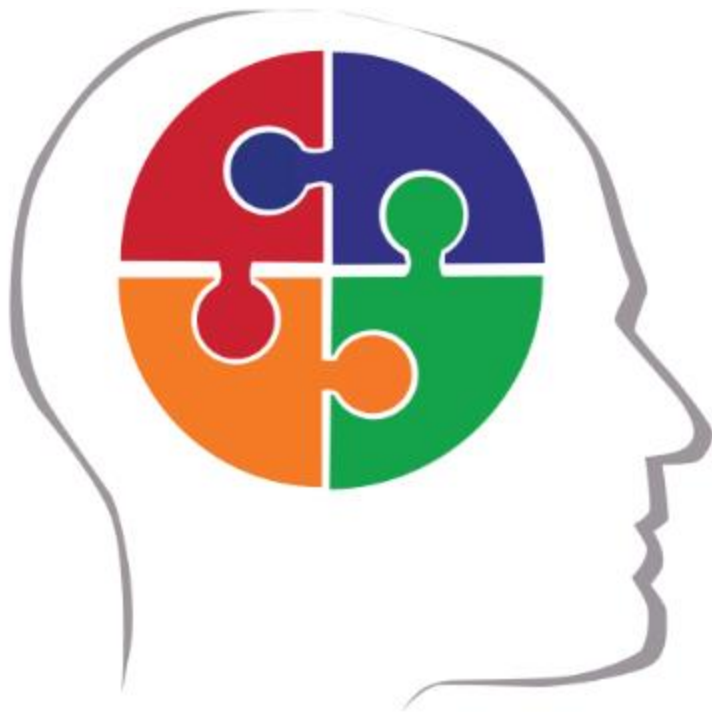




# Neuropsychological Assessments



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# Disclosures

I have the following relevant financial relationship with a commercial interest to disclose:

*Grant Support: Tris*

*Past Grant Support: Shire, NIH; FDA; Lundbeck*

# Search to find Neuropsychological Method to Diagnose ADHD has been longstanding

## The neuropsychological method

- Neuropsychology is the study of how the brain influences a person's cognition and behaviour
- Kolb and Wishaw (1980)- *Fundamentals of Human Neuropsychology*
- Classically, the workhorse of the neuropsychological method was the *lesion study*
  - *If a lesion in a certain area of the brain disrupts a specific cognitive function, then that area of the brain must be essential for that cognitive function*
- Many of examples of circumscribed lesions affecting specific behaviours in human neurology and neuropsychology
  - Damage to the right parietal lobe gives rise to the syndrome of unilateral spatial neglect in which attention to the left side of space is disturbed (Robertson et al, 1998, *Nature*);
  - Damage to the fusiform gyrus gives rise to prosopagnosia – a disorder of face perception (e.g., De Renzi, 1997 Prosopagnosia. In Behavioral neurology and neuropsychology, eds Feinberg TE, Farah MJ (McGraw-Hill, New York), pp 245–255);
  - Damage to the right inferior frontal gyrus gives rise to impairments of response inhibition (**see later**) (Aron et al, 2003, *Nature Neuroscience*);
  - Damage to the right frontal lobe gives rise to sustained attention deficit (**see later**) (Wilkins et al, 1987, *Neuropsychologia*);
  - Damage to the frontal lobe gives rise to increased performance variability (Stuss et al, 2003, *Brain*).

# However...

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- Similar to Numerous Studies with Functional Imaging (fMRI) there is a wide range of heterogeneity

# Clinical heterogeneity in ADHD

- It is now widely recognised that individuals with ADHD differs significantly from one another and that group level findings (ADHD cases vs. controls) lack meaning at the level of the individual (Nigg et al, 2004; Coghill, Seth & Matthews, 2013)
- This is certainly the case for the neuropsychology of ADHD and prevents neuropsychological tests having diagnostic utility for ADHD.

**Table 1.** Illustrative Widely Used Neuropsychologic Measures Comparing ADHD (Combined Type) to Controls: Group Differences and Percent Impaired in 3 Samples

Measure	Sample	Effect Size (d)			% ADHD Beyond Control 90th Percentile
		d	$\eta^2$	p	
SSRT	MI (all)	.88	.133	<.001	51
	CO	.79	.101	<.001	45
RT Variability	MI	.75	.123	<.001	48
	CO	.77	.125	<.001	44
Stroop CW	MI	.50	.045	<.05	25
	CO	.84	.132	<.001	44
	MGH	.62	.09	<.001	25
CPT	MI	.91	.11	<.001	37
	CO	.54	.053	<.001	35
	MGH	.17	.01	.11	16
Trailmaking	MI	.35	.033	<.05	27
	CO	.35	.031	<.01	24

**Table 2.** Illustration of Overlapping Distributions of Impairment Based on Percentage of Individuals in Each Group "Impaired" (>90th Percentile) on a Minimum Number of Measures Across Three Samples

Group	Number of Tasks Failed (%)					
	0	≥1	≥2	≥3	≥4	≥5
Control MI	58	42	18	11	5	2
Control CO	56	44	19	9	3	1
Control MGH	44	56	27	6	1	0
Mean	53	47	22	9	4	1
ADHD MI	27	73	53	30	21	12
ADHD CO	19	81	55	36	18	13
ADHD MGH	18	82	50	28	14	4
Mean	21	79	53	31	18	10





## The World Federation of ADHD International Consensus Statement- making sense of this vast literature on the neuropsychology of ADHD

Cognitive Domain	Effect for ADHD	Reference
IQ	Moderately lower across ages Small deficit in adults but not clinically meaningful	Frazier et al, 2004; Bridgett and Walker,2006
Working Memory	Small-moderate deficit	Schoechlin and Engel, 2005; Pievsky and McGrath, 2018; Ramos, 2019
Reward Processing (e.g., delay discounting)	Moderate deficit	Jackson and MacKillop, 2016; Patros et al, 2016
Sustained Attention	Small-moderate deficit	Schoechlin and Engel, 2005;
Response Inhibition	Moderate deficit, all ages	Pievsky and McGrath, 2018
Reaction Time Variability	Moderate deficit, all ages	Pievsky and McGrath, 2018

# So Why Refer for Neuropsych Eval

*Referral is typically done to answer specific questions about a child's developmental, cognitive, or emotional status*

***Does the student need specialized Instruction?***

***Are there other factors (LD;ED) in addition to ADHD?***

***Is there a comorbidity such as Autism Spectrum Disorder?***



Why all the testing?





# Neuropsychological Test Batteries

- Test batteries are large sets of tests that tap a variety of skills and abilities
- Developed before the era of scanning, in part to help locate site of brain damage
- Wide variety, large number of tests thought necessary because human behavior is so complex

# What is IQ?

- The IQ and Index scores have a mean of 100 and a standard deviation of 15
- IQ score of 90-110 is considered solidly average. Scores above 120 are considered superior and those below 80 are very low
- The official IQ cutoff for intellectual disability is 70; however, there must be other measures given to conclude that this score actually reflects this diagnosis

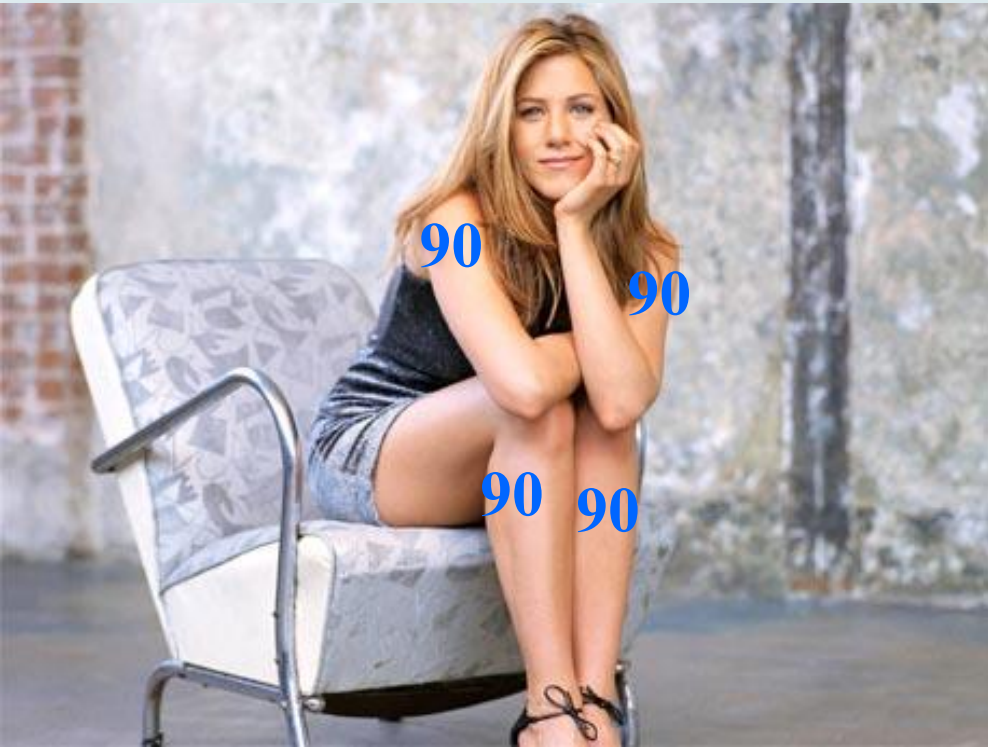
# Information-Processing Approach

- Examines the processes that underlie intelligent behavior
  - **Speed of processing**: how rapidly a person can perform a mental task
    - Is a strong correlate of IQ scores
  - **Knowledge base**: persons with a strong knowledge base in an area are better able to perform a mental task
  - **Ability to apply mental processes**: can a person acquire and use new mental strategies (Executive Functions)
  - **Working Memory**: Prevalent in ADHD and effect of Learning Robust



# Broken Arm or Not??

## Strength Test



Average Strength: 90...Healthy!!



Average strength: 90...No Broken arm

Verbal comprehension Index (VCI)



Perceptual Reasoning Index (PRI)



Full Scale IQ score

=

Average

Working Memory Index (WMI)



Processing Speed Index (PSI)



Verbal comprehension Index (VCI)



Perceptual Reasoning Index (PRI)

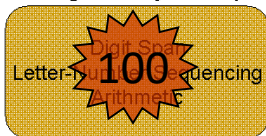


Full Scale IQ score

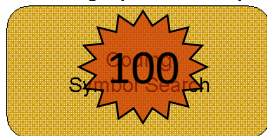
=

Average

Working Memory Index (WMI)



Processing Speed Index (PSI)



Verbal comprehension Index (VCI)



Perceptual Reasoning Index (PRI)



Full Scale IQ score

=

Average

Working Memory Index (WMI)



Processing Speed Index (PSI)



# What Are Executive Functions ?

- Mental operations involved in goal directed behavior and self-regulation, including :
  - Inhibiting, set shifting, self-monitoring, initiating, planning/organizing, task organizing, organizing materials, emotional control, and working memory
- Originally derived from the frontal lobe syndrome in which patients with brain lesions showed disturbances in the area of self-regulation
- ***Shown to have Major Effect on Full Scale IQ***



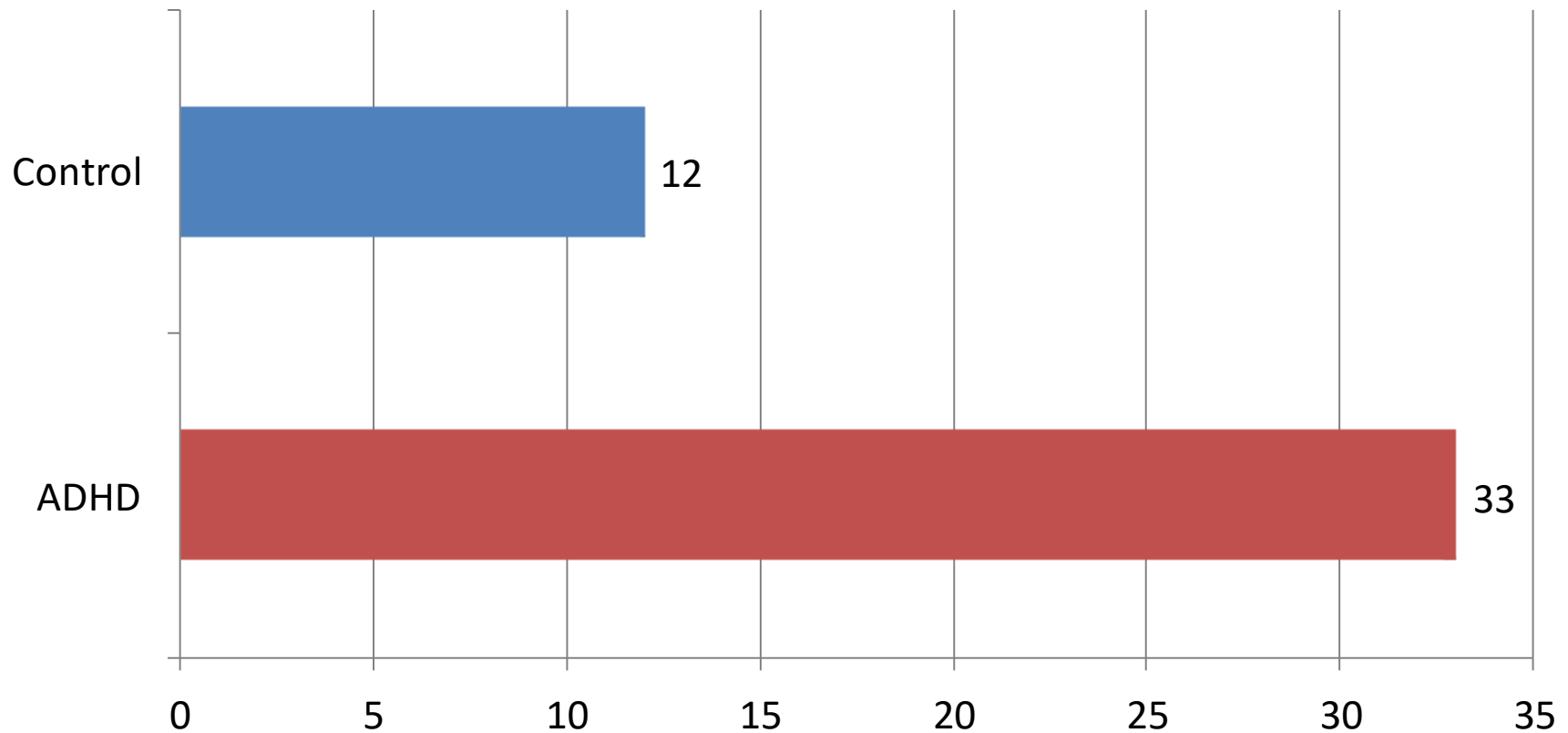
# Impact of EFDs on Children with ADHD

- Examined psychometrically defined EFDs in children with and without ADHD and EFDs
- Included male and female (mean age=12.3-13.7 years old) probands from two longitudinal family studies of ADHD

	Control	ADHD
	N=125	N=159
Male	103	121
Female	122	138

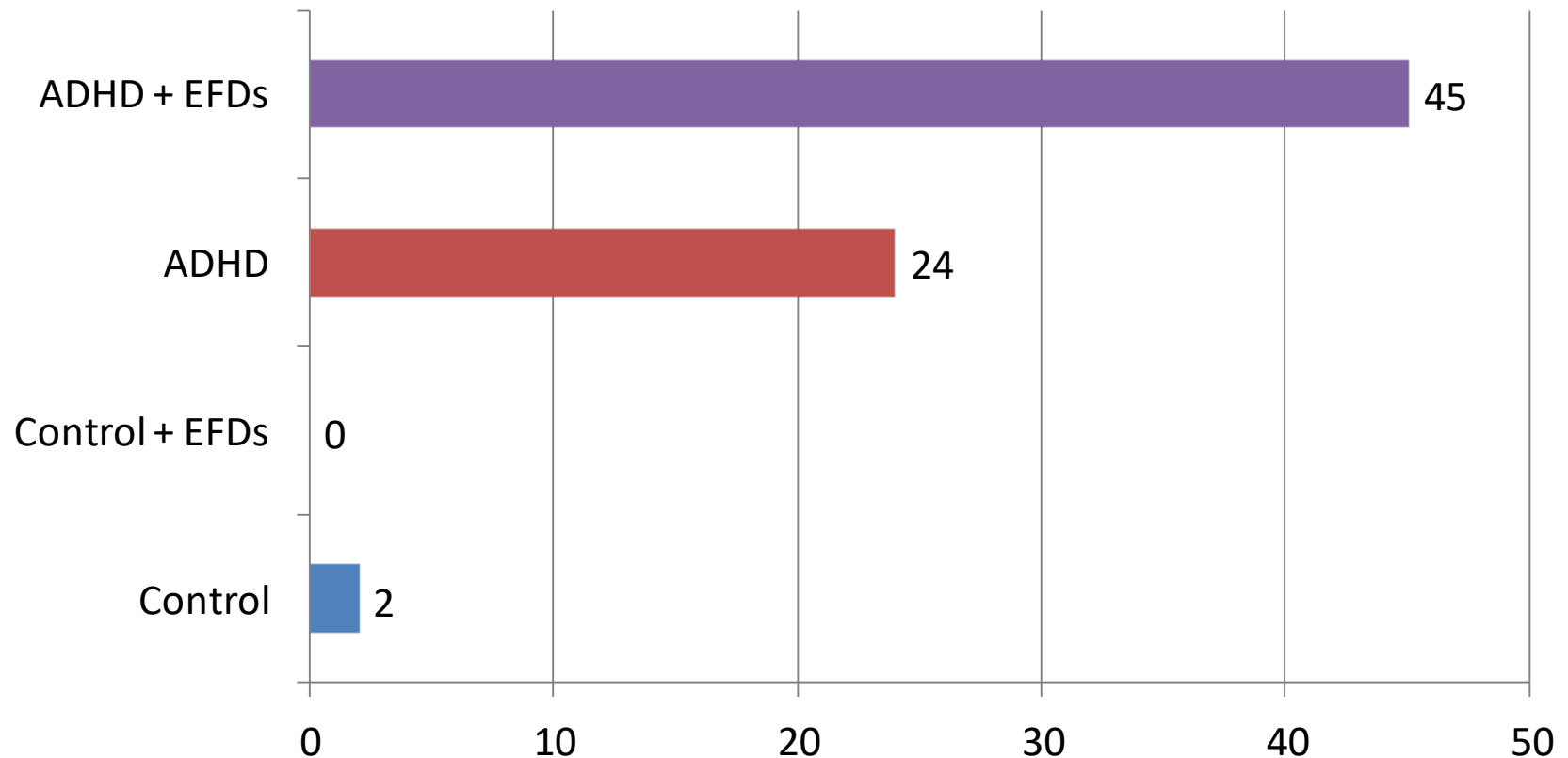
# Impact of EFDs on Children with ADHD

Percent of Subjects with  $\geq 2$  EFDs



# Impact of EFDs on Children with ADHD

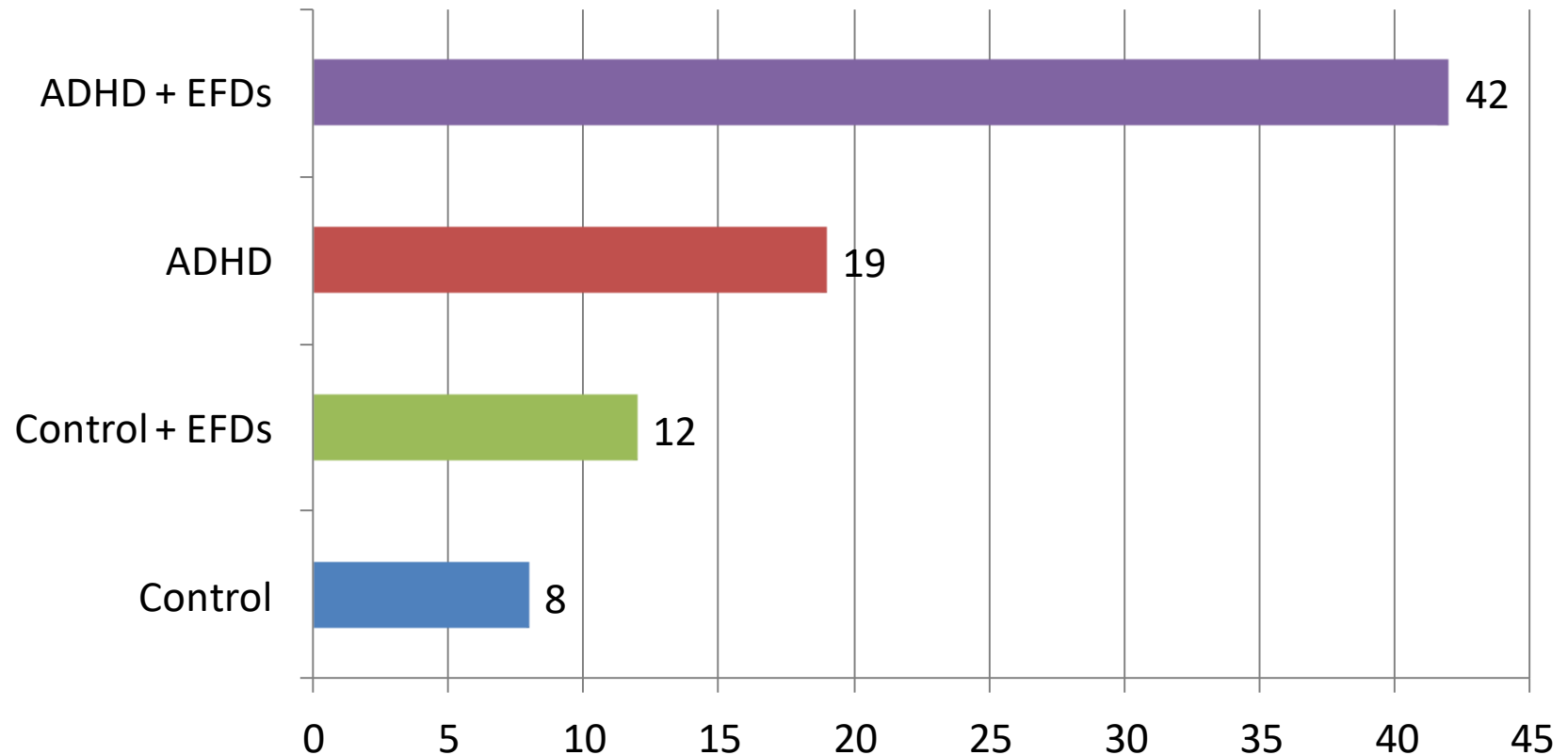
## Special Classes in School



Biederman, J., M. Monuteaux, et al. (2004). "Impact of Executive Function Deficits and ADHD on Academic Outcomes in Children." *J Consult Clin Psychol* 72(5): 757-766.

# Impact of EFDs on Children with ADHD

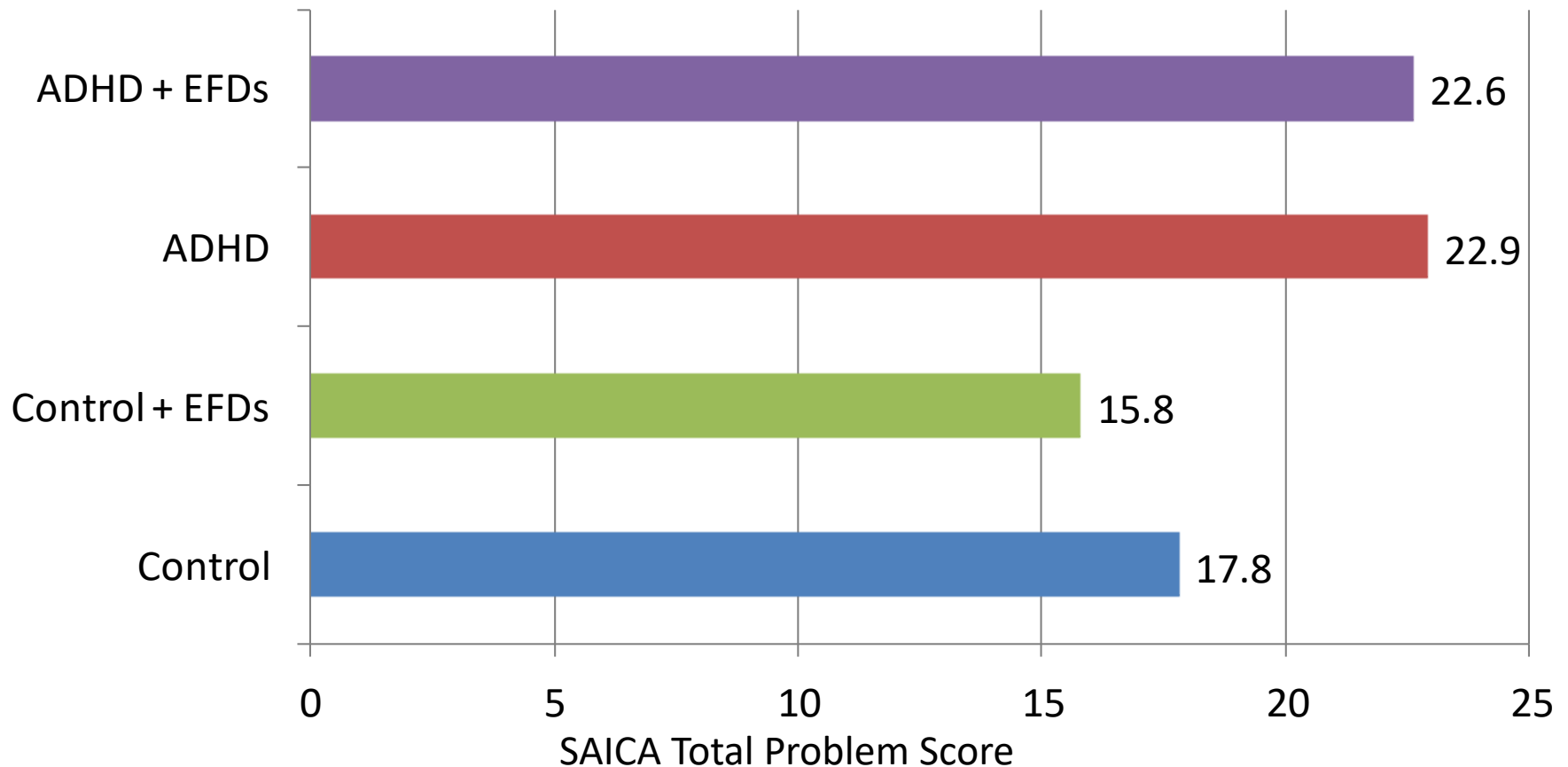
## Repeated School Grade



Biederman, J., M. Monuteaux, et al. (2004). "Impact of Executive Function Deficits and ADHD on Academic Outcomes in Children." *J Consult Clin Psychol* 72(5): 757-766.

# Impact of EFDs on Children with ADHD

## Psychosocial Functioning



Biederman, J., M. Monuteaux, et al. (2004). "Impact of Executive Function Deficits and ADHD on Academic Outcomes in Children." *J Consult Clin Psychol* 72(5): 757-766.

# Impact of EFDs on Children with ADHD

- Using the psychometrically defined method, significantly more children with ADHD had EFDs than controls
- Neuropsychological impairments in children with ADHD have implications for functional outcome above and beyond the diagnosis itself
- Children with ADHD and EFDs had an increased risk for grade retention and a decrease in academic achievement, relative to ADHD alone
- *EFDs Can and Do affect IQ scores in many cases*



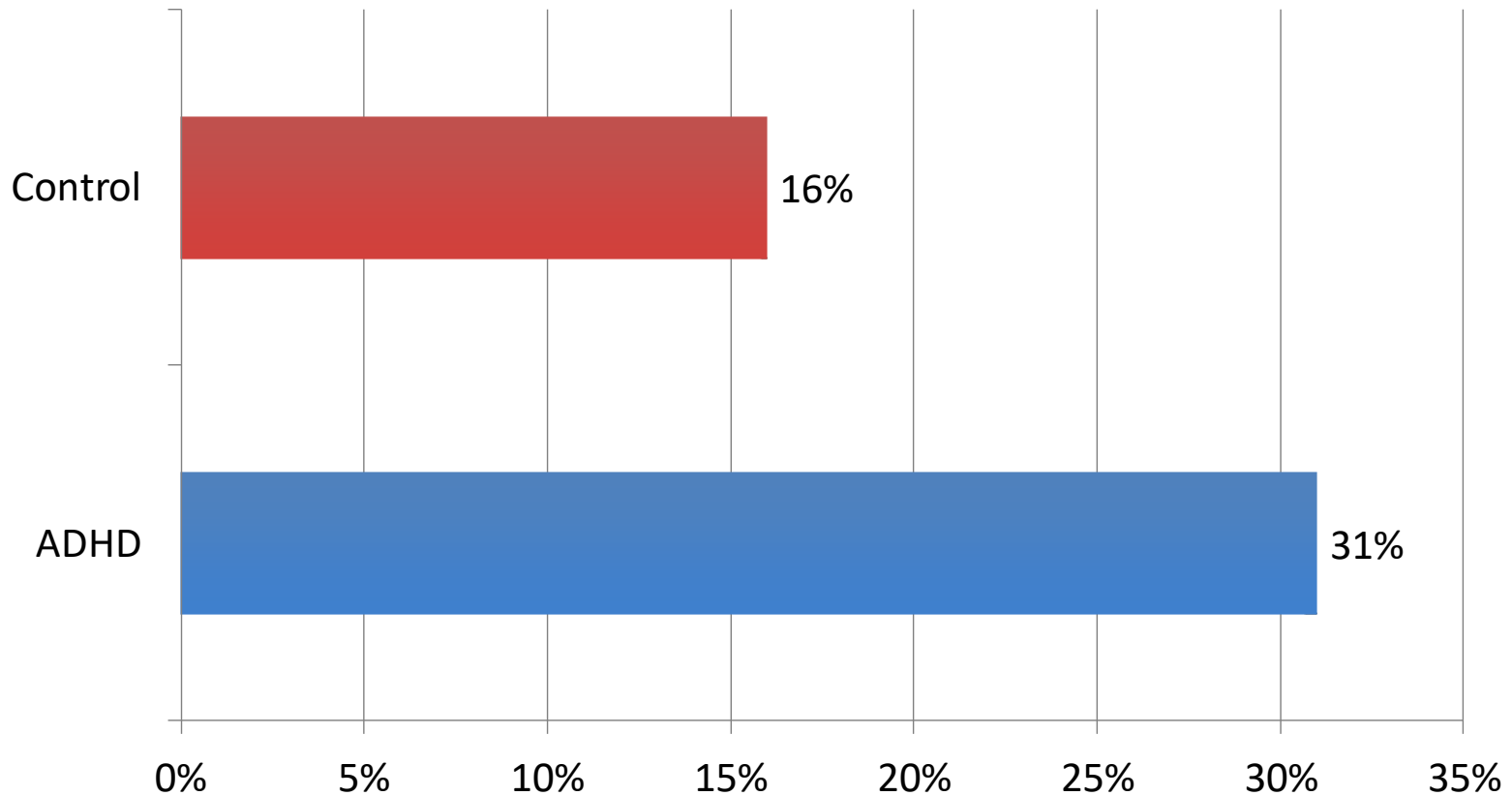
# Impact of EFDs on Adults with ADHD

- Examined psychometrically defined executive function deficits (EFDs) in adults with and without ADHD and EFDs

	Control	Control + EFD	ADHD	ADHD +EFD
	N=122	N=23	N=147	N=66
Age	29.3 ± 8.4	35.4 ± 8.8	34.6 ± 10.4	40.0 ± 10.3
Gender (% male)	55 (45%)	11 (48%)	80 (54%)	33 (50%)

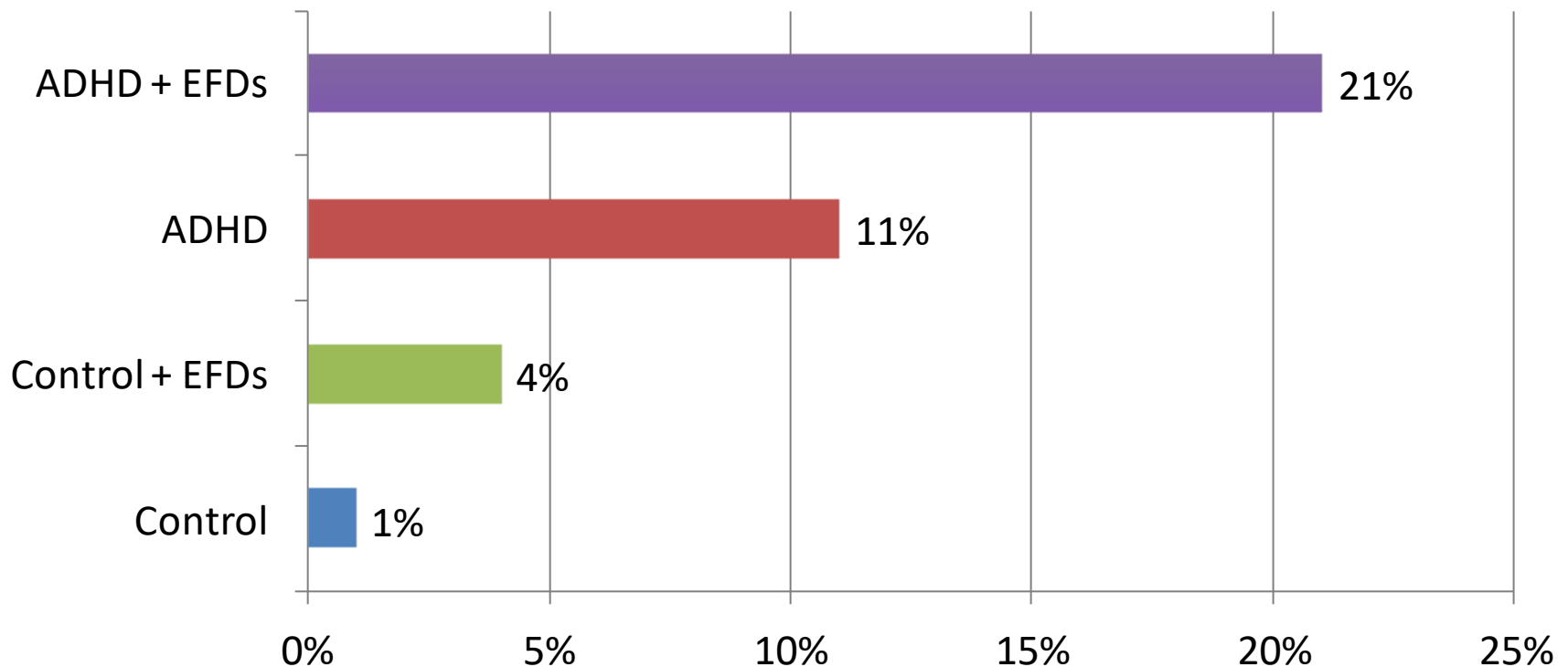
# Impact of EFDs on Adults with ADHD

Prevalence of EFDs in Adults



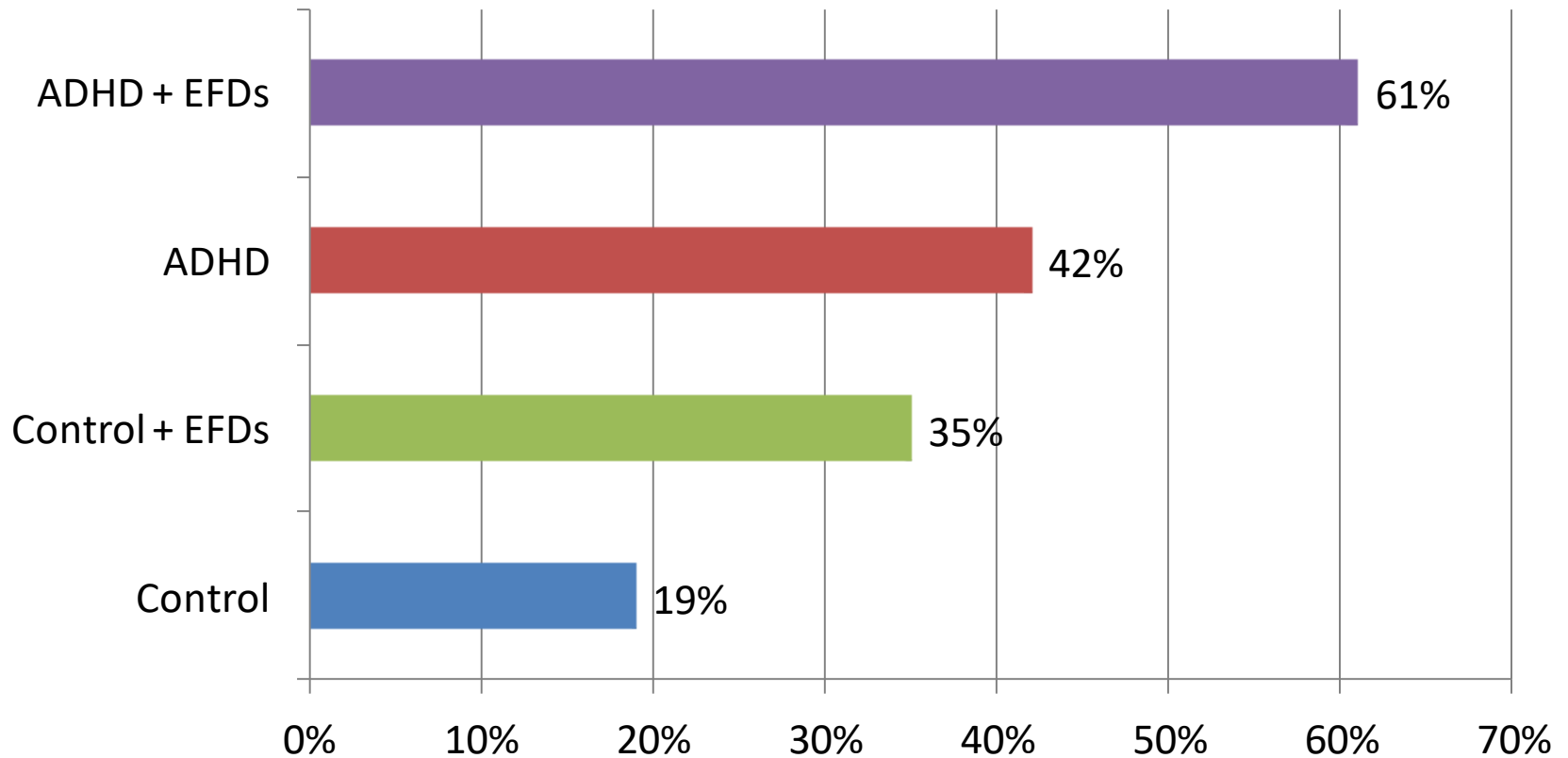
# Impact of EFDs on Adults with ADHD

## Special Classes in School

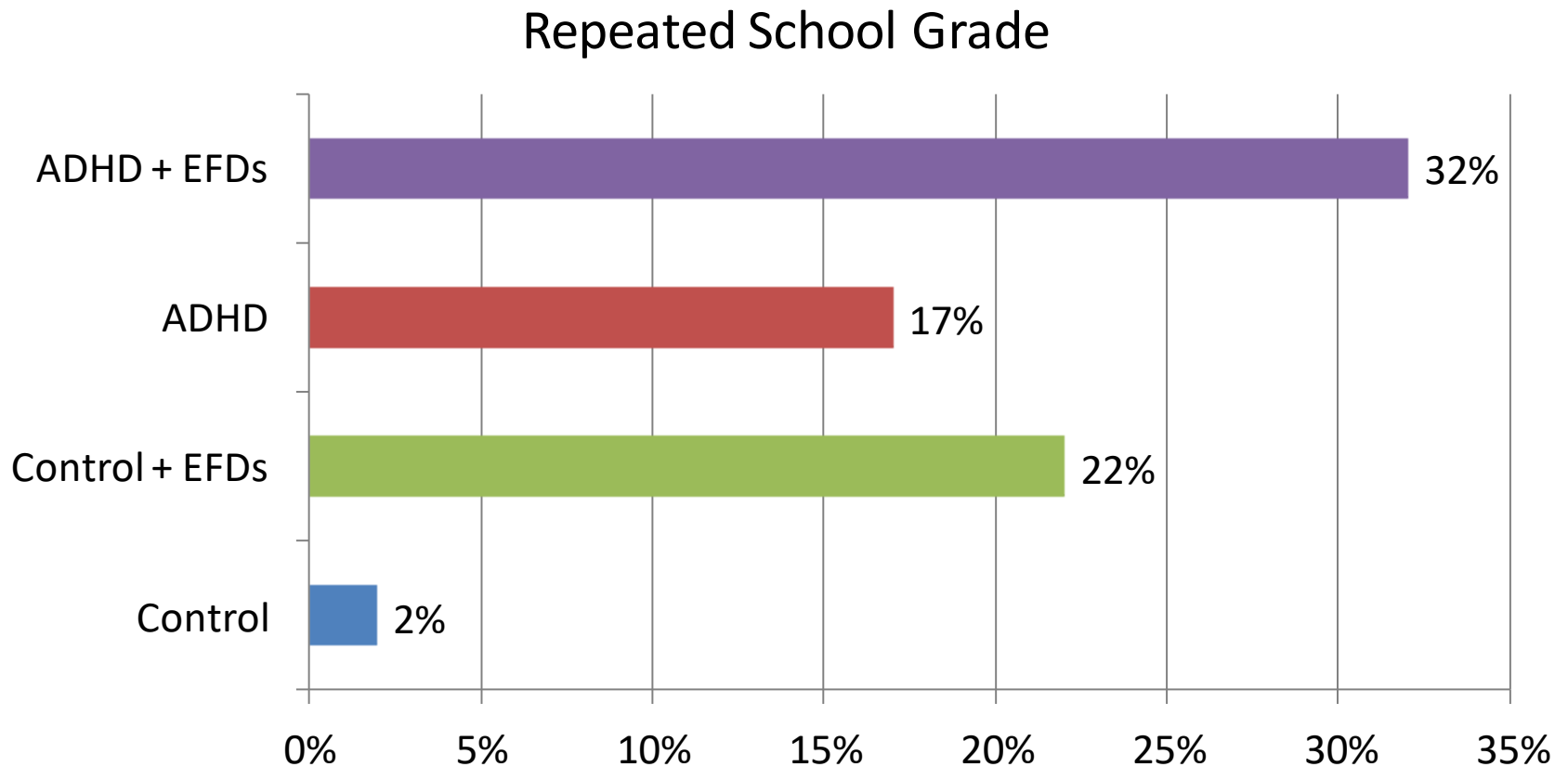


# Impact of EFDs on Adults with ADHD

## Extra Help in School

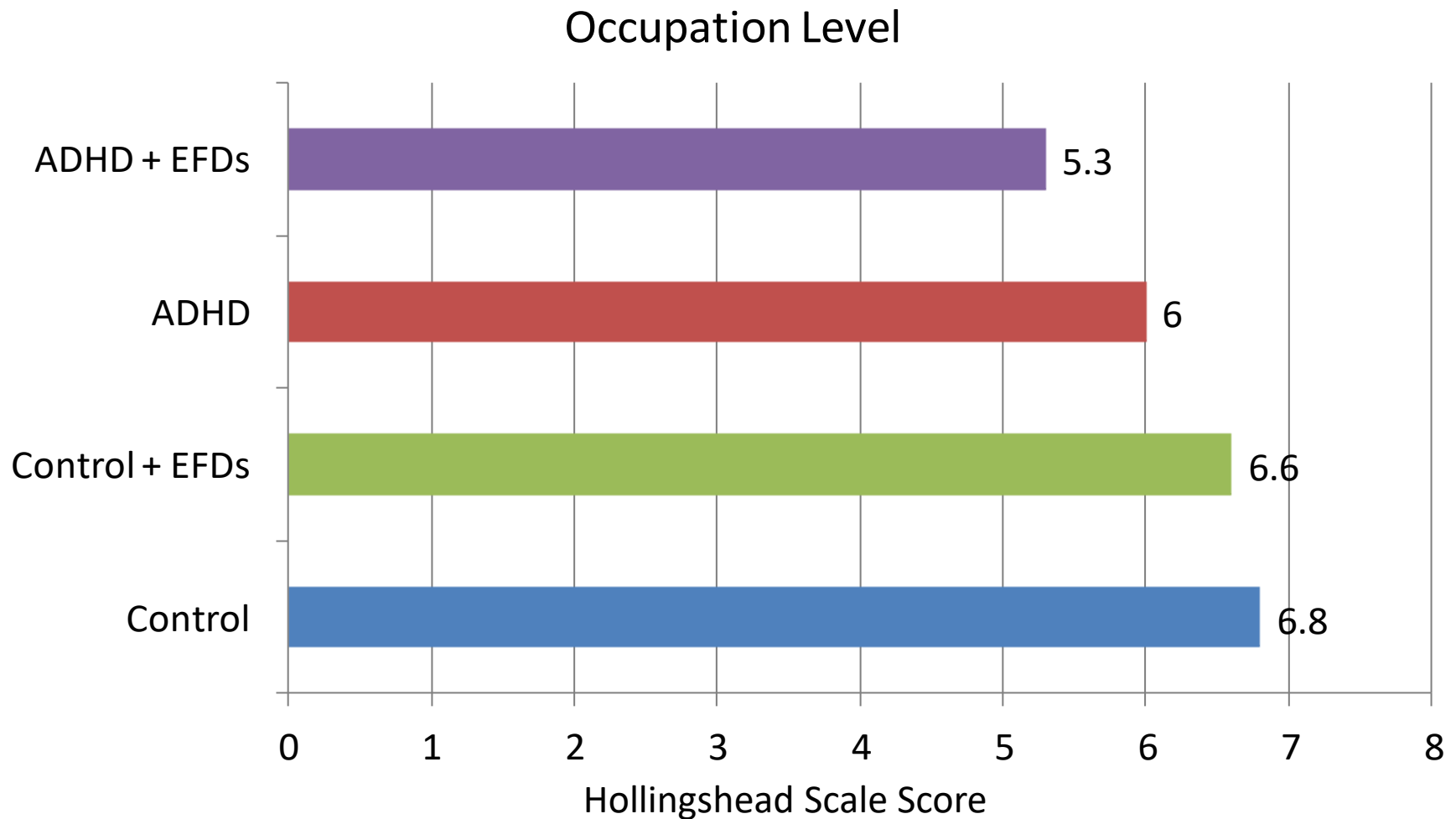


# Impact of EFDs on Adults with ADHD



Biederman, J., C. Petty, et al. (2006). "Impact of psychometrically defined deficits of executive functioning in adults with attention deficit hyperactivity disorder." *Am J Psychiatry* 163(10): 1730-1738.

# Impact of EFDs on Adults with ADHD

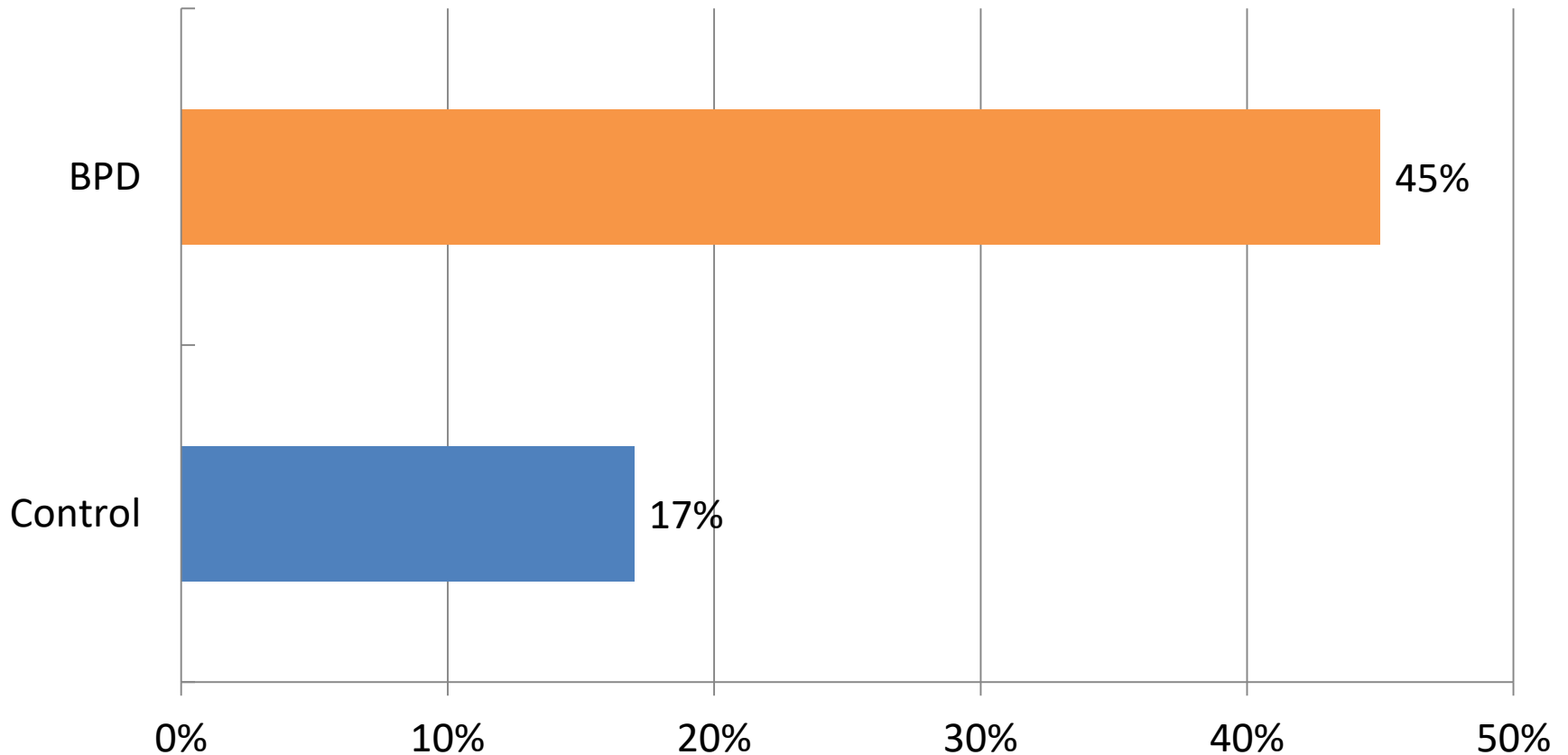


Biederman, J., C. Petty, et al. (2006). "Impact of psychometrically defined deficits of executive functioning in adults with attention deficit hyperactivity disorder." *Am J Psychiatry* 163(10): 1730-1738.



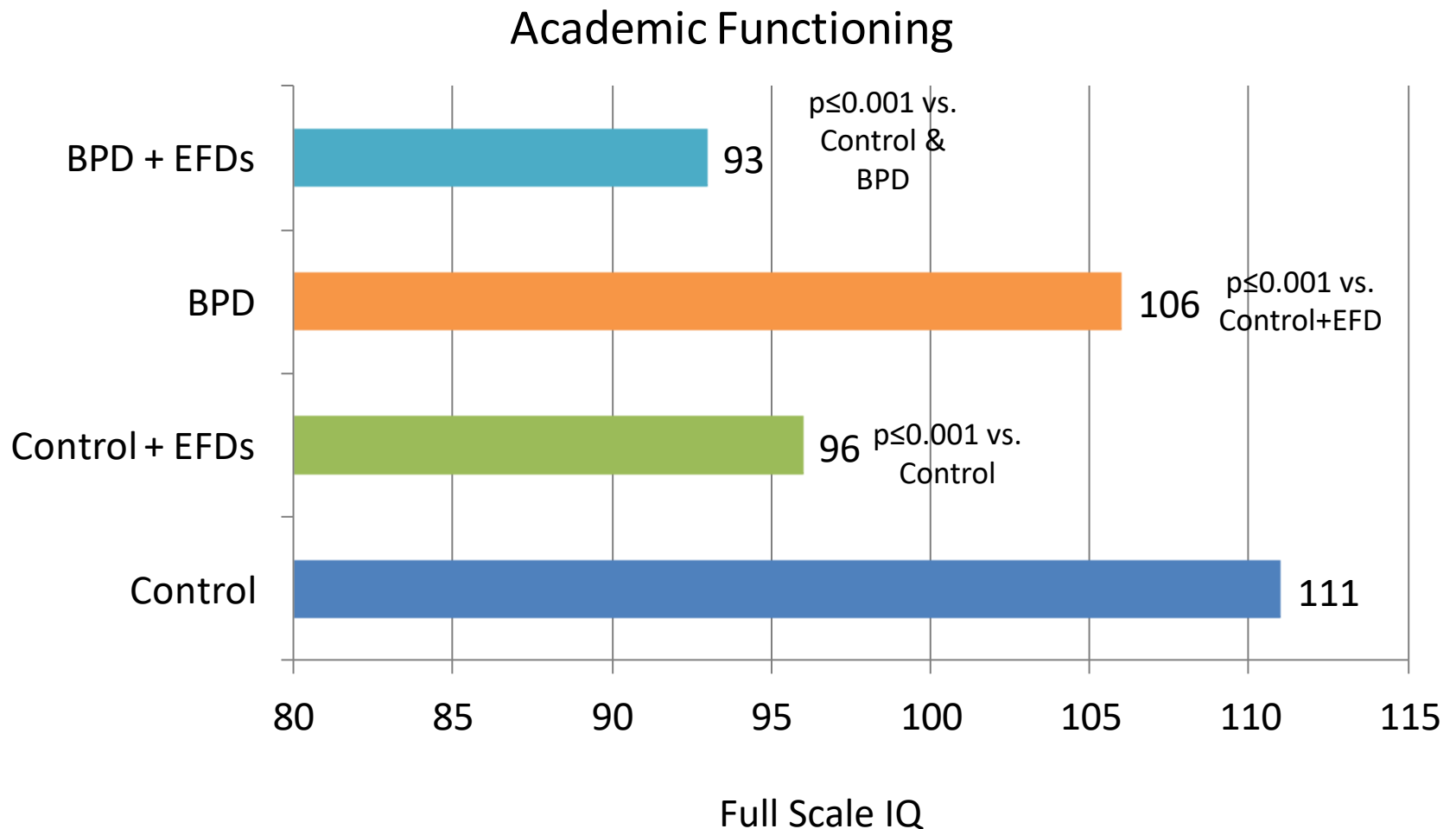
# Impact of EFDs on Youth with BPD

Prevalence of EFDs in Youth



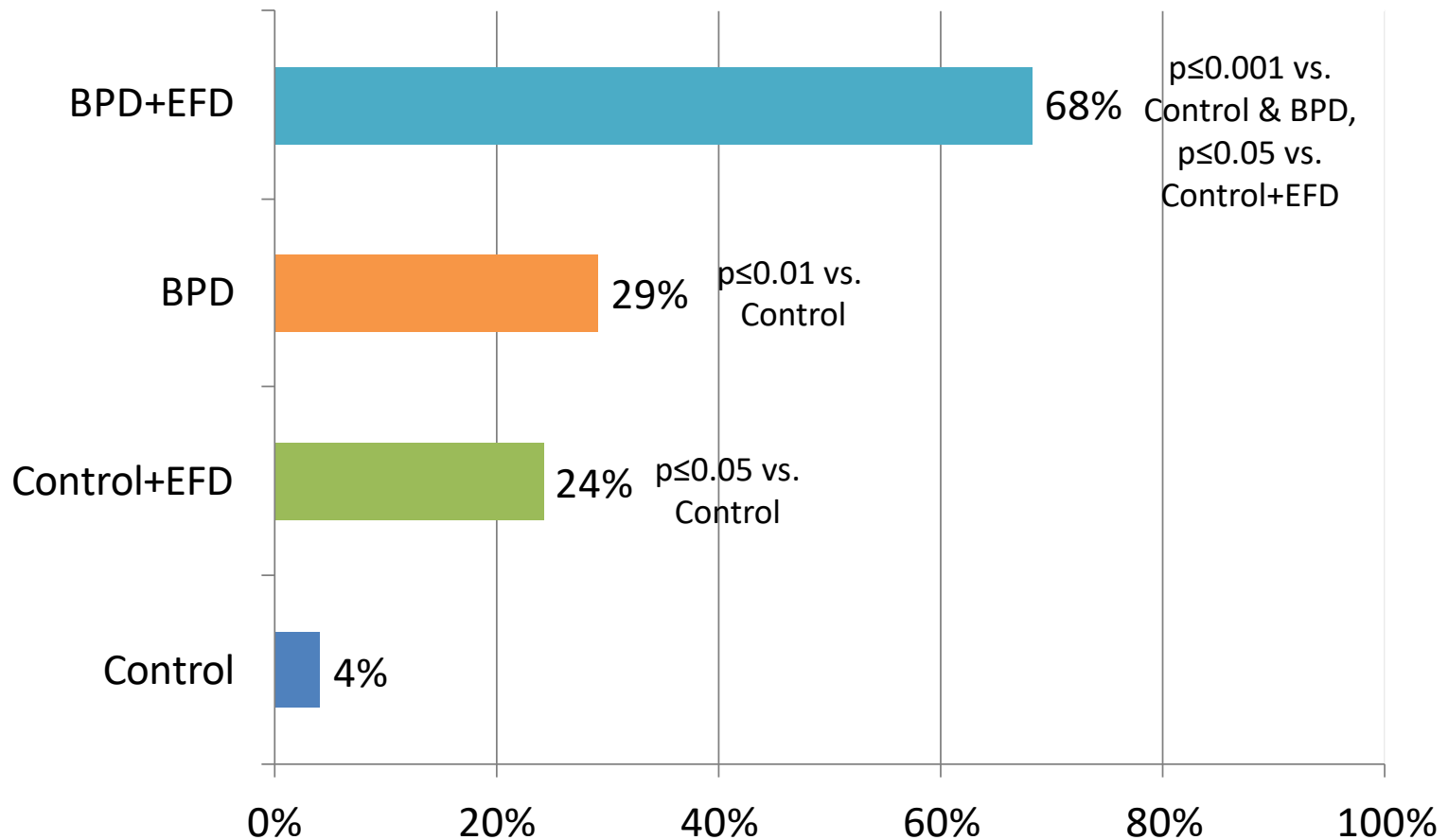
Biederman, J., C. R. Petty, et al. (2011). "Impact of executive function deficits in youth with bipolar I disorder: A controlled study." *Psychiatry Res* 186(1): 58-64.

# Impact of EFDs on Youth with BPD

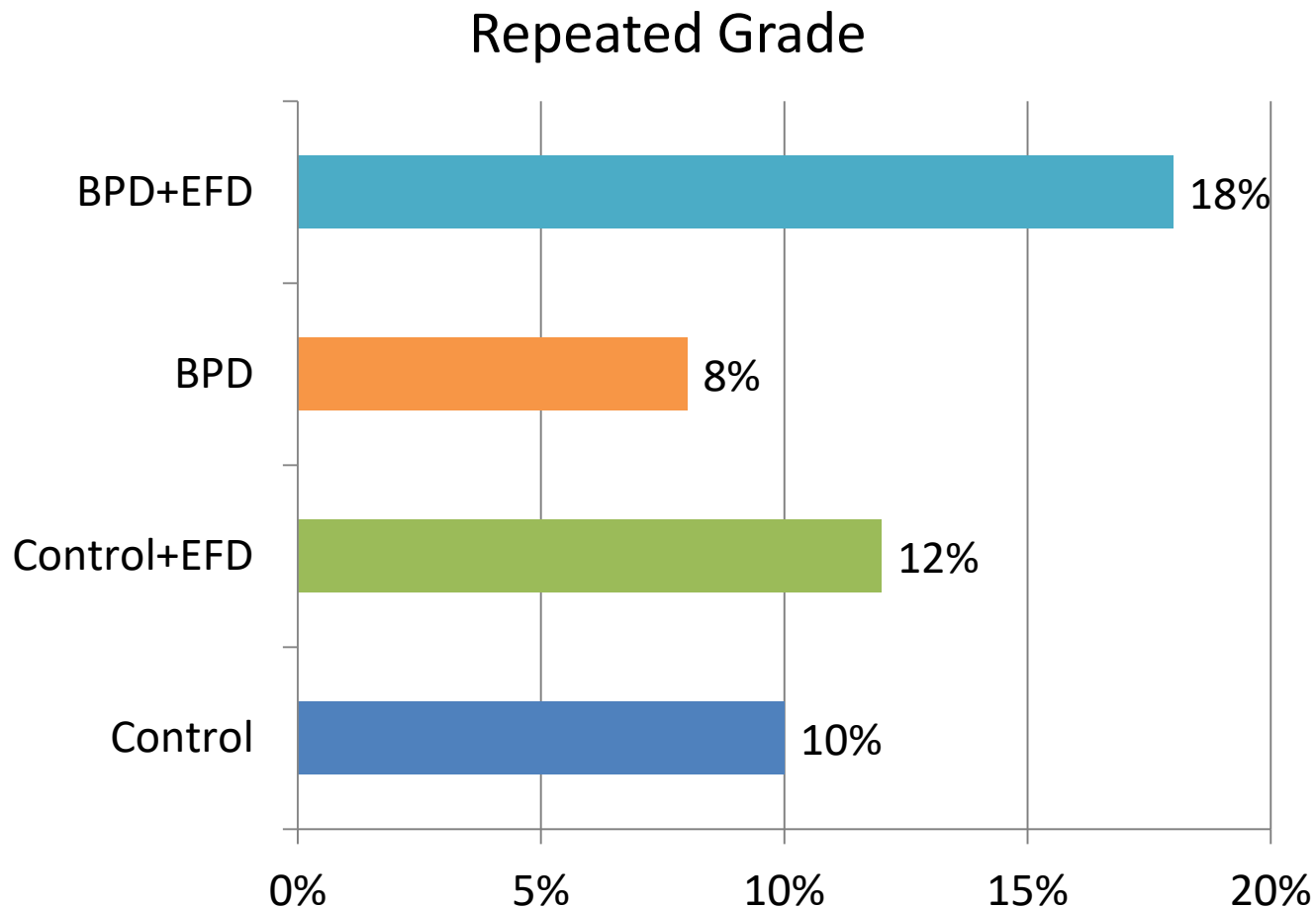


# Impact of EFDs on Youth with BPD

## Special Classes



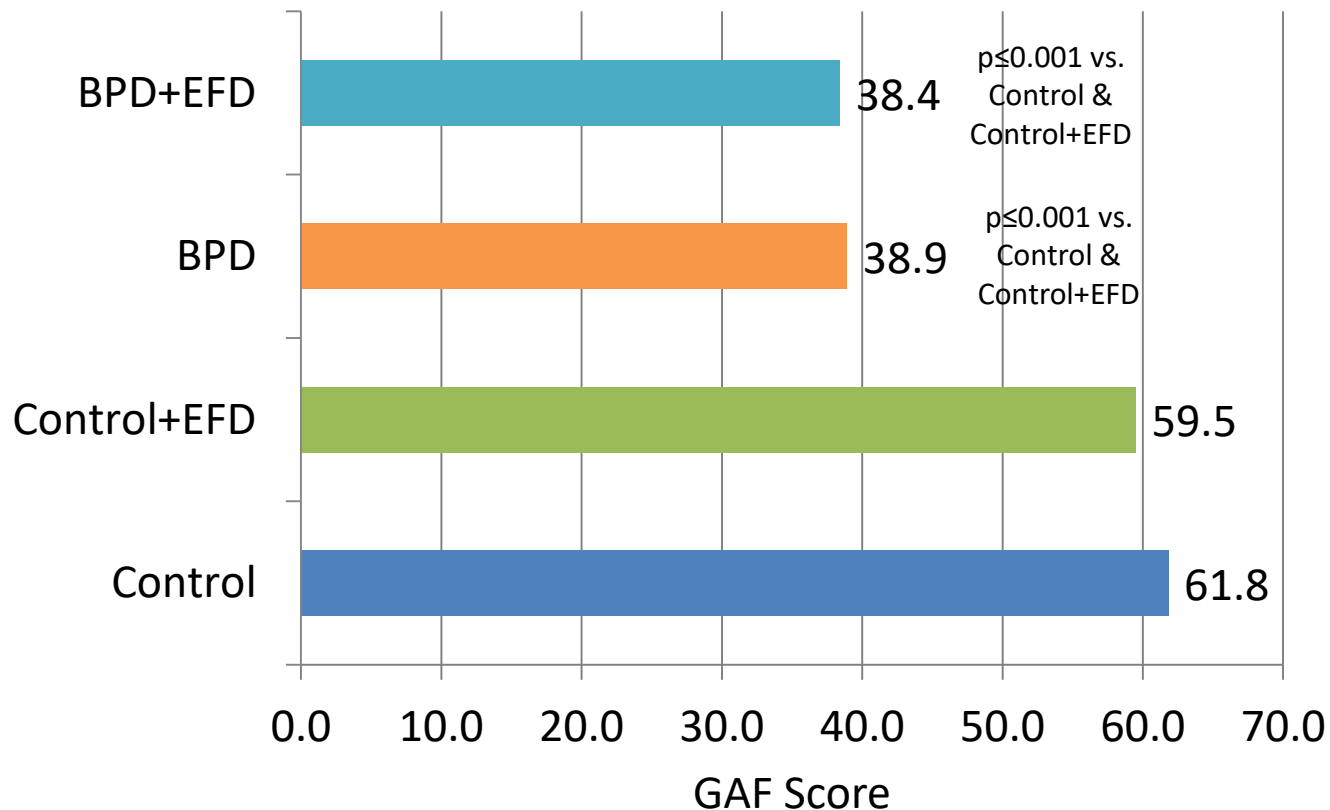
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# Impact of EFDs on Youth with BPD

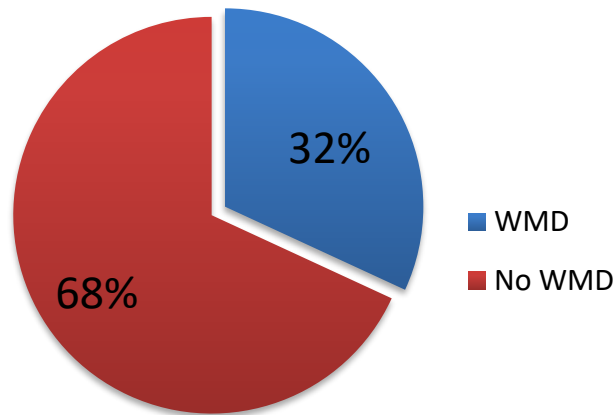
## Global Assessment of Functioning



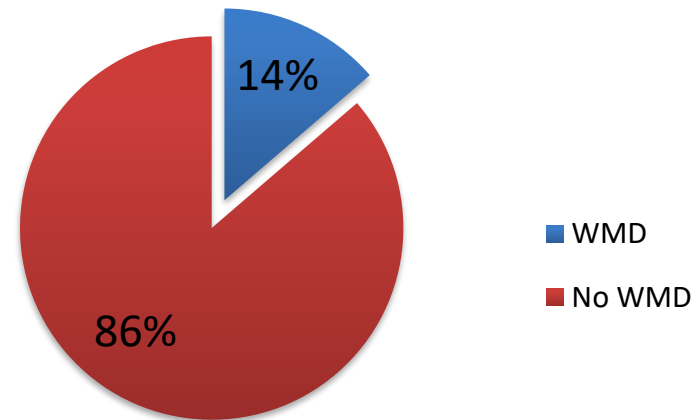
Biederman, J., C. R. Petty, et al. (2011). "Impact of executive function deficits in youth with bipolar I disorder: A controlled study." *Psychiatry Res* 186(1): 58-64.

# Results: Working Memory Deficit Rates

## ADHD Subjects

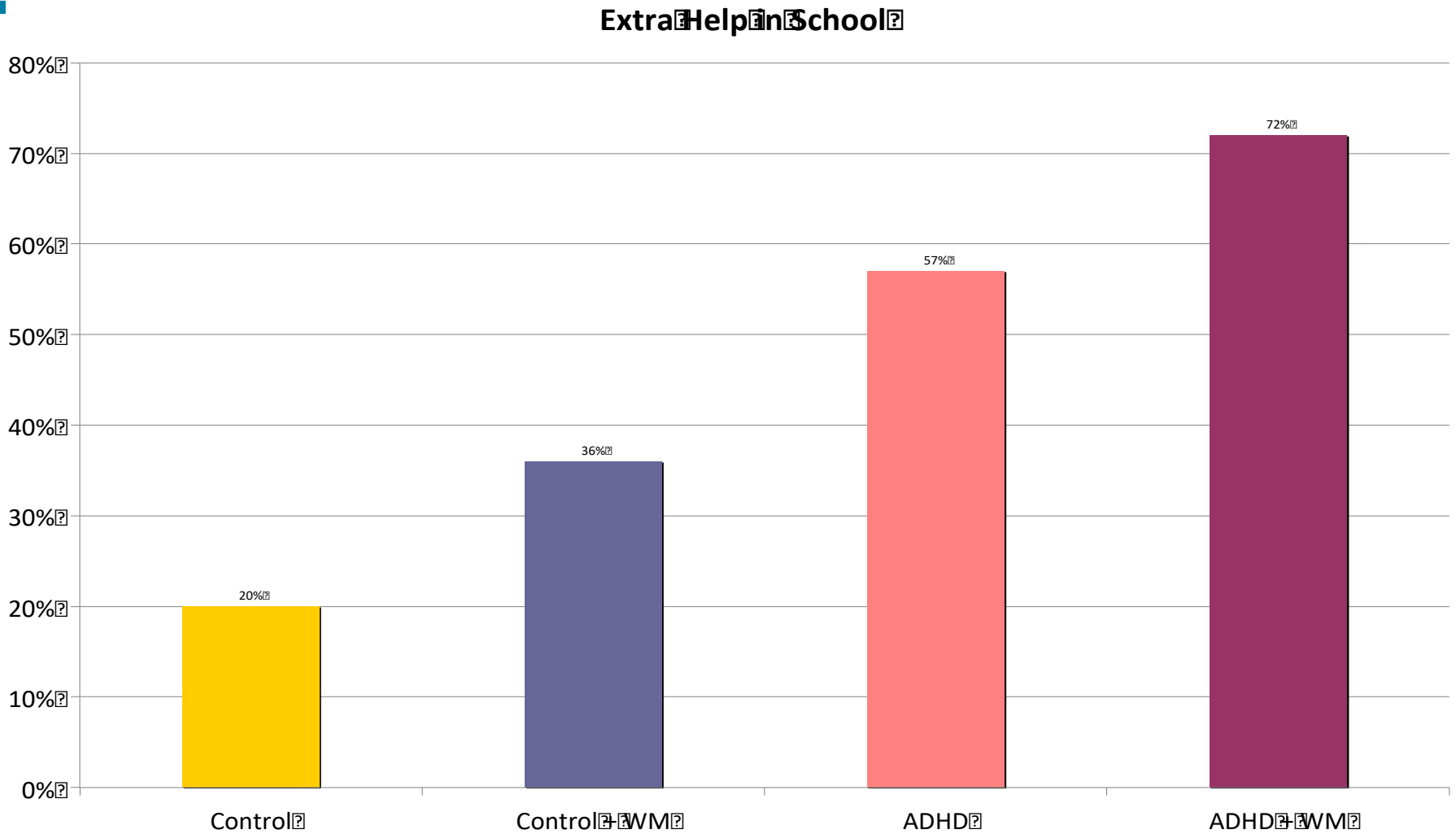


## Control Subjects



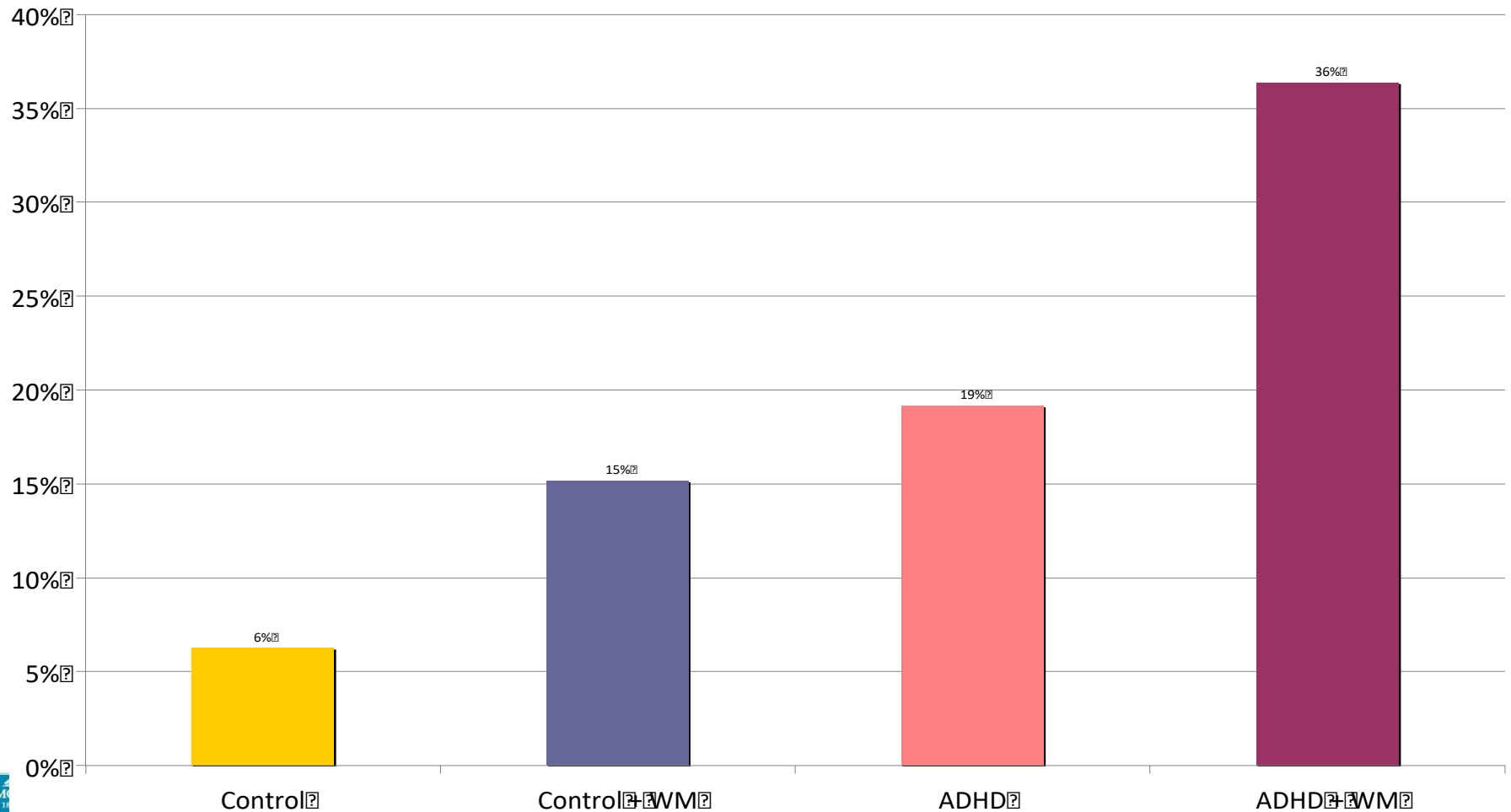


# Extra Help in School



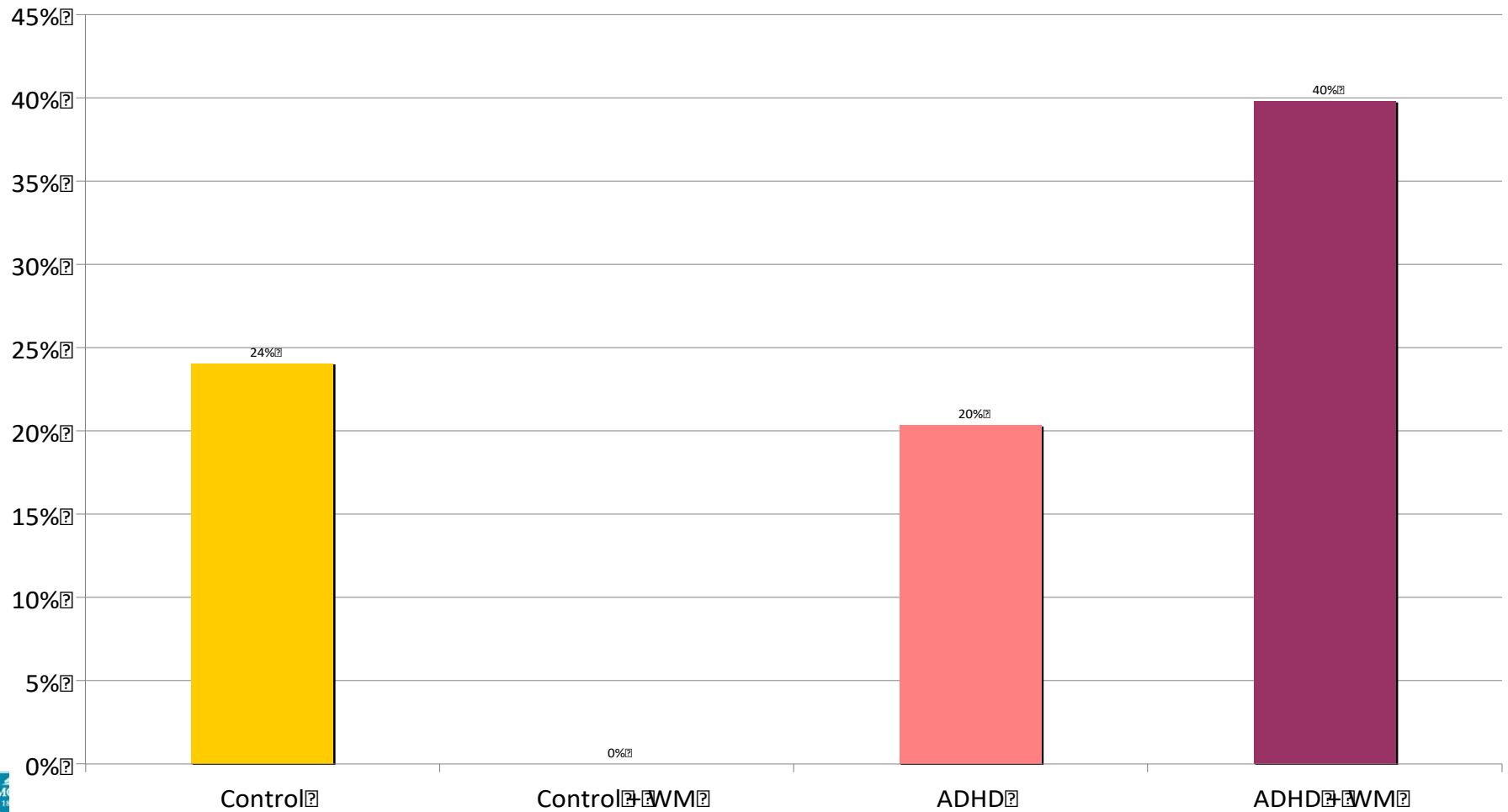
# Repeated Grades

Repeat Grades in School



# Special Classes

Special Class in School

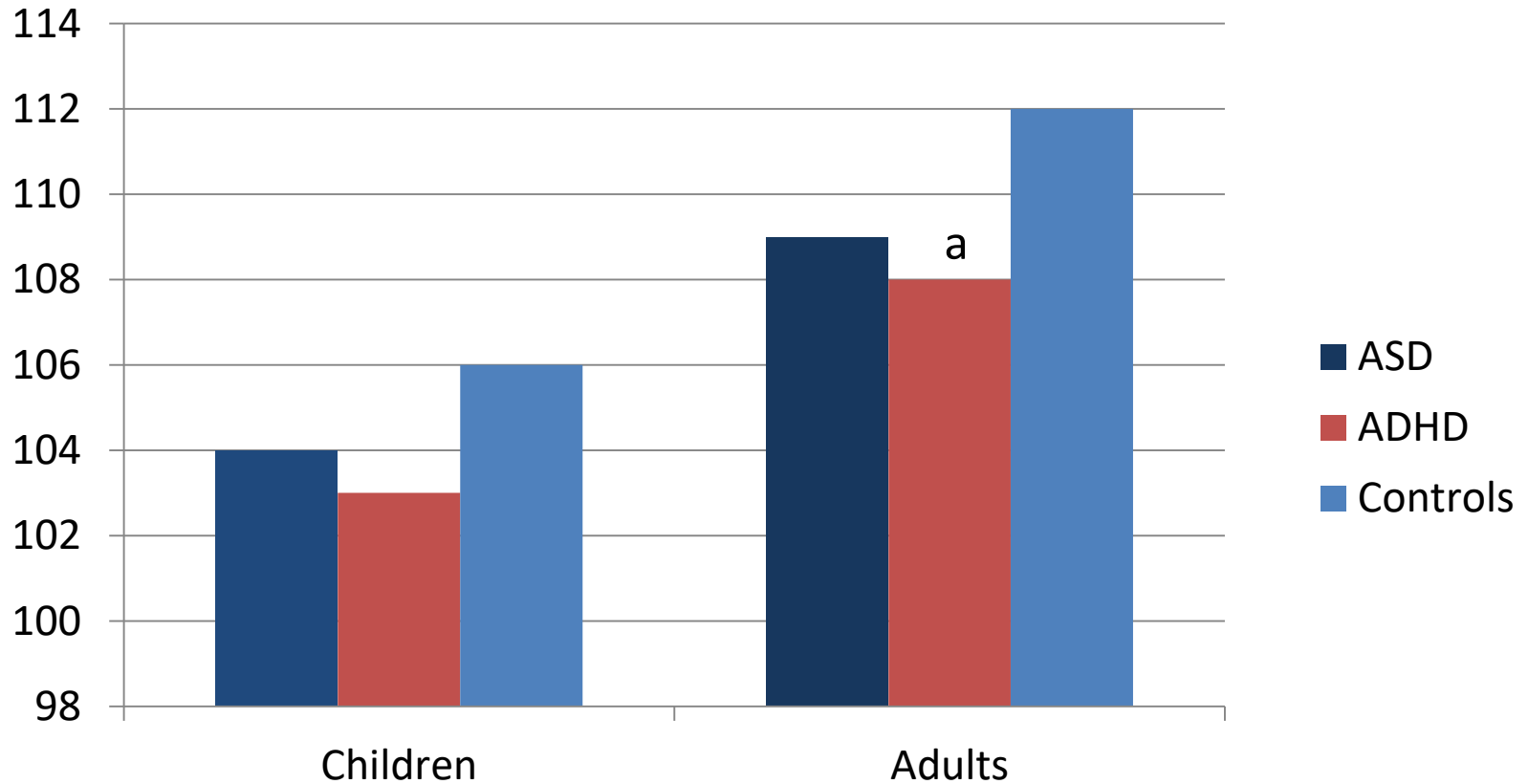


# Neuropsych & Autism Spectrum Disorder

Children	ASD N=49	ADHD N=147	Controls N=32
FS IQ	104 ± 12	103 ± 11	106 ± 13
Age	12.0	14.3	14.0
Sex(Male)	44 (90%)	110 (75%)	18 (56%)
SES	1.85	1.97	1.74

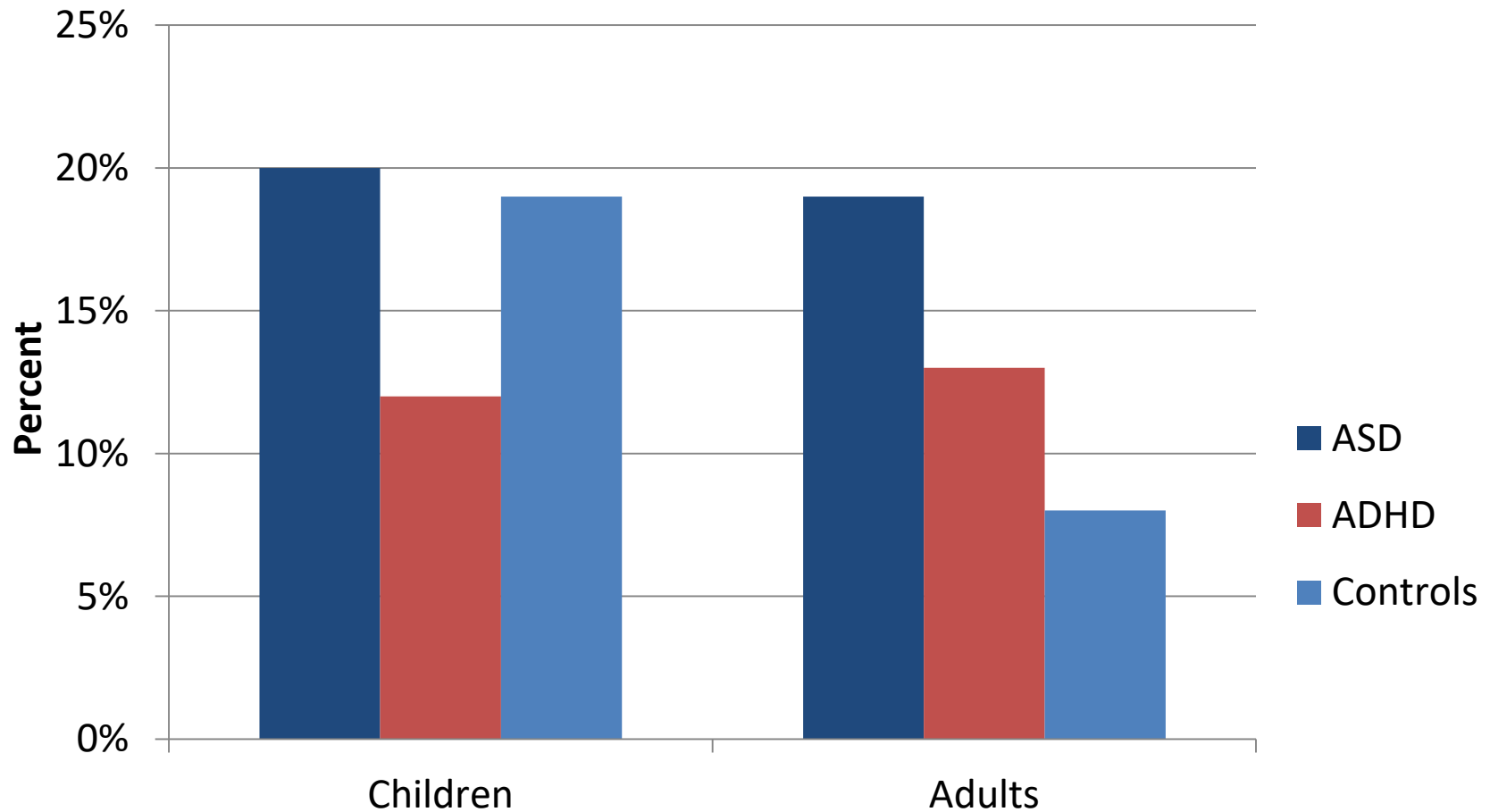
Adults	ASD N=26	ADHD N=89	Controls N=138
FS IQ	109 ± 12	108 ± 14	112 ± 11
Age	27.5	24.6	24.2
Sex(Male)	20 (77%)	45 (51%)	53 (38%)
SES	2.12	2.07	1.87

# Full Scale IQ



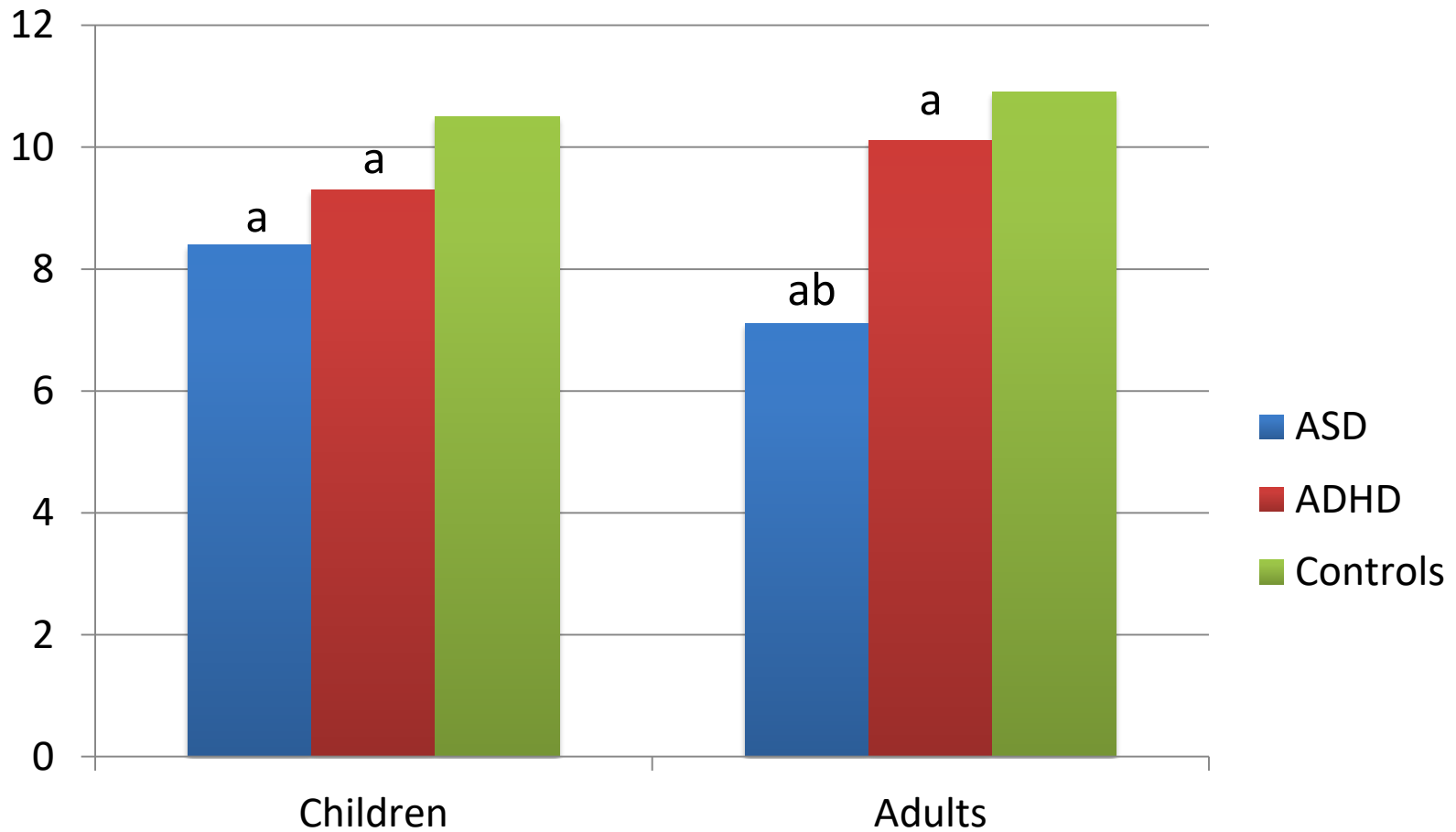
<sup>a</sup>p<0.05 versus controls

# WASI Matrix Score 1SD < Vocab Score



Not significant vs. controls

# D-KEFS Trail Making: Shifting Deficit (EF)



<sup>a</sup>p<0.05 versus controls  
<sup>b</sup>p<0.05 versus ADHD



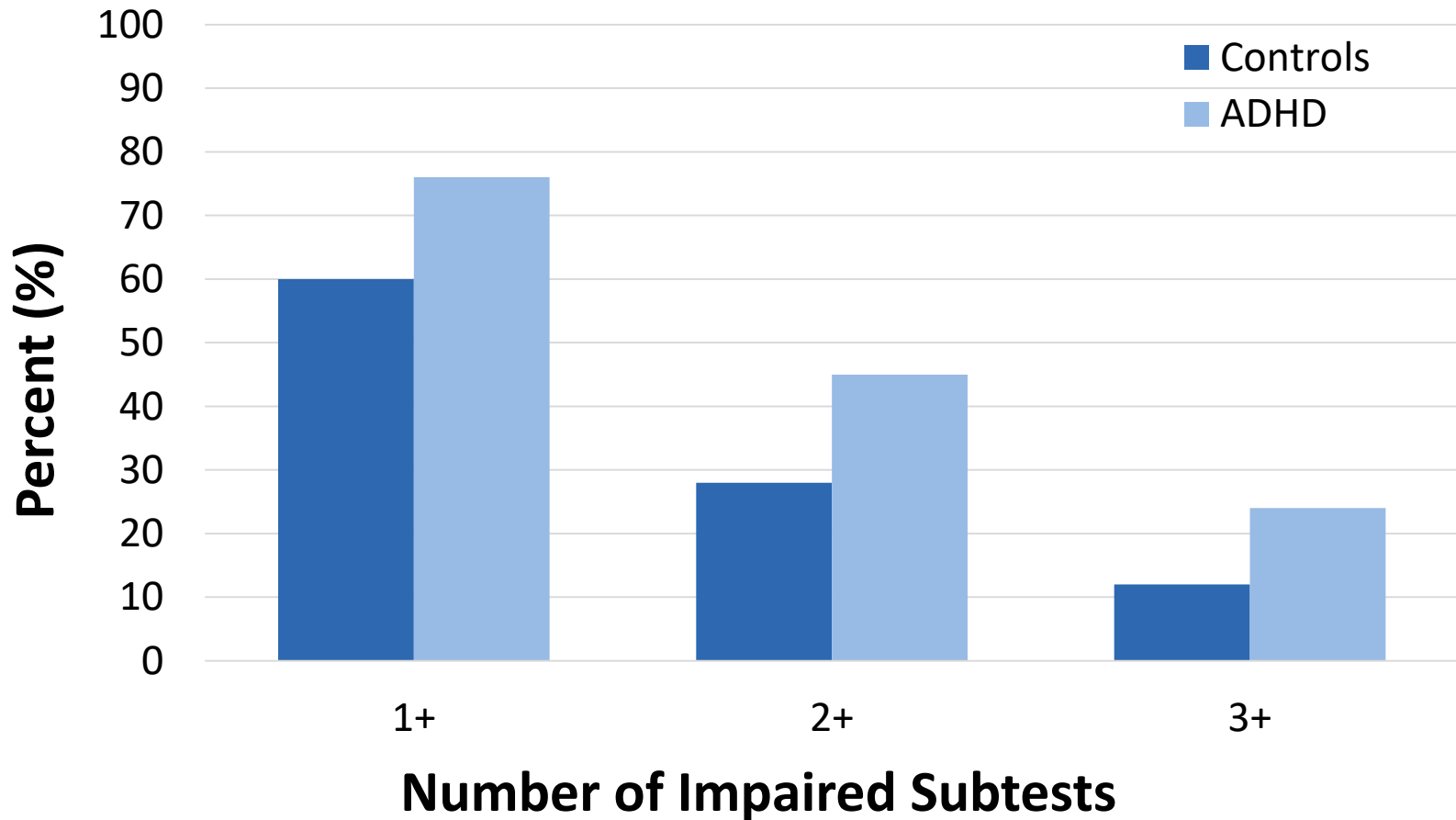
# Can the CANTAB Identify Adults with Attention-Deficit/Hyperactivity Disorder?



# Demographic Characteristics

	<b>Controls</b> N=163	<b>ADHD</b> N=474	<b>Test Statistic</b>	<b>P-Value</b>
	Mean ± SD	Mean ± SD		
Age	30.8 ± 9.9	31.6 ± 11.1	$t_{635}=0.81$	0.42
Full Scale IQ	116.2 ± 11.3	112.7 ± 11.9	$t_{609}=-3.24$	0.001
	N (%)	N (%)		
Male	84 (52)	232 (49)	$\chi^2=0.33$	0.57
Caucasian	134 (85)	390 (88)	$\chi^2=0.76$	0.39
Education Beyond High School	153 (94)	413 (89)	$\chi^2=3.86$	0.05

# Adults with Impaired CANTAB Subtests



# Diagnostic Utility

- Results failed to show any diagnostic utility for the CANTAB in adults with ADHD, even when using the most robust tests
- CANTAB was helpful in identifying executive functioning disorder (EFD) in adults with ADHD when compared with controls.
- Identifying deficits such as working memory is useful to determine the best types of academic interventions to employ (IDEA)
- Considering the morbidity and dysfunction associated with EFDs in adults with ADHD, efforts aimed at identifying EFD's in adults with ADHD are clearly important

	<b>*IDEA</b>	<b>**SECTION 504</b>
<b>PURPOSE</b>	To insure that all children with disabilities have available to them a free education	To prohibit discrimination on the basis of disability in any program receiving federal funds
<b>WHO IS PROTECTED</b>	13 Categories of qualifying conditions	Much broader. Eligibility: a physical or mental impairment that substantially limits a major life activity
<b>DUTY TO PROVIDE A FREE APPROPRIATE EDUCATION</b>	Requires the district to provide IEPs. “Appropriate education” means a program designed to provide “educational benefits.”	“Appropriate” means education comparable to the education provided to non-handicapped students

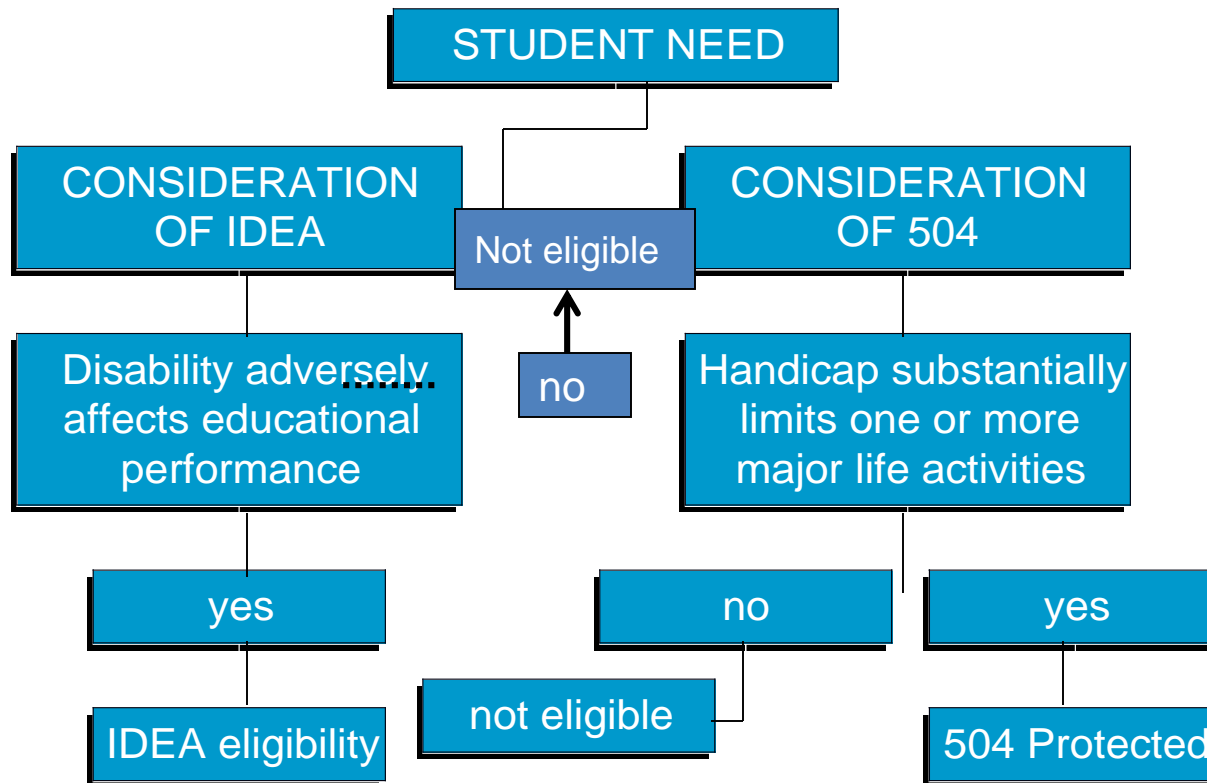
*\*Individuals with Disabilities Education Act (IDEA)*

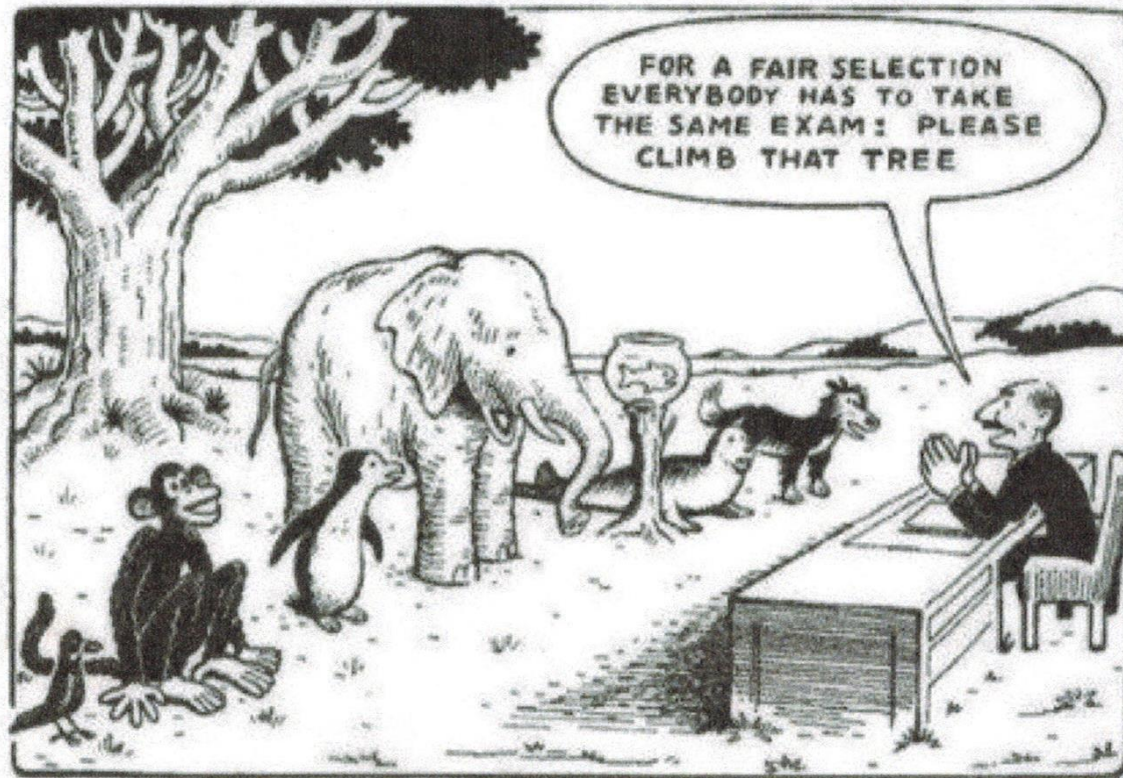
**\*\*Section of the Americans With Disabilities Act (ADA)**

# 13 Categories from IDEA

- autism
- deaf-blindness
- emotional disturbance
- hearing impairment (including deafness)
- mental retardation
- multiple disabilities
- orthopedic impairment
- other health impairment (ADHD)
- specific learning disability
- speech or language impairment
- traumatic brain injury
- visual impairment (including blindness)

# IDEA/504 CHART





# Our Education System