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REVIEW

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Inhibitory abilities in girls and boys: More similarities or differences?

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Abstract

This brief review examined the literature from 1990 to June 2020 on sex differences in inhibitory abilities from early childhood to adolescence, primarily in individuals with typical development (TD) and individuals with atypical development. The 38 articles included (28 on individuals with TD, eight on the attention deficit hyperactivity disorder [ADHD] population, and two on individuals with autism spectrum disorder [ASD]) suggest that the cognitive demand of the task is important, together with contextual factors that may interact with the development of inhibitory ability, for revealing differences between the sexes. The literature has neglected the multicomponential nature of inhibitory abilities, and the emphasis has consequently been placed on response inhibition (vs. other components). The implication of the impurity problem has also been considered. The findings on children and adolescents with ADHD or ASD—even for outcomes that are not conclusive—imply that there is no evidence for a difference in inhibitory abilities between males and females. The literature proposes an asynchrony in the development of inhibitory abilities that may explain what is found in typically developing girls who perform more highly than boys on more demanding tasks.

KEYWORDS
development, inhibitory abilities, sex differences

1 | INTRODUCTION

Inhibitory abilities are fundamental in daily life and crucial for several domains of functioning (e.g., theory of mind, Carlson et al., 2002; self-regulation, Oeri et al., 2018; school achievement, e.g., Allan et al., 2014; Clark et al., 2010). These abilities are represented by several aspects such as control over one's mental processes and responses, which includes neglecting an internal or external stimulus, refraining from acting, or performing an alternative action (Diamond, 2013). In fact, inhibitory abilities are a fundamental component of the executive function processes (Miyake et al., 2000).

Although, recent literature argued the executive functions may not be certainly considered as separate factors (Karr et al., 2018), theoretical studies concerning inhibition have considered different dimensions distinguishable on the basis of the domain (perceptual, linguistic, or motor; Dempster, 1992) or specific processes (behavioral, cognitive, and interference inhibition; Harnishfeger, 1995) involved. The multidimensional nature of inhibition has been empirically confirmed in adults (Friedman & Miyake, 2004; Rey-Mermet et al., 2018; Stahl et al., 2014) and at developmental ages (Gandolfi et al., 2014; Traverso et al., 2020). The ability to manage conflict at the response level has been distinguished from the ability to manage conflict at the stimulus level; therefore, response inhibition has been differentiated from

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interference suppression (Bunge et al., 2002; Cragg, 2016; Martin-Rhee & Bialystok, 2008; Rey-Mermet et al., 2018; but Friedman & Miyake, 2004). Response inhibition is the ability to stop a prepotent response in favor of a nondominant response, whereas interference suppression, also called resistance to distractor interference (Rey-Mermet et al., 2018) or attentional inhibition (Tiego et al., 2018), is the ability to handle interference from distracting stimuli (Bunge et al., 2002; Martin-Rhee & Bialystok, 2008). Response inhibition and interference suppression are distinguished early during development (Gandolfi et al., 2014) and differentially contribute to other cognitive abilities in early childhood (Gandolfi & Viterbori, 2020; Traverso et al., 2020).

The present review examined the literature from 1990 to June 2020 on sex differences in inhibition from early childhood to adolescence in individuals with typical development (TD), and in children showing two specific types of atypical development: attention deficit hyperactivity disorder (ADHD) or autism spectrum disorder (ASD). A total of 538 abstracts were extracted with the following keywords: executive function or control process or executive attention or working memory or inhibition or inhibitory control and gender differences or sex differences or male vs female. The inclusion criteria for selecting the full papers were as follows: being primary studies, presenting measures of inhibitory control, presenting a comparison between males and females, considering a sample size greater than 50 participants at a developmental age (early childhood to adolescence), being written in English, and being published in a scientific journal. Eighty-eight full papers were examined, and 38 articles that met all the aforementioned criteria (28 regarding children with TD, eight on the ADHD population, and two on individuals with ASD) were ultimately included (Table 1).

A preliminary consideration from this analysis comes from the use of terms sex and gender referred to as biological and cultural originated differences, respectively. Literature included in the present review consider gender (20 articles) or sex (12 articles) differences; in five articles, the term sex and gender are both used to describe differences between males and females, whereas, in an article, authors did not refer to this comparison in term of gender or sex characteristics. None of the articles directly investigates the causes of differences as referred to biological or cultural antecedents. As well as the brain regions involved, inhibitory abilities develop from early childhood to late adolescence (Best & Miller, 2010); furthermore, the role of contextual factors in influencing the development of these abilities is well documented (see e.g., Bernier et al., 2012). Thus, disentangling the contribution of biological or cultural factors is an arduous job. Aware of that, in this article, the locution "sex differences" is used consistently to investigate differences between males and females, independently from their sources. The expression "gender differences" is used to indicate cross-cultural differences.

2 | INHIBITORY DIMENSIONS ACROSS TASKS

The majority of the included studies investigated sex differences as a primary goal. Only a few studies reported sex differences as secondary findings (Armengol, 2002; Cheie et al., 2015; Howard et al., 2019; Montroy et al., 2016; Raaijmakers et al., 2008; von Suchodoletz & Gunzenhauser, 2013).

Significance

Inhibitory abilities are fundamental in daily life and crucial for several domains of functioning as they allow individuals to control their mental processes and responses. This mini-review examined the literature from 1990 to June 2020 on sex differences in inhibitory abilities from early childhood to adolescence in individuals with typical development, attention deficit hyperactivity disorder, or autism spectrum disorder. The literature shows that the cognitive demand of the task is important, together with contextual factors that may interact with the development of inhibitory ability, for revealing differences between the sexes. Notably, this review reveals a lack research on the ultimately diverse functional organization of inhibitory processes in boys and girls.

An overview of tasks exploring sex differences in inhibitory abilities (Table 1) shows that tasks requiring response inhibition are the most frequently employed. Among such tasks, the well-known go/no-go paradigm tests the ability of both adults and children to inhibit prepotent responses (Verbruggen & Logan, 2008). In this task, children are asked not only to restrain from making an automatic response, but also to pay attention to and shift between different dimensions of the same object.

In four studies that analyzed children's performance differences by using the go/no-go paradigm, girls outperformed boys, demonstrating a better ability to discriminate between go and no-go trials (Hooper et al., 2004) and to be less impulsive (Cornblath et al., 2019; Mileva-Seitz et al., 2015; Raaijmakers et al., 2008). Whereas this outcome appears consistent for preschoolers (Mileva-Seitz et al., 2015; Raaijmakers et al., 2008), it was uneven for school-aged children and adolescents, with a number of studies reporting no differences (Brocki & Bohlin, 2004; Cheie et al., 2015; Chung et al., 2020; Malagoli & Usai, 2018).

Except for one study (Cornblath et al., 2019), no sex differences were found (Binder et al., 2020; Brocki & Bohlin, 2004) for the continuous performance task (CPT), which asks participants to maintain vigilance regarding simple stimuli and to inhibit their responses to competing stimuli over a prolonged period of time. Only one study used the stop signal task, a choice response timed task in which the participant should refrain from responding when a stop stimulus is given; males performed poorer than girls (Malagoli & Usai, 2018).

In two studies, inhibition was assessed with the Shape School task (Clark et al., 2013; Raaijmakers et al., 2008), which is a colorful storybook designed to examine inhibition and switching processes in young children by asking them to respond to the color of stimuli.

TABLE 1 Samples characteristics, tasks, inhibitory abilities evaluated, variables considered, and results of the articles included in the present review

Article	Age (range)	Sample size (>50) *N* female *N* male	Country	Tasks	Inhibitory abilities	Latent/composite variable	Results
Sex differences on typical development							
Amicarelli et al. (2018)	T1 M = 3.02 years SD = 0.16 T2 M = 5.44 years SD = 0.50	*N* = 406 F = 207 M = 199	The United States	T1: Tower of patience Snack Delay T2: Gift bag Simon says	Motor response inhibition		Boys' IC and positive parenting were significantly associated; no significant association between changes in IC and parenting for girls. Boys' IC at age 5 was significantly different from girls' IC at age 5 when positive parenting at age 3 was below average or "typical" levels of positive parenting in our sample. Low positive parenting was driving the significant interaction between sex and parenting in shaping children's EC
Armengol (2002)	6;6–12;11 years	*N* = 349 F = 173 M = 176	Spain	Stroop test Comalli-Kaplan version (Comalli et al., 1962; Kaplan, personal communication; Mitrushina et al., 1999)	Verbal response inhibition		No differences
Binder et al. (2020)	T1; M = 44.25 months SD = 3.37 T2; M = 56.70 months SD = 3.77 T3; M = 69.31 months SD = 4.24	*N* = 199 F = 92 M = 107	The United States	K-CPT; Conners 2001 Statue (NEPSY)	Motor response inhibition		No differences

(Continues)

TABLE 1 (Continued)

Boelema et al. (2014)	T1 M = 11.1 years, SD = 0.56 T4 M = 19.2 years SD =0.57	T1 *N* = 2230 F = 1133 M = 1097 T4 *N* = 1596 F = 862 M = 734	The Netherlands	Amsterdam Neuropsychological Tasks (Shifting attentional set-visual)	Inhibition shift attention		Linear growth models. For inhibition (INH), resulted in separate models for boys and girls, each with their own intercepts and slopes. For INH, girls had a smaller intercept and thus showed a better performance at baseline. Girls' slope was not significantly different from zero, indicating no change in performance between baseline and follow-up, where boys did improve
Brocki and Bohlin (2004)	6–13 years	*N* = 92 F = 45 M = 47	Sweden	Go/no-go CPT Stroop-like task	Motor response inhibition Verbal response inhibition	Disinhibition (CPT disinhibition; CPT impulsivity; CPT inattentive impulsivity; and Go/no-go commissions)	No differences
Cheie et al. (2015)	M = 74.7 months; SD = 7.49 (5.1–7.3 years)	*N* = 131 F = 65 M = 66	Romania and Russia	Tasks from NEPSY: Statue Knock and Tap Auditory Attention Response Set Visual Attention Inhibition	Motor and verbal response inhibition		Girls > boys on the Response Set subtest No differences on the response suppression tasks (Statue, Knock and Tap, Auditory Attention)
Clark et al. (2013)	T1 = 3 years, T2 = 3.75 years, T3 = 4.5 years, T4 = 5.25 years	*N* = 388 F = 195 M = 193	The United States	Shape School	Verbal response inhibition	–	Subtle differences in the rate of executive control growth for girls and boys
Cornblath et al. (2019)	M = 15.06, SD =3.15 8–22 years	*N* = 879 F = 490 M = 389	The United States	Computerized Neurocognitive Battery (CNB) (Gur, 2010; Gur et al., 2012) CPT	Motor response inhibition		No difference in CPT true positive rate Girls > boys in CPT impulsivity: CPT false positives higher in males
Chung et al. (2020)	12–25 years	*N* = 130 F = 64 M = 66	The United States	Go/no-go	Motor response inhibition		No differences
Cuevas et al. (2016)	3;11.93–4;3.63 years M = 4 years, 25 days; SD = 23 days)	*N* = 144 M = 68 F = 76	The United States	Day–night Stroop (EEG)	Verbal response inhibition		No differences

TABLE 1 (Continued)

Dubuc et al. (2020)	M = 13.1 SD = 1.0	*N* = 187 F = 116 M = 71	Canada	Flanker task	"Interference control"		No differences
Gestsdottir et al. (2014)	T1 M = 74.5	*N* = 260 F = 111 M = 149	France, Germany, Iceland	Head-toes-knees-shoulders (HTKS)	Behavioral regulation		France and Germany: no differences Iceland: boys had lower scores on HTKS (about 1.40 points lower than Icelandic girls)
Gunzenhauser et al. (2017)	M = 8.59 years SD = 0.56 years at Time 1	*N* = 263 F = 134 M = 129	Germany	AGTB 5–12 (Hasselhorn et al., 2012): Stroop Test Go/no-go	Verbal and motor response inhibition	Combined (composite) score	No differences with the original data Girls > boys with the imputed data point
Hooper et al. (2004)	9–17 years M = 12.89 years, SD = 2.75	*N* = 145 F = 79 M = 66	The United States	Go/no-go task (Braver et al., 2001)	Motor response inhibition		Girls> boys in the ability to discriminate between go/no-go trials
Howard et al. (2019)	3.10–5.88 years	*N* = 80 F = 39 M = 41	Australia	Head-toes-knees-shoulders (HTKS)	Behavioral regulation		No differences
Macdonald et al. (2014)	5.25–8.42 years M = 6.98 years SD = 0.88	*N* = 80 F = 38 M = 42	Australia	Big-Small Stroop (Naglieri & Das, 1997). Boy-Girl Stroop (Kerns & McInerney, 2007) Fruit Stroop (Archibald & Kerns, 1999)	Verbal response		Boys > girls after accounting for speed of processing Fruit Stroop: age-by-sex interaction, that indicated an oscillating pattern of development for girls, with a more expected trajectory for boys who improved from 5 to 6 years followed by a small regression from 6 to 8 years
Malagoli and Usai (2018)	14–19 years M = 202.8, SD 18.57 months	*N* = 227 F = 148 M = 79	Italy	Antisaccade task Go/no-go task Stop signal task	Motor response inhibition	Observed measures; Inhibition latent factor	No difference for antisaccade go/no-go Girls > boys; in the 14–17 age range group, females performed better than males in the stop signal task No differences in the 17–19 age range group

(Continues)

TABLE 1 (Continued)

Matthews et al. (2009)	M = 5.45 years SD = 0.33	*N* = 268 F = 139 M = 129	The United States	Head-toes-knees-shoulders (HTKS)	Behavioral regulation		Girls > boys on the HTKS with observable differences in variability of boys' and girls' HTKS scores Boys began the school year at a significant disadvantage in self-regulation in comparison with girls, and although they improved, they did not catch up by spring
Mileva-Seitz et al. (2015)	M = 51.5 SD = 1.3 months	*N* = 752 F = 383 M = 369	The Netherlands	Go/no-go	Motor response inhibition		Boys made significantly more commission errors
Montroy et al. (2016)	3–7 years	*N* = 1386 F = 703 M = 683	The United States	Head-toes-knees-shoulders (HTKS)	Behavioral regulation		Girl showed earlier development trajectories. There were more boys in the later developer group
Mous et al. (2017)	M = 7;1	*N* = 1307 F = 638 M = 669	The Netherlands	NEPSY-II-NL Auditory Attention and Response Set Statue	Motor response inhibition		Girls > boys on Auditory Attention: girls made fewer commission errors than boys Girls > boys on Response Set: girls had a significantly higher total score than boys; girls made significantly fewer errors com- pared with boys Statue: no significant
Raaijmakers et al. (2008)	Aggressive (AGGR) group M = 50.65 months SD = 3.05 Control (CONTR) M = 52.31 months SD = 2.20	AGGR group =82 F = 23 M = 59 CONTR group = 99 F = 35 M = 64	The Netherlands	Go/no-go Shape school (inhibition condition) Day–night task	Motor response inhibition Verbal response inhibition	Inhibition (commission errors)	Girls > boys on inhibition factor
Son et al. (2013)	43–78 months M = 60.67 months, SD = 10.18	*N* = 229 F = 92 M = 137	South Korea	Head-toes-knees-shoulders (HTKS)	Behavioral regulation		No differences
von Suchodoletz and Gunzenhauser (2013)	T1 M = 37 months, SD = 1.77 months T2 M = 47 months, SD = 1.79 months	*N* = 60 F = 31 M = 29	Germany	Head-toes-knees-shoulders (HTKS)	Behavioral regulation		No differences at T1 Girls > boys at T2

TABLE 1 (Continued)

von Suchodoletz et al. (2013)	M = 65 months German sample M = 61.24 months SD = 7.28 Icelandic sample: 55.70 months SD = 3.46	*N* = 412 F = 201 girls M = 211	Germany Iceland	Head-toes-knees-shoulders (HTKS)	Behavioral regulation		Icelandic first-grade sample: Girls > boys German and Icelandic preschool samples: No differences
Yamamoto and Imai-Matsumura (2019)	M = 71.44, SD = 3.6 months	*N* = 111 F = 54 M = 57	East Japan	Head-toes-knees-shoulders (HTKS) Fruit/Vegetable Stroop task (Archibald & Kerns, 1999)	Motor response inhibition Verbal response inhibition		No differences
Wanless et al. (2013)	3.12–6.50 years	*N* = 814 F = 381 M = 433	The United States, China, Korea, Taiwan	Head-toes-knees-shoulders (HTKS)	Behavioral regulation		The United States: Girls > boys Asian societies: No differences
Yücel et al. (2012)	11.7–13.7 years	*N* = 153 F = 74 M = 79	Australia	Stroop task	Verbal response inhibition	–	Girls > Boys: Males were less effective in using strategic control, showing a general slowing on the simpler (i.e., congruent) trials and a trend toward increased errors during the mostly incongruent block
Sex differences on ADHD and ASD							
Houghton et al. (1999)	6;3–13;4 M = 10 years SD = 1 year 9 months	*N* = 122 (94 with ADHD) F = 52 M = 70	Australia	Stroop MMFF	Response inhibition		No differences
Martel (2013)	3–6 years M = 4.34 years, SD = 1.08	*N* = 109 (79 with ADHD/ODD) F = 45 M = 64	The United States	Shape School	Response inhibition		No differences
Nydén et al. (2000)	8–12 years	*N* = 51 (10 with ASD; 24 with ADHD) F = 34 M = 17	Sweden	Visual and auditory Go/No-Go Visual and auditory conflict task	Response inhibition		No differences

(Continues)

TABLE 1 (Continued)

O'Brien et al. (2010)	8–13 years	*N* = 146 (56 with ADHD) F = 68 M = 78	The United States	Conflicting Motor Response PANESS Total Overflow Go/No-Go D-KEFS Color–Word Interference Condition 3: Inhibition	Motor and verbal response inhibition	Boys with ADHD were impaired on the more basic functions (response inhibition, on go/no-go commission rate, and Color Word Interference inhibition). Boys and girls show different profile of impairment in the other tasks
Rucklidge (2006)	13–17 years	*N* = 114 (49 with ADHD) F = 60 M = 54	New Zealand	Stroop CPT	Verbal response inhibition	ADHD males more variable in their responses than the control males and the ADHD females made more omission errors as compared with the controls. Furthermore, the ADHD males were more impaired in Stroop Word, were more variable in their responses on the CPT-II, and were more likely to be classified as ADHD according to the confidence index as compared with the females with ADHD
Rucklidge and Tannock (2002)	13–16 years	*N* = 108 (59 with ADHD) F = 24 M = 35	Canada	Stroop and stop tasks	Verbal and motor response inhibition	No differences
Seidman et al. (2005)	9–17 years	*N* = 383 (204 with ADHD) F = 210 M = 173	The United States	Stroop task	Verbal response inhibition	No differences

TABLE 1 (Continued)

Seymour et al. (2016)	8–12 years	*N* = 181 (81 with ADHD) F = 87 M = 94	The United States	Go/no-go	Motor response inhibition	Interaction TD/ ADHD x SEX x task condition: Boys with ADHD demonstrated higher commission error rate and tau on both the simple and complex GNG tasks compared to TD boys Girls with ADHD did not differ from TD girls on the simple GNG task but exhibited increased commission errors and ISV compared to TD girls on the complex condition Interpretation: Boys with ADHD demonstrate impairments in response control even when cognitive load is minimized; response control is intact among girls with ADHD when cognitive load is minimized with greater impairment emerging with increasing cognitive load
Van Eylen et al. (2015)	8–18 years	*N* = 100 (50 with ASD) F = 40 M = 60	The Netherlands	Go/no-go Flanker task	Motor response inhibition Interference suppression	No differences
Wodka et al. (2008)	8–16 years	*N* = 123; (54 with ADHD) F = 56 M = 67	The United States	Color–Word Interference D-KEFS (Stroop paradigm)	Verbal response inhibition	No differences

As happens for the go/no-go paradigm, the inhibition conditions ask the participant to state the color of cartoon stimuli with happy faces, but to inhibit naming stimuli with sad faces. A significant effect was reported in the switch condition, with girls being more accurate (Raaijmakers et al., 2008) and boys being quicker to respond to this condition (Clark et al., 2013). One interpretation of these results is that there is a differential strategic approach to the specific condition in that girls may slow down their performance on more demanding tasks (Clark et al., 2013).

A number of studies have investigated performance differences with the Stroop-like paradigm (Armengol, 2002; Cuevas et al., 2016; Gunzenhauser et al., 2017; Macdonald et al., 2014; Raaijmakers et al., 2008; Yamamoto & Imai-Matsumura, 2019; Yücel et al., 2012), which requires inhibiting a prepotent verbal response and activating an alternative verbal response. In the preschool version of the Stroop paradigm, during the day–night task developed by Gerstadt et al. (1994), the experimenter presents a white card with a yellow sun and a black card with a white moon and stars on it. The children are instructed that in this game, they must say "night" for the sun cards and "day" for the moon cards (Cuevas et al., 2016; Raaijmakers et al., 2008). In the incongruent condition of the fruit/vegetable Stroop version employed by Yamamoto and Imai-Matsumura (2019), the child is asked to name the original hue of fruits and vegetables depicted in different colors. What kind of inhibitory ability is required by the Stroop task is a matter of debate.

The literature on behavioral outcomes in childhood (Gandolfi et al., 2014; Traverso et al., 2020; Usai et al., 2020) and findings on the neural basis of task performance in adults (Mead et al., 2002) strongly suggest that these tasks load more in response inhibition than in interference suppression. The Stroop paradigm allows for mixing results when the differences between sexes are considered. During preschool age, boys and girls do not appear to differ in terms of performance (Cuevas et al., 2016; Raaijmakers et al., 2008; Yamamoto & Imai-Matsumura, 2019). Additionally, when taking school-aged children into account, boys and girls perform similarly (Armengol, 2002). Macdonald et al. (2014), in an Australian sample of children aged 5.25–8.42 years old, appeared to find an advantage for girls. Notwithstanding, after accounting for the speed of processing, the situation seemed to be the reverse, with boys showing better performance. On the other hand, Yücel et al. (2012), with an Australian sample of early adolescents 11.7–13.7 years old, showed that boys and girls may use different strategies to perform the Stroop task. Girls may exhibit a reduced Stroop effect and a decrease in their response errors on incongruent trials without slowing down on congruent trials, whereas boys can achieve the same level of performance by slowing their response to congruent trials, indicating that incongruent trials represent a greater cost for boys than for girls.

Two studies assessed inhibition using both the response set task and the statue task from the NEPSY-II assessment (Cheie et al., 2015; Mous et al., 2017). The response set indicates a difference between males and females, with girls demonstrating greater accuracy, whereas the statue task does not reveal any advantage for girls or boys. One hypothesis for this difference within the same samples may point to the cognitive demand of each task. The response set task taps into response inhibition and working memory. The child is asked to respond to the word "red" by touching the yellow circle, to respond to "yellow" by touching the red circle, and to respond to the word "blue" by touching the blue circle. All of the other colors and words should be ignored. In contrast, the statue task evaluates one's ability to suppress a response in the presence of nonverbal distractors. Children should stand still in a "statue" position without moving or speaking for a length of time in which distractors are introduced.

All the tasks described above share the common feature of loading on response inhibition abilities. As for performing these tasks, one must refrain from impulsive behavior and stop prepotent (but inappropriate) motor or verbal responses by acting according to the task's rule. Mixed results were found in some studies that reported differences between males and females. Although the outcomes are not always statistically significant, they converge in the direction of differences, with females often revealing better inhibitory abilities than males. More than task features (such as the kinds of stimuli shown or the types of responses required), the cognitive load seems to highlight the differences between boys' and girls' performance. Independent of the paradigm used, when the task demand is too low relative to one's age or ability level, it is unable to capture possible differences in performance between males and females. It is plausible that more differences in inhibitory abilities between boys and girls may be found by increasing cognitive demand with more challenging inhibitory tasks (Seymour et al., 2016). In line with this interpretation, a significant group effect was reported in the switch condition, with girls being more accurate (Raaijmakers et al., 2008) and boys being quicker to respond (Clark et al., 2013). Switch conditions are more demanding; participants may use a differential strategic approach for the specific condition involved, and girls might slow down their performance (Clark et al., 2013).

Importantly, differences in other inhibitory components (such as interference suppression) are understudied. Indeed, an isolated study reported no differences between adolescent boys and girls on the flanker task, which requires handling conflicting stimuli (Dubuc et al., 2020). As stated above, this ability may emerge later than response inhibition. Hence, it can be more engaging from a cognitive angle, as major changes in inhibition tasks starting in middle childhood may be due to the development of interference suppression rather than response inhibition (Cragg, 2016). More research is needed to investigate this specific inhibitory component during development.

Using a different approach that involved the developmental trajectories of a large sample of 3- to 7-year-old children on the head-toes-knees-shoulders (HTKS) task, Montroy et al. (2016) discovered that being a girl was associated with earlier development trajectories in terms of self-regulation. Similar results were found in an extensive prospective cohort study conducted among Dutch preadolescents from age 11 (1st wave) to age 19 (4th assessment), in which Boelema et al. (2014) investigated the maturation of executive functioning. They also analyzed the effects of other variables, such as sex, on

the developmental trajectories of inhibition. By using linear growth models, separate models for boys and girls were detected, each with their own intercepts and slopes. In summarizing these findings, girls had better performance at baseline and no significant changes at follow-up, whereas boys exhibited improvement. The authors suggested that a delayed maturation of inhibition during adolescence is more pronounced for boys than for girls, although boys show better maturation in their general speed of processing in early adolescence. This last finding may suggest an asynchrony in the development of inhibitory abilities with a slight delay for males, which may explain the advantage sometimes observed in females in terms of better accuracy or strategies, especially when the task conditions are more demanding.

3 | TASK IMPURITY: MEASURING INHIBITORY ABILITIES

Another important issue deserves mention in the examination of executive processes: the so-called impurity problem, which refers to the concurrent involvement of several different cognitive processes, in addition to inhibitory processes in the performance of an inhibitory task (Miyake et al., 2000). As mentioned above, the studies reviewed here considered using inhibitory measures that may require different and uneven noninhibitory abilities. Consequently, the differences observed in task performance may reflect differences in noninhibitory demands. The use of factorial or composite scores may limit task impurity, especially if a latent factor approach is used to obtain more accurate measures of inhibitory abilities that better reflect the real organization of inhibitory abilities during development (Miller et al., 2012). A few studies have used composite scores (Brocki & Bohlin, 2004; Gunzenhauser et al., 2017; Raaijmakers et al., 2008) or a latent approach (Malagoli & Usai, 2018).

A difference was detected when, instead of single observed measures, a factor score was employed considering the commission errors of both day–night Stroop and go/no-go tasks. Again, girls exhibited a greater level of inhibitory ability than boys (Raaijmakers et al., 2008). Moreover, only one study expressly aimed to explore a possibly different latent organization in cognitive functioning during development and found a substantial overlap between the sexes in adolescence (Malagoli & Usai, 2018). The application of structural equation models to longitudinal data may be useful in controlling for the effect of task impurity, allowing us to compare variations in the latent organization of inhibitory processes during development and to test their invariance between the sexes.

4 | INHIBITORY CONTROL AND SOCIOCULTURAL CONTEXT

Several studies seem to shift in interest from sex to gender differences. Whereas the former label suggests a biological basis for differences between males and females, the latter evokes the role of sociocultural factors that may shape inhibitory abilities during development.

Differences in boys' and girls' performance on inhibitory tasks have also been explained by considering the role of cultural context. Several studies have employed the HTKS task (McClelland et al., 2007), which is used to assess behavioral self-regulation and requires the child to refrain from touching the part of his/her body named by the adult (a prepotent response, i.e., the head) and to perform a nondominant response by touching another part of his/her body (i.e., the toes). Whereas no differences were found in Asiatic (Son et al., 2013; Yamamoto & Imai-Matsumura, 2019; Wanless et al., 2013) or Australian samples (Howard et al., 2019), girls exhibited better self-regulation abilities in U.S. samples (Matthews et al., 2009; Wanless et al., 2013). Nevertheless, findings related to other regions, such as Germany, are not convergent (Gestsdottir et al., 2014; von Suchodoletz et al., 2013; von Suchodoletz & Gunzenhauser, 2013), suggesting that other factors should be taken into account.

Cultural differences may act on inhibitory ability differences by differently influencing caregiving practices, which are important in the development of self-regulation (Bernier et al., 2012). Notably, some studies have detected factors such as mothers' education, positive parenting, and social resources that interact with sex differences (Amicarelli et al., 2018; Clark et al., 2013; Montroy et al., 2016), implying that these differences may be moderated by aspects of sociocultural context. In particular, males may be more sensitive to poorer social resources than females, demonstrating a potential vulnerability to social network-related stressors that interact with the development of their early inhibitory abilities. Additional studies that include variables such as environmental information and adults' expectations would be necessary to determine the reasons for this different pattern of self-regulation development between boys and girls.

5 | INHIBITORY CONTROL BETWEEN SEXES IN CHILDREN AND ADOLESCENTS WITH ATYPICAL DEVELOPMENT

Inhibitory abilities are often impaired in individuals with ADHD or ASD. The different prevalence of ADHD and ASD in males and females may signal a different cognitive profile influenced by a factor related to sex. Part of the literature has considered the differences in the cognitive profiles of boys and girls with ADHD. Stroop-like tasks (Houghton et al., 1999; O'Brien et al., 2010; Rucklidge, 2006; Rucklidge & Tannock, 2002; Seidman et al., 2005; Wodka et al., 2008) and the go/no-go paradigm (O'Brien et al., 2010; Rucklidge, 2006; Seymour et al., 2016) are the most frequently employed tasks.

Inhibitory abilities appear comparable between males and females when young children are examined (Martel, 2013). For example, no differences were revealed in studies on inhibitory control in school-aged children, independent of the task used (Houghton et al., 1999; O'Brien et al., 2010; Wodka et al., 2008). Interestingly, whereas verbal or motor

responses appear to produce a similar performance in boys and girls, the increasing level of cognitive load leads to lower performance in girls (Seymour et al., 2016). Compared to children with TD, boys with ADHD had impaired performance on both simple and complex go/no-go tasks. Compared to TD controls, girls with ADHD showed impairment in the complex condition but not in the simple condition.

When adolescents were considered, the majority of studies did not indicate any difference in the level of impairment on inhibitory tasks between sexes (Rucklidge & Tannock, 2002; Seidman et al., 2005; Wodka et al., 2008). However, a closer examination of the responses of ADHD individuals compared to their respective controls demonstrated that, whereas males with ADHD had more variability in their responses, girls with ADHD made more omission errors (Rucklidge, 2006).

A greater inhibitory deficit in females is difficult to explain, given that boys frequently present with higher impulsivity and hyperactivity than girls (Gershon, 2002). However, this result is restricted to childhood and comes from a single study. Although the two samples presented comparable comorbid symptomatology, we cannot rule out the possibility that these findings might be due to the ADHD symptom severity difference between female and male participants recruited for the study (e.g., Doidge et al., 2021).

Inhibitory difficulties may contribute to different features in individuals with ASD in both the domain of social communication (Shiri et al., 2018) and repetitive behaviors (Faja & Nelson Darling, 2019; Schmitt et al., 2018). In fact, a meta-analysis by Demetriou et al. (2018) revealed that individuals with ASD exhibited impaired performance in different direct measures of inhibitory control when compared with healthy controls. The literature on sex differences in inhibitory abilities in children and adolescents with ASD is scarce because there are far fewer females with an ASD diagnosis than males.

In a study on children with ASD who had an IQ greater than 70, no differences were detected between boys and girls who performed the go/no-go or the Stroop tasks (Nydén et al., 2000; see also Martel, 2013). In the same vein, Van Eylen et al. (2015), investigating executive functioning performance in relation to sample characteristics and symptom severity in children and adolescents with ASD, discovered that individuals with ASD performed lower on the go/no-go task, but not on the flanker task, than healthy controls. By analyzing the effect of sex, no differences were found, which could be attributed to male or female status.

In conclusion, when children and adolescents with ASD have an IQ greater than 70, males and females do not show any significant differences in performing the go/no-go, the Stroop, or the flanker task. Given the paucity of evidence, further research is needed to better examine sex differences not only in ASD but also in ADHD.

6 | CONCLUSION

This brief review indicates that among the diverse inhibitory components, response inhibition has mostly been considered when the differences between males and females were investigated. The findings imply that a task's level of cognitive demand, in relation to one's age and characteristics, is a central factor that highlights sex differences. While results about children and adolescents with ADHD or ASD (even those that are not conclusive) indicate no evidence for a difference in the inhibitory abilities of males and females, typically developing girls perform better when the tasks are demanding enough to push inhibitory demands to individual limits. Notably, for the typically developing population, asynchrony in functional development was observed in both preschool-aged children (Montroy et al., 2016) and adolescents (Boelema et al., 2014), signaling that girls may exhibit early acquisition of inhibitory abilities, and that boys may go through a prolonged period of changes during adolescence. Different timing in brain development (e.g., Kaczkurkin et al., 2019) may account for this asynchrony, together with cultural beliefs and adults' expectations (von Suchodoletz et al., 2013; Wanless et al., 2013). Cultural specificity is indeed called upon to explain the interaction between inhibitory control acquisition, in addition to educational and social conditions that interact with the development of early inhibitory abilities (Clark et al., 2013).

The task impurity effect was not taken into account in the majority of studies reviewed. Thus, these findings may also reflect differences due to other noninhibitory task components. A different methodological approach, such as structural equation modeling, in addition to the use of a longitudinal design, may help to investigate eventual differences in the latent organization of inhibitory processes between the sexes (Malagoli & Usai, 2018).

A final remark regards the psychometric problems recently highlighted on measures of inhibitory control that include the poor test–retest reliability (Enkavi et al., 2019). Considering that inhibitory tasks derived from consolidated paradigms that produce effects highly replied in the population (i.e., Stroop or flanker effects), it has been suggested that the between-subject variability might be lower than the within-subject for these tasks, resulting in low reliability of the measure (Hedge et al., 2018).

CONFLICT OF INTEREST

The author has no conflict of interest to declare.

AUTHOR CONTRIBUTIONS

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PEER REVIEW

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