UNIVERSIDADE FEDERAL DE MINAS GERAIS

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AVALIAÇÃO DOS PROCESSOS DE DESCONTO TEMPORAL EM PACIENTES COM DÉFICIT DE ATENÇÃO/HIPERATIVIDADE (TDAH), TRANSTORNO DO ESPECTRO AUTISTA (TEA) E CASOS COMÓRBIDOS.

BELO HORIZONTE

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RESUMO

PAIVA, Gabrielle Chequer de Castro. **Avaliação dos Processos de Desconto Temporal em Pacientes com Déficit de Atenção/Hiperatividade (TDAH), Transtorno do Espectro Autista (TEA) e Casos Comórbidos.** Belo Horizonte, 2017. Dissertação (Mestrado em Medicina Molecular) - Faculdade de Medicina, Universidade Federal de Minas Gerais, 2017.

Crianças com Transtorno de Déficit de Atenção / Hiperatividade (TDAH) e Transtorno do Espectro Autista (TEA) parecem apresentar diferenças significativas nos processos afetivo-motivacionais do funcionamento executivo. Apesar da heterogeneidade dos estudos, geralmente é observado um elevado desconto temporal em tarefas de postergação de reforço em crianças com TDAH enquanto o desempenho de crianças com TEA se assemelharia mais ao de crianças com desenvolvimento típico. O domínio afetivo motivacional parece, portanto, particularmente interessante para a diferenciação dos transtornos em termos de perfis cognitivos e para a investigação das alterações relacionadas a comorbidade TDAH+TEA. Não há disponível na literatura nenhum estudo que investigue o desconto temporal em crianças mais novas com TDAH e autismo comórbidos. Nesse estudo nosso objetivo foi investigar diferenças de desempenho numa tarefa de desconto temporal entre crianças com 1) TDAH, com 2) TEA, com 3) Comorbidade de TDAH e TEA e com 4) desenvolvimento típico. Inicialmente foi realizada uma revisão sistemática da literatura a fim de investigar a consistência das evidências encontradas com relação aos padrões de desconto temporal em crianças de 6 a 12 anos com autismo e TDAH, discutindo potenciais diferenças entre esses grupos no domínio afetivo-motivacional das funções executivas. Posteriormente um estudo transversal foi conduzido, utilizando uma tarefa de desconto temporal com recompensa monetária hipotética, que foi aplicada em uma amostra de 100 crianças (35 crianças com desenvolvimento típico; 35 com TDAH; 18 crianças com TEA; e 13 casos comórbidos). Com relação a revisão de literatura, 6 de 8 artigos envolvendo o grupo com TDAH apontaram para um maior desconto temporal em relação aos controles na faixa etária investigada. O único estudo envolvendo crianças com TEA apontou na mesma direção. Nas análises de grupo do estudo experimental, observamos que as crianças com desenvolvimento típico e com TEA tendem a ter um desconto temporal similar, enquanto crianças com TDAH e casos comórbidos apresentaram um padrão significativamente mais impulsivo de escolhas, com preferência maior por recompensas menores e imediatas, não diferindo entre si. Concluímos que nos casos comórbidos de TDAH e autismo a ocorrência do TDAH parece prejudicar significativamente o processamento afetivo-motivacional, levando a descontos temporais mais elevados, ao passo que o TEA não parece apresentar alterações nos processos afetivo-motivacionais envolvendo postergação de reforço.

Palavras Chave: TDAH; TEA; Desconto Temporal; Tomada de Decisão; Processamento de Recompensa.

ABSTRACT

PAIVA, Gabrielle Chequer de Castro. **Avaliação dos Processos de Desconto Temporal em Pacientes com Déficit de Atenção/Hiperatividade (TDAH), Transtorno do Espectro Autista (TEA) e Casos Comórbidos.** Belo Horizonte, 2017. Dissertação (Mestrado em Medicina Molecular)-Faculdade de Medicina, Universidade Federal de Minas Gerais, 2017.

Children with Attention Deficit/Hyperactivity Disorder (ADHD) and Autistic Spectrum Disorder (ASD) seem to present significant differences in the affective-motivational processes of executive functioning. Despite the heterogeneity of the studies, a high temporal discount is usually observed in reinforcing postponement tasks in children with ADHD whereas the performance of children with ASD would be more similar to that of children with typical development. The motivational affective domain seems therefore particularly interesting for the differentiation of the disorders in terms of cognitive profiles and the investigation of the changes related to ADHD + ASD comorbidity. There is no literature available to investigate the temporal discounting in younger children with comorbid ADHD and autism. In this study, our objective was to investigate differences in performance in a temporal discounting task among children with 1) ADHD, 2) ASD, 3) Comorbidity of ADHD and ASD, and 4) typical development. Initially, a systematic review of the literature was conducted to investigate the consistency of the evidence found regarding temporal discounting patterns in children aged 6 to 12 years with autism and ADHD, discussing potential differences between these groups in the affective-motivational domain of executive functions. Subsequently, a cross-sectional study was conducted using a hypothetical monetary reward temporal discounting task, which was applied to a sample of 100 children (35 children with typical development, 35 with ADHD, 18 children with ASD, and 13 comorbid cases). Regarding the literature review, 6 of 8 articles involving the ADHD group pointed to a greater temporal discounting in relation to the controls in the age group investigated. The only study involving children with ASD pointed in the same direction. In the group analyses of the experimental study, we observed that children with typical development and with ASD tend to have a similar temporal discounting, whereas children with ADHD and comorbid cases presented a significantly more impulsive pattern of choices, with a higher preference for smaller and immediate rewards, not differing from each other. We conclude that in the comorbid cases of ADHD and autism the occurrence of ADHD seems to significantly impair affective-motivational processing, leading to higher temporal discounts, whereas the ASD does not seem to present changes in the affective-motivational processes involving postponement of reinforcement.

Key words: ADHD; ASD; temporal discounting; delay discounting; decision-making; reward processing.

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LISTA DE ABREVIATURAS E SIGLAS

ABEP	Brazilian Research Enterprises Association
ADHD	Attention-deficit/hyperactivity disorder
APA	American Psychological Association
ASD	Autism Spectrum Disorder
AUC	Area Under the Curve
BRIEF	Behavior Rating Inventory of Executive Functions
CARS	Childhoold Autism Rating Scale
CBCL	Child Behavior Checklist
CCEB	Brazilian Criterion of Economic Classification
CL	Confidence Level
DDT	Delay Discounting Task
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders
DSM-5	Diagnostic and Statistical Manual of Mental Disorders
FCMMG	Faculdade de Ciências Médicas de Minas Gerais
FET	Fischer Exact Test
fMRI	Functional Magnetic Ressonance Imaging
GAI	General Ability Index
IQ	Intelligence Quotient
K-SADS-PL	Kiddie-Sads-Present and Lifetime Version
MANOVA	Multivariate Analysis of Variance
MTA SNAP-IV	Swanson, Nolan, and Pelham– version IV for evaluation of ADHD symptoms
Nacc	Nucleus Accumbens

NITIDA	Núcleo de Investigação da Impulsividade e Atenção
OCD	Obsessive Compulsive Disorder
ODD	Opositional Defiant Disorder
OFC	Orbital Frontal Cortex
PFC	Prefrontal Cortex
Raven’s CPM	Raven’s Colored Progressive Matrices
SD	Standard Deviation
SES	Socioeconomic status
SPSS	Statistical Package for Social Sciences
TD	Temporal Discount
TDAH	Transtorno de Déficit de Atenção/ Hiperatividade
TEA	Transtorno do Espectro Autista
UFMG	Universidade Federal de Minas Gerais
vmPFC	Ventromedial Prefrontal Cortex

SUMÁRIO

1 - INTRODUÇÃO

Recentemente, duas condições muito frequentes na infância, o Transtorno de Déficit de Atenção/Hiperatividade (TDAH) e o Transtorno do Espectro Autista (TEA) deixaram de ser condições nosológicas excludentes segundo o Manual Diagnóstico e Estatístico de Transtornos Mentais DSM-5 (APA, 2013).

O Transtorno de Déficit de Atenção/Hiperatividade (TDAH) é um dos transtornos do neurodesenvolvimento mais comuns na infância, acometendo mais de 5% da população infantil mundial (Polanczyk et al., 2007). O transtorno se caracteriza por sintomas marcantes de desatenção-desorganização, hiperatividade e impulsividade, além de elevada heterogeneidade clínica em termos de curso dos sintomas e desfechos funcionais (Willcutt et al., 2012). O TDAH está associado a prejuízos funcionais globais, sociais e acadêmicos e a necessidade de tratamento aumenta para cada sintoma adicional (Lahey, & Willcutt, 2010). O TDAH é uma condição crônica do desenvolvimento e não deveria ser visto somente como um transtorno que afeta o comportamento e a aprendizagem de crianças (Barbaresi et al., 2013). O prejuízo acumulativo do TDAH ao longo da vida é considerável, incluindo maior taxa de mortalidade e adversidade social, além de elevada taxa de comorbidades com outros transtornos mentais (~84%) como abuso de substância, transtornos de ansiedade e do humor, transtornos de personalidade e transtornos disruptivos (Barkley et al., 2008; Barbaresi et al., 2013). Comparadas a crianças com desenvolvimento típico, crianças com TDAH usualmente apresentam maiores desvantagens sociais como menor renda familiar, menor escolaridade e taxas maiores de evasão escolar (Biederman, & Faraone, 2005).

O autismo caracteriza-se por alterações sociais e de comunicação e pela presença de padrões fixos e repetitivos de comportamento interesses ou atividades, chegando a afetar 1% da população (APA, 2013). A utilização do termo “espectro” indica a complexidade do diagnóstico e a variabilidade do perfil das pessoas afetadas, sendo que as alterações ocorrerem em diferentes graus de comprometimento (Wing, 1988; 1996). O quadro espectral atinge todas as características do quadro como a comunicação e a interação social, gerando apresentações com gravidade e funcionalidade variáveis conforme os déficits presentes.

Em relação aos processos cognitivos, ambos os transtornos são marcados por déficits executivos significativos (Nigg et al., 2005; Willcutt et al., 2005; Geurts et al., 2004; Johnson et al., 2007). As funções executivas são processos complexos, sendo um domínio cognitivo relacionado ao comportamento deliberativo, incluindo planejamento, execução, análise e flexibilidade. Déficits nessas funções estão fortemente relacionados a desfechos negativos. (Diamond, 2013). Essas funções podem ainda ser divididas em dois domínios, o "frio" e o "quente. O primeiro envolve aspectos mais afetivamente neutros ou mais analíticos, como planejamento e memória operacional. O segundo domínio está relacionado aos aspectos afetivo-motivacionais da tomada de decisão (Zelaso et al., 1997), como por exemplo o desconto temporal. Esse fenômeno pode ser definido como a diminuição do valor subjetivo de uma recompensa proporcionalmente relacionada ao tempo de espera (Critchfield & Kollins, 2001). As tarefas que envolvem o desconto temporal avaliam a capacidade do indivíduo de postergar uma gratificação em função de uma recompensa maior, em detrimento da escolha imediata que leva à uma recompensa menor. Crianças com TDAH parecem apresentar padrões de resposta bastante impulsivos em tarefas desse tipo, demonstrando uma alteração em processos afetivos motivacionais da tomada de decisão (Sonuga-Barke, 2003; Scheres et al., 2006). O TEA parece mais marcado por déficits nas funções executivas "frias", assim como o TDAH, e não parece apresentar diferenças nos processos afetivos-motivacionais quando comparados a crianças com desenvolvimento típico (Demurie et al., 2012). No entanto, poucos estudos foram desenvolvidos no sentido de investigar o processamento afetivo-motivacional em crianças com TEA. A literatura também é escassa com relação ao estudo do desconto temporal em crianças com a comorbidade TDAH+TEA. O único estudo disponível aponta para um padrão de ativação cerebral que não refletiria um endofenótipo comum dos transtornos isolados nem uma terceira patologia. Os resultados desse estudo sugerem que o grupo comórbido apresenta um déficit importante no processamento afetivo-motivacional de recompensas. Em contraposição aos estudos anteriores, os autores relatam ainda, que o grupo com TDAH puro era similar aos seus pares com desenvolvimento típico quanto à capacidade de postergação de reforço, enquanto o TEA e o grupo TDAH e TEA comórbidos eram os únicos a apresentarem descontos temporais mais acentuados (Chantiluke et al., 2014).

A compreensão dos endofenótipos neurocognitivos possibilita a conhecimento de características e a consequente diferenciação das alterações de cada um dos transtornos facilitando a distinção clínica e o planejamento da intervenção de forma personalizada e efetiva (Sonuga-Barke & Halperin, 2010). Nesse sentido, a habilidade de diferenciação de prejuízos compartilhados ou específicos entre os diversos transtornos é fundamental. No presente trabalho, foi hipotetizado que o perfil de desconto temporal dos transtornos individualmente ou na presença de comorbidade poderiam apresentar padrões diferentes consistindo em um endofenótipo interessante na distinção dos transtornos. Dessa forma, pretendeu-se investigar as diferenças no processamento afetivo-motivacional entre crianças com TDAH, TEA, TDAH+TEA e desenvolvimento típico, utilizando tarefas de desconto temporal. Nesse sentido, foi realizada uma revisão sistemática da literatura, reunindo os estudos já disponíveis envolvendo essa população, além de um estudo experimental, no qual 100 crianças foram avaliadas quanto à sua capacidade de postergação de reforço.

1.1 Estrutura da dissertação

A presente dissertação foi organizada em 2 artigos. O primeiro artigo intitulado "Temporal reward discounting in children with Attention Deficit/Hyperactivity Disorder (ADHD), and children with Autism Spectrum Disorder (ASD): A Systematic Review" reune todos os estudos disponíveis na literatura científica que investigaram o desconto temporal em crianças de 6 a 12 anos com quadros de TDAH ou TEA. O segundo artigo da dissertação, intitulado "Temporal reward discounting in children with Attention Deficit/Hyperactivity Disorder (ADHD), children with Autism Spectrum Disorder (ASD), and children with comorbid ADHD and ASD" apresenta os resultados de uma pesquisa transversal, na qual uma amostra de 100 crianças brasileiras (34 com desenvolvimento típico; 35 com TDAH; 18 com TEA; e 13 casos comórbidos de TDAH e TEA) foi avaliada utilizando uma tarefa computadorizada de desconto temporal.

2 - OBJETIVOS

2.1 Objetivo geral

Investigar diferenças de desempenho numa tarefa de desconto temporal entre crianças com 1) TDAH, com 2) TEA, com 3) Comorbidade de TDAH e TEA e com 4) desenvolvimento típico.

2.2 Objetivos específicos

- Realizar uma revisão sistemática da literatura a fim de investigar a consistência das evidências encontradas com relação aos padrões de desconto temporal em crianças com autismo e TDAH, discutindo potenciais diferenças entre esses grupos no domínio afetivo-motivacional das funções executivas.
- Investigar o desempenho dos participantes nas populações avaliadas numa tarefa de desconto temporal usando recompensa monetária hipotética em um estudo experimental.
- Investigar diferenças de grupo na área sob a curva de desconto temporal esperando-se menor desconto temporal para o grupo de indivíduos mais imediatista.
- Verificar se há associação entre o desconto temporal e a idade, inteligência fluida e nível socioeconômico das crianças avaliadas.

3 - Temporal reward discounting in children with Attention Deficit/Hyperactivity Disorder (ADHD), and children with Autism Spectrum Disorder (ASD): A Systematic Review

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ARTIGO DE REVISÃO

Temporal reward discounting in children with Attention Deficit/Hyperactivity Disorder (ADHD), and children with Autism Spectrum Disorder (ASD): A Systematic Review

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These authors contributed equally to this study

Abstract

Children with Attention Deficit/Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD) may present differences in the affective-motivational processes of executive functioning. We sought to systematically review the available literature regarding temporal discounting in children up to 12 years with ADHD and ASD compared to typically developing children (controls). A preliminary list of articles was obtained through searches of the Medline⁄Pubmed and Scopus databases with no publication time restriction. We identified nine studies investigating temporal reward discounting in children between 6 to 12 years, being eight studies with ADHD children (n=329), one with ASD children (n=21), and all of them including typically developing children as controls (n=346). Six of eight studies found greater temporal reward discounting for ADHD children (two studies with differences found only for girls), and the study including ASD children found a smaller ASD capacity to delay gratification compared to control children. Associations with age, ADHD symptoms, and brain connectivity were described. We observed a high heterogeneity between studies regarding the type of temporal discounting task used and the predominance of small sample sizes. The occurrence of ADHD appears to rush even more the decision-making process at this stage of development. There is still a huge hole in the literature regarding temporal discounting in ASD. Studies that include the comorbidity ADHD+ASD are needed for a better understanding of the pattern of temporal reward decision in these neurodevelopmental disorders, as well as its implications for the diagnosis and treatment of these disorders.

Keywords

ADHD; ASD; temporal discounting; delay discounting; decision-making; reward processing

Introduction

Neurodevelopmental disorders are a group of syndromes that begin early in childhood, and its symptoms and functional impairment are usually seen by preschool age. They are marked by developmental deficits that lead to significant losses in short and long term in a variety of contexts (e.g., personal, social, academic and professional) (APA, 2013). Attention Deficit/Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD) are two common neurodevelopment disorders affecting more than 5% and 1% of the world's children population, respectively (APA, 2013; Polanczyk & Rohde, 2007).

ADHD is characterized by symptoms of inattention, hyperactivity, and impulsivity. This disorder has a very heterogeneous clinical presentation, being associated with long-lasting difficulties in finishing studies, a higher rate of repetition, expelling and school exchange, and a below-capacity performance compared to peers (Barkley, 1997). ASD is marked by significant deficits in social cognition and behavioral flexibility, with patients showing deficits in social communication and interaction, a restricted, fixed, and repetitive pattern of behavior, interests, and activities. ASD also has a very heterogeneous presentation and may be associated with other neurodevelopment disorders, including intellectual deficiency and language disorder (APA, 2013). Recently, ADHD and ASD ceased to be nosologically exclusionary conditions.

Although ADHD and ASD are different neurodevelopmental disorders, they share neurobiological, psychological, and behavioral characteristics with some of these similarities being shared endophenotypes. One of the most studied features of both disorders is executive functioning (Craig et al., 2016). Executive function is a heterogeneous cognitive domain related to planning, execution, analysis, and flexibility of goal guided behavior (Diamond, 2013). Some authors split executive functions in "cool” or cognitive executive functions and "hot” or affective executive functions" (Zelaso, Carter, Reznick and Frye, 1997). “Cool” executive functioning relates to the more emotionally neutral or analytical aspects of executive functions, such as goal-directed behavior, planning, and working memory. “Hot” executive functions are related to affective self-regulation, including temporal discounting, affective decision making, and emotional control (Zelaso et al., 1997).

Deficits in the cognitive or "cool" aspects of executive functions may be similarly present in ADHD and ASD. On the other hand, the "hot" affective-motivational processes of executive functioning have been suggested as best candidates for the differentiation between ADHD and ASD executive profiles (Antrop et al., 2006; Demurie, Roeyers, Baeyens and Sonuga-Barke, 2012; Demurie, Roeyers, Baeyens and Sonuga-Barke, 2013). Temporal or delay discounting can be regarded as an affective aspect of the executive functions and describes the phenomenon where the utility (subjective value) of a choice/reward decreases with the increase in waiting (delay) for its consequences (Critchfield & Kollins, 2001). Children with ADHD present alterations in reward processing when compared to the typical developing ones and the most consistent finding is an increased level of temporal discounting related to ADHD (Scheres et al., 2006; Sonuga-Barke, 2003). Temporal discounting could be evaluated by many tasks. Utsumi, Miranda and Muszkat (2016) described three types of tasks, involving 1) hypothetical reward and hypothetical delay; 2) real reward and real delay; and 3) hypothetical reward and real delay. Scheres, Sumiya, and Thoeny (2010) further described that tasks with real delay would be more sensitive to identify the ADHD-related waiting aversion. Temporal discounting has been much less studied in ASD (Demurie et al., 2012). The few studies in the literature may suggest an opposite pattern of temporal discounting than the one found in ADHD, with children and adolescents with ASD performing similarly to children and adolescents with typical development (Demurie et al., 2012; Demurie et al., 2013).

The capacity to delay gratification (ability/willingness to wait) increases with age (Scheres, Tontsch, Thoeny, and Sumiya, 2014) and is associated with better outcomes including domains such as academics and social life (Mischel et al., 2011). Concerning neurobiological development, areas associated with executive functions are still not fully developed until early adult life (Casey, Tottenham, Liston, and Durston, 2005; Moriguchi & Hiraki, 2014). Younger children (6-11 years old) are expected to present higher temporal discounts when compared to older children and adolescents (12-17 years) (Castellanos & Sonuga-Barke, 2006), which makes age an important variable when investigating temporal discounting functions.

In the present study, we sought to systematically review the available literature regarding temporal discounting in children up to 12 years with ADHD and ASD compared to typically developing children (controls). We aimed to investigate the consistency of findings of ADHD and ASD patterns of temporal discounting and to further discuss potential differences between ADHD and ASD in this “hot” aspect of executive functioning.

Methods

Search Criteria

A preliminary list of articles was obtained through searches of the Medline ⁄Pubmed and Scopus databases (June 2017) using the following descriptors: "Temporal Discounting" AND Attention Deficit Hyperactivity Disorder; "Temporal Discounting" AND Autism; "Delay Discounting" AND Attention Deficit Hyperactivity Disorder; "Delay discounting" AND autism; "temporal reward discounting"; "delay reward discounting". No filters were used in the preliminary search (e.g., date of publication).

Screening Procedure

Studies were screened independently by two authors, first on title and abstract, second on full-text reading to assess the study eligibility. The inclusion criteria were: (1) to involve a temporal discounting task, (2) applied to children up to 12 years of age (3) with a diagnosis of ADHD, ASD, or ADHD comorbid with ASD. The exclusion criteria were: (1) studies with adolescents or adults only; (2) studies with children up to 12 years of age and older altogether; 3) interventional studies that involve medication, other psychotropic substances, psychotherapy and other interventions; (4) studies that did not involve a clinical group or that involved other comorbidities; (5) studies using animal models; (6) studies that did not include the delay discounting paradigm; (7) books chapters or corresponding letter; (8) case study, review/theoretical studies; (9) studies written in other languages than English.

Results

The initial search yielded a total of 289 studies. However, only 140 articles remained after exclusion following descriptors and databases duplicates. Another 125 studies were excluded after title or abstract checking, and six were excluded based on the full-text reading. Agreement as to whether the study met the inclusion/exclusion criteria by the two independent selectors was of 100%. The final selection of studies that met all criteria consisted of 9 independent studies. From those, eight were focused in ADHD, one in ASD, and none including the comorbidity ASD+ADHD (see Fig.1). All studies were cross-sectional studies.

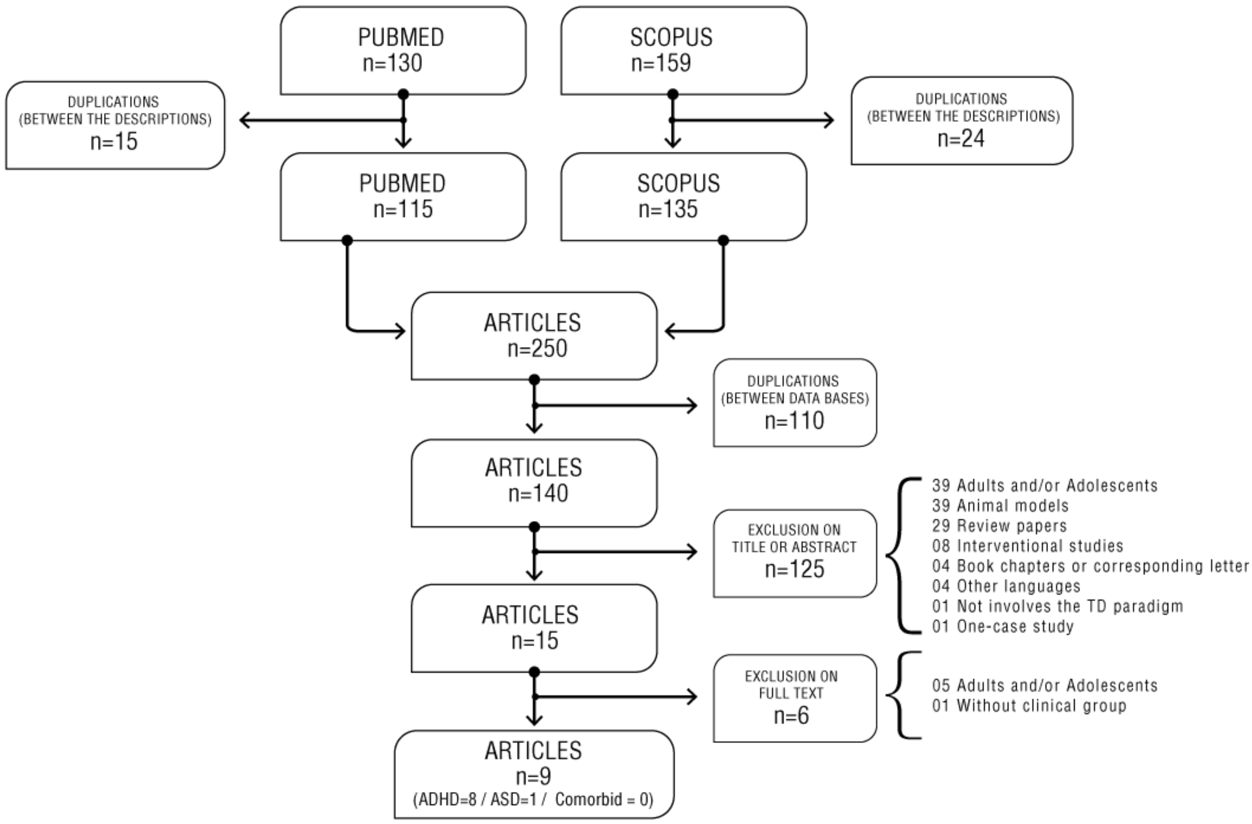

Figure 1. Flowchart of studies' selection

Table 1 provides a summary of the nine studies investigating temporal discounting in children up to 12 years of age with ADHD (n=8) and ASD (n=1).

Table 1. Features of the nine studies reviewed

Study	Temporal Discounting task	Dependent Variable(s)	Age Range (years)	N*	Group (n)	Results (>, =, and < is related to significance regarding delay discounting)
Antonini, Becker, Tamm & Epstein, 2015	Computerized; Hypothetical reward with variable magnitudes ($0,00-$10.00); Hypothetical delays (7, 30, 90, or 180 days); 88 questions.	Discounting gradient (*k*)	7-12	103	ADHD (50) / ADHD+ODD (27) / Control (27)	Age negatively associated with TD (r: -.28, p<.01). Age was included as a covariate for the following analysis: ADHD=ADHD+ODD=CONTROL (F(2,99) = 1.50, p = .23)**/** the number of ADHD or ODD symptoms was unrelated to DDT k values (F(1,98) = 2.22, p = .14).
Dias et al., 2013	Computerized; Hypothetical reward with variable magnitudes ($0,00-$10.50); Hypothetical delays (7, 30, 90, or 180 days); 91 questions.	Discounting gradient (*k*) + Area under the curve (AUC)	7-12	122	ADHD (52) / Control (70)	ADHD>CONTROL (p=0,015, controlling for age)**/** ADHD-Related increased connectivity between Nacc and the pre-frontal cortex was associated with greater impulsivity (steeper delayed-reward discounting) (p<0.05)
Dias et al., 2015	Computerized; Hypothetical reward with variable magnitudes ($0,00-$10.50); Hypothetical delays (7, 30, 90, or 180 days); 138 questions.	Discounting gradient (*k*)	7-12	90	ADHD (36) / Control (54)	ADHD>CONTROL (controlling for age (F(1,87) = 3.812, p = 0.054) **/** The network of children with and without ADHD was organized into three subgroups A; B and C. In subgroup A, ADHD>CONTROL**/** ADHD-A ≠ ADHD-B ≠ ADHD-C (F(2,33) = 4.091, p = 0.026)**/** ADHD-A>ADHD-B (p = 0.028)
Faja & Dawson, 2015	Not computerized; Real reward (food) with variable magnitudes (1 or 2 items); Maximum delay of 15 min; 1 trial.	Duration of delay + Passing rates (percentage of children who waited 15 min)	6-7	42	ASD (21) / Control (21)	ASD > CONTROL ($t(40) = -2.93$, $p = .006$, $d = -0.91$)**/** ASD 57,1% vs. CONTROL 90,5% reached 15 min (Fisher's exact test, one-sided, p = .02)

Martinelli, Mostofsky & Rosch, 2016	**Task 1: C**omputerized; Hypothetical (money) or real (gift cards or prizes) rewards with variable magnitudes ($0,00-$10.50); Hypothetical delays (1, 7, 30, or 90 days); 91 questions. **Task 2:** Computerized; Real reward (time playing a game) with variable magnitudes (15, 30, 45 or 60 seconds); Real delays (0, 25, 50, 75, or 100 seconds); 9 trials**.**	Area under the curve (AUC)	8-12	66	ADHD (26) / Control (40)	ADHD>CONTROL ($F(1, 61) = 6.5$, $p = 0.013$, $d = 0.65$) in the TASK 2, but ADHD-boys=CONTROL-boys ($p = 0.582$). This difference between groups seems to be related to ADHD-girls>CONTROL-girls ($p = 0.009$) **/** IQ (GAI) was significantly positively correlated with TASK 1, ($r(64) = 0.446$, $p < 0.001$)**/** TASK 1 and 2 are positively correlated ($r(64) = 0.285$, $p = 0.020$)**/** A greater effect of cognitive load on response control was a unique predictor of greater delay discounting (TASK 2) for ADHD, but not control children ($r(23) = -0.502$, $p = 0.011$).
Rosch & Mostofsky, 2016	**Task 1: C**omputerized; Hypothetical (money) or real (gift cards or prizes) rewards with variable magnitudes ($0,00-$10.50); Hypothetical delays (1, 7, 30, or 90 days); 91 questions. **Task 2:** Computerized; Real reward (time playing a game) with variable magnitudes (15, 30, 45 or 60 seconds); Real delays (0, 25, 50, 75, or 100 seconds); 9 trials**.**	Area under the curve (AUC)+ Subjective ratings	8-12	120	ADHD (65) / Control (55)	ADHD=CONTROL in the TASK 1 ($F(1,115) = 0.4$, $p = .542$, $d = .11$) with ADHD-boys=CONTROL-boys ($p = .593$; $d = 0.10$) and ADHD-girls>CONTROL-girls ($p = .006$; $d = 0.58$) in the TASK 2**/** ADHD>CONTROL in reward desirability ($p = .030$) and difficulty waiting ($p = .045$)**/** Inattentive symptoms, were significantly correlated with greater discounting on the TASK 1 ($r = -.199$; $p = .030$), but not on the TASK 2 ($r = -.158$; $p = .086$).
Scheres et al., 2006	Computerized; Real reward with variable magnitudes (0-10 cents); Real delays (0,5,10,20, or 30 seconds); 60 trials.	Area under the curve (AUC)	6-11 / 12-17	46	ADHD (22) / Control (24)	ADHD=CONTROL ($F(1,42) = .69$,n.s.; $\eta2 = .02$) / CHILDREN>ADOLESCENTS ($F(1,42) = 4.3$; $p < .05$; $\eta2 = .09$)./ Correlation between age and AUC ($r = .39$, $p < .008$)

Utsumi, Miranda & Muszkat, 2016	3 similar tasks were applied: Computerized; Variable reward (five toys were chosen by the children and placed into frames scoring 10,8,6,4, or 2); Variable delays (5, 10, 20, 40, or 80 seconds); 60 trials. **Task 1**: Hypothetical reward and delay; **Task 2**: Hypothetical reward, real delay; **Task 3**: Real reward (at the end, based on score), real delays.	Area under the curve (AUC) + Subjective value (toy vs. delays)	8-12	49	ADHD (25) / Control (24)	ADHD>CONTROL on Task 2 ($F_{(1,47)}=4.74$; $p=0.034$; $\eta^2_p=0.092$), especially at 10 s ($p=0.019$) and 20 s ($p=0.030$). In these delays, the value of their (ADHD) preferred toy was discounted more steeply**/** Moderate negative association between T2 and the BRIEF scale ($p < 0.035$)**/** Weak negative association between symptoms of hyperactivity-impulsivity and T2 ($r=-0.28$; $p=0.048$)**/** There was weak positive correlation between T1 AUC and age ($r=0.33$; $p=0.019$) alone.
Wilson, Mitchell, Musser, Schmitt & Nigg, 2011	Computerized; Hypothetical reward with variable magnitudes ($0,00-$10.50); Hypothetical delays (7, 30, 90, or 180 days); 91 questions.	Discounting gradient (*k*) + Area under the curve (AUC)	7-9	58	ADHD (27) / Control (31)	ADHD>CONTROL ($F[1.00, 53.00] = 5.31$, $p=0.025$) (this effect did not survive covarying of IQ)**/** Inattention, but not hyperactivity/impulsivity scores were significantly associated with ln(k) ($\beta = .244$, $p = .025$, $R^2 = .091$)

*Sample included in TD Analysis; ADHD = Attention Deficit/Hyperactivity Disorder; ODD = Oppositional Defiant Disorder; TD = Temporal Discounting; DDT = Delay Discounting Task; AUC = Area under the Curve; Nacc = Nucleus Accumbens; ASD = Autism Spectrum Disorder; GAI = The WISC-IV general ability index; BRIEF = Behavior Rating Inventory of Executive Functions; IQ = Intelligence Quotient

Participants Characteristics

All selected studies enrolled children with ADHD or ASD and controls. Considering the samples that were included in TD analyses, the number of subjects were 329 children with ADHD, 21 children with ASD, and 346 typically developing children. Studies were conducted largely in the United States of America, except for one held in Brazil.

The diagnostic criteria used for ADHD were similar among the studies. Seven of the eight studies used a version of the Conner’s' Parent Rating Scale (Conners, 2008), and the other one used only the Kiddie Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (Birmaher et al., 2009). Thus, DSM-IV (APA, 1994) criteria for ADHD was adopted in all studies. Other complementary measures used were: ADHD Rating Scale (Pappas, 2006) and Strengths and Difficulties Questionnaire (Goodman, 2001) (3 studies); Diagnostic Interview for Children and Adolescents, Fourth Edition (Shaffer, Fisher, Lucas, Dulcan, and Schwab-Stone, 2000) and ADHD Rating Scale (Pappas, 2006) (2 studies); and finally, Child Behavior Checklist (Achenbach, Dumenci & Rescorla, 2001), and SNAP-IV (Mattos, Pinheiro, Rohde & Pinto, 2006) (1 study). Oppositional Defiant Disorder comorbidity was described in all studies. Two articles also described symptoms of nocturnal enuresis, anxiety and depression (Scheres et al., 2006); and mood disorders, anxiety and learning disorders (Dias et al., 2015). The study with children with ASD used the Autism Diagnostic Interview-Revised (Rutter, Le Couteur & Lord, 2003) and the Autism Diagnostic Observation Schedule (Lord et al., 2000) as diagnostic criteria. The diagnostic classification was based on DSM-IV criteria.

Two studies reported a significant difference between the clinical and comparison groups regarding the sex of the participants (Dias et al., 2013; 2015). Socioeconomic status was reported just for two studies (Martinelli et al., 2016; Rosch & Mostofsky, 2016), and the samples were drawn mostly from the middle class. Ethnicity was also reported just for four studies (Antonini et al., 2015; Faja & Dawson, 2015; Martinelli et al., 2016; Rosch & Mostofsky, 2016), and the samples were largely white/Caucasian. The age of the children ranged from 6 to 12 years, with one study providing separate data for this range, but also including adolescents (12 to 17 years) (Scheres et al., 2006). Seven studies included children with IQ scores within the normal range (≥80-85) (Antonini et al., 2015; Dias et al., 2013; 2015; Faja & Dawson, 2015; Martinelli et al., 2016; Rosch & Mostofsky, 2016; Utsumi et al., 2016). The other two studies included children within the borderline IQ range (≥70-75) (Scheres et al., 2006; Wilson et al., 2011). Regarding the use of psychostimulants, all the studies described a washout time or included only children who did not use this type of medication.

Temporal Discounting Task Specificities

All articles that investigate the temporal discounting in children with ADHD have used computerized tasks with at least one hypothetical reward version, except for one study that uses only real rewards (Faja & Dawson, 2015). Three articles used more than one version of the task, applied to the same sample, intending to check the effects of hypothetical rewards vs. actual (real) rewards (Martinelli et al., 2016; Rosch & Mostofsky, 2016; Utsumi, 2016).

Six tasks were based on the model proposed by Mitchell (1999), on which delays and rewards are hypothetical, with questions such as "Do you prefer $ 8.00 now or $ 10.00 in 7 days?" (Antonini et al., 2015; Dias et al., 2013; 2015; Martinelli et al., 2016; Rosh & Mostofsky, 2016; Wilson et al., 2011). A new TD task was developed by the authors in the study using real rewards (Scheres et al., 2006). Authors of two studies that used more than one version of the task also developed new versions of the TD task using real rewards (Martinelli et al., 2016; Rosch & Mostofsky, 2016). Finally, the third study that applied more than one version of the TD task, was based on the studies of Demurie and colleagues (2013) and Demurie, Roeyers, Wiersema and Sonuga-Barke (2013a) and Scheres, Sumiya, and Thoeny (2010), adapting three versions that varied regarding the presence of real vs. hypothetical rewards and delays (Utsumi et al., 2016).

The single article investigating temporal discounting in children with ASD used a task based on Mischel1's “The marshmallow test" (Mischel, Shoda & Rodriguez, 1989). The dependent variables extracted were the duration of delay and passing rates (percentage of children who waited the maximum of 15 minutes). Besides these measures, Area Under the Discounting Curve (AUC) was used in four studies and discount gradient (k) in three (see Table 1). One study uses both (k) and AUC measures. Other variables, such as the point of indifference and subjective ratings were also used for specific analyses (3 studies) (see Table 1).

Temporal Reward Discounting (TD) in ADHD Children

Two studies (Antonini et al., 2015; Scheres et al., 2006) reported no significant differences between ADHD and control children in reward temporal discounting. Scheres and colleagues (2006) observed that the difference was not statistically significant between groups in the same age range. However, this study points out an age effect on Temporal Discounting (6-11 vs. 12-17 years) with younger children having a greater degree of discounting. Scheres and colleagues (2006) in the same study, also used a second version of the task, not described in Table 1 of this review, to verify the relation between decision-making and task completion. In general, all participants had a higher temporal discounting when this pattern of choices shortened evaluation time. Antonini and colleagues (2013) also did not find significant differences in TD between children with ADHD, ADHD+ODD, and those with typical development. The study investigated the impairment of "cool" and "hot" executive functions in children with ADHD, with and without ODD comorbidity. Number of ADHD and ODD symptoms did not relate to performance in the temporal discounting task in the study. Antonini and colleagues (2013) also observed an effect of age on the discounting gradient.

Wilson and colleagues (2011) observed a significant difference between control and ADHD children, with a greater degree of discounting from ADHD participants. Differences in TD did not remain significant after controlling for IQ. Authors also reported that the indifference points between groups differed significantly only at the 7-day and 90-day delays. The indifference point refers to the point in which there was no preference between the immediate variable item and the delayed $10.00 at each delay. Authors also found a significant positive correlation between temporal discounting and behavioral inattention, but not with the hyperactivity/impulsivity symptoms.

Dias and collaborators (2015) also did not observe significant differences in temporal reward discounting of children with ADHD and controls. However, after controlling for age, a trend to statistical significance occurred ($p=0.054$) with greater TD for ADHD children compared to controls. This study also features neuroimaging data based on the connectivity of the reward system network. Using this neuroimaging data, the authors divided children into three subgroups, according to the connectivity pattern, that including ADHD and controls children. It was observed that in one of the subgroups, specifically, children with ADHD performed significantly worse than controls on task, and when compared to children with ADHD from one of the other two subgroups. Regarding neuroimaging data, the study found that children with ADHD present weaker connections (from the reward region) including positive connections to the anterior prefrontal cortex (medial frontal gyrus and superior frontal gyrus), middle temporal gyrus, posterior cingulate cortex; and negative connections to dorsolateral prefrontal cortex (PFC) (middle frontal gyrus), inferior parietal lobule bilaterally, and occipital lobe bilaterally. At the same time, stronger positive connectivity to the left orbitofrontal cortex (OFC; inferior frontal gyrus) and stronger negative connectivity to the thalamus were observed. The authors suggest that this unbalance could be the reason of non-adaptive behavior and impulsivity in ADHD.

In 2013, Dias and colleagues correlated resting-state connectivity using fMRI with performance on the TD task. Authors described a strong correlation between delay discounting gradient ln(k) and connectivity from the nucleus accumbens (NAcc) to the PFC, including the ventromedial PFC (vmPFC) and the left anterior PFC. The same results were found regarding the AUC measurement. Controlling age and gender and correcting for multiple comparisons, only the correlations with the AUC measures remained significant. The authors found that stronger correlations between the NAcc and left anterior PFC was associated with greater impulsivity (discounting gradient). It was also found atypical NAcc connectivity to the vmPFC correlation to ln(k). In this study, the ADHD group performed significantly worse (greater temporal discounting) than children with typical development, controlling for age.

Two other studies found greater temporal discounting in the ADHD group than in the control group. However, this difference occurred specifically for girls (Martinelli et al., 2016; Rosch & Mostofsky, 2016). Both studies used two versions of the temporal discounting task, one with hypothetical rewards and delays and another with real rewards and delays, and the difference between groups occurred just in the second version. Rosh and Mostofsky (2016) also observed, through subjective ratings (wanting to play; liking waiting and how much they liked playing their chosen game), that children with ADHD differed significantly from the control group in relation to reward desirability (they wanted the reward more intensely) and difficulty on waiting (they disliked waiting for more). Inattentive symptoms were significantly correlated with greater discounting on the hypothetical task, but not on the real one. Martinelli and colleagues (2006) found a significant correlation between the hypothetical task and IQ, besides a greater effect of cognitive load on response control as a unique predictor of greater delay discounting (on real TD task) for ADHD, but not control children.

Finally, Utsumi and colleagues (2016) observed a greater temporal discounting in children with ADHD when compared to typically developing children, especially in the 10 and 20 seconds delays. In these delays, the value of their preferred toy was discounted more steeply. Important to note is that the task on which this significant performance difference occurred, involved hypothetical reward and real delay. Still, on this version of the task, an association between impulsivity (smaller AUC) and low emotional self-regulation was observed. Authors also observed a negative association between symptoms of hyperactivity-impulsivity and AUC. This study tested three versions of a temporal discounting task, with hypothetical rewards and delays; hypothetical rewards and real delays; and real rewards and delays. Only in the completely hypothetical version, a positive correlation with age was observed (younger age, smaller AUC-greater temporal discount).

Temporal Reward Discounting in ASD Children

Only one study investigated cognitive and behavioral alterations in children from 6 to 12 years with ASD regarding temporal discounting. Despite methodological problems, Faja & Dawson (2015) used a classic task model, based on “The Marshmallows Test” described by Mischel and collaborators (1989), in which an evaluator leaves a candy available in front of the child and explains that he/she will leave the room and if the child does not eat the candy, he/she will gain one more when the evaluator returns. The authors demonstrated that children with ASD could wait for significantly less than the controls. Besides, the percentage of children who could wait the maximum time of 15 minutes was significantly different between groups (ASD=57,1% vs. CONTROL=90,5%).

Discussion

This systematic review identified nine studies investigating temporal reward discounting in children between 6 to 12 years, being eight studies with ADHD children (n=329), one with ASD children (n=21), and all of them including typically developing children as controls (n=346). Six of eight studies found greater temporal reward discounting for ADHD children (two studies with differences found only for girls), and the study including ASD children found a lower ASD capacity to delay gratification compared to control children. Differences tended to be more prominent in real TD tasks, especially regarding real delays (actual waiting). Rewards included money, food, and toys/playing. An age effect on TD was reported for most studies with younger ages associated with greater temporal discounting. ADHD symptoms were inconsistently related to TD, with some studies showing no association, others an association with the inattentive dimension, and others with the hyperactive-impulsive dimension. Differences in brain connectivity may underlie alterations in temporal discounting processes in ADHD. We observed a high heterogeneity between studies regarding the type of temporal discounting task used and the predominance of small sample sizes.

The inconsistency of results between some studies is probably due to differences in the characteristics of the sample and the task used. Although there was a prevalence of tasks based on that proposed by Mitchell (1999), some newly developed ones were used. Additionally, the type of reward varied between studies, and the heterogeneity of neurodevelopmental disorders may also lead to different results. There is no consensus in the literature about de ideal task design to assess temporal discounting in ADHD or ASD children. However, McClure, York and Montague (2004) emphasizes that reward-related aspects, such as type (primary or secondary rewards) and different magnitudes and delays, are directly related to the specific brain response. Despite these specificities, there is a common set of neural structures inherent in reward processing. The orbitofrontal cortex (OFC), amygdala, and ventral striatum/nucleus accumbens (NAcc) are the major regions involved in reward processing in general (McClure et al, 2004). Wilbertz and colleagues (2013) demonstrated an increased activation of the amygdala, that was correlated with behavioral aspects of delay aversion on ADHD adults. The amygdala is related to reinforcer intensity and stimuli arousing. Besides, amygdala activity is strongly associated with sensing aversive stimuli (e.g., delay) (McClure et al, 2004). The two studies with neuroimaging data from this review, found changes in this circuit, with emphasis on the nucleus accumbens (Dias et al., 2013; Dias et al., 2015).

The importance of age can be highlighted in this review, which is consistent with studies including adolescents or adults (Castellanos & Sonuga-Barke, 2006). Scheres and colleagues (2014) described a developmental age effect on TD with steeper temporal discounting in children and adolescents (aged 6-17) compared to adults. Scheres and colleagues (2010) also found that the symptoms of hyperactivity/impulsivity were associated with higher temporal discounting. In another research, Scheres, Lee and Sumiya (2008) observed that tasks with real rewards and delays were more sensitive to ADHD-related delay aversion, and the findings also suggest a link between this behavior and the Combined or Hyperactive/Impulsive Types of ADHD (Scheres, Tontsch & Thoeny, 2013). These results are similar to Utsumi and colleagues (2016) findings. Barkley, Edwards, Laneri, Fletcher, and Metevia (2001) also investigated temporal discounting in an ADHD sample (aged 12-19) and observed that the ADHD group presents significantly greater levels of temporal discounting in a hypothetical monetary task.

Regarding temporal discounting in children with ASD, the reviewed study presents controversial results based on the current literature. Demurie and colleagues (2012) observed a similar pattern of temporal discounting between control and ASD children. In another study (Demurie et al., 2013), the authors also found evidence of smaller temporal discounting in children with ASD. This inconsistency was probably due to methodological issues involving the used task. There are just one trial and no systematic variations of the reward magnitude and the delay duration. We also found one study investigating temporal discounting in a group of children with comorbid ADHD and ASD (aged 11 to 17 years) from a behavioral and neurobiological point of view (Chantiluke et al., 2014). Using fMRI, they found that the pattern of brain activation of the comorbid group was neither an endophenocopy of the two pure disorders nor an additive pathology, and that the performance of the comorbid group as well as the TD association with brain responses were more severe compared to groups with only one of the clinical disorders. However, contradicting previous findings, the authors report that the pure ADHD group was similar regarding the delay discounting to their typically developing peers, while the pure ASD and the comorbid ADHD and ASD groups were the only ones to present steeper delay discounting (Chantiluke et al., 2014).

This systematic review has limitations that should be acknowledged. First, the investigated age range excluded several studies that describe temporal discounting alterations in the groups of interest, leading to a very few number of publications; second, the differences between the measures and the dependent variables used in the studies make it difficult to compare the results; third, a lack of publications related to temporal discounting in ASD compromised this part of the analysis. Future studies should overcome some of these limitations.

This review contribution is related to the synthesis of results found in the current literature regarding increased temporal discounting of children with ADHD, considering an age range of 6 to 12 years. The occurrence of ADHD appears to rush even more the decision-making process at this stage of development, in which brain maturation of important regions for cognitive control has not yet been completed. There is still a huge hole in the literature regarding temporal discounting in ASD, especially in this age range. Studies that include the comorbidity ADHD+ASD are needed for a better understanding of the pattern of temporal reward decision in these neurodevelopmental disorders, as well as its implications for the diagnosis and treatment of these disorders.

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4 - Temporal reward discounting in children with Attention Deficit/Hyperactivity Disorder (ADHD), children with Autism Spectrum Disorder (ASD), and children with comorbid ADHD and ASD

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ARTIGO EXPERIMENTAL

Temporal reward discounting in children with Attention Deficit/Hyperactivity Disorder (ADHD), children with Autism Spectrum Disorder (ASD), and children with comorbid ADHD and ASD

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Abstract

Objectives: Alterations in temporal discounting (TD) may differ between children with Attention Deficit/Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD). The pattern of TD in children with comorbid ADHD and ASD is rather under explored. We sought to investigate differences in TD functions between typically developing children, children with ADHD, children with ASD, and children with comorbid ADHD and ASD (ADHD+ASD). **Methods:** One-hundred boys from five to 13 years old (34 typically developing children, 35 children with ADHD, 18 children with ASD, and 13 children with comorbid ADHD+ASD) performed a TD task with hypothetical variable rewards and real short delays. **Results:** The comorbid ADHD+ASD group performed similarly to the ADHD group alone (i.e., greater temporal discounting), while the ASD group showed a similar degree of TD as their typically developing peers. We found age to be positively associated with TD, but not socioeconomic level or fluid intelligence. **Conclusions:** The results suggest that the affective pattern of ADHD decision making overrides the typical analytical pattern found in ASD when the disorders co-occur. Abnormalities in decision-making are one of the most prominent symptoms of numerous psychiatric disorders, and the emotional aspects of decision-making may be even stronger markers of these complex disorders.

Keywords

ADHD; ASD; temporal discounting; delay discounting; decision-making; reward processing.

Introduction

The understanding of the neuropsychological processes underlying neurodevelopmental disorders is of utmost importance from a translational perspective since the identification of altered mechanisms has the potential to improve diagnostic processes, as well as to offer a perspective of new and more specific treatments (Sonuga-Barke & Halperin, 2010). In this sense, the ability to differentiate shared or specific impairments among the various disorders is fundamental.

Recently, two very common childhood conditions, Attention Deficit/Hyperactivity Disorder (ADHD; estimated prevalence of 5%) and Autism Spectrum Disorder (ASD; estimated prevalence of 1%) are no longer excluding nosologically conditions according to the Diagnostic and Statistical Manual of Mental Disorders DSM-5 (APA, 2013). Individuals with ASD may present clinically significant symptoms of ADHD and vice versa, and the comorbid profile appears to be distinct from any of the conditions separately (Chantiluke et al., 2014; Coghill & Seth, 2011; Gadow, DeVincent & Pomeroy, 2006).

Regarding cognitive aspects, ADHD and ASD would be marked by executive deficits (Nigg et al., 2005; Willcutt et al., 2005; Geurts et al., 2004; Johnson et al., 2007). Executive functions could be divided into two general domains: (1) a more deliberative (inhibition of motor responses, attention, cognitive flexibility, etc.) and (2) a more affective one involving reward processing (incentive) and motivation (affective or impulsive decision-making) (Zelazo & Muller, 2002). They are key components of self-regulation, an essential ability for us to achieve our goals and to avoid impulsive behaviors or decisions that bring long-term adverse outcomes (Timpano, & Schmidt, 2013). Given that the pattern of deficits in the deliberative processes of executive functions are similarly altered in ADHD and ASD, the affective-motivational processes have been suggested as better candidates for the differentiation between ADHD and ASD (Antrop et al., 2006; Demurie et al. 2011, Demurie et al., 2012).

Children with ADHD present alterations in reward processing, the most consistent finding being an increased level of temporal discounting (Sonuga-Barke, 2003; Scheres et al., 2008). With temporal discounting, the utility (subjective value) of a choice/reward decreases with the increase in waiting for its consequences (Critchfield & Kollins, 2001). Temporal discounting, however, has still been under studied in ASD (Demurie et al., 2012). The few studies including children with ASD show that they have a similar performance to that of children with typical development

(Antrop et al., 2006; Demurie et al., 2012; Demurie et al., 2013). It is also possible that individuals with ASD are less influenced by the affective-motivational aspects of decision-making. De Martino et al. (2008) demonstrated that adults with ASD presented an atypical pattern of decision making with less influence of reward contingencies (affective biases) resulting in an unusual logic consistency pattern of decision-making. Despite evidence regarding ASD, Kahneman and Tversky (1979) argue about the failure of rational theories in predicting decision-making by assuming a reasonable, consistent, and logical behavior independent of the contingencies of a choice (perspective theory), since many human decisions are not necessarily optimal from a rational point of view (De Martino et al., 2006; Kahneman and Frederick, 2007). However, this discussion is probably applicable to healthy people, wherein some disorders may directly affect the decision-making process.

Evans (2003) described a “two-systems” or dual model of human judgment, which refers to two different systems associated with the human decision-making process. These systems would work in an integrated way, and system one would correspond to the mechanisms most related to the sympathetic system, or to the more intuitive aspects of decision-making, being faster and automatic. System two would correspond to the more analytical aspects, to reasoning, and to hypothetical thinking, being a slower system. It is possible to hypothesize that individuals with ADHD make choices that are more influenced by intuitive (affective) processes (system one), whereas individuals with ASD may have a more analytical (deliberative) way of decision-making (system two).

In the only study investigating temporal discounting in a group of 13 boys with both ADHD and ASD, the researchers found a greater temporal discounting compared to a group of boys with typical development (Chantiluke et al., 2014). Intuitive processes are employed more quickly and could work with a high volume of information in parallel, but are more susceptible to errors; the deliberative processes are more accurate, but slower and require high computational capacity (Kahneman, 2003). Thus, verifying the influence of affective biases such as the temporal discounting in decision making in a comorbid group with apparently opposing characteristics could increase the understanding of the integration of decision-making processes from a dual-system perspective. The study of this affective bias in decision making in these two populations could also help to clarify possible adaptive differences of the predominance of affective or deliberative processes (De Martino et al. 2008).

Considering the significant role of affective-motivational aspects among ADHD and ASD disorders, we sought to investigate differences in temporal reward discounting functions between typically developing children, children with ADHD, children with ASD, and children with comorbid ADHD and ASD (ADHD+ASD). We hypothesized that children with ADHD would present a greater delay discounting compared to children with typical development and ASD. We further hypothesize that children with ASD would exhibit a more logical pattern of choices, performing equally or better than controls. Regarding the comorbid group, the only study in the literature suggests that the immediacy commonly observed in ADHD prevails over the ASD capacity of delaying gratification. To elucidate these hypothesis, we assessed participants' performance in a temporal discounting task (TD) using hypothetical monetary reward and real delays. The association of temporal discounting with children's age, fluid intelligence, and socioeconomic status was also investigated.

Methods

Participants

Participants were 100 boys from five to 13 years old. From those, 34 typically developing (control) children were from local schools. Thirty-five children with Attention Deficit/Hyperactivity Disorder (ADHD; 15 inattentive, 3 hyperactive/impulsive, and 17 combined presentation), 18 children with Autism Spectrum Disorder (ASD), and 13 children with comorbid ADHD and ASD (ADHD+ASD; 2 inattentive, 0 hyperactive/impulsive, and 11 combined presentation of ADHD were recruited in the Impulsivity and Attention Research Center (NITIDA) at the Clinical Hospital of the Federal University of Minas Gerais, Belo Horizonte, Brazil.

Twenty-nine children were excluded from the initial sample according to the following criteria: be a first-degree relative of another previously evaluated child (4); have border classification in the CBCL (for controls only; 3); have low or no understanding of the temporal discounting task (3); have a diagnosis different from those described in the scope of this research (2); presenting neurological conditions (e.g. epilepsy; 4); to not complete the intelligence measure or have a percentile ≤ than 5 (5); and for being under psychostimulant effects at the time of the evaluation (7). Finally, one child was excluded for being an outlier in the TD task.

Control children were classified as so since mothers did not report child history of psychiatric or neurological disease. Additionally, only children with no borderline or clinical scores in the internalizing and externalizing scales of the Child Behavior Checklist (parent form) (Achenbach, & Rescorla, 2001) were included as controls. Caregivers of the clinical group underwent a semi-structured psychiatric diagnostic interview with the Brazilian version of the K-SADS-PL (Brasil, 2003) and the Childhood Autism Rating Scale (CARS; Schopler et al., 1980) to support clinical diagnosis. However, the final diagnosis of ADHD and ASD was done following the DSM-5 criteria (APA, 2013). Parents of all children gave written informed consent for participation. The present research was approved by the ethical board of the Federal University of Minas Gerais, Belo Horizonte, Brazil.

Instruments

Temporal Discounting Task - The temporal discounting task (TD) was adapted from Scheres and colleagues (Scheres et al., 2006; 2010). Participants were instructed to make 60 choices between an immediate and variable small reward (1, 2, 3, or 4 coins) and a delayed large reward (5 coins after 5, 10, 20, 30, or 60 seconds). There were three trials for each combination (e.g., to choose between 2 coins immediately or 5 coins after 20 seconds). Trials were administered in a not fixed pseudorandom order (the same choice was never presented right after). The maximum gain is of 300 coins and the maximum task duration of 28.5 minutes. Choices were visually shown on computer screen picturing two airplanes with one carrying the large constant reward and the other carrying a small variable reward. The picture of the reverse of a one Brazilian Real coin (showing the Head of Republic) was used in the present version of the TD task. The plane height was proportional to the delay's duration (see Figure 1). In this version, only the analogic amount of coins was shown *per* trial. Small-immediate and large-delayed options were balanced in the left/right side of the computer screen. Participant's choice was made by pressing the button correspondent to the left/right position of the chosen value/delay option. The amount of coins chosen by the participant in each trial was presented to him/her after the chosen waiting interval. Following each trial, the participant was updated about the total amount earned with the quantity shown by Arabic numerals (visual symbolic representation). Participants were told to make choices as they would if the money was real and as if they would actually earn all the coins they hypothetically collected during the task. They were also informed that at the end of the task they would win candies depending on how much coins they won. All children received the same amount of candies independent of TD performance.

The subjective value of the maximum reward (i.e., 5 coins) depending on delay duration was computed by the total amount of earned coins in each delay interval (i.e., 5, 10, 20, 30, or 60 seconds) divided by the number of trials in each interval (i.e., 12). Then, if the participant chose to wait 5 seconds for 5 coins instead of gain 1, 2, 3, or 4 coins immediately in all 12 trials (3 trials per small variable reward) for the 5 seconds delay, the subjective value of 5 coins in 5 seconds is actually 5 (i.e., no temporal discounting). TD performance was computed as the total area under the discounting curve (AUC) following the procedure described by Myerson and colleagues (2001). AUC range is of 0-1 with a smaller AUC suggesting a steeper discounting function (immediacy) (Scheres et al., 2014).

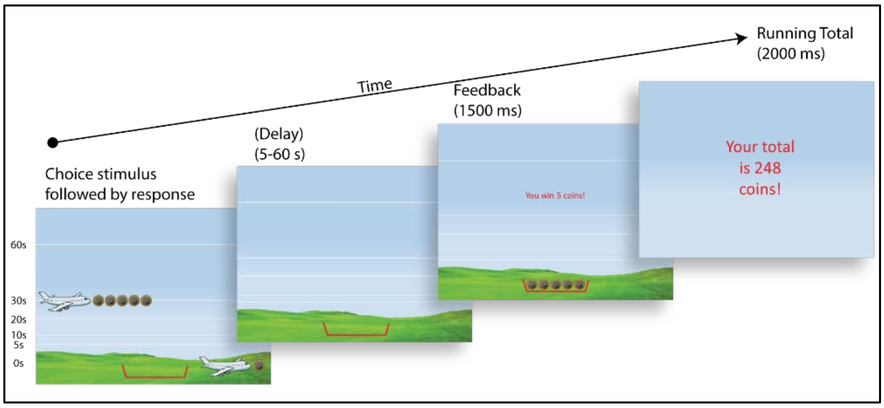

Figure 1. Temporal Discounting Task. Example of a trial representing a choice between 1 coin immediately or 5 coins after 30s.

Raven's Colored Progressive Matrices (CPM) - A widely used nonverbal intelligence test with items composed using abstract line drawings and demanding inductive reasoning (Deary, 2012). Participants' performance was converted into z scores according to age-appropriate parameters of the Brazilian version of the Raven's CPM (Angelini et al., 1999).

Sociodemographic characteristics - Information about children's age was given by parents who also reported the family socioeconomic status (SES) following the *Brazilian Economic Classification Criteria (CCEB)* (ABEP, 2014). CCEB is an instrument of economic classification that provides evidence about purchasing power and general situation of the households through questions about possession of durable goods and educational level of the head of the household. Scores can vary from 0 to 46 and fall in one of six classes: A (averaged income of U$ 6.694,87), B1 (average income of U$ 2.966,03), B2 (average income of U$ 1.555,13), C1 (average income of U$ 866,99), C2 (average income of U$ 520,83) and DE (average income of U$ 246,15) (ABEP, 2014). Higher scores suggest better socieconomic situations. In this sample, participants had the following economic classifications: 6 (6%) A, 18 (18%) B1, 39 (39%) B2, 22 (22%) C1, 11 (11%) C2, 4 (4%) DE.

Procedure

All children were individually assessed in a single session of a maximum of 70 minutes ‘duration. Typically developing (control) children were assessed at their local schools and clinical participants in a special evaluation room in the Impulsivity and Attention Research Center (NITIDA) at the Clinical Hospital of the Federal University of Minas Gerais, Belo Horizonte, Brazil. Twenty-five percent (n=25) of children were currently under some pharmacological treatment (5 ADHD children, 9 ASD children, and 11 ADHD+ASD children). All children in use of psychostimulants (3 ADHD and 3 ADHD+ASD) performed the TD test with a minimum of 48 hours of washout.

Data Analysis

Background characteristics were compared between the groups. For categorical datacomparisons were made by the Fisher’s exact test (FET) with a Monte Carlo approach (CL=99%, *K*=10000). For continuous data, a multivariable analysis of variance (MANOVA) was performed for normally distributed data and the Kruskal–Wallis test for non-parametric data. For the dependent variable (total area under the discounting curve), pairwise comparisons using the Dunn-Bonferroni approach were computed following significance of the Kruskal-Wallis test (Dunn, 1964). Association between background variables and the dependent variable was investigated by Spearman’s correlation analysis. In the present study, effect sizes were interpreted as correlation coefficients (small: r = 0.1, medium: r = 0.3, large: r = 0.5). This sample’s size power to detect small differences between groups with a 95% confidence level was of 11%, 52% for medium differences, and 92% for large differences. Analyses were performed in SPSS 20.0 (IBM, 2011).

Results

Participants’ characteristics and performance are shown in Table 1. Groups were similar in age and socioeconomic level (SES). Fluid intelligence was higher in the control group compared with the clinical groups. Children's age (*r*(98)=.21, p=.032) was significantly associated with the area under the discounting curve (TD-AUC). SES (*r*(98)=.10, p=.311) and fluid intelligence (*r*(98)=.06, p=.536) were not significantly associated with TD-AUC. Therefore, no background features were controlled for TD-AUC comparison between groups.

Comorbid Oppositional Defiant Disorder (ODD) and emotional disorders (anxiety and depression) frequency among the groups was shown for descriptive purposes only. Comorbid ODD was more frequent in the ADHD group compared to the remaining groups and comorbid emotional disorders was more frequent in the ADHD and ADHD+ASD groups.

Table 1. Participants characteristics and performance

	Control (n=34)	**ADHD (n=35)**	**ASD (n=18)**	**ADHD+ASD (n=13)**
Age, mean (SD)/ median	8.82 (2.18)/ 9.50	8.63 (2.07)/ 8.00	8.83 (2.20)/ 9.50	8.23 (1.88)/ 8.00
SES, mean (SD)/ median	33.00 (8.24)/ 32.00	28.02 (8.59)/ 29.00	31.82 (9.84)/ 31.84	30.23 (7.12)/ 30.00
Intelligence (*Z*), mean (SD)/ median**	0.91 (0.75)/ 0.83	-0.02 (1.02)/ -0.04	0.01 (0.88)/ 0.09	0.17 (1.25)/ -0.02
Comorbidity				
ODD, n (%)**	0	11 (31)	1 (6)	1 (8)
Emotional Disorders (anxiety and depression), n (%)**	0	10 (29)	3 (17)	5 (39)
TD AUC, mean (SD)/ median**	0.94 (0.15)/ 0.95	0.85 (0.14)/ 0.80	0.98 (0.15)/ 1.03	0.83 (0.14)/ 0.76

ADHD= Attention Deficit/Hyperactivity Disorder; ASD= Autism Spectrum Disorder; SES= Socioeconomic Status (higher scores indicate better socioeconomic situations); ODD= Oppositional Defiant Disorder; TD= Temporal Discounting Task; AUC= Area Under the Discounting Curve.
Significant at *p<0.05, **p<0.001

There was a statistically significant difference in the total area under the discounting curve (TD-AUC) between groups (χ^2(3)=15.52, p=0.001) with larger differences after the 5-10 seconds interval area (see Figure 2). Control and ASD groups tended to have a higher TD-AUC than ADHD and ADHD+ASD groups with medium to large effect sizes (Table 2). Differences between Control and ASD groups were small, as were the differences between the ADHD and ADHD+ASD groups (Table 2).

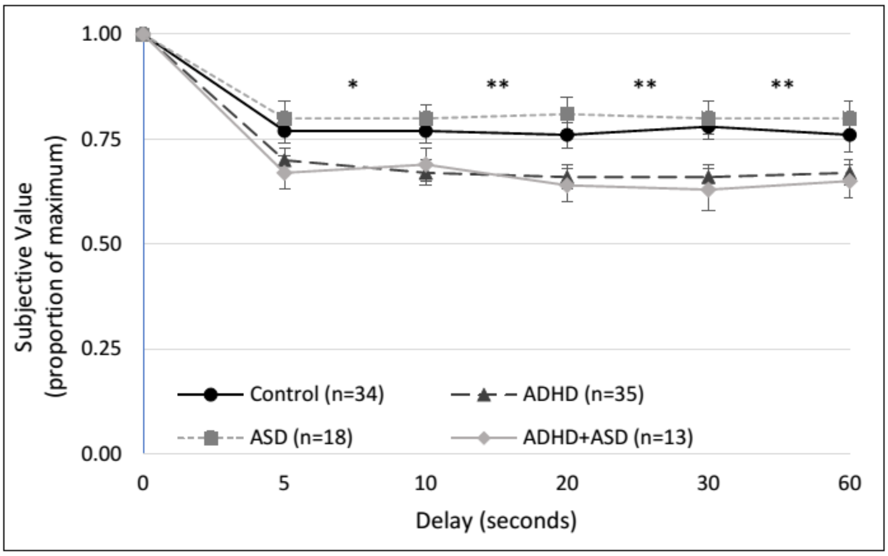

Figure 2. Temporal reward discounting functions for Control, ADHD, ASD, and ADHD+ASD children. Shown are the Means and Standard Error. *Significant at p≤.05; ** Significant at p≤0.01

Table 2. Pairwise comparisons regarding the Area Under the Discounting Curve between groups

	1. Control	2. ADHD	3. ASD
2. ADHD	2.74 (0.006, 0.037)/0.33*	-	
3. ASD	-0.75 (0.454, >0.999)/ -0.10	-3.02 (0.002, 0.015)/ -0.42*	-
4. ADHD+ASD	2.42 (0.015, 0.093)/ 0.35	0.40 (0.687, >0.999)/ 0.06	2.77 (0.006, 0.034)/0 .50*

Pairwise comparisons using the Dunn-Bonferroni approach for multiple comparisons after significant Kruskal-Wallis test. Shown are: *z*-statistic (*P* value, Adjusted *P* value/*r* (r=Z/SQRT(N))
Significant at *p<0.05 after multiple comparisons correction

Discussion

We compared age matched boys with ADHD, ASD, comorbid ADHD and ASD, and typically developing controls in a temporal discounting task with hypothetical variable monetary rewards and real variable delays. ADHD and comorbid ADHD and ASD (ADHD+ASD) groups tended to show steeper delay discounts than ASD and controls. Thus, the comorbid ADHD+ASD group performed similarly to the ADHD group alone (i.e., greater temporal discounting), while the ASD group showed a similar degree of temporal discounting as their typically developing peers. We found age to be positively associated with the area under the discounting curve (TD-AUC), but not socioeconomic level or fluid intelligence, when considering participants altogether.

The investigation of TD in ADHD has compiled more evidence than is the case for ASD. Children with ADHD tend to be more impulsive than typically developing peers in several paradigms assessing choice-impulsivity, although inconsistencies on impulsive decision-making across delay discounting and delay of gratification tasks are still present (Patros et al., 2016). Several studies showed ADHD children as having at least a tendency to be more delay aversive and consistently depicting greater temporal discounting in a range of TD paradigms (e.g., Barkley et al., 2001; Dias et al., 2013; 2015; Martinelli et al., 2016; Rosch & Mostofsky, 2016; Sheres & Lee, 2008; Utsumi et al., 2016; Wilson et al., 2011). Notwithstanding, some studies did not find different patterns of temporal discounting between ADHD children and controls (Antonini et al., 2015; Chantiluke et al., 2014; Demurie et al., 2013; Sheres et al. 2006). One main consideration in the field of TD investigation is the type of paradigm used. Utsumi and colleagues (2016) compared three different tasks using the same sample and found that the TD task with hypothetical reward but real delay was the one where ADHD had a more impulsive performance compared to controls, while the TD tasks using only hypothetical reward and delays, or only real rewards and delay did not yield any performance differences. In a recent study Yu and Sonuga-Barke (2016) found steeper temporal discounting in ADHD children on a completely real task but not in a completely hypothetical one. In other hand, some researchers also found a group difference using completely hypothetical tasks (Wilson et al., 2011; Dias et al., 2013; 2015). Sheres and Lee (2008) observed in an adult sample that tasks with real rewards and delays should be more sensitive to ADHD-related delay aversion than the hypothetical ones. Moreover, TD in ADHD is more likely to also be impacted by delay and reward magnitudes with different computations for small amount and short delays and large rewards and long delays (Scheres et al., 2010a, b). The TD version used in the present study involved 60 trials of hypothetical variable rewards (small amounts from 0 to 5 coins) and real short delays (from 0 to 60 seconds), which has been shown to be more challenging to ADHD children. However, we did involve a financial transaction when assuring children that they would exchange the coins the got for candy. Therefore, we cannot assure that reward processing was completely hypothetical.

Temporal discounting functions are much less studied in ASD. Despite controversies, it is possible that ASD children perform more like typically developing children (Antrop et al., 2006; Demurie et al.; 2012; 2013). Demurie et al. (2012) describes significant differences between ADHD, ASD, and control children with an impulsive pattern of choices in ADHD group, and the ASD group performing similarly to controls. The same result regard the ASD group was described by Antrop et al. (2006). Faja & Dawson (2013) found a different result, pointing to a greater temporal discounting in children with ASD compared to controls in a task similar to the traditional "Marshmallow Test". Children with ASD waited significantly less, and the group had a considerably smaller percentage of children who waited the maximum of 15 minutes for the highest reward. Chantiluke and colleagues (2014) also reported a steeper temporal discounting among ASD children compared do controls. In a recent study, Carlisi et al. (2017) investigated differences in delay discounting in children and adolescents with ASD and obsessive-compulsive disorder (OCD). Using a TD task with hypothetical variable rewards (large amounts £0-£100)) and hypothetical variable long delays (1 week, month or year), they showed boys with ASD having greater choice-impulsivity than OCD and control boys. De Martino et al. (2008) argue about an unusual logic pattern of decision making among adults with ASD due to less affective biases or influence of contextual factors for them. At any rate, the literature is still inconsistent on this matter. We found that ASD children had a similar performance to their typically developing peers and a much less impulsive choice patter than ADHD children and children with comorbid ADHD and ASD. This is the first study using a TD task with hypothetical variable rewards (small amounts) and real short delays in ASD.

In the only research investigating TD in a comorbid ADHD+ASD group (Chantiluke et al., 2014), the ADHD+ASD group showed the steeper delay discounting compared to pure ADHD, pure ASD, and control children. However, contradicting previous findings, the authors report that the pure ADHD group was similar regarding the delay discounting to their typically developing peers, while the pure ASD and the comorbid ADHD and ASD groups were the only ones to present steeper delay discounting (Chantiluke et al., 2014). Using fMRI, they found that the pattern of brain activation of the comorbid group was neither an endophenocopy of the two pure disorders nor an additive pathology, and that the performance of the comorbid group as well as the TD association with brain responses were more severe compared to groups with only one of the clinical disorders (Chantiluke et al., 2014). In our study, the comorbid group also showed greater temporal discounting, but their performance was similar to that of the ADHD group and much more impulsive than the ones of the ASD and control groups. Authors such as Kahneman & Tversky (1979) and Dan Ariely (2008) emphasize the irrational dimension of human decision making, arguing that many human decisions are not necessarily optimal from a rational point of view, probably being more related to affective than analytical aspects. Decision-making refers to the process of selecting a particular action from a set of alternatives expected to produce different outcomes (Lee, 2013) and arises from a combination of intuitive (emotional) and analytic processes (Evans, 2003), in addition to the homeostatic context of the individual (Paulus, 2007). In a dual-model perspective, analytic processes may have a higher biological energy cost, while intuitive processes are less expensive (Kahneman, 2003). If in the ADHD vs ASD pattern of decisions we could find an opposite emotional vs analytic way of decision, the costs of that may define the prevalence of a more intuitive strategy when they both occur simultaneously. Future studies may certainly consider that.

The influence of other variables in the temporal discounting task performance, such as age, IQ and comorbidity need to be highlighted. Regarding comorbidities, Antonini and collaborators (2015) observed in a completely hypothetical task that the presence of ODD did not affect the response pattern of children with ADHD, with no significant differences from ODD to the control group as well. Probably these results are influenced by task characteristics. White et al. (2014) investigated the temporal discounting in adolescents with conduct disorder and found a higher level of impulsivity, with significantly more immediate choices than controls. In our ADHD sample, 31% of children had Oppositional Defiant Disorder (ODD) as a comorbidity. The most frequently disruptive disorder coexisting with ADHD is ODD, reaching 50% of cases (APA, 2013). Therefore, this was not an exclusion criterion. The IQ influence was little studied, with none available research that directly investigated performance differences in TD tasks using groups with different levels of IQ. In the present study, no correlation between temporal discounting and our IQ measure was found, as well as AUC and socioeconomic status. Sheres et al. (2014) investigate the effects of age in three groups of healthy subjects, including children (6-12), adolescents (13-17) and adults (18-19). The results show steeper discounting in children when compared with the other groups. Sheres et al. (2006), Antonini et al. (2015) and Utsumi et al. (2016) also reported a significant correlation between delay discounting and age, demonstrating that younger children had greater discounting as in the present research.

This research had some limitations that are important to highlight. Although presenting low frequency in the disorders studied, the absence of girls in the sample limits the findings and the generalization of the results, besides making it impossible to analyze the influence of gender in TD, already reported in previous studies. Another limitation is the small sample, especially of the comorbid group. The clinical presentation, as well as the cognitive profile of ADHD and ASD are quite heterogenous, and a larger sample would better represent it. Another limitation we can mention is the presence of emotional disorders comorbidity in all clinical groups, which may influence performance in the task. Emotional disorders occur in a greater proportion in the ASD + ADHD group here, reflecting the higher severity of these cases. The use of only one type of TD task can also limit the conclusions. The use of completely real or completely hypothetical tasks could allow new analyses concerning the temporal discounting, which can also include primary rewards. This study focused on the temporal discounting, however, the inclusion of other measures of reward processing (e.g., probability tasks; effort based tasks) would also be interesting for future research in the investigation of affective-motivational processes. Besides that, investigation of affective-motivational processes of decision-making at the neurofunctional level is needed, intending to highlight differences between the groups, especially when they co-occur. A design that relies on more than one version of the task and different task types would also increase the understanding of changes in the decision-making processes evident in ADHD and in the comorbid group.

Our results demonstrate that the presence of ADHD comorbidity may worsens the performance of children with ASD alone in the TD task, but the presence of ASD in the comorbidity did not significantly changes the performance of the ADHD group alone. The results suggest that the affective pattern of ADHD decision making overrides the typical pattern found in autism when the disorders co-occur. A significant difference was found between the comorbid group and the control group, although the effect did not survive the multiple comparisons correction. The difference between the comorbid group and the ASD remained significant. We also found that children with ASD had no alterations on motivational-affective processes as measured by temporal discounting. Abnormalities in decision-making are one of the most prominent symptoms of numerous psychiatric disorders, and the emotional aspects of decision-making may be even stronger markers of these complex disorders (Hasler, 2012; Paulus, 2007), which make the study of theses markers of utmost importance for the understanding of specific and shared mechanisms underlying complex disorders.

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5 - CONCLUSÕES E PERSPECTIVAS

Na presente dissertação, apresentamos resultados de duas investigações específicas. Primeiro buscamos investigar a consistência das evidências disponíveis com relação aos padrões de desconto temporal em crianças com autismo e TDAH, discutindo potenciais diferenças entre esses grupos no domínio afetivo motivacional já descritas na literatura. Os resultados dessa investigação, apontaram para um desconto temporal maior em crianças com TDAH comparadas aos controles, com seis de oito estudos disponíveis apontando nessa direção (Dias et al., 2013; 2015; Martinelli et al. 2016; Rosch & Mostofsky, 2016; Utsumi et al., 2016; Wilson et al., 2011). Com relação ao TEA, o único estudo disponível realizado com crianças de 6 a 12 anos, demonstrou maiores descontos temporais nas crianças com autismo comparadas aos controles (Faja & Dawson, 2015). No entanto, como foi discutido em nosso artigo de revisão, a tarefa utilizada tem algumas limitações, dispondo de apenas um ensaio e sem variações sistemáticas da recompensa e do tempo de espera. Como descrito por Sheres et al. (2010) esse tipo de tarefa não possibilita a descrição de uma função de desconto temporal, na qual observamos a diminuição do valor subjetivo em função do aumento do tempo de espera, dificultando generalização desse padrão de resposta em relação ao autismo.

Estudos com diferentes faixas etárias apresentam achados consistentes que sugerem desempenho similar entre crianças típicas, e com autismo no desconto temporal (Antrop et al., 2006; Demurie et al., 2012; Demurie et al., 2013). Um padrão mais analítico de tomada de decisão relacionado ao transtorno também é descrito na literatura, sugerindo que pessoas com TEA tendem a sofrer menos influência dos aspectos afetivos na tomada de decisão (De Martino et al., 2008). Ainda com relação a nossa primeira investigação, não há encontramos nenhum artigo disponível envolvendo crianças com diagnóstico comórbido de TDAH e TEA que tenham investigado o desconto temporal. O único resultado disponível conta com uma amostra de crianças mais velhas (11-17) e descreve um padrão de escolhas impulsivo no grupo comórbido (Chantiluke et al., 2014). Em nossa revisão, foi possível observarmos ainda um consenso em relação à influência da idade sobre o desconto temporal. Crianças mais novas de fato tendem a ser mais impulsivas em tarefas desse tipo.

Em nosso segundo estudo buscamos analisar em uma amostra de crianças brasileiras as diferenças no desempenho em uma tarefa de desconto temporal, usando recompensa monetária hipotética, entre quatro grupos: TDAH, TEA, controles e casos comórbidos de TDAH e TEA, e analisar fatores correlatos (idade e QI). Nesses estudos observamos que crianças com TDAH tiveram um desempenho significativamente pior comparado a crianças controle e com TEA. As crianças com autismo demonstraram um padrão de escolhas semelhante ao grupo controle, sem diferenças significativas. Por fim o grupo comórbido teve um desempenho similar ao grupo com TDAH, indicando que a presença ou não desse transtorno comórbido ao autismo, provoca alterações significativas no processamento afetivo-motivacional. Em nossa amostra o QI não foi correlacionado ao desconto temporal, em contrapartida, a idade dos participantes teve uma associação significativa com o quanto as crianças conseguiam ou não postergar o reforço. Em concordância com a literatura os resultados demonstram que crianças mais novas tem de fato descontos temporais mais elevados do que crianças mais velhas (Sheres et al., 2014). Todos os resultados encontrados nesse estudo corroboram evidências prévias, e ampliam os achados principalmente em relação ao grupo com TEA e comórbido.

O sistema afetivo motivacional parece ser um domínio particularmente interessante para a diferenciação dos padrões de tomada de decisão em crianças com autismo e TDAH, em especial para uma melhor compreensão da comorbidade. A presença do TDAH leva a maior desconto temporal, ou seja, crianças com TDAH tem grande dificuldade de esperar uma recompensa futura, optando geralmente por recompensas imediatas. O grupo com autismo por sua vez, não diferiu dos controles, sugerindo que o desconto temporal no autismo é semelhante ao esperado no desenvolvimento típico.

O presente estudo tem implicações importantes, fornecendo informações que podem facilitar o processo diagnóstico e ressaltar os impactos da comorbidade. O diagnóstico comórbido pode ser difícil, levando em conta a sobreposição de sintomas comum nos transtornos do neurodesenvolvimento. Os dois estudos dessa dissertação sugerem que um maior desconto temporal parece um fator condicionado ao TDAH, ocorrendo apenas em sua presença. Nesse sentido, na presença do diagnóstico de TEA e maior desconto temporal, deve-se investigar a probabilidade de TDAH comórbido.

O estudo de revisão contou com limitações importantes, com destaque para a pequena quantidade de publicações envolvendo quadros de autismo. As diferenças entre as tarefas utilizadas em cada estudo também tornam as comparações difíceis. Dentre as limitações do estudo dois, podemos destacar algumas características da amostra como a ausência de meninas, a quantidade relativamente pequena de casos comórbidos e a presenta de transtornos de humor ao longo de toda a amostra, exceto pelos controles. A ausência de outras medidas de processos afetivo motivacionais também limita as conclusões. Diferenças com relação ao tipo de recompensa, e seu caráter real/hipotético podem influenciar a performance. Além disso, escolhas sob situações que requerem esforço ou que envolvam probabilidade seriam úteis para compreender o fenômeno de maneira mais concreta.

Para estudos futuros, destacamos a necessidade de medidas de neuroimagem, a fim de ampliar a compreensão dos mecanismos subjacentes às alterações comportamentais já observadas. Um design de pesquisa que envolva mais de um tipo de tarefa também aumentaria o entendimento das alterações no processo de tomada de decisão evidentes no TDAH e na comorbidade TDAH e TEA.

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ANEXO 1 (Folha de Aprovação da Dissertação)

UNIVERSIDADE FEDERAL DE MINAS GERAIS

PROGRAMA DE PÓS-GRADUAÇÃO EM MEDICINA MOLECULAR

FOLHA DE APROVAÇÃO

Avaliação dos processos de desconto temporal em pacientes com Déficit de Atenção/Hiperatividade (TDAH), Transtorno do Espectro Autista (TEA) e casos comórbidos

GABRIELLE CHEQUER DE CASTRO PAIVA

Dissertação submetida à Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação em MEDICINA MOLECULAR, como requisito para obtenção do grau de Mestre em MEDICINA MOLECULAR, área de concentração MEDICINA MOLECULAR.

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Belo Horizonte, 31 de julho de 2017.