Trends
in Psychiatry and Psychotherapy

Review Article

Neuropsychological and behavioral assessment of impulsivity in adolescents: a systematic review

Avaliação neuropsicológica e comportamental da impulsividade em adolescentes: uma revisão sistemática

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Abstract

Introduction: The aim of neuropsychological assessment is to understand the multifaceted relationship between behavior, cognition and brain organization. The main objective of this study was to conduct a systematic review of the literature on impulsivity and inhibitory control in healthy adolescents and preadolescents.
Method: Three researchers conducted a systematic review on November 25, 2014. The first step was to conduct searches on the Web of Knowledge and PubMed databases for articles in English using the following keywords: child; adolescents; impulsivity; inhibition; inhibitory control; and neuropsychology. The second step was to analyze all the references cited in the articles selected from the search results in order to identify further literature.
Results: Just 13 articles met all the inclusion criteria. There was no consistency in the aims of these studies, or in the instruments or procedures employed.
Conclusion: There was no uniformity among the articles that met all the criteria in terms of any of the items analyzed. There was considerable heterogeneity in these studies of impulsivity and inhibitory control, and few of them evaluated healthy samples.
Keywords: Adolescence, neuropsychology, impulsivity, inhibitory control, systematic review.

Resumo

Introdução: O objetivo da avaliação neuropsicológica é compreender a relação multifacetada entre comportamento, cognição e organização cerebral. O principal objetivo deste estudo foi conduzir uma revisão sistemática da literatura sobre impulsividade e controle inibitório em pré-adolescentes e adolescentes saudáveis.
Métodos: Três pesquisadores conduziram uma revisão sistemática em 25 de novembro de 2014. O primeiro passo foi fazer pesquisas nas bases de dados Web of Knowledge e PubMed buscando artigos em inglês usando as seguintes palavras-chave: child; adolescents; impulsivity; inhibition; inhibitory control; e neuropsychology. O segundo passo foi analisar todas as referências citadas nos artigos selecionados a fim de identificar mais literatura.
Resultados: Apenas 13 artigos preencheram todos os critérios de inclusão. Não houve consistência nos objetivos desses estudos, ou nos instrumentos ou procedimentos empregados.
Conclusões: Não houve uniformidade entre os artigos que preencheram todos os critérios em termos de qualquer um dos itens analisados. Houve uma heterogeneidade considerável nesses estudos sobre impulsividade e controle inibitório, e poucos deles avaliaram amostras saudáveis.
Descritores: Adolescência, neuropsicologia, impulsividade, controle inibitório, revisão sistemática.

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Financial support: none. Rosa Maria Martins de Almeida is research productivity fellow at Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Porto Alegre, RS, Brazil.

Submitted Apr 17 2015, accepted for publication Jan 26 2016. No conflicts of interest declared concerning the publication of this article.

Suggested citation: Willhelm AR, Fortes PM, Czermainski FR, Rates AS, de Almeida RM. Neuropsychological and behavioral assessment of impulsivity in adolescents: a systematic review. Trends Psychiatry Psychother. 2016;38(3):128-135. http://dx.doi.org/10.1590/2237-6089-2015-0019

Introduction

Adolescence is a period of life characterized by many different experiences, including increased social interaction, willingness to try new things, seeking approval in one's environment, physical maturation and brain development.[1,2] This phase also features high risk behavior and impulsive acts, such as the use of drugs and alcohol, criminal activities and unprotected sex.[3]

To understand the cognitive and neurobiological changes in adolescence, it must be comprehended as a transitional period.[4] The competence of cognitive control capacities increases during this stage of life and this is dependent on maturation of the prefrontal cortex, which continues to develop until early adulthood.[5]

Full development of the brain occurs when the young adult reaches around 21 years of age.[3] However, studies have shown that in some adults the brain's development is never complete.[6] In adolescence, cognitive control is not fully developed and the reward system in this period leads to increased gratification seeking, irrespective of the risks involved or of rules.[7,8]

During this period, new learning related to new demands and expectations leads to improvement of skills such as selective attention, divided attention, working memory and executive functions, including inhibitory control.[9] This can be explained by the fact that synaptic proliferation and development of the brain in adolescence have neuropsychological consequences, especially for the prefrontal cortex functions.[10]

Inhibitory control is a broad term and refers to the capacity for the flexibility needed to adapt one's behavior when faced with cognitive conflict, interference or competition.[11] This component is essential in regulating the wildest forms of behavior, involving mature resources to delay gratification, inhibit impulsive behavior and organize activities.[11,12]

There are few studies on impulsiveness, inhibitory control and neuropsychological assessment in healthy adolescents.[11,13,14] The aim of neuropsychological assessment is to understand the multifaceted relationship between behavior, cognition and brain organization.[15,16] It was first described in studies that evaluated cognitive deficits secondary to neurological conditions.[17,18] However, the field of developmental neuropsychology, the study of the maturation, maintenance and decline of cognitive functions at different ages and phases of life, is an area of growth in scientific research circles.[16] Studies have been conducted to assess critical stages of life, including language acquisition in children and memory decline in elderly adults.[17-19]

Sex and age-based evaluations and comparisons of samples of healthy adolescents are important for understanding normal development at this stage of life. One study in the field found that male adolescents were less efficient than female adolescents in exercising strategic control to reduce their responses to conflict, suggesting there are sex differences in inhibitory control in adolescents.[11] A study that investigated maturation of inhibitory functions during childhood and adolescence in a sample of 99 Spanish students aged from 6 to 17 years found that inhibitory functions increased with age.[15] This kind of study reports the results of comparisons and illustrates normal development in adolescence.

It is important to investigate impulsivity and control inhibition in healthy adolescents to gain a greater understanding of the relationships between maturation of the prefrontal cortex and these behaviors.[3,8] It is also important to conduct research that compares male and female adolescents in order to understand sex-linked differences in maturation and the prevalence of these behaviors.[11]

The main objective of this study was to investigate the literature on impulsivity and inhibitory control in healthy adolescents and preadolescents by means of a systematic review. Secondary aims were to identify instruments used to assess these phenomena and to determine whether there are any similarities between studies in terms of the ages of participants and the instruments administered. Our focus is on the assessment of impulsivity of people without diagnoses, since this area is not explored in psychology. This paper adopts the positive psychology approach, a research model concerned with potentially healthy aspects of human beings, as opposed to traditional psychology and its emphasis on psychopathology.[20]

Method

A systematic review was conducted by three researchers on November 25, 2014. The review was conducted by searching the Web of Knowledge and PubMed databases for articles published in English only. The first step of the research was conducted using six combinations of keywords: [child AND impulsivity AND neuropsychology]; [adolescents AND impulsivity AND neuropsychology]; [child AND inhibitory control AND neuropsychology]; [adolescents AND inhibitory control AND neuropsychology]; [child AND inhibition AND neuropsychology]; [adolescents AND inhibition AND neuropsychology]. Since the selection criterion was to include studies whose samples included preadolescents and adolescents, the keywords were designed to select studies that evaluated both age groups. The keyword "child" was included in order to identify articles

describing samples that covered the ages of interest (from preadolescence at 10 years old[21] up to the age of 18). The keyword "neuropsychology" was included to cover all types of neuropsychological evaluation: tests, tasks, assessments, instruments, questionnaires and others. All keywords used in the search were Medical Subject Headings (MeSH).

Each researcher independently evaluated the studies found in the first step against the following criteria: 1) publication dates from 2003 to 2014; 2) empirical studies; 3) human research that includes preadolescents and/or adolescents (10-18 years); 4) research that includes healthy individuals only; 5) articles that report some kind of neuropsychological assessment; 6) studies involve assessment of impulsivity and inhibitory control. Papers that failed to meet one or more of these criteria were excluded, so only those that met all of them were included in the analysis. Repeated articles were excluded.

Initially, the articles were analyzed on the basis of their abstracts. When the abstract was not conclusive, methods and results sections were also evaluated. The full texts of selected articles were analyzed. Classification was performed by three researchers, who acted as judges in the analysis of concordance between study characteristics and inclusion criteria.

The initial searches identified 652 articles using all of our keyword combinations to query both databases: 398 articles were found on PubMed and 254 on the Web of Knowledge. Twenty of these met all the criteria, based on their abstracts, and these were read in full. This resulted in the rejection of a further seven articles which did not meet all of the selection criteria in this more thorough assessment. Figure 1 contains a flowchart illustrating the analysis. After the systematic review, a second step was performed in which all the references in the articles included were analyzed in search of further relevant literature.

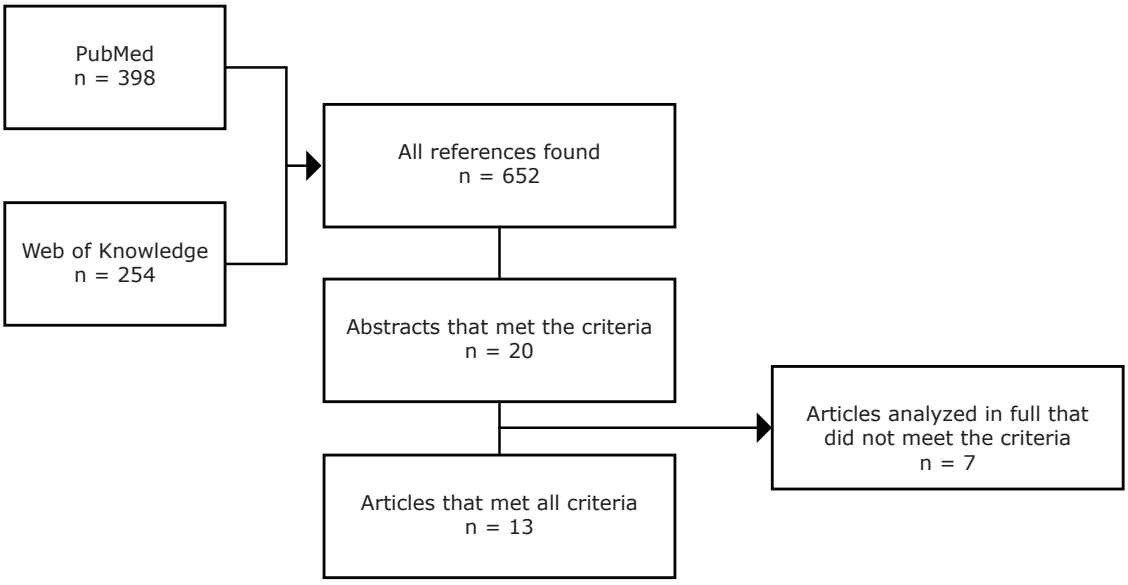

Figure 1 - Flowchart of systematic review.

Results

In the first stage of the selection process, the abstracts of 20 articles met all the search criteria, but after examination of the full texts, just 13 of them were found to meet all the criteria. The results of the review are shown in Table 1, listing the following information about the 13 studies: their aims, number of participants, age or average age of participants, instruments used in the assessments, and their results.

Table 1 - Analysis of selected articles in systematic review

Authors	Number of participants	Age	Aim	Assessment	Results
Wright et al.[22]	155	3-16	Evaluate the Stroop task with images of animals.	A new, Stroop-like measure of inhibitory function.	The task provides a robust measure of inhibitory function across an age range of 3-16 years.
van Deurzen et al.[23]	2,179	10-12	Examine the relationship between neurocognitive functioning and affective problems through adolescence.	Amsterdam Neuropsychological Tasks Program (ANT).	Slower baseline speed, enhanced response time variability, deficient response inhibition and poor working memory were cross-sectionally associated with baseline affective problems in girls.
Urben et al.[24]	62	6-13	Examine the bottom-up influence of emotional context on response inhibition.	Stop signal tasks: one with circles, one with neutral faces, and one with emotional faces (happy and sad).	Emotional context altered response inhibition ability in childhood. However, no interaction found between age and emotional influence on response inhibition.
Aran-Filippetti & Minzi[25]	254	7-12	Analyze associations between different socioeconomic indicators and the executive functions of schoolchildren.	Graffar's modified scale, Kaufman Brief Intelligence Test, Matching Familiar Figures Test-20, Stroop Color-Word Interference Test, Wisconsin Card Sorting Test (WCST), Digit span and letter-number sequencing subtests of the WISC-IV, Porteus Maze Test, the FAS version of the controlled oral word association test (COWAT).	Significant effect of SES (socioeconomic status) on all executive functions tested.
Nichelli et al.[26]	100	6-11	Investigate the development of a capacity to inhibit automatic responses in young and middle childhood.	An animal Stroop task, conflicting motor response task.	Performance clearly improves in both tests during the course of a child's development.
Yücel et al.[11]	153	11-13	Examine how sex, temperament and intelligence are related to different aspects of inhibitory control.	Early Adolescent Temperament Questionnaire - Revised (EATQ-R); Parent report version of the Early Adolescent Temperament Questionnaire (PEATQ) (temperament); The Socio-Economic Indexes for Areas (SEIFA) Index of Relative Socio-Economic Disadvantage (IRSD); WISC-IV; Stroop modified.	Girls were more efficient than boys in the use of strategic control to reduce the magnitude of conflicting responses.
Polderman et al.[27]	1,209	9, 12, 18	Investigate the association between attentional and inhibitory control problems and test the extent of this association due to genetic factors shared with intelligence quotient (IQ).	Stroop Color Word Task, WISC and WAIS.	Attentional problems and inhibitory control were correlated only in the cohort aged 12 years, but this correlation was not significant when IQ was controlled.
Kohls et al.[13]	65	8-12	Assess motivation and inhibitory control.	Go/no-go task, The Behavioral Inhibition Scale (BIS)/Behavioral Activation Scale (BAS).	Both social and non-social rewards significantly improved social task performance, although effects on inhibition were only observed for monetary reward.

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Urben et al.[28]	159	5-12	Analyze the trends of response inhibition development during childhood.	Stop signal task, N-back task and processing speed task.	An improvement in the ability to inhibit the response in the age group 5–10 years.
Silveri et al.[29]	21	9-15	Study the relationship between the microstructure of white matter (WM) and inhibition of impulsive behavior in female and male adolescents.	Bar-On Emotional Quotient Inventory, Stroop Color-Word Test.	Sex-related differences for the relationship between white matter and impulsive behavior in right anterior corpus callosum for males and splenium for females.
Wassenberg et al.[30]	451	7-13	Study the development of the third aspect of selective attention.	D2	Age differences were observed in processing speed, which continued to develop through sixth grade.
Leon-Carrion et al.[15]	99	6-17	Evaluate inhibitory control.	Stroop test.	Existence of sex-related differences in both response time and in errors. The interference increased in the first age group.
Pureza et al.[31]	90	6-12	Observe differences in executive functions.	Verbal fluency, narrative discourse, random number generation, N-Back, Bells Test and Hayling Test.	There is progressive development of executive functions during childhood.

With regard to the main objective of this review, it was observed that there was no consistency across the 13 articles that evaluated inhibitory control and impulsivity in healthy adolescents in terms of type of evaluation, instruments used, study objectives or age of the participants, demonstrating that there is still heterogeneity in this field. For example, some studies used the Stroop Task,[22,26] while others used a battery of instruments.[11,25] This will be discussed in detail below, but this heterogeneity in research in this field shows that a system has not yet been developed and that it is difficult to choose which protocol to follow when investigating inhibitory control in healthy adolescents.

It was observed that just one of the papers analyzed in this review studied the adaptation of a new task for the measurement of inhibitory functions (designed for children aged from 3 to 16 years),[22] but this measure was not primarily focused on adolescents. The most common measure in the remaining studies was the Stroop test (six studies used this instrument).

Three of the studies compared males' and females' performance.[11,23,29] These studies were dissimilar because they used different instruments. One used the Amsterdam Neuropsychological Tasks Program.[23] Another used the Bar-On Emotional Quotient Inventory and the Stroop Color-Word Test.[29] The third also used the Stroop test, but as part of a battery of questions and tasks that were not used in any other study selected for this review, comprising the Early Adolescent Temperament Questionnaire - Revised (EATQ-R); the parent report version of the Early Adolescent Temperament Questionnaire (PEATQ) (temperament); and the Socio-Economic Indexes for Areas (SEIFA) Index of Relative Socio-Economic Disadvantage (IRSD); and the WISC-IV.[11]

The studies also differed somewhat with regard to the ages of their samples, with participants' ages ranging from 3 to 18 years. Eleven studies included children under the age of 10 and thus did not exclusively cover the period of adolescence. Most of the studies were designed to evaluate young people's development from childhood to adolescence, rather than focusing on a specific age. The two studies that did focus on specific age groups were by Yücel et al.,[11] who evaluated youths aged 11-13 years with a mean age of 12.6 years, focused on pre-teens, and by Deurzen et al.,[23] who also focused on preadolescents, aged 10 to 12 years.

One study found that inhibitory control performance improved with age and that when the task required a stronger inhibitory control the response time trends were more varied.[22] Another paper evaluated four age groups (7, 11, 15 and 21 years) and concluded that there was an improvement in inhibition from 11 to 15 years, when participants attained adult levels in the tasks, although the proportion of perfect solutions increased into adulthood.[32] The results of one study showed an improvement in the ability to inhibit responses between the ages of 5 and 10 years.[27] This improvement remained significant after controlling for the influence of working memory and processing speed.

One study of children, preadolescents and young adults (n = 81) tested cognitive control and used a selective inhibition task that required participants to keep the selection rule active in their working memory.[33]

The results suggest that the selective inhibition task imposed high demands on cognitive control processes.[33] This was the only study of cognitive control and selective inhibition.

In another study, the authors did not mention age in their results, however, they found that most children had high scores on scales with rewards and showed an improvement in the inhibition of responses only when a monetary reward was offered.[13] This study used the go/no-go task, and the Behavioral Inhibition (BIS)/ Behavioral Activation Scale (BAS) to evaluate children and adolescents (n = 65), and was the only study to use this assessment.

Finally, another paper observed no relationship between age and emotional influence on the inhibitory response of emotions and valence (positive or negative), although it was concluded that emotional contexts alter the ability to inhibit response in childhood.[24]

Two papers analyzed the construction of verbal intelligence and reading in correlation with inhibitory control.[15,27] One found that the reading of words plays an important role in the performance of the Stroop test.[15] In the other study, Polderman et al.[27] conducted a study of twins and concluded that the association between attentional and inhibitory control problems reported in the literature could be derived mainly from genetic factors that are shared with intelligence quotient (IQ). Another study featured in this review found a significant effect between socioeconomic status and the executive functions tested.[25] This was the only study that attempted to relate socioeconomic status to impulsivity.

Analysis also revealed that one of the papers combined assessment by neuropsychological instruments with neuroimaging. This study used the Bar-On Emotional Quotient Inventory and Stroop Color-Word Test to assess healthy adolescents who also underwent diffusion tensor imaging using a 3.0-T magnetic resonance imaging system.[29]

Discussion

All the articles analyzed in this review differ from each other in terms of the nature of the assessments conducted and the age of participants. The objective of this first systematic review was to find out what instruments are being used and whether there is any similarity between the assessments. There were no similarities across the papers. Rather, each research study used different assessments and evaluated different age groups.

Overall, there are few studies of inhibitory control in healthy adolescents using neuropsychological assessments.[11,13,14] This is probably the reason why there is such a lack of uniformity among studies of this population. Adolescence itself is a period of many changes[1,2] and this may explain why studies select just one phase of adolescence to evaluate or choose to compare specific ages, as illustrated by the results of this review. Furthermore, in general, the objectives of these studies were not only to evaluate inhibitory control, but also to compare it with other variables, which necessarily generated differences in the assessments chosen. Notwithstanding, it is important to point out that there was also variation in the type of evaluation used specifically to assess inhibitory control.

As noted in the results, three studies evaluated inhibitory control/impulsivity by comparing male and female adolescents.[11,23,29] Comparison between the sexes is important, since adolescents of the same age may exhibit different results for the measures tested. However, there was no uniformity in the results of these three studies, since one study found that emotional problems in girls can result in poor response inhibition[23] and another showed that girls tend to avoid conflict and resolve their problems without arguing or fighting.[11] Since adolescence is marked by risky behavior and multiple changes,[3] it may be difficult to find consensus in the literature on comparisons between the sexes. It is possible that neurobiological understanding is particularly important when comparing the sexes, since there are differences in brain activation between boys and girls, as shown in the study by Silveri et al.[29]

Regarding age, there was a consensus among the studies in this review that there is an increase in inhibitory control as adolescence progresses. This trend has also been observed in other literature reviews.[1,2,7] As described in the results of this study, 11 out of the 13 articles selected for this systematic review also evaluated children as part of their samples and reported in their findings that inhibitory control is lower among children than in adolescents, demonstrating an increase over childhood levels of inhibitory control during adolescence. A review of the literature on brain development suggests that cognitive development during adolescence is associated with a progressive increase in the efficiency of cognitive abilities of control.[34]

The results also showed that two studies evaluated verbal intelligence in correlation with inhibitory control. Studies like this are important because the literature indicates that inhibitory control can assist in intelligence tests.[35-38] One of the studies[27] that assessed intelligence and inhibitory control (and the only study of this kind, using twins) enriches the field, since it showed that IQ is also shared with genetic factors. Also unique among the studies selected for this systematic review was a study

comparing impulsiveness with socioeconomic status.[25] This research reported important results for analysis of economic class and impulsive behaviors in young people. Furthermore, the association between socioeconomic status and executive functions is particularly explained by cognitive impulsivity.[25]

A limitation of this systematic review was the restriction of article selection to those published in English. If the search had been opened up to more languages and run on a larger number of databases the results might have been different and possibly more articles would have been analyzed and included in the results. Another limitation that can be singled out is the criterion of only selecting papers that assess healthy subjects; if studies had been included that evaluate clinical and control groups, it is likely that more articles would have been eligible for the review. We suggest that clinical groups and controls be included in future systematic reviews.

In conclusion, in this review we found no uniformity between articles in any of the items analyzed. Inhibitory control and impulsivity were correlated with many other factors, such as executive functions, emotion, intelligence, reading and socioeconomic status. There is great diversity in studies of impulsivity and inhibitory control, and few of them include healthy participants in their samples, which was a criterion for selection for analysis in this paper. No articles were found that focused exclusively on the 10-18 years age group, the adolescent phase. However, some studies restricted their samples to the 10-12 years age group and others extended this criterion and investigated both childhood and adolescence.

Final considerations

The importance of this study to the field of neuropsychological evaluation of inhibitory control and impulsivity is founded on the thorough search for articles evaluating these variables in healthy adolescents. This study has a significant impact on the area because it found that there is no uniformity across evaluations, showing that there is a need for a widely-accepted protocol to further research in the area. In conclusion, more research into these behaviors in healthy adolescents is needed in order to provide a better understanding of cognitive functioning in preadolescence and adolescence.

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