglected the vast heterogeneity of IC measures and conceptualizations. The present meta-analyses examined the association of IC with parent-reported externalizing (N = 3160, 21 studies) and internalizing (N = 1758, 12 studies) behavior problems, assessed with the Child Behavior Checklist (CBCL), in non-clinical populations of children aged 2–8 years. They further investigated the moderating effects of a priori IC categorization, according to a recently proposed two-factor model of IC ("Strength/Endurance" account, Simpson & Carroll, 2019). In line with previous research in the clinical domain, the current results corroborate the notion of a robust, but small association between IC and externalizing behavior problems (r = −0.11) in early childhood. However, although frequently proposed in the literature, no significant linear association could be identified with internalizing behavior problems. Furthermore, in both meta-analyses, no significant moderating effects of IC categorization could be revealed. These findings enhance our knowledge about the cognitive underpinnings of early-emerging maladaptive behavior, indicating that different subtypes of IC are statistically related with externalizing, but not internalizing behavior problems. Overall, the small association of IC ability with behavior problems in non-clinical populations provokes broader questions about the role of IC in behavioral adjustment.

KEYWORDS
behavioral adjustment, Child Behavior Checklist (CBCL), externalizing behavior, inhibitory control, internalizing behavior, meta-analysis

1 | INTRODUCTION

Inhibitory control (IC), broadly defined as the capacity of an individual to suppress or override a strong dominant response that is incompatible with a higher-order (cognitive) goal (Hofmann et al., 2012; Rothbart & Posner, 1985), is regarded as one of the fundamental building blocks of goal-directed and adaptive behavior (Anderson, 2002). Past research and theory has extensively progressed in identifying (i) the developmental trajectories of IC in childhood (Buttelmann & Berger, 2019; Carlson, 2005; Petersen et al., 2016), and (ii) its important role in the development of social and emotional capabilities, such as Theory of Mind (Carlson & Moses, 2001; Carlson et al., 2002) or emotion regulation (Carlson & Wang, 2007; Hudson & Jacques, 2014). Conversely, as suggested by the research reviewed below, *impairments* in inhibitory functioning might represent one of the key internal risk factors for the emergence of abnormalities in behavioral adjustment across childhood and adolescence.

Research Highlights

- Deficient inhibitory control (IC) is viewed as a vital aspect in the emergence of maladaptive behavior in early childhood.
- Does this view applies for externalizing and internalizing domains of parent-reported behavior problems in non-clinical populations of children? Are there moderating effects of IC subtypes?
- Meta-analysis on the association of IC with externalizing ($N = 3160$) and internalizing ($N = 1758$) behavior problems in young children.
- Results suggest a small, but robust association of IC with externalizing, but no relation with internalizing behavior problems. No moderating effects of IC conceptualization.

1.1 | The association of IC with externalizing behavior problems

In developmental research, the majority of studies investigating the relation of IC with impairments in behavioral adjustment were conducted in the domain of *externalizing* behavior problems (Ogilvie et al., 2011). This subtype of maladaptive behavior is typically indicated by either physical aggression, impulsiveness, hyperactivity, or a combination of those (Campbell et al., 2000), and is recognized as an early predictor of juvenile delinquency and mental health problems in adulthood (Betz, 1995; Farrington, 1989). On average, externalizing behavior problems, such as reflected in aggressive, hyperactive, or oppositional behavior were shown to exert a gradual decrease across early childhood (Gilliom & Shaw, 2004). Research linking IC with externalizing behavior problems has largely focused on clinical populations, revealing deficits in inhibitory functioning in children with related clinical conditions, such as attention deficit/hyperactivity disorder (AD/HD) or disruptive behavior disorder (DBD; Alderson et al., 2007; Oosterlaan et al., 1998; Pauli-Pott & Becker, 2011, 2015; Schoemaker et al., 2013). For example, in the meta-analyses by Schoemaker et al. (2013) and Pauli-Pott and Becker (2011), medium-sized effect sizes were shown for inhibition deficits in children at-risk for externalizing behavior disorders. Against this background, deficits in IC have been speculated as a crucial mechanism of early-emerging maladaptive behavior, as reflected in later diagnosis of AD/HD and DBD (Pauli-Pott & Becker, 2021). While these results provide important insight into the relationship of IC with behavioral adjustment in children with clinical manifestations of externalizing behavior problems, it remains unclear, whether these meta-analytic results also apply to non-clinical populations. In fact, evidence from a broad range of correlational studies in typically developing children indicate a similar negative association (e.g., Caughy et al., 2016; Eiden et al., 2007) and longitudinal investigations have demonstrated that early impairments in IC predict later externalizing behavior problems in those children (Olson et al., 1999; Riggs et al., 2003).

1.2 | The association of IC with internalizing behavior problems

Much less is known about the relationship between IC and *internalizing* behavior problems, which capture somatic complaints, anxiety, depression, and social withdrawal (Liu et al., 2011). On average, internalizing behavior problems show a gradual increase across early childhood as well as significant intercorrelations with externalizing behavior problems (Gilliom & Shaw, 2004). While internalizing problems in childhood and adolescence are a central focus of current research in developmental psychopathology and related disciplines, investigations regarding the cognitive underpinnings in early childhood remain inconclusive (Kooijmans et al., 2001; Oosterlaan & Sergeant, 1996). In traditional accounts, children with internalizing problems were characterized as "overly controlled" in their behavior, as reflected by low impulsivity and high rates of behavioral inhibition (Achenbach, 2011; Block & Block, 1980; Nigg, 2000; Quay, 1988, 1993). However, empirical evidence from studies using standardized behavioral measures to assess IC (as opposed to the use of external rating procedures) provides only limited support for these hypotheses. In particular, while a few studies have identified a predicted positive association of IC measures with internalizing behavior problems in children (Murray & Kochanska, 2002), there is also clear contradictory evidence, showing no evidence for an association (Blanken et al., 2017; Eisenberg et al., 2005; Oosterlaan et al., 1998), or even an inverse relation (Kim-Spoon et al., 2019; Lengua, 2003; Oldehinkel et al., 2007; Wagner et al., 2014). Thus, it is currently unclear whether the association between IC and behavioral adjustment, as identified in the domain of externalizing behavior problems, can be generalized to the domain of internalizing behavior problems, highlighting the need for meta-analytic research.

1.3 | IC development and potential moderating effects of IC conceptualization

Evidence from over three decades of research suggests that IC undergoes rapid development from early childhood to early school-age, with marked improvements between the ages of 3 and 5 years (Diamond, 2013; Petersen et al., 2016). This development has been closely attributed to the maturation of the prefrontal cortex (Casey et al., 1997; Crone & Steinbeis, 2017; Schroeter et al., 2004) and potentially forms the basis of improvements observed in many domains of cognition in a similar age range, including language (Ibbotson & Kearvell-White, 2015), reasoning (Handley et al., 2004), and social cognition (Benson et al., 2013). However, one aspect that might have significantly contributed to the inconsistency of past research on the relationship with behavioral adjustment is the heterogeneity of methods used to assess IC in early childhood (Petersen et al., 2016) that often were subsumed in different types of conceptualization approaches. In particular, factor-analytic research has repeatedly shown that tasks being considered to measure IC in early childhood load onto two factors, rather than one (e.g., Carlson & Moses, 2001; Murray & Kochanska, 2002). Over the years, several influential models of conceptualizing the two-factor structure of early IC have emerged (Carlson & Moses, 2001; Garon et al., 2008; Simpson & Carroll, 2019; Zelazo & Carlson, 2012). For example, the "Conflict/Delay" proposal by Carlson and Moses (2001) suggests that IC tasks can be divided based on the type of inhibition included: Whereas standard "conflict" IC tasks require children to respond in a certain way in the face of a salient, *conflicting* response option (e.g., Day/Night task; Gerstadt et al., 1994), "delay" IC tasks measure the child's ability to delay a salient *impulse* (e.g., Delay of Gratification task; Mischel et al., 1989). Similarly, however, these types of tasks can also be distinguished by the level of motivational and emotional salience (i.e., "Hot-Cold" distinction, Zelazo & Carlson, 2012). Integrating previous proposals on the two-factor structure of IC with recent behavioral and factor-analytic evidence, Simpson and Carroll (2019) proposed a novel conceptual distinction between IC tasks tapping inhibitory *strength* (IC-S; i.e., suppressing responses high in prepotency) and those tapping inhibitory *endurance* (IC-E; i.e., suppressing responses that remain active over a longer timeframe). Importantly, and in contrast to previous conceptualization approaches the "Strength/Endurance" account generates testable predictions for the influence of IC subtypes on behavioral adjustment variables. More specifically, the authors hypothesized that performance in IC-S tasks might be related with outcome domains that require the *brief* suppression of prepotent responses, such as implied in (socio-)cognitive abilities, including Theory of Mind (Carlson & Moses, 2001), attention and reasoning (Beck et al., 2011; Sabbagh et al., 2006). On the other hand, they hypothesized that performance on IC-E tasks might be related with demands of *sustained* suppression of prepotent responses, as found in behavioral adjustment and social-emotional functioning (Mann et al., 2017; Simpson & Carroll, 2019).

1.4 | The current study

The aim of the current study was to provide a quantitative meta-analysis of the literature to delineate the association of IC with externalizing and internalizing domains of behavioral adjustment in early childhood, whilst taking the proposed moderating effects of IC conceptualization (Simpson & Carrol, 2019) into account. While being the period of life where behavior problems in the externalizing and internalizing domains start to appear, early childhood also represents a period of rapid improvement in IC functioning (Diamond, 2013; Petersen et al., 2016). Focusing on non-clinical populations of children aged 2–8 years (Petersen et al., 2016), in a first step, we applied separate meta-analyses for the association of overall IC with parent-reported externalizing and internalizing behavior problems, assessed with the Child Behavior Checklist (CBCL; Achenbach & Edelbrock, 1983). In doing so, we tested for significant moderating effects of age (Utendale & Hastings, 2011) and gender (Campbell, 1997). Then, moderating effects of a priori IC categorization according to the "Strength/Endurance" approach (Simpson & Carroll, 2019) were examined. Based on previous meta-analyses in clinical populations (Alderson et al., 2007; Oosterlaan et al., 1998; Pauli-Pott & Becker, 2011; Schoemaker et al., 2013), we hypothesized a negative correlation of IC with externalizing behavior problems. Furthermore, based on previous literature (Achenbach, 2011; Block & Block, 1980; Nigg, 2000), we expected a positive association of IC with internalizing behavior problems. However, as suggested by previous theoretical considerations (Nigg, 2000; Simpson & Carroll, 2019), we also expected moderating effects of IC subtypes for the association with both domains of behavioral adjustment, indicating that IC-E tasks are more strongly related than IC-S tasks with both types of behavioral adjustment.

2 | METHOD

2.1 | Literature search

A systematic literature search in the database PsycINFO (American Psychological Association) was performed in July 2019, using the boolean search string: *((inhibitory control OR inhibition OR effortful control OR executive functioning OR self-regulation) AND (externalizing OR internalizing OR problem behavior OR behavior problems)). In addition, we applied a manual search on Google Scholar with the search string ((inhibitory control AND problem behavior), (inhibitory control AND externalizing problems OR inhibitory control AND internalizing problems), (effortful control AND behavior problems), (effortful control AND externalizing problems), (effortful control AND internalizing problems), (puzzle task AND behavior problems), (day night task AND behavior problems AND internalizing OR externalizing), (windows AND behavior problems AND internalizing OR externalizing), (simon says AND behavior problems AND internalizing OR externalizing), (bear dragon AND behavior problems AND internalizing OR externalizing),*

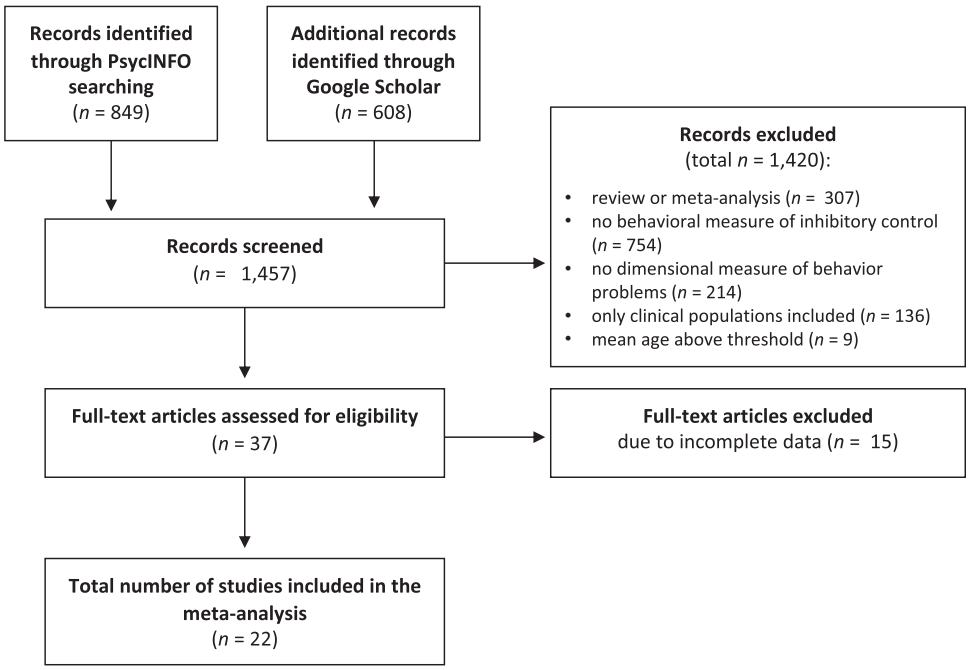

FIGURE 1 Flow chart describing literature search

(*grass snow AND behavior problems AND internalizing OR externalizing*)), and further applied backward citation searches. Literature search was restricted to publications in English in peer-reviewed journals (see Figure 1 for a flow chart on study search and selection).

2.2 | Inclusion criteria

After initial selection of studies, the following inclusion criteria were applied: (1) The study reported original empirical research findings. (2) The study included at least one standardized behavioral IC task, which required participants to suppress an irrelevant response while pursuing a higher-order cognitive goal (Petersen et al., 2016; Rothbart & Posner, 1985). (3) The study included at least one full-scale standard measurement of externalizing or internalizing behavior by means of the CBCL (Achenbach & Edelbrock, 1983). The CBCL is a long established, widely used, and cross-culturally validated behavior rating scale that provides standardized descriptions of behaviors rather than diagnostic categories. In particular, with this assessment, dimensions of internalizing and externalizing behavior problem scores are obtained using parental report. The long-term stability and validity of the CBCL scales have been shown in a variety of longitudinal investigations from the preschool period (CBCL 1½–5) into childhood and adolescence (CBCL 4–18; c.f. Kerr et al., 2007; Tick et al., 2007). Since including other types of assessment that measure single symptoms or clinical conditions in the internalizing and externalizing domain might introduce additional between-study variance and heterogeneity, as well as a potential bias towards specific clinical conditions or symptoms, we restricted the current search to studies using the CBCL. (4) The study included a community sample of typically developing children with no indication of a clinical diagnosis. (5) The mean age of the sample included was between 24 and 96 months at the time of IC assessment. This age range was based on previous meta-analysis on IC development in children, considering only the age range for which common IC measures are useful for detecting individual differences (see Petersen et al., 2016). In any case where information was missing in the original studies, the corresponding authors were contacted. This was applied for 18 studies and we received answers from authors of eight studies. The search generated 1457 studies, which were subsequently reviewed for relevance by a trained coder. Of those, 37 studies were assumed as relevant according to the above criteria from a first check of manuscript and abstract. They were further assessed for eligibility by one trained coder and double-checked by another independent coder. After this procedure, 22 studies met all inclusion criteria. While 21 of these studies investigated the correlation of IC with externalizing behavior problems (see Table 1), 12 studies investigated the correlation of IC with internalizing behavior problems (see Table 2). See Figure 1 for a detailed description of study selection and exclusion procedure.

2.3 | Coding

Studies were identified by the above literature search, and if applicable, coded for (1) effect size, (2) sample size, (3) range, mean and standard deviation of sample age, (4) gender distribution (% boys), (5) names of measures for IC, and (6) type of behavior problem scale (externalizing vs. internalizing). Given that partial correlations or beta values in multiple regression might be confounded by other variables of interest (i.e., age), only raw correlation scores were included (Schmidt & Hunter, 2015). Subsequently, IC measures and behavior scores were independently categorized to either the "strength" or "endurance" IC domain by two raters, based on the definition provided by Simpson and Carroll

TABLE 1 Characteristics of studies included in the three-level meta-analysis for the correlation of inhibitory control (IC) with externalizing behavior problems, including sample size (*N*), mean age (months), reported IC measures or composite scores (CS), and their respective categorization

Study	*N*	Mean age (months)	Gender distribution (%boys)	IC measures	IC category
Beauchamp et al. (2017)*	81	43	49	Shape Stroop	Strength
	84	43	49	Delay	Endurance
Cassidy et al. (2017)	135	51	41	Puppet says	Strength
Caughy et al. (2016)	195	30	53	*CS*: Snack Delay, Gift Delay, Bow	Endurance
Crespo et al. (2019)	100	24	–	*CS*: Waiting Task, Gift Delay	Endurance
Dennis et al. (2007)	37	60	38	*CS*: Wrapped Gift, Dinky Toys	Endurance
Eiden et al. (2007)	227	36	51	*CS*: Snack Delay, Lab Gift	Endurance
Eiden et al. (2009)	100	36	49	*CS*: Snack Delay, Lab Gift	Endurance
Eiden et al. (2014)	97	36	51	*CS*: Snack Delay, Price Delay	Endurance
Gagne et al. (2011)	291	25	53	*CS*: Snack Delay, Dinky Toys, Gift Delay	Endurance
Gagne et al. (2019)*	198	47	52	Day/Night	Strength
	198	47	52	*CS*: Snack Delay, Gift Delay	Endurance
Houck and Lecuyer-Maus (2004)	78	60	67	Delay	Endurance
Kahle et al. (2018)	98	55	50	Day/Night	Strength
Kim-Spoon et al. (2019)	218	80	50	Number Stroop	Strength
Loe et al. (2019)	79	54	–	*CS*: Bird/Dragon, Day/Night	Strength
Olson et al. (2005)	220	41	51	*CS*: Tongue Delay, Lab Gift	Endurance
Olson et al. (2011)	155	53	52	*CS*: Grass/Snow, Day/Night, Hand Game	Strength
Ren et al. (2018)	109	38	41	Head/Toes/Knees/Shoulders	Strength
Riggs et al. (2006)	318	96	50	Stroop	Strength
Schaub et al. (2019)	138	36	–	*CS*: Dinky Toys, Wrapped Gift	Endurance
Utendale et al. (2011)	180	64	52	*CS*: Day/Night, Tapping	Strength
van Prooijen et al. (2018)	103	25	50	Gift Delay	Endurance

Note. Studies from which multiple effect sizes were used are marked with an asterisk (*).

(2019; see Tables 1 and 2). This procedure resulted in 100% agreement between the raters. If combined scores were reported that consisted of measures from both IC domains, these were not included in the meta-analyses and the authors were contacted, in order to receive separate correlational coefficients for each domain.

All effect sizes were recoded so that a negative value indicated that low IC was associated with a higher amount of behavior problems, or vice versa. In cases where a study reported multiple effect sizes on the same outcome of interest, as for example through (1) reporting correlations of multiple tasks measuring the same construct (IC-S or IC-E), or (2) a longitudinal design, these effects were averaged. This procedure was applied to Crespo et al. (2019), Gagne et al. (2019), Loe et al. (2019), Olson et al. (2005, 2011), Schaub et al. (2019), Utendale et al. (2011). However, as we were interested in the moderating effects of IC subtypes, we allowed studies to contribute one correlation for each IC domain with internalizing and externalizing behavior problems (i.e., Beauchamp et al., 2017; Gagne et al., 2019).

2.4 | Statistical analysis

Meta-analyses were performed with *R* (*R* Core Team, 2019; https://www.R-project.org/). The preprocessed data and analysis scripts are available online (https://osf.io/gcwfj/?view_only=b29e9f4f3fcf4ff3956ab7f8ef9ff1bc). All studies reported Pearson's correlation coefficients (*r*). Before pooling the effect sizes in terms of a meta-analytic model, the correlation values were transformed using Fisher's Z transformation, and sampling variances were calculated using the "*escalc*" function (*R*-package "*metafor*," Viechtbauer, 2010). Because two of the studies (i.e., Beauchamp et al., 2017; Gagne et al., 2019) included in the analyses reported correlations of IC-S *and* IC-E subtypes with internalizing or externalizing behavior problems in the same sample, the assumption of independence underlying traditional meta-analytic approaches was violated. Thus, we applied a three-level meta-analysis using the "*rma.mv*" function (*R*-package "*metafor*," Viechtbauer, 2010) in order to compensate for interdependencies in

TABLE 2 Characteristics of studies included in the three-level meta-analysis for the correlation of inhibitory control (IC) with internalizing behavior problems, including sample size (*N*), mean age (months), reported IC measures or composite scores (CS), and their respective categorization

Study	*N*	Mean age (months)	Gender distribution (% boys)	IC measures	IC category
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Crespo et al. (2019)	100	24	–	*CS*: Waiting Task, Gift Delay	Endurance
Dennis et al. (2007)	37	60	38	*CS*: Wrapped Gift, Dinky Toys	Endurance
Kim-Spoon et al. (2019)	218	80	50	Number Stroop	Strength
Liu et al. (2018)	218	54	48	*CS*: Crayon Delay, Tongue Delay	Endurance
Loe et al. (2019)	79	54	–	*CS*: Bird/Dragon, Day/Night	Strength
Olson et al. (2005)	220	42	51	*CS*: Tongue Delay, Lab Gift, Snack Delay	Endurance
Ren et al. (2018)	109	38	41	Head/Toes/Knees/Shoulders	Strength
Riggs et al. (2006)	318	96	50	Stroop	Strength
Schaub et al. (2019)	133	36	47	*CS*: Dinky toys, Wrapped Gift	Endurance
van Prooijen et al. (2018)	103	25	50	Gift Delay	Endurance

Note. Studies from which multiple effect sizes were used are marked with an asterisk (*).

the data (see Van den Noortgate et al., 2013). More specifically, we used a three-level model including sampling variation for each effect size (level 1), variation between effect sizes within the same study (level 2), and variation between studies (level 3; Assink & Wibbelink, 2016). Parameters were estimated using the restricted maximum likelihood procedure (REML), and standard errors of the coefficients in the multilevel meta-analytic models were estimated with the Knapp and Hartung method (2003).

Analyses were conducted in a three-step procedure:

1. Two three-level meta-analyses were calculated for the correlation of overall IC with externalizing and internalizing behavior problem scores, respectively. Statistical heterogeneity among studies was evaluated by Q-statistic and quantified by the Iš statistic.
2. Moderating effects of a priori IC categorization (Simpson & Carroll, 2019) were assessed by conducting multilevel mixed-effects (random-effects model within subgroups, fixed-effect model between subgroups) subgroup analyses for internalizing and externalizing behavior problems, respectively. In addition, meta-regressions were performed for the continuous moderators (i.e., age and gender distribution).
3. Publication bias was examined with contour-enhanced funnel plots (Peters et al., 2008) and Egger's regression test (Egger et al., 1997; Sterne & Egger, 2006) in which the standard error of the effect sizes was used as a moderator. Here, it was tested, whether the intercept of this regression significantly deviates from zero, which would indicate that the association between precision and size of studies is biased (Sterne & Egger, 2006). A deviation from zero was considered significant if $p \leq 0.10$ (Egger et al., 1997). Furthermore, sensitivity of the multilevel meta-analytic models was evaluated via outlier detection and subsequent influence diagnosis with model comparisons (Viechtbauer & Cheung, 2010). Specifically, outliers were defined as effect sizes with hat values greater than two times the average hat value and standardized residual values exceeding 3 (Aguinis et al., 2013; Viechtbauer & Cheung, 2010).

3 | RESULTS

3.1 | Sample and study characteristics

The meta-analyses for externalizing behavior problems included 21 studies with a total sample of 3160 children (sample sizes ranging from 34 to 318, 50.01% boys; Table 1). The mean age of children included was 47.17 months (range: 24 to 96 months, Table 1). Conversely, in the meta-analyses for internalizing behavior problems, 12 studies were included with a total sample of 1758 children (sample size ranging from 37 to 318, 46.80% boys; Table 2). The mean age of children included in those studies was 50.20 months (range: 24 to 96 months, Table 2).

3.2 | Association between overall IC and behavioral adjustment

A significant negative association was obtained between overall IC and externalizing behavior problems with a medium effect size of $r(23) = -0.11$ ($p < 0.001$, 95% CI [−0.15, −0.07]), while heterogeneity was non-significant among studies in the externalizing domain ($Q(22) = 17.58$, $p = 0.731$; $I^2 = 0\%$). No significant association could be identified between overall IC and internalizing behavior ($r(13) = -0.05$, $p = 0.505$, 95% CI [−0.11, 0.00]), and no significant

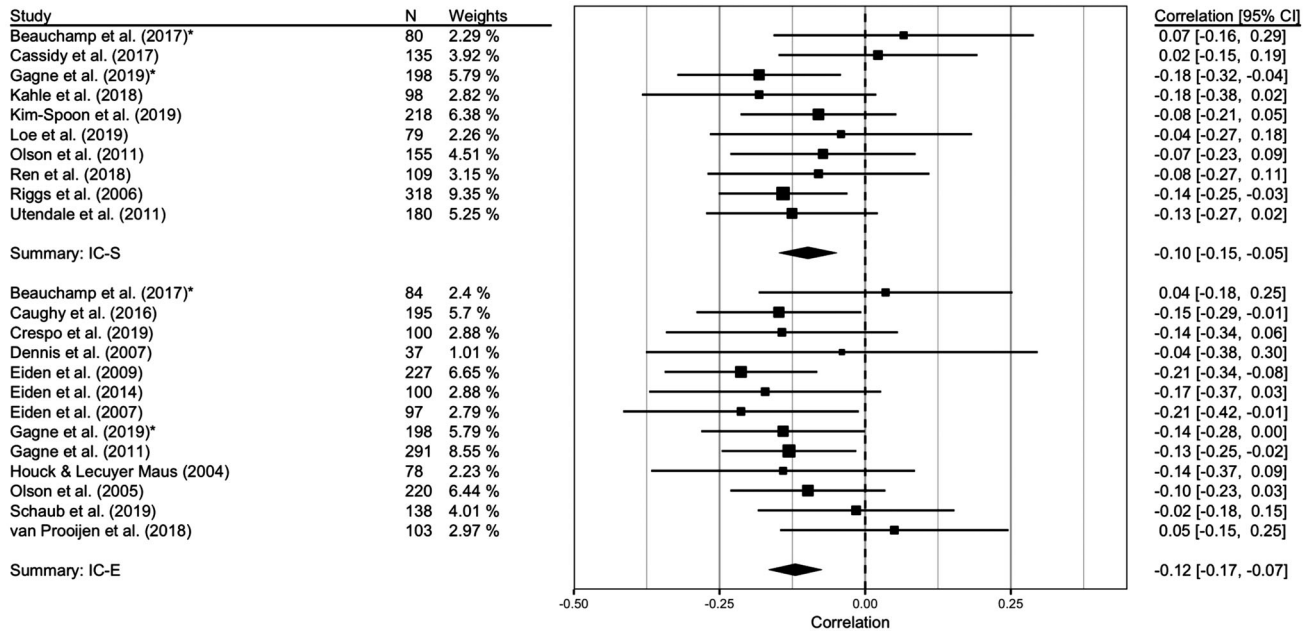

FIGURE 2 Forest plot of moderator analysis for externalizing behavior problems using the a priori defined "Strength/Endurance" (IC-S/IC-E) IC categorization as a subgroup variable. *Note*. Studies from which multiple effect sizes were used are marked with an asterisk (*)

heterogeneity was found among included studies in the internalizing domain ($Q(12) = 10.90, p = 0.538; I^2 = 11\%$). No significant moderating effects of age or gender could be identified for externalizing behavior problems (age: $F(1, 21) = 0.01$, $p = 0.940$; gender: $F(1, 18) = 2.42$, $p = 0.137$). However, a non-significant trend was observed for a moderating effect of mean age of the study sample in the analyses of internalizing behavior problems ($F(1, 11) = 3.68$, $p = 0.081$), while no significant moderating effects of gender could be identified ($F(1, 9) = 2.36, p = 0.159$).

3.3 | Subgroup analyses: A priori IC categorization

Moderator analyses with a priori defined IC categorization (IC-S vs. IC-E) as a subgroup variable were performed. For externalizing behavior problems, both subtypes of IC were found to be negatively associated with behavior problem scores (IC-S: $r(10) = -0.10$, $p = 0.004$, 95% CI [−0.16, −0.04]; IC-E: $r(13) = -0.12$, $p < 0.001$, 95% CI [−0.17, −0.07]). No significant differences between IC subtypes could be identified ($F(1, 21) = 0.39, p = 0.537$, see Figure 2).

For internalizing behavior problems, no significant association could be revealed with either subtype of IC (IC-S: $r(6) = -0.05, p = 0.397$, 95% CI [−0.17, 0.08]; IC-E: $r(7) = -0.05$, $p = 0.217$, 95% CI [−0.13, 0.04]). No significant differences between subgroups could be revealed ($F(1, 11) = 0.10, p = 0.755$, see Figure 3).

3.4 | Publication bias

Contour-enhanced funnel plots and Egger's regression were used to investigate asymmetry. No statistically significant funnel plot asymmetry was obtained with Egger's method for the relation of IC with externalizing behavior problems ($F(1, 21) = 2.47, p = 0.131$; see Figure S1A). However, asymmetry was revealed for the relation between IC and internalizing behavior problems ($F(1, 11) = 4.54, p = 0.057$; Figure S1B). A closer examination of the contour-enhanced funnel plot for the association of IC with internalizing problems suggested that the asymmetry was mainly based on small studies identifying null-results, while studies with larger sample sizes and sampling variances showed significant negative effects. Thus, in view of the funnel plot, the "missing" studies can be assumed in areas of statistical significance (i.e., in the negative direction). This suggests that the observed asymmetry was not due to publication bias based on statistical significance alone, but that other confounding sources have to be considered (Egger et al., 1997; Peters et al., 2008; Sterne & Harbord, 2004). Because a non-significant trend in the analysis of age as a moderator variable was identified for the relationship between IC and internalizing behavior problems, we performed exploratory analysis, testing for potential confounding effects of sample mean age on the current results. Here, a strong correlation was revealed between study size and sample mean age in the analyses of internalizing behavior problems ($r(11) = 0.62$, $p = 0.023$), indicating that larger studies tested older children. Conversely, in the analyses of externalizing behavior problems, no such correlation could be identified ($r(26) = 0.18$, $p = 0.351$). Last, we explicitly checked for outliers in both datasets and found no indication of influential outliers in both meta-analyses.

4 | DISCUSSION

A broad range of theories consider the concept of IC as an important aspect in child development and psychopathology (Schachar & Logan,

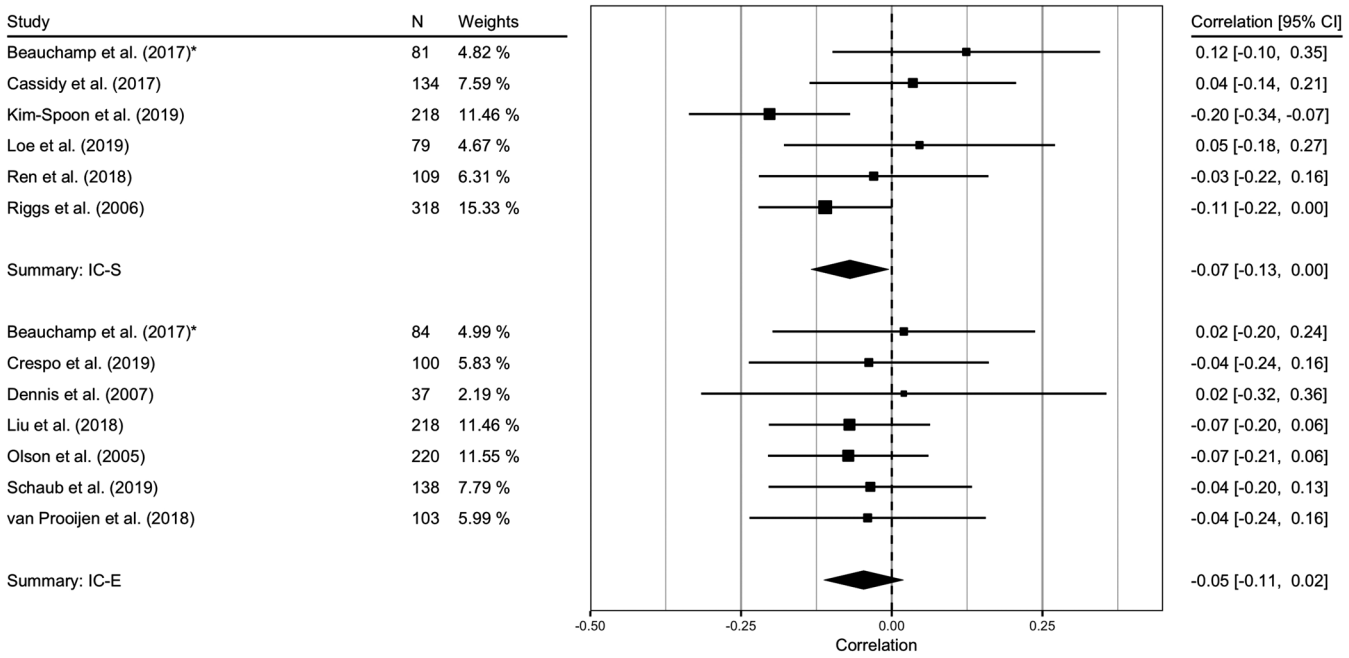

FIGURE 3 Forest plot of moderator analysis for internalizing behavior problems using the a priori defined "Strength/Endurance" (IC-S/IC-E) IC categorization as a subgroup variable. *Note*. Studies from which multiple effect sizes were used are marked with an asterisk (*)

1990; Schachar et al., 1993). Particularly, in early childhood, impairments in IC are thought to play a fundamental role in the emergence and progress of difficulties in behavioral adjustment. The current meta-analyses sought to examine (1) the association of IC with difficulties in behavioral adjustment, as indicated by internalizing and externalizing behavior problems in early childhood, and (2) the moderating effects of IC subtypes, as defined in the "Strength/Endurance" account (Simpson & Carroll, 2019). Together, our results indicate that the association of IC with behavioral adjustment in early childhood might be restricted to the externalizing domain, although only a small association could be revealed in typically-developing children. The two IC subtypes do not show moderating effects on this association.

4.1 | The association between IC and externalizing behavior problems

As hypothesized, the results of the current meta-analyses corroborate previous meta-analytic findings in children with clinical conditions, such as AD/HD or DBD (Alderson et al., 2007; Oosterlaan et al., 1998; Pauli-Pott & Becker, 2011; Schoemaker et al., 2013), revealing a small, but robust correlation of IC with the amount of externalizing behavior problems in typically developing children. However, based on the current results, this correlation seems to be reduced in non-clinical ($r = -0.11$, 95% CI [−0.15, −0.07]), as compared to clinical populations (Schoemaker et al., 2013). This indicates that the inverse association between IC and the expression of hyperactivity and/or aggression might be more pronounced in young children with high levels of externalizing behavior problems (Utendale & Hastings, 2011). Please note, however, that although the low heterogeneity across studies suggests a robust association, the identified correlation might not be considered practically meaningful. That is, recent studies in the clinical domain have shown that the association between executive functioning and behavior problems might be inflated due to confounding between-subject variation (Willoughby et al., 2019). Interestingly, a similar small, but robust association between IC and externalizing behavior problems was obtained in both endurance- and strength-oriented IC subtypes (Simpson & Carroll, 2019), and no significant differences could be revealed between subtypes. These results do not support the hypotheses raised in Simpson's and Carroll's theory (2019), but are generally in line with previous meta-analytic evidence in clinical conditions showing associations of externalizing behavior problems with a broad variety of IC tasks encompassing the strength and endurance domain (Pauli-Pott & Becker, 2011; Schoemaker et al., 2013). Together, these findings indicate that IC subtypes might not add to our understanding of externalizing behavior problems in typically-developing children. Instead, it may be that IC subtypes exert a common adaptive function (Zelazo & Carlson, 2012), showing a small association with early-emerging behavior problems.

4.2 | The association between IC and internalizing behavior problems

Although frequently proposed in the literature (e.g., Nigg, 2000; Quay, 1988, 1993), no significant linear association was found between IC and internalizing behavior problems in the current meta-analysis. While these findings might conflict the notion of children with internalizing symptoms being "overly" controlled in their behavior (Block & Block, 1980; Nigg, 2000), our results underline a broad range of

investigations showing no indication of increased depression or anxiety rates in children with high or low behavioral inhibition (see e.g., Eisenberg et al., 2001; Krueger et al., 1996; Oosterlaan et al., 1998). However, please note that based on the studies included in the current meta-analysis, we cannot rule out the possibility of a non-linear association between IC and internalizing behavior problems (c.f. Murray & Kochanska, 2002). Some previous studies have suggested that the heterogeneity of inhibitory functioning assessments might be important to further characterize the relation of IC to maladaptive behavior in childhood (Eisenberg et al., 2001; Nigg, 2000; Simpson & Carroll, 2019). However, the current meta-analysis did not reveal moderating effects of a priori IC conceptualization.

4.3 | Limitations and future directions

The present findings might stimulate future research in important ways. First, the current investigation was limited to non-clinical populations of young children, using a dimensional approach to assess difficulties in behavioral adjustment (Achenbach & Edelbrock, 1983; Hudziak et al., 2007). While this approach constitutes an important perspective to further characterize the underpinnings of early-emerging problems in behavioral adjustment, some pitfalls might arise for the assessment of internalizing behavior problems in particular. More specifically, the evaluation of internalizing behavior problems in early childhood via parental rating procedures demands the rater to infer internal affective states (Murray & Kochanska, 2002). In contrast, externalizing behavior problems are considered to be much more salient and frequent in this period of life, and can be evaluated almost entirely based on direct observation of the caregiver, even in the absence of clinical manifestations. Together, these dissimilarities in the assessment of behavior problems might have led to a systematic underrepresentation of internalizing behavior problems in the reviewed studies. Second, we found some indication that age of the participants might be a relevant moderating factor for the relationship between IC and internalizing behavior problems, highlighting the possibility that this association might change in the course of development, as already suggested in the domain of externalizing behavior problems (Utendale & Hastings, 2011). Interestingly, we also found that mean age of the participants was significantly related with sample size of the studies included in the current meta-analyses, potentially leading to asymmetry in observed effect sizes for the domain of internalizing behavior problems.

Together, these considerations highlight the need for further investigations in the domain of internalizing behavior problems in early childhood. Specifically, one future direction for research further characterizing this association involves the investigation of children with high rates of internalizing behavior problems, as reflected in clinical conditions (i.e., child depression, anxiety disorder) across a variety of age groups. To our knowledge, only a few studies have investigated IC in clinical populations related to internalizing problems, showing no clear evidence for a significant association (Mueller et al., 2012; Oosterlaan et al., 1998). Furthermore, future studies testing clinical and non-clinical populations should consider combining parental rating measures with systematic direct observation to assess behavioral adjustment (Christ et al., 2008) from a broader perspective.

5 | CONCLUSION

In sum, this meta-analysis shows a small significant association of IC with early emerging maladaptive behavior in non-clinical populations of children, while no moderating effects of IC conceptualization (as defined in the "Strength/Endurance" account; Simpson & Carroll, 2019) could be revealed. While these results highlight the need for a differentiation between externalizing and internalizing domains when studying the cognitive underpinnings of maladaptive behavior in early childhood, the small association of IC ability with behavior problems in non-clinical populations provokes broader questions about the role of IC in behavioral adjustment. As motivated by indications of publication bias and a confounding influence of age in the internalizing domain, more research needs to be undertaken to improve our understanding of the association between IC and internalizing behavior problems in early childhood.

CONFLICT OF INTEREST

We have no conflicts of interest to disclose.

DATA AVAILABILITY STATEMENT

The data and analysis scripts that support the findings of this study are openly available in OSF at https://osf.io/gcwfj/?view_only = b29e9f4f3fcf4ff3956ab7f8ef9ff1bc.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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