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Inhibitory control profile in clinical and control groups: A preliminary study of Stroop and Go/No-Go paradigms

Perfil de controle inibitório em grupos clínicos e controle: Um estudo preliminar dos paradigmas Stroop e Go/No-Go

Perfil de control inhibitorio en grupos clínicos y de control: Un estudio preliminar de los paradigmas Stroop y Go/No-Go

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Resumo

A avaliação do controle inibitório, especialmente através dos paradigmas Stroop e Go/No-Go, é crucial para compreender os perfis cognitivos, comportamentais e emocionais de crianças e adolescentes. Este estudo, envolvendo 82 participantes predominantemente de uma clínica ambulatorial de psiquiatria infantil e adolescente, tenciona analisar a variabilidade do controle inibitório entre grupos clínicos e de controle. Os participantes foram categorizados em três grupos: (1) Transtorno do Espectro Autista (TEA); (2) Transtorno do Desenvolvimento Intelectual (TDI); e (3) desenvolvimento típico (grupo de controle). Nenhuma diferença foi identificada entre os grupos TEA e controle na tarefa Stroop, mas foram observadas discrepâncias entre os grupos TEA e TDI na primeira cartela da tarefa Stroop (p=0,016). Na tarefa Go/No-Go, surgiram diferenças entre os grupos TEA e controle, enquanto nenhuma distinção foi encontrada entre os grupos TEA e TDI. Ao comparar o efeito das variáveis sociodemográficas (sexo e faixa etária) no desempenho dos três grupos, apenas o grupo diagnóstico composto pelos dois grupos clínicos mostrou um efeito significativo (F=15,2692, p<0,001). Os resultados ressaltam a importância de considerar as demandas específicas das tarefas ao avaliar o controle inibitório, mostrando níveis variados de demanda com implicações clínicas, especialmente no autismo.

Palavras-chave: transtornos do neurodesenvolvimento; transtorno do espectro autista; deficiência intelectual; funções executivas.

Abstract

The assessment of inhibitory control, notably through the Stroop and Go/No-Go paradigms, is crucial for understanding the cognitive, behavioral, and emotional profiles of children and adolescents. This study, involving 82 participants predominantly from an outpatient child and adolescent psychiatric clinic, aims to analyze the variability of inhibitory control between clinical and control groups. Participants were categorized into three groups: (1) Autism Spectrum Disorder (ASD); (2) Intellectual and Developmental Disabilities (IDD); and (3) typically developing (control group). No differences were identified between the ASD and control groups in the Stroop task, but discrepancies were observed between the ASD and IDD groups in the first card of the Stroop task (p=.016). In the Go/No-Go task, differences emerged between the ASD and control groups, while no distinction was found between the ASD and IDD groups. When comparing the effect of sociodemographic variables (sex and age group) on performance across the three groups, only the diagnostic group composed of

both clinical groups showed a significant effect (*F*=15.2692, *p*<.001). The results underscore the importance of considering task-specific demands when assessing inhibitory control, showing varying levels of demand with clinical implications, especially for autism.
Keywords: neurodevelopmental disorders; autism spectrum disorder; intellectual disability; executive functions.

Resumen

La evaluación del control inhibitorio, especialmente a través de los paradigmas Stroop y Go/No-Go, es crucial para comprender el perfil cognitivo, conductual y emocional de niños y adolescentes. Este estudio, que involucra a 82 participantes atendidos principalmente en una clínica psiquiátrica infanto-juvenil, tiene como objetivo analizar la variabilidad del control inhibitorio entre grupos clínicos y un control. Los participantes se dividieron en tres grupos: (1) Trastorno del Espectro Autista (TEA); (2) Discapacidad Intelectual y del Desarrollo (DID); y (3) desarrollo típico (grupo control). Al contrastar el rendimiento en los paradigmas, no se encontraron diferencias entre el TEA y el control en la tarea Stroop, pero sí diferencias entre TEA y DID en la primera etapa del Stroop (*p*=0,016). En la tarea Go/No-Go, surgieron diferencias entre TEA y el grupo control, mientras que no hubo distinción entre TEA y DID. Al comparar el efecto de variables sociodemográficas (sexo y edad) sobre el rendimiento de los grupos, solo el grupo diagnóstico, compuesto por los grupos clínicos, mostró un efecto significativo (*F*=15,2692, *p*<0,001). Estos resultados subrayan la importancia de considerar las tareas específicas al evaluar el control inhibitorio, mostrando diferentes niveles de demanda con implicaciones clínicas, especialmente en el autismo.
Palabras clave: trastornos del neurodesarrollo; trastorno del espectro autista; discapacidad intelectual; funciones ejecutivas.

Introduction

In recent years, researchers have increasingly conducted empirical and theoretical studies to investigate cognitive and behavioral skills in children and adolescents (Dias et al., 2024; Gunnell et al., 2019). These efforts offer valuable insights into the multidimensional and intricate nature of cognitive development (Miyake & Friedman, 2012). The development of executive functions has been shown to play a critical role in the academic, social, and emotional skills of children and adolescents (Best et al., 2011). Notably, executive function models have garnered attention for their link to behavior regulation, problem-solving, and decision-making (Diamond, 2013), skills that are crucial for adaptive functioning across various life domains (Zelazo, 2020; Zelazo & Carlson, 2020).

Executive functions encompass a range of mental abilities that enable individuals to organize and manage their actions according to personal goals and intentions (Diamond, 2013). Considerable debate exists regarding the components of executive functions. Adele Diamond's (2013) model highlights core cognitive processes such as inhibitory control, working memory, and cognitive flexibility, alongside higher-level functions like reasoning, problem-solving, and planning. However, other models emphasize executive processes like monitoring, self-regulation, and classification (Lezak et al., 2012). Findings indicate that adequate development of executive functions is related to improved academic performance, social skills, self-management, and mental health (Blair & Razza, 2007; Diamond, 2013; Moffitt et al., 2011).

Among these core executive functions, inhibitory control is a central and predictive factor for executive and cognitive functioning (Nigg, 2001). Inhibitory control refers to the ability to suppress distracting or irrelevant responses, manage the influence of internal and external interferences, and is linked to attention processes as well as emotional and behavioral regulation (Diamond, 2013). Inhibitory control can be divided into two main functions: interference control and response inhibition. Interference control involves resisting both proactive and retroactive interferences, aiding in the inhibition of cognitive stimuli, and primarily supporting attentional control.

Two widely used paradigms for assessing inhibitory control in clinical and research settings are the Stroop task (Scarpina & Tagini, 2017; Spreen & Strauss, 1998) and the Go/No-Go task (Kohls et al., 2013; Nigg, 2001; Putra et al., 2021). In the Go/No-Go task, participants must quickly respond (Go) to specific target stimuli while refraining from responding (No-Go) to others. There are several variations of the same task incorporating different stimuli like faces and emotions (Egner et al., 2008), food-related figures (Veling et al., 2017), and computerized visual stimuli (Tyburski et al., 2021). Thus, the expression of inhibitory control can be verbal or physical depending on which version is adopted. Moreover, performance in inhibitory control tasks strongly predicts general executive functioning, with deficits impacting cognitive and behavioral skills (Friedman & Robbins, 2022; Nigg, 2001).

It is important to consider the diversity of Go/No-Go versions. Research indicates that individuals with autism spectrum disorder (ASD) often exhibit unique sensitivities to social stimuli (e.g., faces), which can influence their inhibitory control. Studies exploring neural responses to social stimuli in individuals with ASD have identified differences in activation patterns during inhibitory control tasks, indicating the influence of social cues on inhibitory processes in this population (D'Cruz et al., 2013). Conversely, non-social stimuli, such as food-related cues, may also elicit distinct responses in individuals with ASD, providing insights into impulse control relevant to dietary behaviors and health (Schienle et al., 2003). This acknowledges the variability in responses to different stimuli among individuals with ASD.

Discrepancies in inhibitory control skills and impairments emerge based on neuropsychological paradigms (Hill, 2004). Individuals with ASD show minimal deficits in tasks like the Stroop test, similar to non-clinical groups (Adams & Jarrold, 2012). However, they encounter greater difficulties in Go/No-Go tasks (Kohls et al., 2013; Putra et al., 2021), likely due to challenges with irrelevant distractors (Adams & Jarrold, 2012). Research on inhibitory control in children and adolescents with Intellectual Development Disorder (IDD) is limited, but generally, IDD cases show significant declines in executive performance, especially in inhibitory control tasks, compared to their peers (Spaniol & Danielsson, 2022). Therefore, while both ASD and IDD groups have inhibitory control impairments, the extent varies by task type. Comparing inhibitory control in ASD and IDD is essential for understanding cognitive profiles and needs (Kenworthy et al., 2008), particularly how IQ impacts performance on these tasks and the ability to understand instructions or inhibit responses (Scheuffgen et al., 2000). Sociodemographic factors like gender, age, and IQ also influence performance (Sadeghi et al., 2022; Yücel et al., 2012).

A key consideration is the intricate relationship between cognitive ability and inhibitory control – processes like attention, working memory, and cognitive flexibility are closely tied to inhibitory control (Diamond, 2013). Individuals with comorbid ASD and IDD often exhibit lower IQ scores, which can significantly impact their task comprehension and response adaptation. Indeed, Kenworthy and colleagues (2008) found that children with lower IQ scores faced more challenges in inhibitory control tasks, such as a higher error rate. For this reason, understanding the influences of the task format and the different levels of the constructs evaluated becomes crucial when evaluating inhibitory control, as these tasks demand precise adherence and response inhibition – lower cognitive abilities can lead to difficulties in comprehending complex instructions, potentially hindering task performance (Scheuffgen et al., 2000).

A critical consideration in cognitive psychology is the impact of cognitive ability on inhibitory control, with research highlighting nuanced relationships influenced by assessment paradigms. Diamond (2013) emphasizes the intertwined nature of cognitive functions such as attention and working memory with inhibitory control processes. Studies such as Kenworthy et al. (2008) underscore how lower IQ scores in children correlate with poorer inhibitory control, manifested in increased error rates during tasks. The choice of assessment tools further complicates this relationship; Miyake and Friedman (2012) note that while measures like the Wechsler scales may reflect executive impairments affecting inhibitory tasks, assessments like the Raven's Matrices show greater independence from such influences. This variability prompts a critical examination of paradigms used in inhibitory control research. Task formats requiring precise adherence and response inhibition may disproportionately challenge individuals with lower cognitive abilities (Scheuffgen et al., 2000), potentially skewing interpretations of inhibitory control deficits. Therefore, researchers must carefully select paradigms that align with the cognitive profiles of their study populations to accurately evaluate inhibitory control and its implications across varying levels of cognitive ability and task contexts.

Given the similar features of ASD and IDD in cognitive and behavioral functioning, the present study aims to dissect the peculiarities of the Stroop and Go/No-Go paradigms for the assessment of inhibitory control. Thus, this study has three primary objectives: (1) evaluate and compare the performance of clinical (ASD and IDD) and control groups in both the Stroop and Go/No-Go tasks; (2) identify potential differences between the ASD and IDD groups in inhibitory control by comparing them separately to controls; and (3) examine potential influences of gender, age, and IQ in task performance. Based on previous studies by Adams and Jarrold (2009, 2012), we expected that the autism group would exhibit performance similar to that of the control group on the Stroop task. Conversely, due to more global deficits in inhibitory control in the current study, it was anticipated that the group with Intellectual Developmental Disorder (IDD) would perform worse compared to the autism group on both the Go/No-Go and Stroop tasks. In the Go/No-Go task, it is hypothesized that the autism group will have performance levels closer to the IDD group, given the higher number of visual distractors involved in this task.

Methods

Participants

The study involved a total sample of 89 participants, aged between 6 and 15 years (*M* age=9.24, *SD*=2.13). Most participants attended the fifth grade at an elementary school in Rio de Janeiro. Recruitment took place in two specific institutions: a public school and an outpatient psychiatry clinic for children and adolescents in Rio de Janeiro. The sample was categorized into three groups, based on specific characteristics:

Autism Spectrum Disorder Group (ASDG): This group consisted of children and adolescents previously diagnosed with autism spectrum disorder after undergoing neuropsychological and psychiatric assessments. The analysis included individuals exclusively from the level 1 support group, most of whom did not have an intellectual disability. Participants with an IQ below 70, as determined by the Wechsler Abbreviated Scale of Intelligence (WASI), were excluded to avoid confounding variables and to focus on participants without cognitive impairment. This IQ cutoff is consistent with the DSM-5-TR criteria for Intellectual Development Disorder (APA, 2023). All participants were literate.

Intellectual Development Disorder Group (IDDG): Children and adolescents who exhibited a cognitive profile with an IQ above 70 but compatible with Intellectual Development Disorder based on the neuropsychological and psychiatric assessments were included in this group. Individuals with an IQ below 70, along with impairments in adaptive behavior and/or functional difficulties in daily life, were part of the IDD group. All participants were literate.

Control Group (CG): This group comprised children and adolescents without clinically significant cognitive or behavioral impairments. Participants were recruited from a public school in Rio de Janeiro using the same assessment protocol applied to the clinical groups. Participants with IQs below 70 were excluded from the analyses.

Inclusion criteria encompassed participants under 16 years old who willingly agreed to participate and, for clinical groups, had undergone psychiatric evaluation. Data from individuals who had an ASD diagnosis with an IQ below 70 or coexisting intellectual impairment, or lacked a diagnosis confirmed by the psychiatric team, were not included in the analysis. In specific cases in the control group (e.g., suspected neurodevelopmental disorder), individuals were referred for neuropsychological evaluation or psychological monitoring in outpatient clinics.

Among the three analyzed groups, the control group comprised 48 participants (62%), with a majority being females (40.2%). The age range of this group was from 7 to 12 years old (*M*=8.96, *SD*=1.56). In total, there were 34 participants within the clinical sample, with one group diagnosed with autism spectrum disorder (ASD) (22.0%) and another group exhibiting intellectual and developmental disability (IDD) profiles (19.5%). The ASD group had an average age of 8 years and was predominantly composed of males. In contrast, participants in the IDD group were generally older (*M*=10.27, *SD*=2.99).

Instruments

Initially, participants' parents provided information about developmental milestones, social and behavioral complaints, and details regarding previous treatments and diagnoses. Subsequently, during assessment sessions, standardized instruments and tasks were administered. To assess potential differences in inhibitory control development and IQ in children and adolescents, the following paradigms were analyzed:

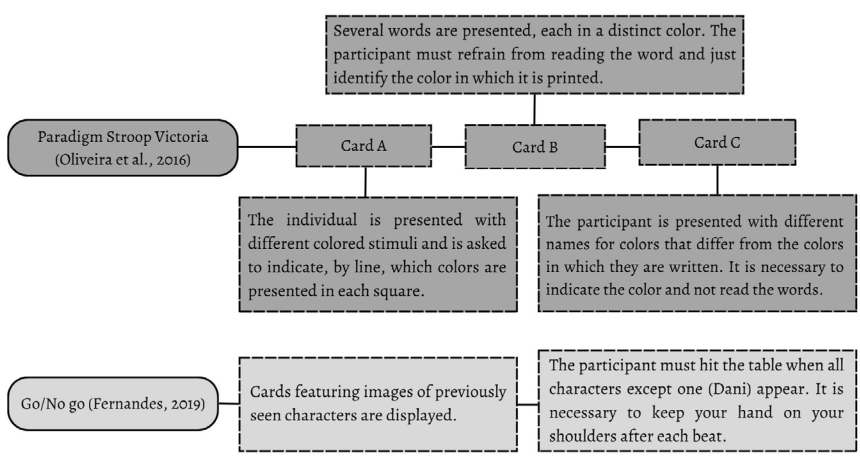
Stroop-Victória paradigm (Oliveira et al., 2016; Spreen & Strauss, 1998): This test assesses individuals' susceptibility to interference. It consists of three parts in which participants name colored squares under different conditions. In the first part, they name the colors presented in the squares. In the second part, they name colors again while being shown random words. In the third part, they name colors while being presented with random names of colors. Execution times were measured and converted into z-scores. Inhibitory control is particularly engaged in the third stage, which requires the inhibition of a prepotent response (reading the written color). In a literature review covering 2020-2022, Martins et al. (2023) identified that 85% of Brazilian studies using the Stroop task utilized the Stroop-Victória paradigm. The version employed was standardized in 2016 by Oliveira and colleagues, who reported satisfactory results in construct validity through cluster analysis and internal consistency assessments.

Go/No-Go paradigm (Fernandes, 2019): A part of the Theory of Mind Battery (ToM-B), this task introduces four characters to the child. During the Go/

No-Go task, participants are instructed to perform a hand movement (knock on the table) when any character except Dani appears. For the Dani character, participants must keep their hands on their shoulders. Similar to other versions, this task involves inhibiting a prepotent response (performing the movement). More impulsive individuals or those with inhibition difficulties are expected to make more errors. The task measures the number of correct answers. The task measures the number of correct answers. The version used in the current study was developed by Fernandes (2019), who presented satisfactory results in content validity findings with Intraclass Correlation Coefficient (ICC) analyses by expert review and construct validity with hierarchical cluster analysis.

Wechsler Abbreviated Scale of Intelligence (WASI) (Wechsler, 2014): This is a concise tool for assessing intelligence across a wide age range, from 6 to 89 years old. This assessment provides insights into various cognitive aspects, including verbal knowledge, visual information processing, spatial and non-verbal reasoning, as well as fluid and crystallized intelligence. It is based on four subtests and provides information on Total IQ, Performance IQ, and Verbal IQ, as well as the Vocabulary and Similarities subtests, Block Design, and Matrix Reasoning. Studies have demonstrated the WASI's strong psychometric properties, including high reliability and validity in measuring intellectual abilities across different populations (Abu-Hilal et al., 2011; Irby & Floyd, 2013; Wagner et al., 2014).

Figure 1 — Descriptions of versions of the Stroop paradigms (Card A, B and C) and Go/No-Go



Ethical procedures

The current study is a sample of the results obtained from a project previously conducted in Plataforma Brasil (CAAE 41590729.4.40000.5227). Its primary objective within the context of neuropsychological assessment is to investigate the characteristics of the neuropsychological, socio-emotional, and behavioral profiles of children with ASD. Participants in the clinical groups were recruited and participated in the research through a child and adolescent psychiatric outpatient clinic in Rio de Janeiro, following a psychiatric evaluation. The control group was selected from schools in Rio de Janeiro. Both groups initiated the neuropsychological assessment process after accepting and signing an Informed Consent Form, which outlined the project's purpose and its potential future use in research. Participation was voluntary, and the participants' guardians were informed that they could withdraw from the assessment process at any time.

Data analysis

Data were checked for inconsistencies, coding errors, and potential outliers using SPSS software (IBM Corp., 2023). Descriptive analyses were conducted to present the demographic characteristics of the sample, including means, standard deviations, and percentages. To ensure data accuracy, a filter was applied post-processing, based on participants' IQs. Those diagnosed with ASD and an IQ below 70 were excluded from the analysis. While participants with IQs below 70 (without ASD) were included in the IDD group, a cutoff point used in previous studies analyzing inhibitory control tasks in ASD groups (Cruz et al., 2022; Panerai et al., 2014) to differentiate IDD groups. After processing and addressing potential inconsistencies, and after the analyses of normality of the distribution and homogeneity of variance, Welch's t-test was employed to assess group differences with Cohen's d to assess effect sizes. For the simultaneous analysis of the two dependent variables (Go/No-Go and Stroop C), a multivariate analysis of variance model (MANOVA) was applied. In this study, only the Stroop final card (Stroop C) was used, because it assesses inhibitory control more accurately compared to other stages and requires participants to override their automatic reading response in favor of naming the ink color, which directly measures their ability to inhibit cognitive interference. Research by MacLeod (1991) highlights that this stage is particularly effective at measuring inhibitory control, because it involves a high level of cognitive conflict and demands substantial executive function resources.

All analyses were conducted using R and the RStudio environment (RStudio Team, 2023), with the following packages: tidyverse, mirt, psych, janitor, summarytools, MANOVA.RM, tidyr, and ggplot2. Code and outputs are accessible at: https://osf.io/nu7jg/

Results

Potential differences in sociodemographic characteristics between the groups were examined. This analysis aimed to pair individuals and verify possible outliers. It was observed that only the gender variable showed a significant difference ($p<.003$) between the clinical groups and the control group. Consequently, a bootstrap technique was applied with 1,000 repetitions to obtain a paired data sample using the gender variable as a stratification factor. Table 1 presents an overview of the participant characteristics within the two clinical groups and the control group after implementing the bootstrap.

Table 1 — Characteristics of the groups (post-stratification)

Characteristics		CG (*n*=48)	ASDG (*n*=18)	IDDG (*n*=16)
Sociodemographic	Age	8.96 (1.56)	8.61 (2.00)	10.81 (2.99)
	Sex			
	Female	33 (68.8%)	1 (5.6%)	7 (43.8%)
	Male	15 (31.2%)	17 (94.4%)	9 (56.2%)
	Scholarity			
	1st year of elementary school	5.1% (*n*=4)	1.3% (*n*=1)	1.3% (*n*=1)
	2nd year of elementary school	16.5% (*n*=13)	8.9% (*n*=7)	3.8% (*n*=3)
	3rd year of elementary school	3.8% (*n*=5)	7.6% (*n*=6)	—
	4th year of elementary school	7.6% (*n*=6)	2.5% (*n*=2)	1.3% (*n*=1)
	5th year of elementary school	17.7% (*n*=14)	—	2.5% (*n*=2)
	6th year of elementary school	7.6% (*n*=6)	—	—
	7th year of elementary school	—	1.3% (*n*=1)	2.5% (*n*=2)
	8th year of elementary school	—	—	—
	9th year of elementary school	—	—	—
	1st year of high school	—	—	—
	2nd year of high school	—	1.3% (*n*=1)	3.8% (*n*=3)
	3rd year of high school	—	—	—

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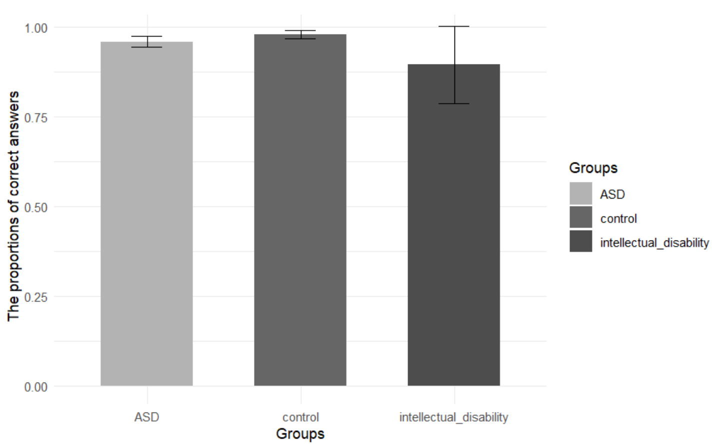
	Characteristics	CG (*n*=48)	ASDG (*n*=18)	IDDG (*n*=16)
WASI	IQ	95.02 (12.70)	84.47 (15.98)	61.62 (9.76)
	Verbal index	98.34 (15.51)	81.67 (18.43)	62.25 (10.09)
	Performance index	93.60 (10.68)	90.73 (15.38)	68.38 (9.16)

Note: IQ (intelligence quotient) obtained in the calculation of the global functioning index in WASI.

Go/No-Go task

In the Go/No-Go task, participants in the control group (CG) achieved higher scores (*M*=0.97, *SD*=0.03). This result can be associated with the number of errors made by this group, which was substantially lower compared to the clinical groups. Figure 2 illustrates these results. It was observed that the clinical groups had the highest overall error rates in the Go/No-Go test. The group with intellectual disabilities made the most mistakes (10%), followed by the ASD group (4%) and the control group (2%) with fewer errors.

Figure 2 — Proportions of correct answers on the Go/No-Go task with standard deviation bars for the ASD group, intellectual disability group, and control group

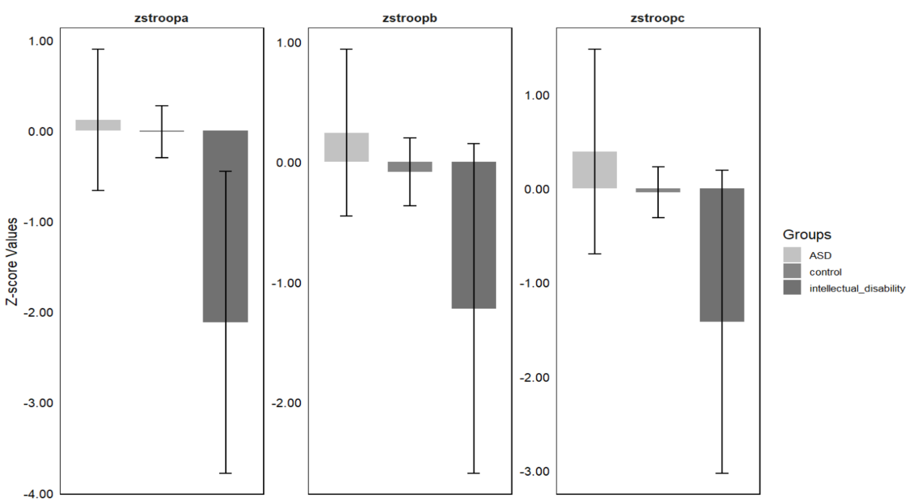


This figure shows the proportions of correct answers in the Go/No-Go task for the ASD group, intellectual disability group, and the control group. The error bars represent the standard deviations.

Stroop task

In the Stroop task, the estimated time to complete the three-step task and z-scores were calculated. To assist in the clinical interpretation of the scores, especially considering the time necessary to complete the task, the punctuation sign (negative or positive) was standardized such that results with time above expectations obtained standard deviations with negative signs (below 0). In general, it was noted that the ASD group completed the task faster than the other participants in the three Stroop cards. It was observed that the IDD group had a standard deviation above 2. Figure 3 illustrates these results.

Figure 3 — Time comparison by groups (ASD, IDD, and control) in the Stroop task represented by z-score (time used – expected time / *SD*)



This figure compares the time taken by the ASD, IDD, and control groups to complete the Stroop task, represented by *z*-scores. Negative values indicate faster completion times than expected.

Hypothesis testing

Two hypothesis tests were conducted: first, to verify possible differences between the performance of the ASD group and the IDD group in the Go/No-Go task, and second, to compare the ASD group with the control group in the same task. The *t*-test results indicate that there is no significant difference in the means between the ASD group (*M*=0.96, *SD*=0.03) and the IDD group (*M*=0.90, *SD*=0.20), with a *p*-value of .222. However, when comparing the ASD group (*M*=0.96, *SD*=0.03) with the control group (*M*=0.98, *SD*=0.04) in the same Go/No-Go task, a significant difference was observed (*p*=.045).

When the performances of the experimental groups in the Stroop task were compared (Table 2), an initial *t*-test was conducted between the ASD group and the IDD group. Comparing the means of these two clinical groups revealed a significant difference specifically in card A ($t(17.4)=2.65$, $p=.016$). Upon analyzing the outcomes related to cards B ($t(18.4)=2.08$, $p=.052$) and C ($t(20.8)=2.04$, $p=.054$), no statistically significant differences were observed between the groups. The autism group showed better performance considering the z-scores: A (*M*=0.12, *SD*=1.02), B (*M*=0.24, *SD*=0.97), and C of the Stroop task (*M*=0.39, *SD*=1.52) compared to the scores obtained by the IDD group in Stroop A (*M*=–2.12, *SD*=2.89), Stroop B (*M*=–1.22, *SD*=2.38), and Stroop C (*M*=1.42, *SD*=2.79). Although statistically significant differences were not observed for cards B and C, the calculated Cohen's coefficients indicate that the disparities between the groups are substantial in magnitude. When comparing the performance of the control group (Stroop A: *M*=–0.01, *SD*=0.92; Stroop B: *M*=–0.08, *SD*=0.91; Stroop C: *M*=–0.04, *SD*=0.86) with the ASD group, no significant differences were observed across the three stages of the Stroop test. In terms of effect size, only small effect sizes were observed for the ASD group on Stroop performance (see Table 2).

Table 2 — Comparison between groups in the Stroop cards

Groups	Variable	*t*	*df*	*p*	MD	SED	CI	*d*
ASDG X IDDG	Stroop A	2.65	17.4	.016*	2.24	.843	[.461, –4.01]	1.033
	Stroop B	2.08	18.4	.052	1.46	.706	[.706, –.016]	.807
	Stroop C	2.04	20.8	.054	1.81	.888	[.88, –.037]	.805
ASDG X CG	Stroop A	–.360	11.0	.725	–.132	.367	[–.940, –.676]	–.136
	Stroop B	–.967	13.0	.351	–.327	.338	[–1.05, .404]	–.347
	Stroop C	–.869	10.4	.404	–.434	.499	[–1.54, 0.67]	–.351

Note: * $p \leq 0.05$; MD = mean difference; SED = standard error of difference.

Multivariate analysis of variance (MANOVA)

The results of a MANOVA model indicate significant differences in the means of the dependent variables Go/No-Go and Stroop between the clinical groups (ASD and IDD) and the control group. The Pillai test (*V*) yielded a significant and relatively high value (V=0.32, p<.001), indicating a significant effect of diagnostic condition on the skills assessed by Go/No-Go and the Stroop C. However, when examining the independent variables individually, only the "diagnosis" factor reached statistical significance (F=15.26, p<.001). This suggests that the performances on the Go/No-Go task and the Stroop C card were primarily influenced by the diagnosis (ASD and IDD), while gender and age did not exhibit significant effects on these abilities.

Discussion

Inhibitory control skills, encompassing the capacity to suppress improper stimuli and responses, are vital for everyday development and performance. However, neurodevelopmental conditions such as ASD and IDD may impair these abilities, affecting the quality of life of children and adolescents. Despite this, only a limited number of Brazilian studies have explored inhibitory control differences between clinical and control groups. This study examined the performances of the ASD, IDD, and control groups, resulting in the following findings: no notable distinction between the ASD and control groups in the Stroop test; the ASD group outperformed the IDD group in the Stroop test; the ASD group differed from the control group in the Go/No-Go test but not from the IDD group. Clinical groups significantly influenced Go/No-Go and Stroop C, showing overall poorer performance than children with typical development.

This study observed performance disparities in the Stroop and Go/No-Go paradigms within the two clinical groups with neurodevelopmental disorders. It is crucial to understand that the inhibition skills required by these paradigms, though aimed at restraining automated responses, fluctuate in intensity and correlation with other cognitive functions. The Victória Stroop paradigm engages attention, language (in the final stages), and the suppression of dominant automatic responses (Scarpina & Tagini, 2017). In this Stroop variant, the primary factor causing interference is the ability to read and comprehend semantic phrases (MacLeod, 1991). Conversely, in Go/No-Go tasks, the focus is on restraining automatic motor responses rather than impulsive reactions to non-target stimuli (Littman & Takács, 2017). Therefore, both tasks involve processing visual stimuli, but their content and required response diverge, leading to distinct cognitive demands. The Stroop-Victória paradigm stimulates attention, semantic processing, and interference resolution skills alongside the suppression of automatic responses (Scarpina & Tagini, 2017). In contrast, the Stroop-Victória paradigm focuses on suppressing verbal responses and semantic interference, while the Go/No-Go task emphasizes restraining impulsive motor reactions. These cognitive differences might manifest in distinct patterns of brain activity during execution (Rubia et al., 2001).

Some researchers point out the limitations of these tasks, especially when reaction time is not measured. For example, in a study of individuals with autism, results suggested that the Stroop task may not be as sensitive for assessing inhibitory control in this population (Joseph & Tager-Flusberg, 2004). Conversely, the study by Cissne et al. (2022) employed eye movement identification technology to track the reaction time of children with ASD in an inhibition task and switching between demands. The authors also noted a substantial correlation between this task's performance and the prevalence of repetitive behaviors. Similarly, when applying other tasks involving reaction time and inhibition, such as resisting a distracting stimulus (stop-signal response inhibition task) (Jones et al., 2021) or mapping a stimulus and its stop (controlled responses) involving attentional aspects (Raud et al., 2020; Verbruggen & Logan, 2008), individuals with ASD show inhibitory impairments. Verbruggen and Logan (2008) indicate that such impairments in inhibition in controlled processes observed in clinical groups may over time interfere with previously preserved automatic inhibition demands.

Besides assessing individual reaction times and task completion durations, the specific type of inhibition required could predict the performance of clinical groups in inhibitory control tasks, especially among those with ASD. Christ and colleagues (2007) conducted a study involving 28 children on the autism spectrum, evaluating their ability to resist proactive interference and inhibit prepotent responses, as seen in tasks like the Stroop test. However, these children displayed significant impairments in a visual flanker task, which required resisting interference from visual distractors. This study observed similar differences in inhibitory demands compared to the Stroop tasks. This evidence underscores the importance of assessing reaction times in inhibitory control tasks for individuals with ASD and adopting various approaches and measures for a comprehensive assessment of executive functions in clinical settings. In a previous review of studies on executive dysfunction and ASD, Geurts et al. (2014) highlighted that a few portions of individuals with ASD have significant deficits in inhibitory control. When observing these deficits, this group has more difficulty inhibiting irrelevant distractors but not preponderant automatic responses (Adams & Jarrold, 2009, 2012).

Studies of individuals with IDD indicate that children and adolescents with this condition experience a significant decrease in executive functioning, particularly in planning skills and inhibitory control (Sesma et al., 2009). Similar impairments were observed in a study by Gligorović and Buha Đurović (2014), which examined the performance of 56 children with moderate-severity IDD in the Stroop (day-night version) and Go/No-Go paradigms. It was found that in the Go/No-Go task, there were a significant number of errors, indicating difficulty in preventing or postponing a motor response. The authors noted that performance on this task exhibited a significant relationship with planning, suggesting that impairments in inhibitory control in this clinical group can be associated with difficulties in problem-solving. In other studies, it was observed that children with ASD performed similarly to control groups in the Stroop task (Christ et al., 2007; Hill, 2004; Parsons & Carlew, 2016). This can be attributed to certain cognitive characteristics of ASD. For example, individuals with ASD tend to engage in more detailed and less automatic processing of information, facilitating the identification of ink color while ignoring the semantic meaning of words (Baron-Cohen et al., 2001).

Regarding the level of support linked to the ASD diagnosis, it is crucial to highlight that the actual study predominantly included individuals with level 1 support, indicating autism without intellectual or language impairments. Given the diversity of symptom experiences and variations in executive dysfunction, acknowledging this diagnostic distinction is vital for interpreting inhibitory control task performance. In this context, Lai et al. (2017) conducted a meta-analysis examining executive dysfunctions in ASD children and adolescents without intellectual disabilities, analyzing studies from 1978 to 2015. They identified impairments in most tasks across seven types, including inhibitory control. It is important to consider that the current study utilized a sample of children and adolescents with ASD without intellectual disabilities and without language impairments. Previous research has shown that intellectual disabilities and language impairments significantly affect performance in inhibitory control tasks (Hopkins et al., 2017; Tonizzi et al., 2022). Recognizing the different clinical presentations within ASD and IDD is essential for properly interpreting the study results. Furthermore, a more in-depth analysis of inhibitory control impairments is necessary to fully understand the executive dysfunctions in these populations.

Prior studies have linked Stroop performance with verbal fluency and vocabulary knowledge (Laws & Bishop, 2003; Scarpina & Tagini, 2017). This suggests that individuals with IDD, who might struggle with language and verbal processing, could encounter challenges during Stroop tasks, particularly in steps involving reading and word processing. Children with IDD may also exhibit specific deficits in language aspects like word comprehension, impacting how words are processed and interpreted in the Stroop paradigm. Previous research has highlighted such deficits (Laws & Bishop, 2003; Viviani et al., 2023).

This research highlights noteworthy limitations that warrant further attention in future studies. Firstly, the sample size for both clinical groups was smaller than anticipated based on the power calculation. Currently, data collection is ongoing, with the aim of expanding the sample size. Secondly, a limitation pertains to the autism-diagnosed group, primarily comprising children without intellectual disability. Future studies should aim to encompass a broader range of symptomatic levels within this group to enhance the generalizability of findings. Another limitation of the study pertains to the heterogeneity of the sample, which required the use of the bootstrap technique. However, even with this technique, differences were still observed when considering the sex of the participants. This characteristic should be considered when interpreting the results and in future studies. By employing new recruitment and selection techniques, the number of girls with ASD in the sample can be expanded.

No significant effect of sociodemographic variables was found on inhibitory performance, revealing only an effect of having a neuropsychological condition that impairs performance in the Stroop task (which requires high inhibitory and attentional capabilities) and the Go/No-Go task. The present study indicates that research with more representative samples should be conducted to evaluate the neuropsychological profile in ASD using different measures of the same constructs. Lastly, given the varying severity and symptom experiences in both clinical groups (ASD and IDD), the current study focused on a collective comparison, emphasizing the need for individualized analyses, as recommended by Geurts et al. (2014). This approach can provide deeper insights into the interplay between specific group characteristics and inhibitory control functioning.

Conclusion

The study revealed no significant difference between the control group and the ASD group in the Stroop paradigm. However, the IDD group performed worse on this task compared to both the control and ASD groups. In the Go/No-Go paradigm, there was no observable difference in performance between the ASD and IDD groups, suggesting similar performance within these clinical groups. Notably, the ASD group encountered greater difficulty in the Go/No-Go task compared to the Stroop task. No significant effect of sociodemographic variables was found on inhibitory performance, revealing just an effect of having a neuropsychological condition that impairs performance in the Stroop task (which requires high inhibitory and attentional capabilities) and the Go/No-Go task. The present study indicates that research with more representative samples should be conducted to evaluate the neuropsychological profile in ASD using different measures of the same constructs, because ASD is a heterogeneous condition with variations in the level of inhibition required as described in traditional paradigms of inhibitory control presented in the literature. When examining the inhibitory control profile of IDD children and adolescents, it is essential to consider the link between intellectual skills, verbal skills, and motor skills. Furthermore, the importance of conducting future research that explores potential variations among individuals with different diagnostic subtypes and phenotypes and the possible impact of these circumstances on performance in both paradigms is emphasized.

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Contribution of each author for the article

All authors contributed to the study's conception and design.

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Thomas Eichenberg Krahe: Reviewing the manuscript's English language and content.

Helenice Charchat-Fichman: Assistance in the study design and manuscript review.

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