

Temporal discounting and attention-deficit/hyperactivity disorder in childhood: reasons for devising different tasks

Desconto do futuro e o transtorno de déficit de atenção/hiperatividade: razões para o desenvolvimento de diferentes tarefas

Daniel Augusto Utsumi,¹ Mônica Carolina Miranda²

Abstract

Introduction: Temporal discounting (TD) describes how a certain reward is seen as less valuable the more its delivery is postponed. There are two main types of TD tasks, hypothetical and real, both of which use monetary rewards. Over the last few years, however, variants of these tasks have been adjusted to assess clinical groups of children showing impulsivity as found in attention-deficit/hyperactivity disorder (ADHD).

Objective: To review and discuss studies conducted over the last 10 years on the use of TD tasks in the assessment of pediatric patients with ADHD.

Method: For this literature review, articles were non-systematically selected from PubMed, MEDLINE and SciELO databases to include experimental studies on the use of at least one TD paradigm to assess and distinguish ADHD and non-ADHD groups.

Results: Of the studies assessed, 76.19% used hypothetical tasks, followed by real tasks (28.57%), and, finally, tasks using different types of reward, such as toys or rewarding activities (14.28%).

Conclusions: Although assessed in few studies, real and alternative tasks appeared to be effective in differentiating clinical groups and suitable for investigating hot executive functions in childhood.

Keywords: ADHD, temporal discounting, hypothetical task, real task, children.

Resumo

Introdução: O desconto do futuro (DF) é um processo no qual uma determinada recompensa é vista como menos valiosa à medida que sua entrega é postergada. Existem dois tipos principais de tarefas de DF, hipotéticas e reais, sendo que ambas usam recompensas monetárias. Nos últimos anos, no entanto, variantes dessas tarefas têm sido adaptadas para avaliar grupos clínicos de crianças que apresentam comportamento impulsivo, como no caso do transtorno de déficit de atenção/hiperatividade (TDAH).

Objetivo: Revisar e discutir os estudos realizados nos últimos 10 anos sobre o uso de tarefas de DF na avaliação de pacientes pediátricos com TDAH.

Método: Para esta revisão de literatura, os artigos foram selecionados de forma não sistemática nas bases de dados PubMed, MEDLINE e SciELO, de forma a incluir estudos experimentais sobre o uso de ao menos um paradigma de DF para a avaliação e distinção de grupos com e sem TDAH.

Resultados: Dos estudos avaliados, 76,19% utilizaram tarefas hipotéticas, seguidas de tarefas reais (28,57%) e, finalmente, de tarefas com diferentes tipos de recompensa, como brinquedos ou atividades recompensadoras (14,28%).

Conclusões: Embora avaliadas em poucos estudos, tarefas reais e alternativas parecem ser eficazes na diferenciação de grupos clínicos e adequadas para investigação de funções executivas quentes na infância.

Descritores: TDAH, desconto do futuro, tarefa hipotética, tarefa real, crianças.

¹ Departamento de Psicobiologia, Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil. ² Programa de Mestrado em Psicossomática, Universidade Ibirapuera, São Paulo, SP, Brazil.

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Introduction

Temporal discounting (TD) refers to tendency of rewards to be discounted the more their delivery is delayed.^{1,2} Initially designed for the assessment of adults, in recent years this paradigm has helped draw important parallels between emotion and decision-making³ in neurodevelopmental disorders marked by impulsivity, including attention-deficit/hyperactivity disorder (ADHD).⁴ Research shows that patients with ADHD have higher TD rates than typically developing individuals,⁴⁻¹¹ especially among younger children as compared to adolescents and adults.^{12,13} These data are reinforced by neuroimaging studies that have detected alterations in circuits associated with encoding rewards and intertemporal choice in patients with ADHD during TD tasks.^{11,14}

Essentially, TD tasks consist of a series of trials offering a choice between a small immediate reward and a large one delivered after a certain delay.^{1,15} Varying the range of immediate rewards and delays obviously requires an increased number of trials to obtain averages. After tasks are completed, the level of discounting may be calculated for each choice, based on specific parameters. The free parameter k reflects the sensitivity for delayed reinforcers,^{1,16} but many studies have used the indifference point at which a subject no longer shows any preference between waiting for a larger reward or taking an immediate smaller one.¹⁷ By determining a set of indifference points for each delay, the total discounting rate may be estimated by calculating the area under the curve (AUC).^{10,17}

There are basically three types of TD tasks: hypothetical, real, and those that will here be called alternative tasks. The former uses longer delays, ranging from days to weeks, and larger monetary rewards. Real tasks are formally very similar to hypothetical ones and also involve monetary rewards, but rewards are actually delivered and time intervals may be experienced.¹⁰ Unlike studies using hypothetical tasks, real tasks commonly use smaller rewards (a few cents) and shorter delays (from a few seconds to a few minutes). Alternative tasks may feature combinations of hypothetical and/or real tasks and rewards such as toys, food, or rewarding activities.

Of the many theories attempting to explain the performance of patients with ADHD on TD tasks, the delay aversion model is one of the most widely used. This model gives special emphasis on the behavioral aspect and states that preference for immediate reward is motivated by the desire to avoid experiencing negative emotional states associated with enforced waiting.¹⁸⁻²⁰ More recently, Sonuga-Barke & Fairchild²¹ have also developed a decision-making model based on psychiatric

neuroeconomics, which posits that deficits of patients with ADHD on TD tasks arise from dysfunctions in three distinct but correlated brain circuits: 1) prospective, involving the default network; 2) the reward circuit; and 3) the executive network.²²

It is important to note that variables such as age, type of tasks, magnitude of the reward, length of delay, and symptomatological characteristics are fundamental to better adjust TD tasks to children's preferences, ensuring more consistent results based on neurodevelopmental stages.

In view of the foregoing, several variables should be considered when devising TD tasks, especially the age of the participants, symptomatological characteristics, types of tasks, and models employed. Thus, the present study reviews research published in the last 10 years on the use of TD paradigms to assess patients with ADHD, analyzing the influence of the factors mentioned above on the differentiation of the experimental groups.

Method

This study is a narrative review. Articles on the use of TD tasks to assess ADHD published between January 2006 and July 2017 were non-systematically selected from the PubMed, MEDLINE and SciELO databases. The terms "ADHD AND (Temporal OR Delay) Discounting" were used in the search.

The following eligibility criteria were observed: experimental studies that used at least one TD task to assess ADHD and control groups not using methylphenidate. Reviews, studies that did not evaluate ADHD or emphasized the investigation of other disorders, research with animals, studies lacking information about tasks and results, and articles in languages other than English, Portuguese and Spanish were excluded.

Results

Articles whose title did not meet the eligibility/exclusion criteria at first reading were automatically excluded. Of the remaining articles, many were excluded after reading the abstract, and a smaller portion after reading the full text. A total of 21 articles met the eligibility criteria explained above, i.e., experimental studies on the use of TD tasks in ADHD and control groups not using medication. Figure 1 shows the flowchart for study selection. Sixteen studies (76.19%) used hypothetical monetary tasks. Of these, 9 (56.26%) found differences between patients with

ADHD and controls, regardless of age.^{4,5,7,8,11,23-26} In terms of age groups, 9 studies evaluated only children and adolescents.^{4,6-8,11,22,26-28} Five of these (55.55%) were successful in distinguishing ADHD from non-ADHD groups.^{4,6,8,11,29} One found a slight difference between ADHD and control groups, which did not resist covariation with intelligence quotient (IQ).⁷ Of the four studies that evaluated adults alone,^{5,14,23,30} two (50%) were able to distinguish between patients with ADHD and controls,^{5,23} and the two studies covering a wider range of age groups (children, adolescents, and adults) were also capable of distinguishing individuals with ADHD from healthy ones.^{25,26}

The six studies (28.57%) that used real monetary tasks evaluated only children and adolescents (Figure 1). It is important to note that some of them also applied hypothetical tasks and were previously described here. Of these, three (50%) studies were able to differentiate between ADHD and control groups consisting of children and adolescents,^{8,9,22} especially between patients with combined ADHD presentation and controls.^{8,9} The other three studies found no differences between groups.^{26,31,32} However, two of these used even smaller rewards and shorter delays than the conventional ones for this type of task.^{26,32}

Only three (14.28%) studies used alternative tasks. One applied a task with hypothetical monetary reward and a real-time task with consumable rewards,³³ but only the latter yielded between-group differences, which were attributed to the interaction between group and sex. Another study used three types of tasks with toys as rewards: hypothetical, real, and a new type entitled as hypothetical with temporal expectation, in which toys were not delivered but delays could be experienced.³⁴ This was the only task that showed significant between-group differences. Both studies covered the same age group, i.e., 8-12 years old. Demurie et al.⁶ assessed participants aged 8-16 years using other types of rewards, such as edibles, social gains, material rewards, and gratifying activities, but did not find between-group differences, although they found that monetary rewards and material gains such as toys showed similar levels of reinforcement.

Discussion

As predicted, hypothetical tasks with monetary rewards were the most widely used, followed by real tasks with monetary rewards and, finally, alternative

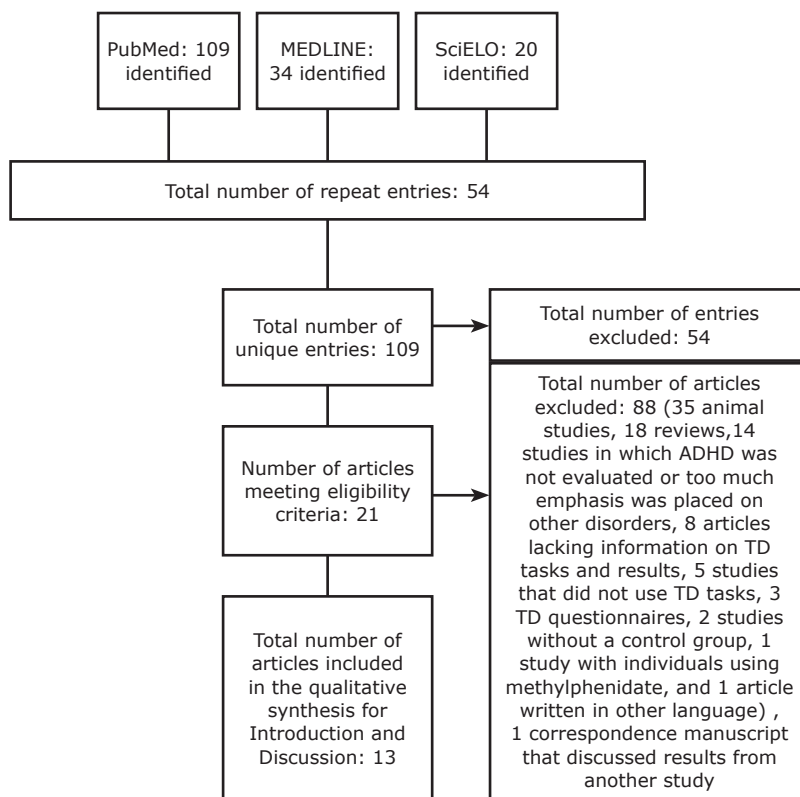


Figure 1 - Study selection process across different stages of the review

tasks. Hypothetical and real tasks were similar in terms of differentiation between ADHD and control groups in childhood. Despite the small number of studies, real and alternative tasks held promise for assessing children and adolescents.

Differences between ADHD and non-ADHD groups appear to be more pronounced among younger children. This may be related to the notion that the processes involved in decision-making depend on the maturation of executive functions, which takes place most intensely from adolescence onwards due to remodeling of the dopaminergic and reward systems, as highlighted by a relevant review.¹² A meta-analytic review conducted by Pauli-Pott et al.¹² showed significant differences between ADHD and control groups, especially in preschoolers as compared to school-age and adolescents participants.

Together with this factor, type of task may or may not favor assessment of children. According to Sonuga-Barke & Fairchild,²¹ hypothetical tasks would involve much more prospective activity in comparison with real tasks, requiring the individual to create subjective projections about the future and consequently more sophisticated considerations.

This hypothesis certainly poses a more persuasive explanation than the delay aversion model, especially given the data reported by Scheres et al.,⁸ who have experimentally shown that high TD rates are not necessarily linked to a waiting aversive notion. In addition, the delay aversion model seems to be more concerned with the hyperactivity-impulsivity, rather than the inattention, observed in ADHD. In this respect, studies show that hyperactivity-impulsivity symptoms predict high discounting rates on TD tasks, whereas inattention symptoms do not.^{8,9,11} This point, in addition to the age-related performance differences found between ADHD and control groups, may indicate that children with combined ADHD presentation are more likely to present impairments in TD tasks, although this is not an absolute fact. Scheres et al.,³² for example, also found performance differences among children and adolescents in TD tasks, but not between ADHD and control groups. Thus, other factors are equally fundamental for the design of effective tasks for the differentiation of clinical groups.

An important aspect is how length of delay and magnitude of reward affect TD tasks. As mentioned above, real and hypothetical tasks differ in magnitude of reward and length of delay,^{22,34} since using large amounts of money and long intervals is not practical for real tasks. However, a key question is to what extent delays and rewards may be diminished while still triggering impulsive responses. This explains why the two studies that used smaller rewards failed to detect intragroup differences.^{26,32}

In addition to the magnitude of rewards, the type of reward used for tasks is a key aspect, since monetary tasks have been created to assess adults. TD tasks have also been adapted, as shown by studies involving alternative tasks.^{6,33,34} Regardless of the results, these studies have demonstrated that other types of rewards trigger behavioral responses such as those observed when using money in children and adolescents. In addition, the study by Utsumi et al.³⁴ demonstrated the effectiveness of a new type of task called hypothetical with temporal expectation.

When discussing these experiments, a relevant question arises in relation to the subjective value posed by non-monetary rewards. Although two of the studies had previously sought to assign objective value to rewards,^{6,34} this issue may be the main bias that limits the use of alternative rewards in TD studies. At the same time, these studies favor the delineation of new tasks, which are similar to daily decision-making situations.

The present study shows that, despite their infrequent use, real tasks with monetary rewards are as effective as hypothetical tasks when assessing intertemporal choice in patients with ADHD based on the neurodevelopmental stages of executive functions. In addition, this study highlights the importance of re-examining length of delay and magnitude and type of reward to devise more appropriate tasks for children's preferences.

Disclosure

No conflicts of interest declared concerning the publication of this article.

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Correspondence:

Mônica C. Miranda
 Rua Embaú, 54, Vila Clementino
 04029-060 - São Paulo, SP - Brazil
 Tel.: +55 (11) 55496899
 E-mail: mirandambr@yahoo.com.br