Review Article **IJPRR (2019) 2:19**

International Journal of Psychological Research and Reviews
(ISSN:2639-6041)

Systematic Review of Attention Testing in Allegedly "Untestable" Populations

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ABSTRACT

Test use is extremely important, not only for clinical practice, but also for scientific research. Nonetheless, some populations have been considered "untestable". Among the different cognitive abilities assessed using tests, attention is a fundamental one. The present study presents a systematic review of the literature on attention testing in people with Intellectual Disability or Autism Spectrum Disorder, in order to identify: (1) if there are any tests that are fit to assess these populations; (2) which adaptations would be necessary for such tests to become fit; and (3) what limits and needs are involved. Our literature review identified 39 studies (review papers and empirical studies), all of which concern the administration of attention tests for people with Intellectual Disability or Autism Spectrum Disorder. The selected papers are presented and discussed from two analysis categories: (a) tests, attention abilities, and populations under study; (b) procedures and adaptations made to the testing settings. We identified 72 attention tests, where the majority of the groups of participants in the studies that were analyzed presented mild symptoms. The main adaptations done to the tests refer to strategies used to assist the comprehension of tasks, to communicate instructions, to assure engagement during the procedure, and ways to emit answers. The implications of our results are discussed.

Keywords: Test; Attention; Untestable; Intellectual disability; Autism spectrum disorder.

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The Second author earns a Research Productivity Fellowship granted by Brazilian National Council for Scientific and Technological Development – CNPq.

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How to cite this article:
Verônica M. Rosário, Cristiano Mauro A. Gomes and Cybelle Maria V. Loureiro. Systematic Review of Attention Testing in Allegedly "Untestable" Populations. International Journal of Psychological Research and Reviews, 2019, 2:19

eSciPub LLC, Houston, TX USA.
Website: https://escipub.com/

Public Significance Statement: This study shows that there are many attention tests that may be administered for people with Intellectual Disability (ID) or Autism Spectrum Disorder (ASD), even though only a few of them are compatible with the needs of individuals who present a significant impairment. The analyses performed in this paper may assist the administration or design of more appropriate tests, by presenting some strategies that have been used by researchers in this field to test such populations.

Introduction: The term "untestable" has been used to describe individuals who, due to significant deficits of intelligence or to a low cognitive and social functioning, would not be fit for conventional testing (Alpern, 1967; Bathurst & Gottfried, 1987; Walton & Ingersoll, 2013). Such traits are characteristic of people with Intellectual Disability (ID) or Autism Spectrum Disorder (ASD), who present, to a greater or lesser extent, limited abilities to comprehend instructions and perform tasks. The present paper aims to analyze the challenges of testing these two specific groups from the following questions: (a) Are there any tests that are fit to assess these populations? (b) If so, how is the testing setting defined in order to elicit an answer to instructions? (c) What are the specific limits and needs when testing these populations?

This study presents a systematic review to answer such questions. This was done by selecting and analyzing papers that present tests, specifically related to attention, used to assess people with ID or ASD. It became necessary to delimit a target ability for this study given the wide set of cognitive abilities assessed via testing. Regardless of our focus on a specific domain, we anticipate that the contribution of the analyses presented in this paper concerning the needs of our target group is fully generalizable to other testing formats.

Since the terms "test" and "testing" bear multiple meanings, in the present paper, test is strictly defined as an assessment instrument presenting systematic and standardized procedures to evaluate performance in tasks, that is, it collects samples of behavior through the assessment of answers solicited to the respondent, in light of its accuracy or quality (Urbina, 2014). Thus, it is necessary that the instrument presents a consistent set of stimuli and instructions, prescribing parameters according to which the answers can be performed, and generating the encoding, scoring, or measurement of the behavior produced (Megargee, 2000).

Attention was selected as our area of interest since the assessment of this ability is an essential procedure as a diagnosis and prognosis criterion in clinical and educational practice, as well as in research and cognitive rehabilitation of different populations. Such an assessment is mandatory in any neuropsychological exam, and it precedes all the other cognitive functions (Coutinho, Mattos, & Abreu, 2010).

On the other hand, studying cognitive abilities in people with ID and/or ASD is a challenge, given these groups difficulties in comprehending tests or tasks, particularly when instructions are given and verbal answers are required. A low motivation may also interfere with performance (Giuliani, Favrod, Grasset, & Schenk, 2011). Moreover, characteristics that are commonly found in these populations, such as impairments regarding perception, language, motor ability, and ability to remain focused on a task, add an extra specificity to testing (Mungkhetklang, Crewther, Bavin, Goharpey, & Parsons, 2016).

ID is defined by deficits in the intellectual and adaptive functions, beginning in childhood or adolescence, in the conceptual, social, and practical domains. Intellectual deficits may impair functions such as reasoning, problem solving, planning, abstract thinking, judgment, academic learning, and learning from experience. Deficits in adaptive functions bear difficulties in attaining standard development patterns, besides impairing sociocultural patterns related to personal independence and social responsibility. The different levels of severity range between mild, moderate, severe

and profound, and they are defined according to the level of adaptive functioning in order to determine the level of support required (American Psychiatric Association [APA], 2014).

As for ASD, it is characterized by a persistent deficit in social communication and in social interaction, as well as by restricted and repetitive patterns of behavior, interests or activities. Although the presence of symptoms in the early developmental period is a fundamental diagnosis criterion for this disorder, some difficulties might be masked as a result of interventions, compensations, or given support. The term spectrum is used because of the great variability shown by the population affected in terms of symptoms severity levels, intellectual ability, language, development level, and age. The delimitation of specifiers severity is based on impairments in social communication and in restrict patterns of behavior, which entail different levels of support: level 1 (requiring support), level 2 (requiring substantial support), and level 3 (requiring very substantial support) (APA, 2014; Klin, 2009).

Even though ID and ASD are different disorders, it is common to associate them. There are data which point out that ID is present in about 50% of people diagnosed with ASD (Joseph, 2011). Other forms of comorbidity in these populations concern motor and language disorders (APA, 2014).

The ability to focus attention is one of the cognitive abilities impaired in individuals with ID (Honora & Frizanco, 2008). The debates around the relation between ID and attention started in 1960 (Zeaman & House, 1963). The first studies suggested that an attention deficit was the source of the impairment, in other words, its cause. However, more recent research tends to consider low attention ability as a functional deficit related to the general difficulty in processing information that is distinctive of this population (Oka & Miura, 2008).

A general difficulty in directing or maintaining attention, as well as hyper selective attention, which is understood as a tendency to give more attention to detail than to the whole, are characteristics often found in people with ASD (Silva & Mulick, 2009). Evidence shows that changes in attention which underlie autism are likely related to neurodevelopmental mechanisms. People with ASD present impairments in the processing of basic attention operations, making it difficult for them to select relevant information in the environment. Consequently, it is common to see these individuals focusing their attention on inappropriate and insignificant stimuli, seldom directing their focus to conventional stimuli (Montiel-Nava & Peña, 2011).

Attention is a phenomenon that is complex, multidimensional, and hard to define, given the several elements that are accepted as its essential characteristics (Montiel & Capovilla, 2008). According to Sternberg and Sternberg, attention may be defined as “the means by which we actively process a limited amount of information from the enormous amount of information available through our senses, our stored memories, and our other cognitive processes" (Sternberg & Sternberg, 2012, p. 137).

Considering that attention is not one single process, different classification criteria may be used (Cohen, 2014). The most frequent classification categories of attention are: focus (ability to respond to a specific stimulus), sustained attention (ability to maintain a constant attention response along a continuous and repetitive activity), selective attention (ability to select relevant stimuli among other less relevant), shifting attention (ability to change the focus of attention, alternating it between different stimuli), and divided attention (ability to respond simultaneously to multiple stimuli) (Sohlberg & Matter, 2001).

Attention is usually measured using tests that apply the following paradigms: cancellation, continuous performance, and dual task. Cancellation tests enable the assessment of

selective attention using tasks that demand selecting and signaling a target stimulus; they also make it possible to assess sustained attention, requiring that a subject is attentive and persists in the task. The dual task paradigm is meant to assess divided attention, since a subject is required to perform simultaneous tasks, in which she/he must select certain stimuli from a wider set of several randomly placed stimuli. Continuous performance tests are computerized and are defined by the presentation of target stimuli and distracters, presented in previously set intervals (Montiel & Capovilla, 2008). The tests that apply such paradigms usually require reading abilities or the ability to use a computer, as well as understanding verbal instructions, and performance tasks. All of which are incompatible with this study's target populations.

The challenges of administering tests to people with ID or ASD who have a hard time understanding instructions and producing responses are not limited to the assessment of attention and have been reported and discussed by different authors (Alpern, 1967; Bathurst & Gottfried, 1987; Courchesne, Meilleur, Poulin-Lord, Dawson, & Soulières, 2015; Plesa-Skwerer, Jordan, Brukilacchio, & Tager-Flusberg, 2016; Tylenda, Beckett, & Barrett,2007; Wolf-Schein, 1998). The literature has been acknowledging the presence of a few fundamental aspects related to this challenge. However, such acknowledgment is more related to signaling difficulties and proposing alternative assessment formats to tests.

Wolf-Schei (1998) highlights that, considering the difficulties concerning the perception and comprehension of instructions that are characteristic of these populations, communication, a key-element in testing, becomes a real challenge in this context. Researchers such as Courchesne and collaborators (2015) and Roid, Nellis and McLellan (2003), claim that verbal instructions may be ineffective when used with these populations, given their limitations regarding oral and written language. Hall, Hammond, Hirt and Reiss (2012) also assert that rejection or lack of interest in interacting face to face are both common in these populations, making it even more difficult to communicate instructions in these tasks.

Another aspect that is considered fundamental in the testing problem regards cooperation (Bathurst & Gottfried, 1987). However, these populations may present engaging difficulties that are related to different factors, such as: tendency for distraction; unfamiliarity with the testing environment; lack of motivation; anxiety about test performance; and frustration with performance as test items get harder (Plesa-Skwerer et al., 2016). The administration time of tests, tasks, or objects that are unappealing, as well as the need for continuous interaction with the test administrator, may be elements that interfere with the engagement of a person with ID or ASD in testing (Schum, 2004).

One final element that is emphasized in the literature regarding difficulties experienced in administering tests for people with ID and/or ASD is the great variability of cognitive, motor, and language characteristics in these populations. The heterogeneity of these groups calls for a very careful selection of the test that will be used, considering the participants specificities (Deutsch, Dube, & McIlvane, 2008; Freeman, Gray, Taffe, & Cornish, 2016). Non-adapted tests carry a high risk of unfeasibility, since they produce the so-called floor effect, that is, scores that are very close to the minimum score (Lamb, 2012).

Despite the challenges found in the administration of tests for people with ID and/or ASD, Wolf-Schein (1998) states that nobody is "untestable”, as long as the instrument administered is appropriate to the characteristics and needs of that person. Moreover, this author claims that labeling a person as "untestable" reflects more the examiners choice of assessment tools than the respondent’s abilities.

On the other hand, both this author and other researchers who study this topic usually propose a set of alternatives out of the focus of this study, bearing in mind that they do not present standardized tests to ascertain the target ability using performance measures.

Perhaps this tendency to administer alternative instruments in testing is a key-element responsible for the lack of systematic reviews with goals similar to the ones of the present study. The systematic review studies found on the psychometric instruments administered for these populations refer to other assessment modalities, such as observation scales, interviews, and self-report questionnaires (Loureiro, Pio-Abreu, Machado, Gonçalves, & Cerejeira, 2015; Zeilinger, Stiehl, & Weber, 2013).

Thereby, our research interest on instruments that assess cognitive abilities using performance measures is justified whether for the difficulties that characterize these populations in the context of testing, or for a tendency shown in the literature to avoid testing the target public of this study. When combined, these elements point to the relevance of this study about the existence of tests, tasks, or testing settings that are able to carry out such an assessment. Therefore, the goal of the present review is to: (1) identify tests that assess attention in people with ID and/or ASD; (2) analyze what adaptations and specificities are proposed for the testing setting; and (3) assess the specific limits and needs of this procedure.

Method

The systematic review performed in this study includes all PRISMA guidelines (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*; Moher, Liberati, Tetzlaff, Altman, & the PRISMA Group, 2009). Our bibliographic search was guided by the stage concerning the entrance in the Systematic Bibliographic Review (SBR) *Roadmap*, presented by Conforto, Amaral, and Silva (2011).

Primary sources, such as books, papers, and thesis regarding neuropsychological assessment, attention assessment, and assessment of people with ID and/or ASD, were examined to familiarize with the topic. Moreover, researchers and experts in this area were consulted.

The search strings, that is, the keywords used to perform it, included the combination of the terms "intellectual disability" or "autism" or "pervasive developmental disorders" with the words "assessment" or "test" or "attention". Thus, six groups of strings were used in our search.

The selection of works to be considered in our study followed a few inclusion criteria. We determined as target test all attention tests administered to people with ID or ASD, which were standardized and managed performance measures to assess such ability, regardless of being called tests or tasks by their authors. We chose literature reviews that presented a target test. We also selected studies that described target tests, or that presented validation studies or clinical research about them. We included published studies in papers or thesis. As for the exclusion criteria followed, we disregard: studies that did not strictly present tests, such as self-report and qualitative assessment instruments; studies that were not written in English or Portuguese; studies whose full texts were not available. No single study was excluded on the grounds of the journals or the papers impact factor.

Three filters were used to refine the search, in order to select the studies. The first filter was to perform an exploratory reading of the studies found from the strings, which included reading the title, abstract, and keywords. This filter was used to eliminate duplicate papers, and papers that clearly referred to other populations or types of assessment. As for the second filter, an exploratory reading of the studies method was carried out, to detect a possible target test. The third filter included reading the full papers that were selected to identify the studies that

respected all inclusion and exclusion criteria. The selection of articles was carried out by the first author of this article, with the conference of the second author. Therefore, the articles selected in the last filtering were defined in agreement.

The bibliographic search took place from July to December 2016, in different databases, such as Scopus, Web of Science, MEDLINE/Pubmed, PsycARTICLES, Wiley, and SAGE, among other collections that are incorporated in the CAPES Scientific Journals Gateway (Capesgovbr, 2017).

The studies selected underwent two categories of analysis. The first category aimed to determine the relationship between the use of the attention tests identified in the review and the level of cognitive impairment and age range of the population that was assessed, as well as the attention abilities involved. The second category is directly related to the testing issues themselves regarding people who have difficulties concerning instructions and providing a response. In this category, we identify and discuss if there are any special administration procedures for this population, including the specificities of the testing setting.

Results and Discussion

The outcome of the literature review is shown in Figure 1. We found 2,101 studies in our search. After reading the titles, abstracts, and keywords (filter 1), a total of 543 studies was selected. After reading the studies method (filter 2), 79 studies were selected. When the full reading of these studies (filter 3) was done, 39 studies were selected, which represents a rate of inclusion of approximately 1.8%.

Among the selected studies, we found three literature review papers (Klinger & Renner, 2000; Matson, Rieske, & Williams, 2013; Schum, 2004), and one doctoral thesis in neuropsychology (Foster-Owens, 2016). The remaining papers concerned empirical studies. We found studies published from 1990 to 2016. A higher concentration of published studies can be observed from 2004 on (79%, *n* = 31), and the number of published studies in the last five years is high (43.5%, *n* = 17).

The results are described and discussed simultaneously using two categories of analysis. The first category concerns the selected studies, providing information about the attention tests used, the populations involved, as well as the attention abilities measured. The second category describes procedures and adaptations in the testing setting aimed at the specific needs of the respondents.

Category 1: Tests, Attention Abilities Measured, and Populations

All papers selected are listed in Table 1, which presents the attention tests found, the attention abilities measured, and the population who participated in the studies. We identified 72 attention tests, including subtests of cognitive assessment batteries (58.3%, *n* = 42), tests (33.3%, *n* = 24), and tasks specially designed for the conducted research (8.3%, *n* = 6).

Some of the batteries cited here make attention tests available as part of a wider assessment of cognitive functions. There are other batteries, though, that were specially designed to enable a global assessment of attention, providing tests directed at different components of the attention processes.

The paradigm originally developed by Rosvold (1956), known as Continuous Performance Test – CPT, is noticeably predominant when assessing sustained attention in individuals with brain damage. This paradigm is a reference to build different attention tests. Tests that are identified by their authors as a modality of CPT were used in 11 studies (28.2%). The CPT paradigm was also used in tests included in several batteries (Crutcher et al., 2016; Foster-Owens, 2016; Jauregi et al., 2007; Knox et al., 2012; Matsuura et al., 2014). Therefore, we observed that this paradigm was used in 17 studies (43.4%).

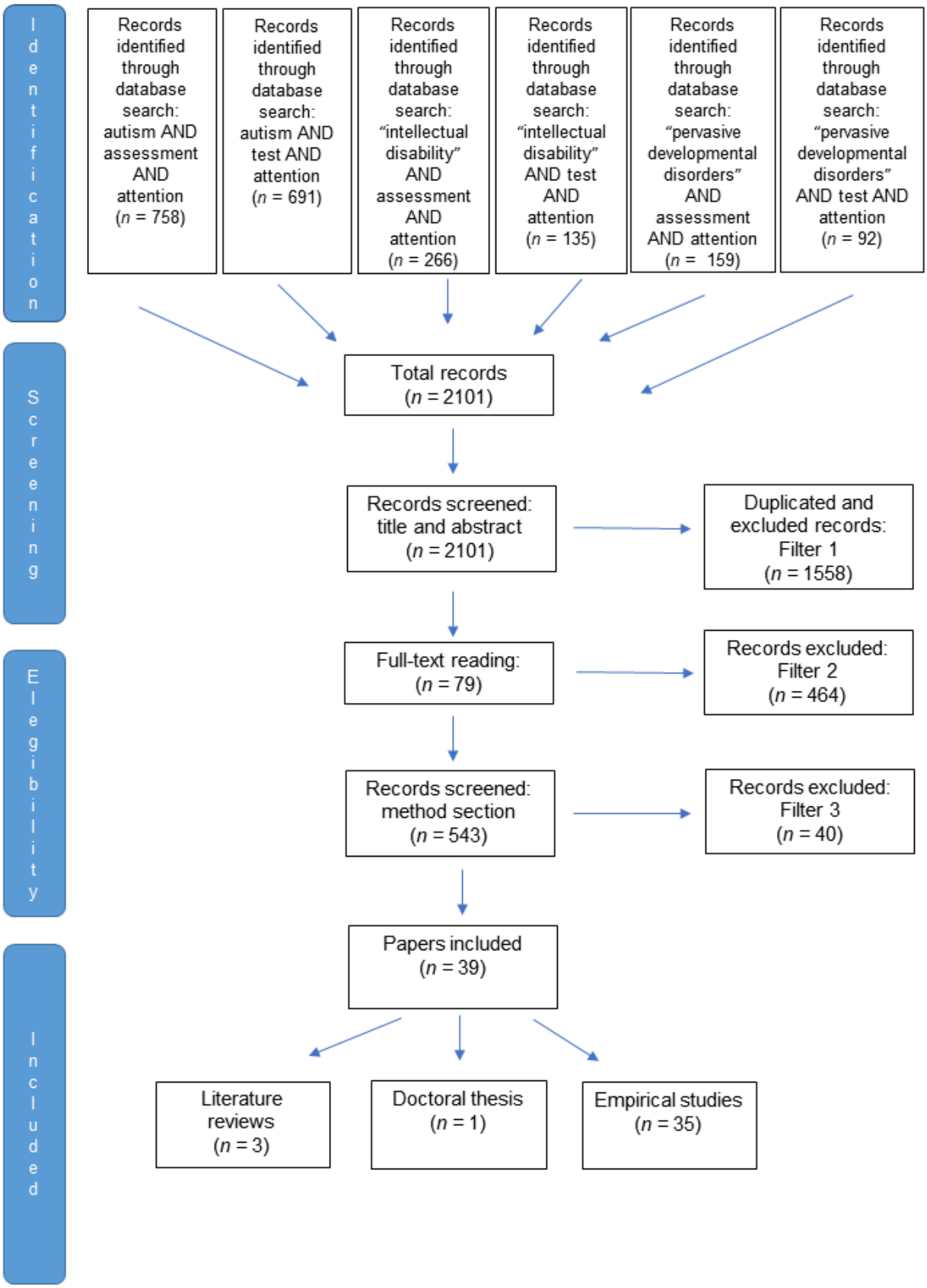

Figure 1 - Flow diagram of the systematic review search strate

Table1. Description of Studies: Tests, Abilities and Populations

Authors – Year	Test	Abilities	Population
1. Aman, Kern, MacGhee& Arnold (1993)	(1) Breadth of Attention	(1) Selective attention	Mild ID
	(2) CPT	(2) Sustained attention	
2. Bogte, Flamma, Van Der Meere& Van Engeland (2009)	No name	Divided attention	High-Functioning Autism
3. Borgwardt et al. (2015)	Leiter-R		Mild, moderate and severe ID
	Attention sustained	Sustained attention	
4. Corbett & Constantine (2006)	IVA-CPT	Sustained attention	High-Functioning Autism; AS
5. Crutcher et al. (2016)	KiTAP		ID and/or ASD*
	(1)The Witch	(1) Psychomotor speed	
	(2)The Owls	(2) Attention	
	(3)The Ghost´s Ball	(3) Working memory	
	(4)The Dragon´s House Cogstate	(4) Executive functions	
	(5) Identification	(5) Attention	
6. De Vries& Watson (2008)	TEA- Ch		Mild ID
	(1) Sky Search	(1) Selective attention	
	(2) Score!	(2) Sustained attention	
	(3) Sky Search Dual Task	(3) Divided attention	
7. Fan et al. (2012)	ANT-R	Attentional network	High-Functioning Autism; SA
8. Foster-Owens (2016)	ANT-C	Attentional network	High-Functioning Autism; SA
	WATT		
	(1) Visearch	(1) Selective attention	
	(2) Visearch-dual	(2) Switching/ executive control of attention	
	(3) Vigilan	(3) Sustained attention	
9. Garretson, Fein &Waterhouse (1990)	CPT	Sustained attention	ASD*
10. Haigh et al. (2016)	No name	Visual attention and auditory attention	High-Functioning Autism
11. Huguenin (1997)	No name	Visual attention	Severe ID
12. Huguenin (2004)	No name	Visual attention	Severe ID
13. Jauregi et al. (2007)	CalCAP		Mild and moderate ID
	(1) Simple reaction time	Attention	
	(2) Choice reaction time		
14. Jiang, Capistrano & Palm (2014)	Attentive tracking task	Sustained visual attention	High-Functioning Autism; SA
15. Keehn, Lincoln, Müller &Townsend(2010)	ANT	Attentional network	High-Functioning Autism
16. Klinger & Renner (2000)	Posner´s Paradigm	Shift attention	ASD*
17. Knox et al. (2012)	KiTAP		ID*
	(1) The Witch	(1) Alertness	
	(2) The Happy and Sad Ghosts	(2) Distractibility	
	(3) The Dragons House	(3) Flexibility	
	(4) The Bat and the Cat	(4) Inhibition	

	(5) The Witches's Parade	(5) Visual Scanning	
	(6)The Mirror	(6) Vigilance	
	(7) The Ghost´s Ball	(7) Sustained attention	
	(8) The Owls	(8) Divided attention	
18. Lerner, Pottoff& Hunter (2015)	NEPSY II		High-Functioning Autism; SA
	Auditory Response Set	Attention and set-shifting	
19. Lundervold et al. (2016)	CCPT-II	Sustained attention	High-Functioning Autism
20. Matson, Rieske& Williams (2013)	CAS**		ASD*
	(1) Expressive attention	Attention	
	(2) Number detection		
	(3) Receptive attention		
	TEA**		
	(4) Map Search	(4) Selective attention	
	(5) Elevator Counting	(5) Sustained attention	
	(6) Elevator Counting with Distraction	(6) Selective attention /Working memory	
	(7) Visual Elevator	(7) Attentional switching	
	(8) Elevator Counting with Reversal	(8) Attentional switching/ Working memory	
	(9) Telephone Search	(9) Selective attention	
	(10) Telephone Switch while Counting	(10) Sustained and divided attention	
	(11) Lottery	(11) Sustained attention	
	(13) IVA- CPT	(13) Auditory and visual sustained attention	
	(14) TOAD	(14) Auditory attention	
21. Matsuurael et al. (2014)	CANTAB		High-Functioning Autism; AS
	Rapid Visual Information Processing	Attention	
22. Merrill, Conners, Yang &Weathington(2014)	Contextual Cueing	Attentional guidance	ID*
23. Noterdaeme, Amorosa, Mildenberger, Sitter &Minow(2001)	TAP		High-Functioning Autism
	(1) Alertness	(1) Simple reaction time	
	(2) Selective visual attention task	(2) Selective visual attention	
	(3) Selective auditory attention task	(3) Selectiv eauditory attention	
	(4) Sustained visual attention task	(4) Sustained visual attention	
	(5) Sustained auditory attention task	(5) Sustained auditory attention	
	(6) Incompatibility task	(6) Incompatibility	
	(7) Go/No go task	(7) Inhibition	
	(8) Shift of attention task	(8) Shift ofattention	
	(9) Visual scanning task	(8) Sustained visual attention and planning	
24. Oka & Miura (2008)	Dual task	Divided attention	Mild and moderate ID
25. Palmer (2006)	The Color Trails Test	Attention/ Executive functions	Mild and moderate ID
26. Pascualvaca, Fantie, Papageorgiou& Mirsky (1998)	(1) CPT	(1) Sustained attention	High-Functioning Autism
	(2) Digit Cancellation Task	(2) Focused attention	

	(3) WCST	(3) Shifting attention	
	(4) Computerized Matching Task	(4) Shifting attention	
	(5) Same-Different Computerized Task	(5) Shifting attention	
27. Remington, Campbell &Swettenham(2012)	(1) Selective attention task	Selective attention	High-Functioning Autism
	(2) Nonface control task		
28. Rose, Bramham, Young, Paliokostas&Xenitidis(2009)	(1) CPT	(1) Sustained attention	Mild ID
	TEA		
	(2) Telephone Search	(2) Selective attention	
	(3) Telephone Search While Counting	(3) Divided attention	
	(4) Visual Elevator	(4) Switching attention	
29. Rose et al. (2013)	VPC com Eye-tracking	Visual attention	Severe ID
30. Schatz, Weimer&Trauner(2002)	TOVA	Sustained attention	AS
31. Schott &Holfelder (2015)	Trails-P	Inhibitory control and set switching	ID*
32. Schum (2004)	Leiter- R**		ID and/or ASD*
	(1) Attention sustained	(1) Sustainedattention	
	(2) Attention divided	(2) Dividedattention	
33. Siegel, Nuechterlein, Abel, Wu, &Buchsbaum(1995)	CPT	Sustainedattention	ASD*
34. Sinzig,Morsch&Lehmkuhl(2008)	TAP		High-Functioning Autism; SA
	(1) Sustained auditory attention task	(1) Sustained attention	
	(2) Go/No go task	(2) Inhibition	
	(3) Set-shifting task	(3) Set-shifting	
35. Taddei &Contena (2013)	CAS		ASD*; AS
	(1) Expressive attention	Attention	
	(2) Number detection		
	(3) Receptive attention		
36.Tenenbaum, Amso, Abar&Sheinkopf,(2014)	No name	Visual attention	ASD*
37. Thompson, Thompson& Reid(2009)	(1) TOVA	(1) Attention	High-Functioning Autism; AS
	(2) IVA - CPT	(2) Visual attention and auditory attention	
38. Trezise,Gray, K. M., & Sheppard (2008)	SART	Sustained attention	ID*
39. Vinck et al. (2007)	TEA – Ch		Mild, moderate and severe ID
	Score!***	Auditory attention	

Note. CPT = Continuous Performance Test; IVA- CPT = Integrated Visual and Auditory Continuous Performance Test; KiTAP = Test of Attentional Performance for Children; TEA-Ch =Test of Everyday Attention for Children; ANT-R = Attention Network Test - Revised; ANT-C = Attention Network Test for Children; WATT = Wilding Attention Test for Children;CalCAP = California Computerized Assessment Package; ANT = Attention Network Test ; NEPSY II =Developmental Neuropsychological Assessment, Second Edition; CCPT – II = Conners Continuous Performance Test – Second Edition; CAS = Cognitive Assessment System; TEA = Test of Everyday Attention; TOAD = Test of Auditory Discrimination; CANTAB = Cambridge Neuropsychological Test Automated Battery; TAP =TestbatteriezurAufmerksamkeitsprüfung; WCST = Wisconsin Card Sorting Test; VPC = Visual paired-comparison Paradigm; TOVA = Test of Variables of Attention; Trails-P = Trail-Preschool Test; SART = Sustained Attention to Response Test; ID =Intellectual Disability;AS = Asperger´s Syndrome; ASD = Autism Spectrum Disorder.

* Unspecified severity level; ** Battery cited in review article without subtests presentation; *** The authors cited the name of the test in Dutch: “Tel Mee!”

The cancellation paradigm, a popular task to assess selective attention, was identified in five studies (12.8%) Likewise, the dual task, in which performance in two simultaneous tasks is assessed, was employed in five studies (10.2%). The spatial orienting paradigm, developed by Posner (1980) to assess the ability to shift the focus of attention in space, was found in four studies (10.2%) (De Vries & Watson, 2008; Knox et al., 2015; Matson et al., 2013; Oka & Miura, 2008; Rose et al., 2009), including the Posner's Paradigm test, and the different versions of the Attention Network Test (Fan et al., 2012; Foster-Owens, 2016; Keehn, Lincoln, Muller & Townsend, 2010). Trail making test, a paradigm used to assess visual-motor speed, originally developed in 1994 (Lezak, 1995), was implemented in two studies (5.1%) using the Color Trails Test (Palmer, 2006), and the Trails-P Test (Schott & Holfelder, 2015). Thus, the aforementioned paradigms of continuous performance, cancellation, and dual task, which we described as the most used ones in the general assessment of attention, are also the most frequent ones in populations with mild difficulties concerning instructions.

As for the tasks specially designed in the research context, only one was presented in two studies (Huguenin, 1997, 2004), with one of the changes made to the test having been performed in the most recent paper. Two tasks used eye-tracking resources (Rose et al., 2013; Tenebaum et al., 2014), two studies performed double experiments (Haigh et al., 2016; Remington et al., 2012), and one task was based on a study conducted in 1977 (Bogte et al., 2009). All tasks used computerized resources.

The review studies we selected cite three tests and three batteries as being instruments that are fit for the assessment of people with ID or ASD. The tests mentioned were Integrated and Visual and Auditory Continuous Performance Test (IVA-CPT), Test of Auditory Discrimination (TOAD), and Posner's Paradigm, while the batteries identified were CAS, TEA, and Leiter-R. To analyze if the empirical studies used the tests indicated in the review studies, it was observed that TEA was the most used one (7.7%, *n* = 3); in two of these studies, the child version of the battery was used, and none of the studies administered all subtests. Even though Posner's Paradigm test was not administered in any study, we found three papers that used different versions of the Attention Network Test, which is a test based on the paradigm by Posner, as previously mentioned. The IVA-CPT was administered in two studies (5.1%), the three attention tests of the CAS battery were implemented in one study (Taddei & Contena, 2013), one subtest of the Battery of Attention and Memory on the Leiter-R was used in one study (Borgwardt et al., 2015), and the TOAD test was not administered in any test.

It was possible to observe that a wide variety of abilities was considered to form attention. The attention abilities are mentioned in the present review as cited by the authors of the selected papers. In the case of those batteries cited in review papers in which the subtests were not nominated, they were presented, and the target abilities were referred to according to McCallum (2003), and Strauss, Sherman, and Spreen (2006). A few divergences concerning the target ability of a few tests were detected. For instance, Knox and collaborators (2012) report that *The Ghost's Balls* test, included in the KiTAP battery, is a sustained attention test, while Crutcher and collaborators (2016) defined it as a working memory test. There are also differences concerning the classification and designation criteria of attention abilities. For example, we found studies in which the attention abilities were defined according to the mechanisms involved (focus, sustained attention, selective attention, shifting attention, and divided attention), while in other studies the attention abilities were defined according to the sensorial modality involved (visual or auditory). Some studies considered both the mechanisms of attention abilities and the sensorial modalities.

The challenge faced in terms of disagreement around the nomenclature of abilities is emphatically presented regarding attention and executive functions. According to Diamond (2013), the executive functions are composed of the working memory, inhibitory control, and cognitive flexibility abilities. We found papers in which batteries were administered to assess attention, such as the *Testbatterie zur Aufmerksamkeitsprüfung* (TAP) and the KiTAP, with the executive function abilities being identified as the testing target of the subtests. On the other hand, we found studies, whose goal was to assess executive functions, using batteries such as CANTAB and CAS, which include subtests destined to assess attention.

Another aspect wrapped in disagreement regards the nomenclature of abilities, visible in situations in which one same ability name is mentioned in studies that use different testing procedures. For instance, we selected studies with tests that require visual-spatial identification of alternate stimuli (Crutcher et al. 2016; Foster-Owens, 2016; Knox et al., 2015; Noterdaeme et al., 2001; Sinzig et al., 2008), as well as studies that present procedures involving the ability to deal with the change of goals in one same task (Lerner et al., 2015; Pascualvaca et al., 1998; Rose et al., 2009). According to Ravizza and Carter (2009), the alternation of visual-spatial targets and the alternation of criteria do not reflect the same cognitive process. Nonetheless, it was considered that shifting attention tests included those that examined visual shift in search of targets (Sinzig et al, 2008), as well as those that aimed to assess the ability to solve problems after the alternation of criteria (Pascualvaca et al., 1998). On the other hand, the tests that required the identification of different visual targets were considered measures of cognitive flexibility by Knox and collaborators (2015), while to Noterdaeme and collaborators (2001) they refer to the assessment of shift of attention.

The Attention Network Test, a computerized test based on the theory by Posner and Fan (2004), sees attention as a system composed of three specialized neurofunctional networks: alerting, orienting, and executive control. While Posner's Paradigm is a test based on the same theory and applies the same paradigm, the review paper that cites this instrument gives more relevance to the process of orienting attention and cites the shift of attention ability as the key-element of this construct (Klinger & Renner, 2000).

With respect to attentional networks, which assess the ability to set free from a certain attention focus and direct the attention to a new target (Posner, 1980), all the empirical studies selected in the present review were performed with people diagnosed with highly functional ASD. According to Klinger and Renner (2000), this is a highly impaired ability in people with ASD, even among individuals with high functioning. Thus, the assessment of the attention orientation ability could be seen as a diagnostic evidence in regard to ASD.

The most frequently cited ability was sustained attention, having been assessed in 17 papers (43.4%). Collecting all the tests that assessed aspects related to shifting attention, this ability becomes the second most frequently cited (23.7%, *n* = 9), followed by selective attention (17.9%, *n* = 7), visual attention (17.9%, *n* = 7), divided attention (15.4%, *n* = 6), and auditory attention (13.9%, *n* = 5). Attention was cited as a target ability with no specification in any modality in a total of four papers (10.2%), attentional network and inhibition were assessed in three papers each (7.7%). The remaining abilities were cited in only one paper.

The most commonly assessed population in the studies was people with high-functioning ASD or Asperger (38.5%, *n* = 15), followed by people with ASD with undeclared severity (15.4%, *n* = 6), and in the majority of the studies, the complexity of tasks emphasizes that participants did not present significant comprehension difficulties. We identified four studies with people

with ID with undeclared severity (15%). Five studies included participants with different levels of severity of ID (12.9%), with three studies presenting people with mild and moderate ID, and the other two studies including people with mild, moderate, or severe ID. Three studies focused specifically on the assessment of people with severe or profound ID (7.5%, *n* = 3). Two papers only included participants with mild or borderline ID (5.23%), and the same number of papers referred to groups that contained people with ID and ASD in comorbidity or mixed groups, composed of people with ID or ASD with undeclared severity (5%, *n* = 2). No studies were found exclusively dedicated to people with moderate ID or with ASD requiring substantial or very substantial support.

We noted that visual attention was the target ability in every study exclusively dedicated to people with severe ID (Huguenin, 1997, 2004; Rose et al., 2013). In the two studies with mixed groups that included people with severe ID, one assessed sustained attention (Borgwardt et al., 2015), and the other did not specify the mechanism of attention involved, even though having used a test that originally intended to assess sustained attention using an auditory stimulus (Vinck et al., 2011).

Although joint attention is an ability that is often studied in people with ASD, the studies that assessed this dimension were excluded in our third stage of paper selection, since none of the instruments presented a score based on task performance. They referred to standardized behavior observation scales.

The age range of participants in the empirical studies was rather varied. The selected papers included: one longitudinal study that followed participants for 15 years (1.6%); fourteen studies with children (35.9%); six with children and adolescents (15.4%); four with adolescents (10.2%); three with adolescents and adults (7.5%); eight with adults (20.5%); and one with participants with different age ranges (1.6%). The review studies did not present age range (7.5%, *n* = 3).

Some papers presented studies with populations whose clinical state of ID or ASD was associated to different diagnoses, including diverse genetic syndromes (Borgwardt et al., 2015; Crutcher et al., 2016; Jauregi et al., 2007; Merrill et al., 2014; Rose et al., 2013; Scott & Holfelder, 2015; Trezise et al., 2008; Vinck et al., 2007). A few of the syndromes related to ID or ASD, such as the Rett Syndrome, add testing challenges concerning the significant motor and language impairment in these populations (Rose et al., 2013). We also identified some studies in which the target population presented other disorders in comorbidity, such as Attention-Deficit Hyperactivity Disorder (Aman et al., 1993; Lundervold et al., 2016; Sinzig et al., 2008), schizophrenia (Siegel et al., 1995), and Alzheimer's Disease (Palmer, 2006; Rose et al., 2009). Palmer (2006), and Matsuura and collaborators (2014) point out the importance of developing cognitive tests that are fit for people with limitations regarding instructions, so that differential diagnoses, and also, the identification of associated comorbidity, may be done more precisely and, consequently, a fitter treatment be provided to patients.

Category 2: Procedures and adaptations in the testing setting

Regardless of the level of cognitive impairment of the population under assessment, several studies stated that individuals had been excluded or that the data analysis regarding participants' performance was unviable in result of difficulties in testing (28.2%, *n* = 11). Some challenges were related to difficulties in responding to tasks given the inability to understand given instructions (Aman et al., 1993; de Vries & Watson, 2008; Foster-Owens, 2016; Garretson et al., 1990; Jauregi et al., 2007; Knox et al., 2012; Merrill et al., 2014; Palmer, 2006; Thompson et al., 2010), to extreme anxiety, distress, frustration, lack of conformity in following rules, difficulty in staying

seated or pressing the response button (Thompson et al., 2010), to auditory sensitivity (Foster-Owens, 2016), and to excessive agitation, lethargy, or impossibility to find a comfortable position due to orthopedic impairments (Rose et al., 2013).

Before administering the tests, a few studies reported visits to the testing setting to enable the familiarization with the environment and the examiner. This strategy is aimed at reducing participants´ anxiety towards the procedure (Schott & Holfelder, 2015; Tenenbaum et al., 2014). The literature highlights that people with ID respond to stressful situations with higher levels of anxiety (Matson & Laud, 2007), and that people with ASD are particularly prone to feeling anxiety in situations in which they do not know what is expected from them (Gillberg, 2007). Thereby, a previous contact with the examiner and the testing setting should play an important role in enabling a sense of predictability and trust. In line with Ryan and Sackett (2013), such familiarization increases the sense of safety regarding the assessment process, since it creates a more comfortable environment for testing.

Among the adaptations mentioned to adapt tests to the populations needs, we noticed the administration of untimed tests or with an increase of the time conventionally used to perform the task (Borgwardt et al., 2015; Jiang et al., 2014; Palmer, 2006; Schum, 2004). Schum (2004) claims that the advantages of a more flexible administration time relate to motor coordination impairments, as well as to difficulties in concentrating, both of which are often found in these populations. Concerning the testing issue involving people with ID, Tylenda and collaborators (2007) state that the test administration time is particularly variable with this population. However, a maximum time limit should be established, as well as a certain number of consecutive errors, to assure the viability of testing.

Aiming at surpassing the barrier related to the incomprehension of tasks, several studies report many training sessions before the actual administration of tests (33.3%, *n* = 13). Some papers described training sessions in steps, in which each element of the task was practiced by order of difficulty, and the remaining steps were only presented after a certain number of sequential hits (Corbett & Constantine, 2006; Garretson et al., 1990; Huguenin, 1997, 2004; Merrill et al., 2014; Oka & Miura, 2008). When describing a training procedure in steps, Garretson and collaborators (1990) highlighted that the usual tasks might be complex to people with difficulties related to instructions, and that they may prefer simple and repetitive goals. These procedures are aimed at participants familiarization with the stimulus used in the test, and the format to emit responses. In sum, the training sessions require a direct interaction between examiner and examinee, an additional testing time, and the development of a device that enables the gradual discrimination of each element in the test.

How instructions are communicated is also regarded as a key-element in understanding instructions. Numerous authors highlighted the value of using simple sentences, repeated several times, and spoken enthusiastically and with encouragement (Knox et al., 2012; Pascualvaca et al., 1998; Tenenbaum et al., 2014; Trezise et al., 2008). A communicative strategy used by Huguenin (1997), and by Schott and Holfelder (2015), was to tell stories associated to the symbols, to facilitate the identification of these elements in the testing procedure. On the other hand, Noterdaeme and collaborators (2014) cited evidence that children with ASD experience more difficulty in performing tests in which the rules are transmitted verbally. Schum (2004) also claimed that communicating instructions non-verbally is more effective for populations with higher level of cognitive impairment.

Once the instructions have been communicated and comprehended, another aspect becomes important for the continuity of testing, which is engagement. Many studies aimed to create a playful testing environment; when presenting the test, examiners would invite examinees to participate in a game, to increase their motivation (30.8%, *n* = 12). The choice of stimuli was considered a crucial element to foster test´s attractiveness. The selected stimuli included: animal figures (Foster-Owens, 2016; Jiang et al., 2014); figures of objects or symbols (De Vries & Watson, 2008; Garretson et al., 1990, Huguenin, 1997, 2004; Keehn et al., 2010; Pascualvaca et al., 1998; Rose et al., 2009); fairy tales characters (Aman et al., 1993); and tasks situated in children stories (Crutcher et al., 2016; Foster-Owens, 2016; Knox et al., 2012). Some of the criteria identified for the choice of stimuli included familiarity, emotional neutrality, and level of complexity (Garretson et al., 1990).

Another resource used to increase the length of permanence performing the task that was fairly used in the selected studies refers to reward strategies (33.3%, *n* = 13). The most frequently used rewards were: computerized visual and auditory stimuli associated to the task (20.5%, *n* = 8); concrete prizes, such as coins, treats, snacks, and toys (17.9%, *n* = 7); and verbal incentives (15.4%, *n* = 6). Garretson and collaborators (1990) aimed to compare the effect of social rewards (such as a smile and compliments) to the effect of concrete rewards (such as pretzels and coins), when analyzing the permanence of people with ASD on the task. The results showed that concrete rewards were more effective in enabling a higher frequency of behaviors related to the task.

Considering the motor and communication impairments that are usually associated with people with ID and ASD, the mechanisms of the testing setting related to the response emission means might influence directly the viability of the administration of a test for these populations. According to Mecca (2012), creative ways of approaching these populations with motor and communication impairments, that make it possible for them to show their knowledge, are an important factor to be considered in order to select an appropriate test. Among the selected studies, Oka and Miura (2008) noted that pencil and paper tasks have the following advantages: simplicity of resources; independence between the perceptual and motor processing stage that is necessary to execute responses, and the expression of the target cognitive ability; the possibility to compare respondents´ performance without the interference of interpersonal differences. The Leiter-R, considered by Schum (2004) and by Borgwardt and collaborators (2015) as one of the main tools to assess people with difficulties concerning instructions, uses non-verbal communication and physical handling of objects to administer the tests and emission of responses. Another strategy concerning response mechanisms was advanced proposed by Huguenin (1997, 2004), that used a touch screen attached to a computer monitor screen, in order to adapt testing to the significant limitations in terms of motor, cognitive, and language abilities of people with severe ID. The assessment of responses through eye tracking was also a specific strategy for people with extreme impairments, such as the case of the girls with Rett Syndrome (Rose et al., 2012). Among the papers including people with moderate, severe, or profound ID in the sample (20.5%, *n* = 8), only one study used a common computerized test in which the answers are emitted by touching the keyboard (Jauregi et al., 2007), whereas the remaining studies preferring to use the strategies described above to emit the responses.

Conclusion

In light of the relevance of testing, and the difficulties in testing people who have difficulties concerning instructions and responses, the present study aimed to analyze three fundamental issues: (a) to examine if there were any studies using fit attention tests to assess

people with ID and/or ASD; (b) to suggest the adaptations that are needed in the testing setting; (c) to appraise the specific limits and needs of the current testing procedures. The answers we found in this study may be summarized as follows:

1. The studies that include attention testing in participants with ID or ASD are primarily meant to assess individuals with no cognitive impairment, or with a mild level of impairment, and usually presume samples with mild difficulties concerning the comprehension of instructions (cf. Results and Discussion section, p. 15, §3).

2. In the case of assessing people with significant difficulties in comprehending instructions and emitting responses, particularly in what concerns severe ID, testing has been undertaken using tests that are specifically crated for these populations, in particular research contexts (cf. Results and Discussion section, p. 15, §4).

3. The customary administration of conventional tests already acknowledged in the clinical practice tends to produce an elimination of participants, even of people with mild difficulties concerning instructions, which implies the need to adapt testing settings (cf. Results and Discussion section, p. 17, §2).

4. The lack of agreement about the designation or the conceptual definition of the attention abilities measured by one same test or testing paradigm make it difficult to select a fit test to assess specific attention dimensions that may be related to characteristics and needs that are specific of people with difficulties in comprehending instructions (cf. Results and Discussion section, pp. 12-14).

5. The paradigms of continuous performance, cancellation, and dual-task, commonly used to measure attention in the population in general, remain predominant in the assessment of people with ID and/or ASD who have mild difficulties in comprehending instructions and emitting responses (cf. Results and Discussion section, p. 11, §4).

6. The complexity of testing people who have significant difficulties in comprehending instructions and emitting responses, such as people with severe ID, narrows the assessment to basic attention dimensions, such as focused attention and sustained attention (cf. Results and Discussion section, p. 15, §4).

7. The testing adaptations made for people with difficulties in comprehending instructions include procedures and decisions that are former to the implementation of the test, such as: visits to the testing setting, in order to familiarize with the environment and the examiner; extension of the conventional time to administer the test; training in steps, to break the barrier of lack of comprehension of tasks (cf. Results and Discussion section, p. 17, §3, and p. 18, §1-2).

8. Impairments in receptive and expressive language are common in people who have difficulties in comprehending instructions, making it necessary to develop strategies to communicate instructions, such as: simplicity, repetition, and enthusiasm; narration of stories involving the symbols that are used as stimuli in the task; non-verbal communication (cf. Results and Discussion section, p. 18, §3).

9. The lack of engagement, common among people with difficulties related to instructions, is a challenge that requires strategies to increase motivation, such as: creation of a playful atmosphere during testing; use of stimuli that are attractive, familiar, emotionally neutral, and simple; development of reward strategies, with concrete rewards appearing to be more stimulating than symbolic or verbal rewards (cf. Results and Discussion section, p. 19, §2-3)

10. The motor impairments that are commonly associated to the target population in this study entail the need for resources that enable the emission of responses without the interference of motor precision and speed. The means to emit responses that are used as alternative resources to the answers through touching a

computer keyboard, or pencil and paper, include: handling objects; computer touch screen technology; and eye tracking (cf. Results and Discussion section, p. 20, §2).

The findings in this paper may help to design tests that are fit to assess people with difficulties related to the comprehension of instructions and the emission of responses, since it presents a few strategies that have been used by researchers in this field to test these populations. Such evidence gives strength to Wolf-Schein's (1998) claim that nobody is "untestable", as long as the tools used are appropriated for the examinees needs. Since the number of tests adapted for people with ID or ASD who have significant difficulties is fairly scarce, we recommend that researchers continue to refine and develop strategies to adapt and design tests that are comprehensible, easily communicated, using motivating stimuli, and response tools that are capable of adapting to the many idiosyncrasies that are present in this population.

Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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