



Original

Antisocial Behavior and Executive Functions in Young Offenders[☆]



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ABSTRACT

Antisocial behavior is related to the injury of the prefrontal cortex and a growing body of research points to the executive dysfunction as a risk factor for the onset, maintenance and abandonment of delinquency. Due to the complexity of the study of executive functions and the diversity of methodologies used for the study of this relationship, the empirical evidence is divergent. The aim of this paper is to clarify the relationship between delinquency and executive dysfunction in juvenile samples. For this purpose, a meta-analysis is performed with 33 published articles until 2014. The results of the meta-analysis support the existence of an executive alteration in young offenders. The magnitude of this alteration could be influenced by the age and the type of test used to evaluate executive functions.

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Conducta antisocial y funciones ejecutivas de jóvenes infractores

RESUMEN

La conducta antisocial se relaciona con la lesión del córtex prefrontal, y un cuerpo creciente de investigaciones señala la disfunción ejecutiva como factor de riesgo para el comienzo, mantenimiento y abandono de la conducta delictiva. Debido a la complejidad del estudio de las funciones ejecutivas y a la diversidad de metodologías utilizadas para el estudio de esta relación, las evidencias empíricas son divergentes. El objetivo de este trabajo es clarificar la relación existente entre la conducta delictiva y la disfunción ejecutiva en muestras juveniles. Para ello se realiza un metaanálisis con 33 artículos publicados hasta 2014. Los resultados del metaanálisis apoyan la existencia de una alteración de las funciones ejecutivas en la población juvenil con conducta antisocial penada, y señalan que la magnitud de esta alteración puede verse influida por la edad y por el tipo de prueba utilizada para la evaluación de las funciones ejecutivas.

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Palabras clave:

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Introduction

Executive functions (EF) are defined as a set of high-level cognitive abilities that are involved in readjustment or adaptation of behavior in order to meet complex objectives requiring a novel, creative approach (Gilbert & Burgess, 2008). While there are numerous definitions that emphasize their participation in different cognitive processes (flexibility, attention, decision making, planning,

fluency, inhibition and processing speed, etc.), executive functioning in short refers to a number of mechanisms involved in resolving complex situations (Friedman et al., 2008; Tirapu, Muñoz-Céspedes, & Pelegrín, 2002). Thus, EFs make it possible consider both the immediate consequences and the medium- and long-term repercussions of one's behavior (Bechara, Damasio, & Damasio, 2000), and to exercise adequate cognitive and emotional regulation (Barkley, 2001; García-Fernández, González-Castro, Areces, Cueli, & Rodríguez Pérez, 2014; Tirapu-Ustárrroz, García-Molina, Luna-Lario, Roig-Rovira, & Pelegrín Valero, 2011). Two types of functions are described: "cold" EF, that is, metacognitive functions involved in processes like problem solving, planning and concept formation; and "hot" EF, those that coordinate cognition with emotion/motivation (Ardila & Ostrosky, 2008; Steinberg, 2005, 2007). Although EFs are primarily associated with the prefrontal cortex (PFC), other brain areas involved in the circuits that

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connect with this area (gray nuclei, thalamus and cerebellum) also intervene in proper EF functioning (Masterman & Cummings, 1997). Consequently, the complexity of the functions, structures and connections incorporated in this concept make assessment especially challenging for researchers in this area (Flores, Ostrosky-Solís, & Lozano, 2008). It also explains why EFs are involved in the appearance of several disorders: dysexecutive syndrome (DS), autism spectrum disorders (ASD), Tourette's syndrome, attention deficit disorder (ADD), attention deficit with hyperactivity disorder (ADHD) and behavior disorders. In relation to antisocial behavior (ASB), the study of EFs cannot be simplified.

With regard to the onset and persistence of ASB, several theories and many authors indicate a number of risk factors that may increase its likelihood of appearing; these include school failure or dropout, peer influence, drug use, the neighborhood, family structure, parenting style, socioeconomic level, personal traits, opportunity and certain genetic and biological factors. In this line, Moffitt's taxonomy (1993) differentiates between factors involved in ASB that is typical of the adolescent stage, and factors involved in persistent ASB; she indicates that the presence of neurocognitive deficits from an early age is a key characteristic in individuals whose ASB appears early and persists throughout their life. It is also known that individuals with frontal damage tend to present significant impairments in behavior, in regulating their mood, in thought and in social behavior (Stuss & Levine, 2002), and that EF competency is key for optimal, socially adapted functioning (Lezak, 2004). It is therefore suggested that certain neuropsychological deficits, especially executive dysfunction, can be related to aggressiveness. Furthermore, the current rise in neuroscientific disciplines favors the study of biological, genetic and neuropsychological mechanisms involved in development of violent behaviors, and there is evidence that supports Moffitt's theory, with results in favor of the association between ASB and executive dysfunction (Price, Beech, Mitchell, & Humphreys, 2014; Tung & Chhabra, 2011).

There have been two attempts to date to clarify the relationship between ASB and EF: the Morgan and Lilienfeld (2000) meta-analysis and the Ogilvie, Stewart, Chan, and Shum (2011) meta-analysis. The former analyzes 39 studies with a total sample of 4589 participants, and its results yield a difference of 0.62 standard deviations between EF measures in antisocial groups and EF measures in the comparison groups. Moreover, of the 39 studies analyzed, 79% present an effect size indicating poorer test performance in the antisocial samples. However, results are heterogeneous depending on the ASB group and the type of EF measure used. More sizable effects were found in the group of adult delinquents ($d = 1.09$) and young delinquents ($d = 0.86$) and in the qualitative score on the Porteus Maze Test ($d = 0.8$). The Ogilvie et al. (2011) meta-analysis includes 126 studies and 14,786 subjects in the sample; its results show a mean effect of 0.44 under the fixed effects model, and 0.53 under the random effects model. Just as in the first study, the effects vary according to the ASB group and the type of EF measure used: the greatest effects are found in the group of delinquent adults ($d = 0.61$), the group of individuals with behavior disorder ($d = 0.54$), the group of psychopaths ($d = 0.42$); and on the SOR task (self-ordered pointing) ($d = 0.83$) and the Porteus Maze Test ($d = 0.71$). Therefore, although both meta-analyses find a robust relationship between ASB and poor performance on tasks that involve EF, the effect varies as a function of the groups and of the type of measure used. Consequently, it seems essential to analyze the relation between EF and ASB in more homogeneous antisocial groups, in order to outline the characteristic deficits in each subgroup.

For this reason, starting from a broad description of ASB—practicing behaviors that are not socially approved (Rutter, 2003)—these behaviors may or may not lead to psychopathologies related to antisocial personality disorders, dissociative disorder

or behavior disorder, or to psychopathological personality traits (Hare, 1996). However, in our study we focus on a more specific ASB that can be operationalized in legal terms. Commonly known as delinquent behavior, we prefer to call it sanctionable antisocial behavior (S-ASB) in an attempt to unify terminologies from the fields of psychology, education and criminology. S-ASB refers to antisocial acts that break or transgress the law, that is, a classification established at any given time by the penal code, where some kind of sanction applies (García, Zaldivar, de la Fuente, Ortega, & Sainz-Cantero, 2012).

Finally, we study relations between EF and S-ASB during the stage of youth, based on certain criteria. On one hand, the population of minors found in the Juvenile Justice Services fits into this stage, as defined by the World Health Organization (WHO, 2001), who consider the stage to be a transition between childhood and adulthood, spanning the ages of 10–24 years, and having three periods: puberty or early adolescence, ages 10–14 years; middle adolescence, ages 15–19; and full youth, ages 20–24. On the other hand, the WHO (2003) indicates that crime, delinquency and juvenile violence are a public health problem typical of this life stage, and have severe social repercussions, increasing the cost of healthcare, social and judicial services, reducing productivity and devaluing goods, although in most countries, special juvenile penal systems hold young people responsible between 12–14 and 18 years of age, with measures in effect until full youth.

Therefore, the objective of this study is to quantify the relationship between EF and S-ASB in the specific group of young offenders, using the technique of meta-analysis.

Method

Article search and inclusion

The database search was performed between September and December 2014, using the key words shown in Chart 1. In addition, Figure 1 shows the search process that was followed, consisting of analyzing the prior meta-analyses that addressed studies related to the present task, and reinforcing the 2010–14 search. The studies taken into account span the period of 1942 to 2014.

The following criteria were used to select studies for this paper: (a) the sample used to study the relation between EF and ASB falls within the stage of youth; (b) the criterion for an ASB classification is behavior prohibited by the applicable penal system, in other words, the antisocial groups in the sample of each study are drawn from the systems and resources of Juvenile Justice, to ensure that we are addressing S-ASB; (c) EFs are measured using batteries, tests and standardized neuropsychological measures designed for this purpose; (d) the study includes a non-antisocial comparison group; (e) the results of the studies allow calculation of effect size, and (f) the language of publication is English or Spanish.

Codifying the information

After the selection of studies, an information collection template was prepared in Excel. In addition to the substantive variables of executive functions and S-ASB, any possible moderating variables were recorded, as well as the type of measure used to assess executive functions, gender (measured as the percentage of females in the sample), average age of the total sample, average age of the S-ASB group, average IQ of the sample, IQ of the S-ASB group, and study quality, measured on a 4-point Likert scale. Codification was carried out by two members of the research team, average agreement index for variable extraction was obtained with a Kappa estimate of 0.886 and ranging between 0.851 and 0.903. Nonetheless, final agreement was resolved with consensus from all the authors, after

Table 1
Mean effects according to the test used to assess EF

Group	k	Effect size and 95% confidence interval				Z	p	
		$d^+ a$	Standard error	Variance	CI 95%			
AB-AC	1	0.37	0.57	0.32	-0.75	1.49	0.64	0.51
BCT	1	0.79	0.59	0.35	-0.37	1.95	1.32	0.18
Bender-Gestalt	1	-1.62	0.61	0.38	-2.83	-0.41	-2.62	0.00
Brixton EF	1	0.68	0.62	0.38	-0.54	1.90	1.90	0.27
CANTAB	2	-0.16	0.40	0.16	-0.95	0.63	-0.39	0.69
Card Playing	1	0.32	0.57	0.33	-0.80	1.44	0.55	0.57
COWAT	4	0.72	0.29	0.08	0.14	1.31	2.45	0.01
CPT	18	0.17	0.15	0.02	-0.12	0.46	1.14	0.25
D2	1	0.24	0.64	0.41	-1.02	1.50	0.37	0.71
Delay Memory	1	-0.18	0.60	0.36	-1.36	1.00	-0.29	0.76
DGT	4	0.28	0.30	0.09	-0.31	0.87	0.92	0.35
Digit span	5	0.16	0.27	0.07	-0.36	0.69	0.60	0.54
Gambling task	3	0.45	0.34	0.11	-0.21	1.12	1.34	0.18
Go-nogo	5	-0.20	0.27	0.07	-0.73	0.32	-0.75	0.45
Hayling EF	1	0.44	0.62	0.38	-0.77	1.65	0.70	0.47
ID/ED	10	-0.17	0.18	0.03	-0.54	0.19	-0.94	0.34
Immediate	1	-0.12	0.60	0.36	-1.30	1.06	-0.19	0.84
PMT	12	1.14	0.17	0.03	0.79	1.48	6.50	0.00
RAVLT	2	0.08	0.43	0.18	-0.76	0.93	0.19	0.84
ROCFT	6	0.26	0.26	0.06	-0.24	0.77	1.00	0.31
SOC	2	0.43	0.42	0.17	-0.38	1.26	1.04	0.29
Spatial span	1	0.45	0.58	0.33	-0.68	1.58	0.77	0.43
Stroop	16	0.47	0.15	0.02	0.17	0.77	3.09	0.00
SWM	1	0.40	0.58	0.33	-0.73	1.53	0.68	0.49
TMT	10	0.45	0.18	0.03	0.08	0.82	2.40	0.01
TOL	2	0.39	0.43	0.18	-0.45	1.24	0.90	0.36
VFT	2	1.03	0.40	0.16	0.23	1.82	2.53	0.01
WCST	16	0.17	0.15	0.02	-0.12	0.48	1.15	0.25
WISC-R	2	0.37	0.43	0.18	-0.47	1.22	0.87	0.38
Overall	132							

Note. AB-AC, test of paired-associated learning AB-AC; BCT, Booklet category test; CANTAB, Cambridge Neuropsychological Test Automated Battery; COWAT, Controlled Oral Word Association Test; CPT, Continuous performance test; D2, D2 test of attention; DGT, delay of gratification task; ID/ED, intra-dimensional/extradi-dimensional set shift task; Immediate, Immediate Memory Task; k, number of that use each test; PMT, Porteus Maze Test; RAVLT, Rey's Auditory Verbal Learning Test; ROCFT, Rey-Osterrieth Complex Figure Test; SOC, Stockings of Cambridge; SWM, spatial working memory task; TMT, Trail making test; TOL, Tower of London; VFT, Verbal Fluency Test; WCST, Wisconsin Card Sorting Test; WISC-R, Wechsler Intelligence Scale for Children - Revised.

^a A positive value indicates a deficit in executive functions in the S-ASB group with respect to the comparison group.

analyzing the discrepancies that arose in codifying the substantive and moderating variables.

Estimating effect size

The protocol for estimating the effects and analyzing the data is described below:

1. First, the individual effect (d) is estimated for each psychological test or EF measure within each study, comparing the performance of the antisocial group with that of the comparison group. Hedges correction (g) for small samples was applied to all the effects, and the variance and weight of each individual effect was found, in order to make it possible to calculate the weighted effect of each study.
2. Next, a weighted effect was calculated (\bar{d}) for each study, except for four articles. In these four articles, two weighted effects were calculated, since the data was reported according to gender (Porteus, 1942, 1945) and as a function of comorbidity with attention deficit disorder (Moffitt & Henry, 1989; Moffitt & Silva, 1988).
3. Finally, the mean effect was calculated based on the weighted effects of each article, and the homogeneity analysis was performed. We used the formulas described in the Ogilvie et al.

meta-analysis (2011) for calculating individual and weighted effects.

4. Effect sizes were calculated by one researcher using the Wilson calculator (Wilson, n.d.) and another researcher who calculated them using the program Comprehensive Meta-Analysis version 3. There were no discrepancies in the fundamental computations of the 169 effect sizes generated, and the intraclass correlation between the two calculations was 0.995, with a 95% CI (.993-.996).

Data analyses

Due to the level of generalization under consideration, as well as sample heterogeneity, and the number of studies being sufficient, average effect size was calculated by following the random effects model. Average effect size was also calculated by the fixed effect model for comparison with the previous meta-analyses.

Additionally, a heterogeneity analysis was performed using the Q and I^2 statistics. Analysis of moderating variables was performed using group comparison for categorical variables, and meta-regression for quantitative variables. These were calculated under the mixed effects model, and with a calculation of unrestricted maximum likelihood in the Comprehensive Meta-Analysis (CMA) program, version 3.0.

For the sensitivity analysis and the study of publication bias, a multiple strategy was followed: sensitivity of the meta-analysis was studied using the technique of successively eliminating one study, as well as using the *Trim and Fill* strategy (Duval & Tweedie, 2000). For the study of publication bias, we calculated Rosenthal's fail-safe number, as well as Orwin's proposal, and the Egger test, all implemented in CMA 3.0.

In addition, given that some of these techniques do not function properly in conditions of heterogeneity (Citkovicz & Vevea, 2017), they were complemented with an analysis of the effect calculation for the extreme groups of sample size as a function of their percentiles (P_{25} and P_{75}) and with meta-regression between effect sizes and the sample size.

Results

Sample

The 33 articles included in this study produce a total sample of 5752 adolescents, of which 2557 belong to the S-ASB group and 3195 to the comparison group. In this sample, 555 are female and 5197 are male. These 33 articles generate 37 independent studies, since in two articles the data are reported according to gender (Porteus, 1942, 1945) and two others reported data as a function of comorbidity with attention deficit disorder (ADD) (Moffitt & Henry, 1989; Moffitt & Silva, 1988). Clinical comorbidities unrelated to antisocial behavior do not appear in the rest of the articles, so comorbidity was not studied later as a moderating variable.

Based on the available data, the following means were calculated: 15.96 years for the total sample, 15.68 years for the sample with S-ASB, a mean intelligence quotient (IQ) of 84.22 for the antisocial group and 88.60 for the comparison group. IQ was assessed using the Wechsler scales, Raven Test and K-BIT.

Calculation of mean effect

Based on the 37 weighted effects, a statistically significant mean effect was obtained from the fixed effects model ($ES = 0.242$; $p < .01$; $CI\ 95\% [0.21, 0.26]$) and another statistically significant, higher effect from the random effects model. Figure 2 shows the values of mean effect, of individual effects, the variance, confidence

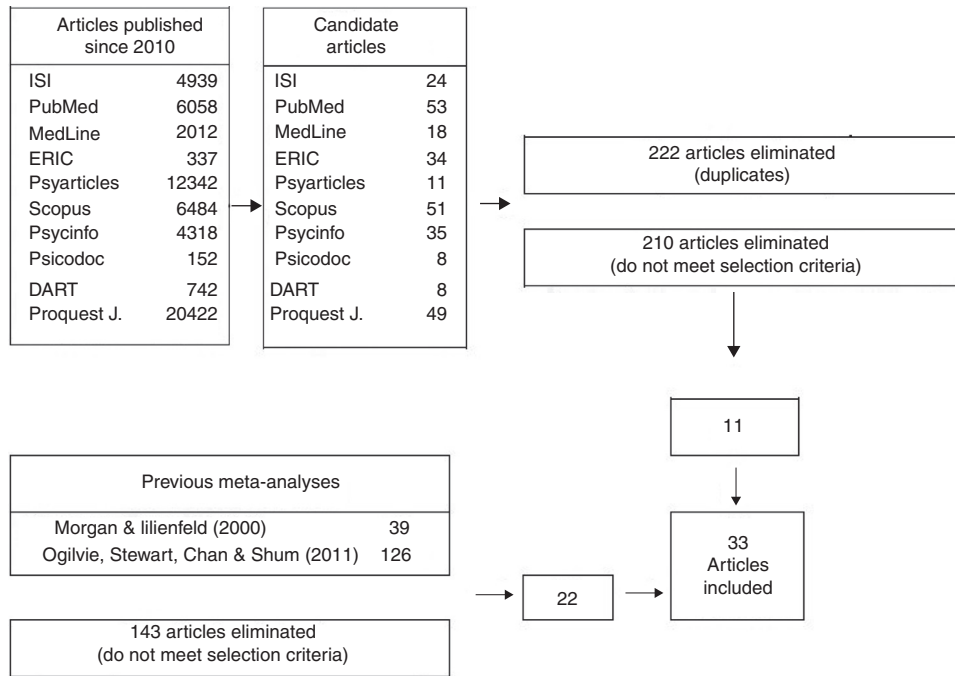


Figure 1. Search and selection process for articles to be included in the meta-analysis.

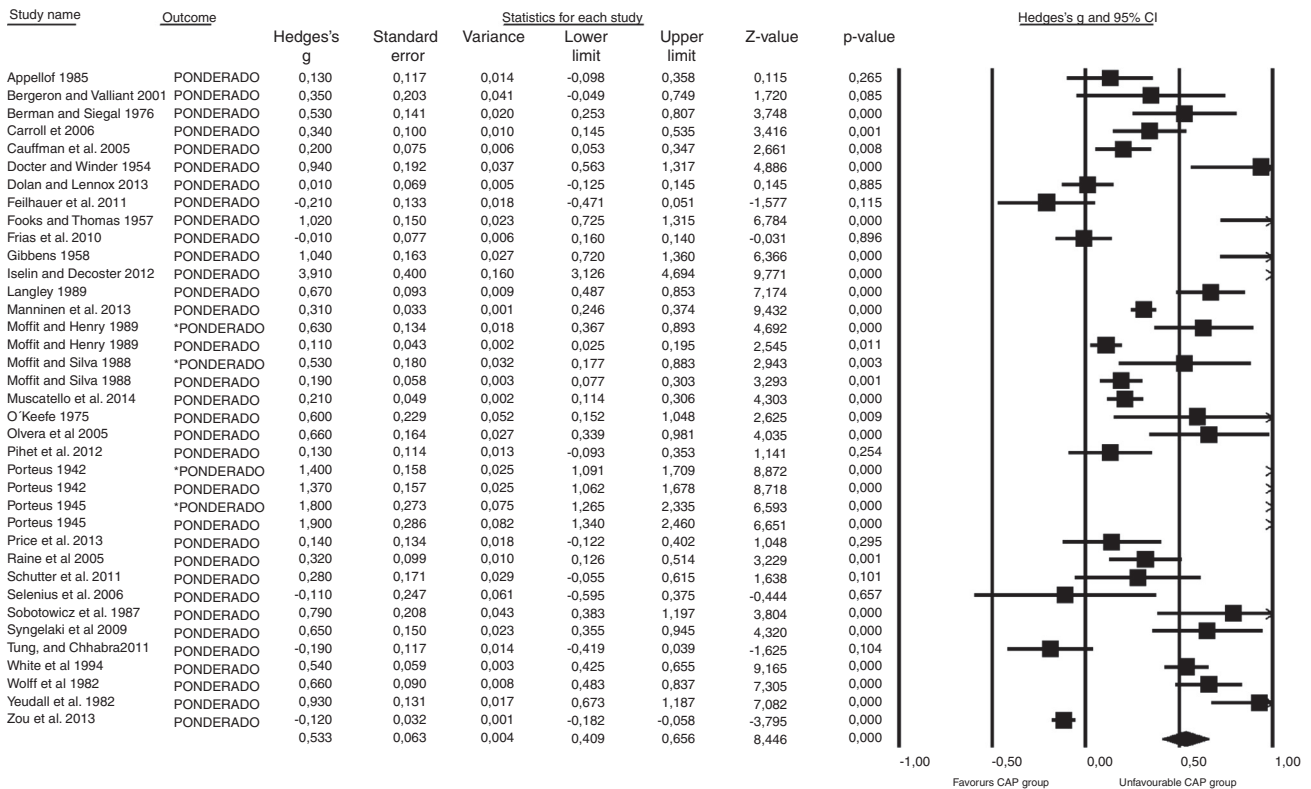


Figure 2. Mean effect, individual effects, variance, confidence intervals and forest plot for the different studies, adopting the random effects model.

intervals and the forest plot, adopting the random effects model since the number of studies is reasonably high ($k > 30$) and there is high heterogeneity in the effects ($I^2 = 94.48$). As can be observed, most of the effects found have medium magnitude. Positive effect sizes indicate a deficit in executive functions in the S-ASB group with respect to the comparison group. Therefore, the calculation of

mean effect under the random effects model ($ES = 0.533$; $p < .01$; CI 95% [0.409, 0.656]) suggests a relationship between S-ASB and an EF deficit.

On the other hand, in Table 1 shows the average effect size calculated for each of the tests and tasks used in the studies analyzed.

Table 2
Meta-regression analysis of possible moderating variables

	K	B	CI 95% of β	Q_R	Q_E	R^2
Total IQ	16	.00	-.00, .02	.8	283.36**	.06
Antisocial IQ	16	.00	-.01, .02	.81	284.33**	.07
Antisocial age	25	-.10	-.29, .07	1.31	345.34**	.08
Total age	20	-.43	-.78, -.08	6.10*	265.97**	.29
female % of total	32	.00	-.00, .01	3.26	531.8**	.13

Note. β , regression coefficient; CI 95%, confidence intervals at 95%; IQ, intelligence quotient; K, number of number of studies; Q_E , Q residual; Q_R , Q of the model; R^2 , percentage of variance explained.

* $p < .05$.

** $p < .01$.

Analysis of moderating variables

Since the homogeneity test is statistically significant ($Q_{36} = 653.17$; $p < .01$) and the I^2 index is high, we analyzed the influence of possible moderating variables: study quality, the test used to assess EF, gender, the age of the sample and of the antisocial group, IQ of the sample and IQ of the antisocial group. Of all these variables, age of the sample and type of test used to assess EF were statistically significant. Table 2 shows the individual meta-regression values obtained for each of the quantitative variables analyzed.

The effects found as a function of study quality and of the type of test used to assess EF were examined. No influence was found from study quality on the variability of effect sizes ($Q(2)_{between} = 2.863$, $p = .239$). In the case of the tests used, in order to avoid possible dependency of scores on the different tests and tasks, dummy variables were created with two independent values, that is, for each test, we calculated the difference in effect size between the average effects of the tests and the average effect of the rest of the studies that do not consider that test. Specifically, no statistically significant differences were found with the rest of the studies in the case of the following tests: COWAT [$Q_{between}(1) = 0.727$, $p = .394$], CPT/Go-nogo [$Q_b(1) = 0.811$, $p = .368$], Digit Span [$Q_b(1) = 2.437$, $p = .119$], ROCFT [$Q_b(1) = 0.140$, $p = .708$], TMT [$Q_b(1) = 0.060$, $p = .807$] and WCST [$Q_b(1) = 2.454$, $p = .117$]. The differences were statistically significant in the case of ID/ED, [$Q_b(1) = 7.390$, $p = .007$], PMT [$Q_b(1) = 39.830$, $p < .001$] and STROOP [$Q_b(1) = 5.167$, $p = .023$]. This suggests the influence of tests on the variability in effect sizes, both in the sense of deficit (PMT and Stroop) and in low effects (ID/ED).

Analysis of sensitivity and publication bias

Regarding the sensitivity analysis, first, the average effect size calculation was not substantially altered in the different meta-analyses generated through sequential elimination of each study; the average effect was in the same direction, approximate

Chart 1

List of databases reviewed and key words used

Databases	Key words
ISI Web of Knowledge, PubMed, MedLine, ERIC, Psycarticles, Scopus, Psycinfo, Psycodoc, DART Europe, Proquest Psychology Journals	Adolescents, Adolescence, Aggression, Antisocial, Antisocial personality disorder, Attention, Attentional control, Conduct disorder, Criminal, Delinquency, Executive functions, Externalizing disorder, Frontal lobe, Impulsivity, Inhibition, Juvenile, Neuropsychological, Neurocognitive, Oppositional defiant disorder, Psychopathy, Sex offender, Violence, Working memory

Note. ERIC, Education Resources Information Center.

magnitude and statistical significance, whereby we may conclude that the results are robust with non-inclusion of each of the studies that finally made up the meta-analysis.

On the other hand, as an added element of sensitivity and bias, the *Trim and Fill* strategy (Duval & Tweedie, 2000) was used. The *Funnel Plot* method is combined with an estimate and correction of the average effect size by seeking Funnel symmetry. No study is allocated to the left side of the chart (see Figure 3); this constitutes a proof that publication bias is absent, although this result possesses low power under conditions of heterogeneity. On the right side, and adjusted for symmetry, three non-contemplated studies are allocated, which may increase our estimate of the effect size (see the black dots in Figure 3). Under the random effects model, the point estimate and the 95% confidence interval for the pooled studies is 0.53 [0.41–0.65]. With the use of adjustment, the point estimate allocated is 0.63 [0.45–0.79]; while this indicates an underestimation of the effect size on our part, the estimate is within the confidence interval calculated in the *Trim and Fill* strategy.

As for publication bias, we used the strategy of calculating the fail-safe number. The present meta-analysis incorporates data from 37 studies, ($Z = 23.61$; $p < .001$); Rosenthal's fail-safe number was calculated at $N(f_s) = 5335$ and Orwin's at 160, these represent the number of missed studies needed in order to nullify our results. On the other hand, with Egger's test we obtained a statistically significant result, evidence that a publication bias exists, $b_0 = 4.55$; $t(35) = 4.60$, $p = .00005$, although once again, this test is sensitive to high heterogeneity.

It is important to make clear that publication bias due to the effect of studies with lower sample sizes is not the only explanation for Funnel asymmetry; heterogeneity may lead to asymmetry, and all these measures may be affected within the small studies included in a systematic review. In this situation, the average effect size for the 25th percentile of the smaller sample sizes was calculated ($n < 74$, $d^+ = 0.69$; CI 95% = -0.116 ; 1.501) and for the 75th percentile of the larger sample sizes ($n > 200$, $d^+ = 0.57$; CI 95% = 0.240 ; 0.905). Finally, a meta-regression between effect sizes and sample size yielded a non-statistically significant result ($p = .346$), giving evidence that there is no influence from the study sample size on calculation of effects.

Discussion

This paper studies the relationship between EFs and ASB. Although different evidence tends to indicate that executive dysfunction or impairment may be related to different forms of ASB, studying this relationship leads to controversy, owing to the complexity of both concepts. The objective of this study was to specifically address the involvement of EFs in ASB during the period of youth. Results indicate an effect of medium magnitude, indicating that the juvenile antisocial group would present impairments or

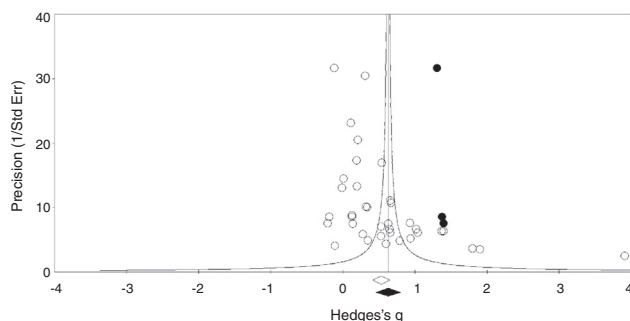


Figure 3. Funnel plot with estimation and correction of the average effect ("Trim and Fill" strategy).

deficits in carrying out neuropsychological tasks that involve use of EFs. However, this effect value diminishes somewhat with respect to results obtained by Morgan and Lilienfeld (2000) and Ogilvie et al. (2011), if compared to the subsamples related to committing crimes.

There are several factors that may influence this decrease in magnitude: first, within the juvenile samples included in this study, there may be subjects with typical adolescent ASB. This fact justifies the result of a lower effect, given that neuropsychological dysfunction is characteristic of subjects with persisting ASB (Moffitt, 1993); therefore, in the previous meta-analyses, which also include the study of EFs in adult samples, larger differences appear. Another important factor that may influence results is that EF development is under way. These functions are perfected and reach optimal development during adolescence; consequently, it is likely that differences between one group and another are yet to become more marked. Finally, one must also consider that the study's high heterogeneity also affects the results: analysis of moderating variables indicates that both age of the sample and type of test used to assess EF influence the magnitude of the effect.

Regarding age, results indicate that, the younger the age of the sample, the greater the difference in test performance between the comparison group and the antisocial group. These results could be expected, since, as noted above, adolescence is a key period for EF development. Moreover, research indicates that while the network involved in cold EF (cognitive processes involved in abstract reasoning and logic, planning, self-regulation) matures at about age 15, the network of hot EF (related to emotional control, impulsivity and decision making) takes longer to develop, is affected by hormonal changes in early adolescence, and continues to develop during youth and early adulthood (Steinberg, 2005, 2007). Therefore, a delay or impairment in EF development, especially in the "hot" or socio-emotional network, may be implicated in the appearance of risk behaviors or ASB during adolescence (Seguin, 2009).

As for influence from the type of task used to assess EF, the Porteus Maze Test is the test that yields the greatest magnitude of effect. Similar results were found in the previous meta-analysis studies. The Q score from this test provides an indicator of emotional tension, impulsivity and inability to control emotions and follow rules, and is related to ASB (Porteus, 2009). This association is not new, given that impulsivity and limited self-control are key factors in the appearance of some types of ASB, and reinforces the idea that delayed or inadequate development of the hot EF network facilitates adolescents' involvement in risk behaviors. Other important effects were obtained for the Stroop and Trail Making Tests, primarily related to inhibition processes and cognitive flexibility. These tests were applied in a large number of the studies included in the meta-analysis, and in both cases, a medium magnitude effect is obtained. Finally, although high effects were obtained for the agility and fluency tests VFT and COWAT, these results cannot be considered relevant due to the small number of studies where they were applied. Regarding performance on tasks that assess the working memory capacity, no important effects were found.

According to these results, there seems to be an evident need for further study of the relation between ASB and EF, and to do so in a more concrete manner in primary studies. Future research could use specific subgroups of young people with grouping variables such as crimes committed, their gravity, and other characteristics of the antisocial act, since these can be related to impairment of cognitive abilities of one type or another. Similarly, it seems pertinent to define what aspects of EF should be explored, and what tests best capture the differences in the target population. Finally, assessment of impaired EF in this population might improve our understanding of the variables that sustain ASB, and make possible a more effective, multidisciplinary approach to intervention and prevention of ASB.

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