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Importance of Assessing Nonlinguistic Cognitive Skills in Bilingual Children with Primary Language Impairment

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Abstract: Many bilingual school-aged children are misdiagnosed as having a Primary Language Impairment (PLI) when in reality they are in the process of learning a second language (L2). The reverse is also true. How can we differentiate between these two groups? How do we overcome the bilingual assessment challenge? Recent research has shown that children with PLI often have subtle weaknesses in their nonlinguistic cognitive processing skills. This paper will look at how we can assess these skills and establish intervention goals accordingly by looking at a review of the existing literature. Articles that have studied nonlinguistic processing skills in children with and without PLI have been examined. Deficits in processing speed, sustained attention, selective attention, cognitive control, and working memory are often present in children with PLI. A plethora of tools exist to assess these abilities, which is why an assessment protocol is required. The tools have been grouped according to age range, the language in which they are available and the qualifications required for administration. This will facilitate the assessment of bilingual children by providing teachers, speech-language pathologists, psychologists and other professionals, assessment options founded on evidence-based practice.

Keywords: Nonlinguistic Cognitive Skills, Primary Language Impairment, Bilingualism

Overview

Several studies have examined the relationship between language skills and cognitive skills (e.g., Ebert and Kohnert 2009; Kohnert and Ebert 2010). In fact, children who have a primary language impairment (PLI) also have lowered performances on cognitive tasks (e.g., Archibald and Gathercole 2007; Bishop and Norbury 2005; Gathercole 2006; Hoffman and Gilman 2006; Im-Bolter, Johnson and Pascual-Leone 2006; Ellis Weismer et al. 2005). The existence of subclinical weaknesses of working memory, attention and processing speed in children with PLI has been shown to impede language learning, and could consequently contribute to language deficits (e.g. Ebert, Rentmeester-Disher and Kohnert 2012; Kohnert and Ebert 2010; Leonard et al. 2007). Ebert and Kohnert (2011) performed a meta-analysis of sustained attention in English-speaking children with PLI, exposing the presence of reduced sustained attention.

Bilingual or multilingual children with PLI struggle to learn all of the languages to which they are exposed (Kohnert 2010). Essentially, they often acquire both or multiple languages at a slower pace (Hakansson, Salameh, and Nettelbladt 2003). However, due to limited resources in assessment tools for certain languages, it is often difficult to assess all of the languages spoken by bilingual children. This challenge often leads to the misdiagnosis of PLI (e.g. Mayer-Crittenden 2013), which in turn can create longer wait lists or delayed treatment if the diagnostic conclusion is only given much later. Currently, many researchers are turning to nonlinguistic cognitive tests and tasks to assess and measure the underlying cognitive abilities of monolingual and bilingual children with PLI. However, very few, if any, clinicians and teachers have access to these tools. The goal of this paper was to identify the assessment tools and tasks that are currently available for clinicians and teachers to use with children.

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Language Impairments

Specific language impairments (SLI) are a high incidence developmental disorder presumed to be the result of innate factors interrelating with language learning without any frank neurological or cognitive delays (Leonard 1998). Primary language impairment (PLI), a term introduced in 2003, comprises the subtle nonlinguistic processing weaknesses along with the more evident language delays such as neurological, sensory or motor impairments (Tomblin et al. 2003).

Anglophone children with PLI typically have difficulties with morphology (Rice and Wexler 1996). More specifically, verb tense is often problematic (Gopnik and Crago 1991; King, Schelleter, Sinka, Fletcher, and Ingham 1995) and the use of infinitives seems to be a good clinical marker for PLI (e.g. *Yesterday, I **go** (went) to school*). As a result, children's mean length of utterances tend to be shorter than their typically developing age-matched peers (Bedore and Leonard 1998). Anglophone children with PLI also have difficulties with receptive grammar and vocabulary (Conti-Ramsden, Crutchey and Botting 1997), expressive phonology (e.g. Aguilar-Mediavilla, Sanz-Torrent, and Serra-Raventos 2002; Conti-Ramsden, Crutchey and Botting 1997), and narrative skills (e.g. Fey, Catts, Proctor-Williams, Tomblin, and Zhang 2004; Gutiérrez-Clellen 2004; Scott and Windsor 2000), among other areas. Expressive vocabulary is also an area of difficulty (e.g. Conti-Ramsden 2003). In French, Italian and Spanish, all roman languages, not all the same difficulties are noted. Some researchers believe that the infinitive root is also problematic in roman languages (e.g. Jakubowicz 2003), however, others have not seen those same difficulties (Elin Thordardottir and Namazi 2007) and state that language difficulties are present across all language domains, be it lexical, morphosyntactic, syntactic or narrative abilities (Mayer-Crittenden 2013; Elin Thordardottir and Namazi 2007). A study conducted with Italian-speaking children revealed difficulties with object clitics in preschool children (Bortolini, Arfé, Caselli, Degasperi, Deevy and Leonard 2006). Similar results were obtained with Spanish-speaking children (e.g. Gutiérrez-Clellen, Restrepo and Simòn-Cereijido, 2006). According to Elin Thordardottir et al. (p. 581 2011):

> There is widespread agreement on the general definition of SLI/PLI; however, considerable variability exists in diagnostic practices within and across language communities, both in terms of the tests that are used and the diagnostic criteria used to separate typical performance and performance that indicates impairment, as well as in the details of how the deficit is defined

At the present time, numerous studies indicate that some nonlinguistic capacities are breached among children with PLI. These nonlinguistic abilities include executive functions or cognitive control (e.g. Baddeley, Gathercole, and Papagno 1998; Baddeley 1996; Bishop and Norbury 2005; Ullman and Pierpoint 2005), procedural memory and abstraction (e.g. Evans and Pourcel 2009), auditory processing (e.g. Tallal 2003), speed of information processing (e.g. Catts, Adlof, and Ellis Weismer 2006), working memory (e.g. Archibald and Gathercole 2006; Bishop 1996; Ellis Weismer et al. 1999; Kohnert et al. 2006; Leonard 1998; Ullman and Pierpoint 2005), phonological working memory or verbal working memory (e.g. Archibald 2006; Bishop 1996; Bishop et al. 1999; Wager, Smith, and Jonides 2003), and discrimination of nonverbal components (e.g. Amitay et al. 2002; Tallal and Piercy 1973), among others.

The diagnostic criteria of PLI alter according to linguistic and cultural contexts and have to be adjusted for every assessment tool. In numerous studies directed among children with PLI, it is noted that the diagnosis is based on not only what is present with the child (inclusive) but also on what is not present within the child (exclusive). In 1997, Tomblin et al. established that nearly 7% of monolingual school aged children are affected by SLI each year.

Cognitive Factors

In the subsequent paragraphs, certain nonlinguistic cognitive abilities will be described. For all of these abilities, researchers have indicated that children with PLI show a deficit in their performance when compared with their typically developing peers. The following cognitive factors will be described: cognitive control, fluid reasoning, cognitive flexibility, categorization, sustained attention, verbal and spatial working memory and processing speed.

Cognitive control, often known as executive function, is the ability to direct thoughts and actions according to internal objectives, particularly in tasks that are new, challenging, or that are conflicting (Miller 2000). There is growing evidence suggesting that children with PLI have deficits in cognitive control (e.g. Gillam, Cowan, and Day 1995). It appears as though these children may be especially vulnerable to interference from supplementary or irrelevant material (Tropper 2009). Some cognitive control tasks require inhibition, which is an active dampening process used for the suppression of extraneous information and prevalent responses (e.g. Lorsbach, Wilson, and Reimer 1996). Trooper (2009) investigated inhibition of non-verbal material in children with PLI when presented with irrelevant stimuli in linguistic and nonlinguistic Go/No-Go tasks. Such a task involves a simple choice between an action and a non-action (Rubia et al. 2001). According to Trooper (2009), the event-related potentials of children with PLI on the linguistic task were similar to those of children with typical language development who were on average three years younger.

Fluid reasoning or fluid intelligence is the ability to solve problems and to think logically in novel situations (e.g., Gray, Chabris, and Braver 2003; Horn and Cattell 1967). It develops in the first two or three years of life (Cattell 1987) and is moderately independent of culture and education (Horn and Cattell 1967). Some authors (e.g., Blair 2006; Cattell 1987) state that fluid reasoning serves as a scaffold in helping children develop other abilities. In the case of language, an example of fluid intelligence would be the coordination, the planning, the monitoring and the execution of all complex cognitive activities of which language activities are a part (Peets and Bialystok 2010). According to Paradis (p. 120 2010) "[…] deficits arising from disruptions in neurological development could be present in representational systems or in fluid mechanisms […]".

Cognitive flexibility can be described as the ability to move from one strategy or idea to another with little or no effort (Hux and Manasse 2003). It emerges during problem resolution when there is a certain degree of difficulty (Deák 2003; Chevalier and Blaye 2006). It is required for tasks that are unfamiliar and unexpected such as preparing a novel response (Deák 2003). In fact, some have found that children who have phonological impairments have difficulties in non-verbal rule derivation and cognitive flexibility (e.g. Gierut 1998; Crosbie et al. 2005). The research reviewed suggests that most children who have phonological impairments have a specific cognitive deficit in abstracting appropriate rules and don't have the cognitive flexibility to change these rules in order to apply them to speech and literacy (e.g. Dodd and Cockerill 1985).

Categorization, also known as the ability to classify, appears around the age of 18 months (Gopnik and Meltzoff 1987). Indeed, children as young as 4-years-old have been found to overrule perceptual information when it is inconsistent with its taxonomical category (Gelman and Markman 1986). According to Cullis (2011), there exists a relationship between attention, categorization, and part-whole skills in children with language impairments, specifically those who have phonological deficits. In fact, phonological awareness development relies heavily on dynamic categorization and understanding of part-whole relationships (e.g. Smith and Samuelson 1997). In theory, categorization can work fluidly and respond to changing demands.

Sustained attention is the ability to maintain alertness and attention over an extended period of time (Warm, Parasuraman, and Matthews 2008). It is defined as the capacity to become and to remain involved during an activity (Krakow and Kopp 1983). Sustained attention is required to complete all cognitive activity (Zarghi et al. 2011) and remains an essential factor in human cognitive capacity (Sarter, Givens, and Bruno 2001). Sustained attention would be more impacted when children with PLI process information that is language-based than information that is not language-based (Ebert and Kohnert 2011). According to Marton (2008), children with PLI have difficulty controlling their attention. In fact, according to some, clinical attention deficits and child language impairments are both a result of a core neurodevelopmental shortfall (See Redmond 2005, for a review). Furthermore, Noterdaeme et al. (2000) examined sustained selective attention in children with PLI and found that they performed significantly worse than their typically developing peers. However, these authors also stated that some of these difficulties could have been due to working memory difficulties.

Working memory is responsible for the treatment and temporary classification of information, but is also known to be a limited system (Baddeley and Hitch 1974). Baddeley's model (2000) shows that working memory is comprised of four components: the episodic buffer, the phonological loop, the visual spatial sketchpad and the central executive. The episodic buffer has a direct link with long-term memory, which in turn, could be very useful when learning new information (Pickering and Gathercole 2004). It utilizes multidimensional codes in order to integrate representations from the working memory to the long-term memory into episodic representation units that could correspond to conscious experiences (Pickering and Gathercole 2004). The phonological loop plays an important role in sub-vocal rehearsal and provides a temporary storage of verbal information (Alloway, Gathercole, and Pickering 2006; Baddeley and Hitch 1974). As for the visual spatial sketchpad, also known as the visuo-spatial working memory, it specializes in the maintenance and handling of visual and spatial representations and the central executive is responsible for the control and regulation of cognitive processes (Baddeley and Della Sala 1996). "The central executive is in charge of planning future actions, initiating retrieval and decision processes as necessary, and integrating information coming into the system" (Ashcraft and Klein 2010, p. 192). Many studies have shown that children who have PLI obtain lower scores on working memory measures than their typically developing peers of the same age (e.g. Bishop, North and Donlan 1996; Dollaghan 1998; Edwards and Lahey 1998; Ellis Weismer et al. 2000). According to Marton (2008), children with PLI performed more poorly than their age-matched peers in space visualization, position in space, and design copying. On the contrary, Archibald and Gathercole (2006) found that children with PLI performed comparably with age-matched control children on visuo-spatial working memory tasks. Similarly, Hick, Botting, and Conti-Ramsden (2005) found that only visual-spatial processing tasks that involve working memory seemed more difficult for children with PLI but not visual-spatial processing tasks that do not require the use of working memory. The abilities of children with PLI with regards to this competency continue to show controversy and further research is needed.

Last but not least, children with PLI process information at a slower rate than typically developing children (Kohnert, Windsor, and Ebert 2009; Ullman and Pierpont 2005). A study by Leonard et al. (2007) demonstrated a causal relationship between processing speed and PLI. For example, they are slower at processing linguistic tasks such as naming pictures, and making lexical judgments (Windsor et al. 2008). They are also slower at processing nonlinguistic tasks such as mentally rotating geometrical shapes (Windsor et al. 2008). Children with PLI also have a slower response time when detecting pure tones that have a brief duration, when reproducing a series of colored lights, when tapping their fingers rapidly in response to stimuli, when moving pegs on a board, and when stringing beads (e.g., Bishop 1992; Johnston and Ellis Weismer 1983; Miller et al. 2001; Miller et al. 2006; Powell and Bishop 1992).

A Systematic Review of Cognitive Assessment Tools and Tasks

The aim of this paper was to provide clinicians, specifically speech-language pathologists, and teachers with easy-to-use information regarding nonlinguistic tools that can be utilized for the assessment of cognition in children with PLI. To date, very few clinicians in Canada make use of the existing nonlinguistic assessment tools and tasks that could facilitate the identification of language impairments. These tools and tasks are mostly used in experimental research studies. Due to their seemingly complicated and sophisticated nature and to their high cost, they are often dismissed by clinicians who shy away from them. However, as the previous paragraphs have shown, most children with PLI show subtle difficulties in various nonlinguistic processing skills. The assessment of these skills could potentially help in the identification of children with PLI, in turn preventing false negatives. In light of this information, the following research questions were formulated: 1) Which assessment tools and tasks are currently available for children?; 2) What qualifications are required to administer the tools?; and 3) How can we ensure that nonlinguistic cognitive competencies in bilingual children who are risk of having a language impairment are assessed?

Method

Literature Search

A systematic search for empirical articles addressing nonlinguistic cognitive processing skills in children with PLI was conducted in May and June 2013. Databases searched included ERIC, Medline, PsycINFO, CINAHL (Cumulative Index to Nursing and Allied Health Literature) and Dissertations and Theses (Proquest). The search term combinations *language impair* and nonlinguistic cognit* process** and *language disorder and nonlinguistic cognit** were applied to titles, keywords, and abstracts in each database.

In order to find available nonlinguistic cognitive tests that have been standardized, the articles found using the aforementioned search were used as well as random searches in some of the top publishers of assessment tools such as: Pearson Canada Assessments (2013), Pearson UK Assessments (2013), Western Psychological Services (2013), Psychology Resource Centre (2013), Nelson Education (2013), among others.

Procedure

We used Pearson Canada (2013) and Pearson UK (2013) assessment Inc.’s policy as well as the American Psychological Association (APA) standard for Educational and Psychological testing (1999) for qualifying agencies, individuals or organizations. In accordance with the APA standard for Educational and Psychological testing (1999), Pearson Canada (2013) established a classification system differentiating the types of individuals that may purchase the tests. The qualification levels vary not only according to the administration, scoring and interpretation of each test but also according to the required training. This particular classification system contains five levels of qualification (A, B, C, Q1, Q2): For the Level A qualification, products generally do not necessitate an individual to have advanced training in interpretation and assessment. The next level up is the Level B qualification. Generally, the assessment and interpretation of B-level instruments are more complex than A-level instruments. An individual who has acquired expertise in a specific area or completed specialized training may purchase these products. The third level according to Pearson Canada (2013) is Level C. These tests demand authorization of a doctorate in education, psychology or a related field of licensure. Under Level C are two sublevels: 1) Qualification Level Q1: Persons who have a license or a degree in the healthcare or allied healthcare field may purchase these tests; 2) Qualification Level Q2: Individuals who have completed formal supervised training in speech/language, mental health and/or educational training settings and formal training in the administration, interpretation and ethical use of standardized psychometrics and assessment tools may purchase these products.

Similarly, according to Pearson UK (2013), there are five qualification levels. The first is the UNAS qualification, which stands for unassigned test. These tests require no qualification and are accessible to all individuals. The second is the CL3 qualification. These tests do not demand an individual to have formal training in interpretation and assessment. According to the information available, this is equivalent to a level A of Pearson Canada (2013). The third is the CL2R qualification. These tests demand a supplementary JCQ (Joint Council for Qualifications) approved or similar qualification. The fourth is the CL2 qualification. Individuals that have a graduate and/or postgraduate qualification relevant to their profession or that are certified by a professional organization recognized by Pearson Assessment may purchase these products. This being said, CL2 qualification tests are directed to mental health professionals, health practitioners, occupational or speech therapists as well as all psychologists (excluding those mentioned in the CL1 qualification description). The last is the CL1 qualification. These tests may be purchased by a Chartered Psychologist or by an individual that has a protected title in the field of psychology.

All nonlinguistic cognitive tests found on the abovementioned assessment websites were thoroughly reviewed and added to this study. The authors are aware that some tests may not have been captured by the search criteria used.

Results

A total of 30 articles and one doctoral thesis were identified using these search words. All 31 publications were reviewed. This led to the finding of three more articles that had not come up in our initial search. Of the 34 publications, 19 were excluded because they did not meet the criteria set out by the authors. Some of the excluded articles included adults as their participants while others did not include participants with a language impairment. In total, 15 articles were reviewed for a total of 38 tasks. It should be noted that many of the tasks were similar but not identical. The following information was retained: the type of nonlinguistic cognitive task used as established by the authors as well as a brief description of the task as stated by the authors of the specific articles, the age of the participants, the format; be it computer-based of paper-and-pencil based, the time of administration (when available), the different competencies measured, the results of the studies as well as the name of the author and date of the article. Some of the tasks used by the researchers included but are not limited to: simple auditory detection – which requires participants to respond to the presence of an auditory tone; choice visual detection – which requires participants to press two response buttons at the presence of a visual stimuli; simple visual discrimination task – which involves the movement of a joystick in the direction of a moving target; auditory sustained selective attention – which entails the pushing of a button when the participant hears a target sound among other environmental stimuli, among others. When information was not made available in the article, the cell was left empty. A complete list of the tasks can be found in table 1.0. These have been presented according to authors/articles.

Table 1.0. Detailed List of Various Nonlinguistic Cognitive Tasks

VSP: Visuospatial Processing (perceptual organization and visual immediate memory); PS: Processing Speed; Sustained Attention; TRA: Temporal Resolution Abilities; IC: Inhibitory Control; EF: Executive Functions; WM: Working Memory; CF: Cognitive Flexibility; Attention Shift; AF: Attentional Functions; VD: Visual Discrimination; SA: Sustained Attention

NSD: No significant difference between groups; Cells were left blank when the information was not available

Task	**Brief description of task**	**Ages and admin time**	**Format and cost**	**Skill measu-red**	**SLI perfor-mance relative to TD peers**	**Authors and year**
Hierarchical Forms Memory task Groups: SLI and TD	Presentation of a model hierarchical form stimulus; Reproduc-tion of the model form from memory	6-12	Paper-and-pencil	VSP	SLI < TD	Akshoomoff, Stiles, and Wulfeck 2006.
Rey-Osterrieth Complex Figure task Groups: SLI and TD	Presentation of a complex figure; reproduction of the figure	11-12	Paper-and-pencil	VSP	SLI < TD	Akshoomoff, Stiles, and Wulfeck 2006.
Visual search (VS) task– *nonverbal speeded task* Groups: SLI without ADHD, ADHD without SLI, and TD	Responding by key press whether or not the target was present in the correct array (5 possible positions of the target)	6:5-11:3	Laptop computer with peripheral numeric keypad	PS	NSD in number of invalid or error responses	Cardy et al. 2010.
Simple reaction time (SRT) task– *nonverbal speeded task* Groups: SLI without ADHD,	Striking of a single key in response to a signal as quickly as possible	6:5-11:3	Laptop computer with peripheral numeric keypad	PS	SLI and ADHD had slower RTs than TD	Cardy et al. 2010.

Task	**Brief description of task**	**Ages and admin time**	**Format and cost**	**Skill measu-red**	**SLI perfor-mance relative to TD peers**	**Authors and year**
ADHD without SLI, and TD						
Visual continuous performance task (CPT) Groups: SLI and TD	Monitoring for a target stimuli while ignoring distractor stimuli	5-6 25 min.	E-Prime software	SA	SLI was less accurate, but NSD	Finneran, Francis, and Laurence 2009.
Temporal resolution task Groups: SLI and TD	Detecting a tone in three masking conditions containing silent gasps			TRA	Both groups had similar performance SLI required more ascending trials to achieve the threshold criterion	Helzer et al. 1996.
Antisaccade task – *automatic eye movement* Groups: SLI and normally developing language (NL)	Presentation of a target stimulus (arrow) - indication of the direction of the arrow (left, right, or up) with a button press response	7-12 Approx. 6 min.	Computer-based	IC	SLI < NL	ImBolter, Johnson, and Pascual-Leone 2006.
Choice auditory detection Groups: English-only (EO) with LI, TD EO, and TD Spanish-English (BI)	Pressing two response buttons at the presence of a low tone (500 Hz) and a high tone (2000 Hz)	8-13 25 min.	E-Prime software	PS	EO was faster than LI; BI was faster than LI but NSD	Kohnert and Windsor 2004.
Simple auditory detection Groups:	Responding to a presence of a 2000Hz tone	8-13 25 min.	E-Prime software	PS	EO and BI were a little faster than LI, but NSD	Kohnert and Windsor 2004.

Task	Brief description of task	Ages and admin time	Format and cost	Skill measu-red	SLI perfor-mance relative to TD peers	Authors and year
English-only (EO) with LI, TD EO, and TD Spanish-English (BI)						
Simple visual detection Groups: English-only (EO) with LI, TD EO, and TD Spanish-English (BI)	Pressing of a key marked by a coloured dot in response to a blue circle	8-13 25 min.	E-Prime software	PS	EO was faster than LI; BI was faster than LI, but NSD	Kohnert and Windsor 2004.
Choice visual detection Groups: English-only (EO) with LI, TD EO, and TD Spanish-English (BI)	Pressing two response buttons at the presence of a blue and red circle	8-13	E-Prime software	PS	EO and BI were faster than LI	Kohnert and Windsor 2004.
Visual number search – *lower-level nonlinguistic task* Groups: EO, BI and PLI	Identifying target numbers in serial displays	8-13	Computer -based	PS	NSD	Kohnert, Windsor, and Ebert 2009.
Visual odd man out – *lower-level nonlinguistic task* Groups: EO, BI and PLI	Identifying non-paired stimulus in spatial displays	8-13	Computer -based	PS	PLI had slower RT than EO; NSD between BI and EO, nor between BI and PLI	Kohnert, Windsor, and Ebert 2009.
Visual pattern matching – *lower-level nonlinguistic task*	Comparing shape displays with 1 to 4 sec. delay	8-13	Computer -based	PS	PLI had slower RT than EO; NSD between BI	Kohnert, Windsor, and Ebert 2009.

Task	Brief description of task	Ages and admin time	Format and cost	Skill measu-red	SLI perfor-mance relative to TD peers	Authors and year
Groups: EO, BI and PLI					and EO, nor between BI and PLI	
Visual serial memory – *lower-level nonlinguistic task* Groups: EO, BI and PLI	Repeating 2 to 5 item sequences in visual displays	8-13	Computer -based	PS	NSD in terms of RT; EO had better accuracy than PLI; NSD between BI and PLI	Kohnert, Windsor, and Ebert 2009.
Mental rotation – *higher-level symbolic tasks* Groups: EO, BI and PLI	Matching match non-sense shapes at 4 rotation angles	8-13	Computer -based	PS, VSP	EO and BI had higher accuracy and faster RT than PLI, but NSD between BI and PLI in terms of RT	Kohnert, Windsor, and Ebert 2009.
Auditory pattern matching – *lower-level nonlinguistic task* Groups: EO, BI and PLI	Comparison of 2 to 5 tone auditory sequences	8-13	Computer -based	PS	PLI had slower RT than EO; NSD between BI and PLI; EO and BI had better accuracy than PLI	Kohnert, Windsor, and Ebert 2009.
Rapid serial visual presentation task Groups: SLI and TD	Detection of two visual targets presented serially with distracter items with varying inter-target intervals	Adoles-cents	Computer -based (15-inch LCD Dell Latitude D600 laptop computer)	PS (atten-tional blink – AB)	SLI had an AB which differed from TD in both magnitude and duration	Lum, Conti-Ramsden, and Lindell 2007.
Design copying (DC) task	Copying lines and abstract figures in	5:3-6:10 Approx 45 min/	In accordan-ce to the test	EF, VSP, and WM	NSD	Marton 2008.

Task	**Brief description of task**	**Ages and admin time**	**Format and cost**	**Skill measu-red**	**SLI perfor-mance relative to TD peers**	**Authors and year**
Groups: SLI and TD	given empty spaces	session	manual (Ayres, JA. 1979. 1988.)			
Position in space (PS) task Groups: SLI and TD	1) Matching a series of figures to visually similar abstract forms; 2) Remember-ing of a row of figures that had been previously presented	5:3-6:10	In accordanc e to the test manual (Ayres, JA. 1979. 1988.)	EF, VSP, and WM	SLI < TD	Marton 2008.
Space visualization (VS) task Groups: SLI and TD	Finding an appropriate block and putting it in the form board; mental rotation and response by choosing one of two alternatives	5:3-6:10	In accordanc e to the test manual (Ayres, JA. 1979. 1988.)	EF, IC, VSP, and WM	SLI < TD	Marton 2008.
Tapping task – *motor task* Groups: SLI, nonspecific language impairment (NLI) and TD	Tapping one or two keys as quickly as possible in 5 sec. (3 conditions)	14 Approx 5-10 min.	Computer -based	PS	SLI and NLI < TD	Miller et al. 2006.
Visual search task – *nonverbal cognitive task* Groups: SLI,	Presentation of a target figure; Pressing one key if the target is	14 Approx 5-10 min.	Computer -based	PS	SLI and NLI < TD	Miller et al. 2006.

Task	Brief description of task	Ages and admin time	Format and cost	Skill measu-red	SLI perfor-mance relative to TD peers	Authors and year
(NLI) and TD	present, and another key if it is absent					
Mental rotation task – *nonverbal cognitive task* Groups: SLI, (NLI) and TD	Presentation of a target figure on the left with the same picture on the right; Striking one key if the figure matches the target, and another key if it is a mirror image	14 Approx 5-10 min.	Computer -based	PS	SLI and NLI < TD	Miller et al. 2006.
Simple RT task – *motor task* Groups: SLI, (NLI) and TD	Pressing of a key marked by a coloured dot in response to a visual signal	14 Approx 5-10 min.	Computer -based	PS	SLI and NLI < TD	Miller et al. 2006.
Sustained auditory attention task Groups: autistic, SLI and compa-rison group	This is identical to the selective auditory attention task, except for the duration of the task	7-21 10 min.	Computer -based	PS	SLI < other groups	Miller et al. 2006.
Shift of attention task Groups: autistic, SLI and compa-rison group	Shifting the focus of attention between two categories of geometrical symbols	7-21	Computer -based	SA, CF, EF, and PS	SLI and autistic groups differed from compari-son group (RTs and error rate); NSD between SLI and autistic groups	Noterdaeme et al. 2001.

Task	Brief description of task	Ages and admin time	Format and cost	Skill measu-red	SLI perfor-mance relative to TD peers	Authors and year
Incompatibi-lity task – *interference task* Groups: autistic, SLI and compa-rison group	Pressing of a right key when the arrow points to the right and vice-versa	7-21	Computer -based	EF, IC, and PS	NSD between SLI and comparison groups	Noterdaeme et al. 2001.
Selective auditory attention task Groups: autistic, SLI and compa-rison group	Presentation of a high tone (1000 Hz) and a low tone (440 Hz); Pressing of a key when an irregularity is detected	7-21	Computer -based	AF, PS	NSD between groups; SLI had a higher overall error rate	Noterdaeme et al. 2001.
Selective visual attention task Groups: autistic, SLI and compa-rison group	Selective responding when a specified pattern of crosses appears on the screen	7-21	Computer -based	AF, PS	NSD	Noterdaeme et al. 2001.
Sustained visual attention task Groups: autistic, SLI and compa-rison group	Presentation of a pattern of dots jumping alternatively between the lower and upper part of a square; detection of irregularities in the serial, alternating pattern	7-21 10 min.	Computer -based	AF, PS	NSD; SLI had a higher overall error rate	Noterdaeme et al. 2001.
Alertness task – *simple RT test* Groups: autistic, SLI	Pressing of a key when a visual target is presented	7-21	Computer -based	AF, PS	NSD	Noterdaeme et al. 2001.

Task	Brief description of task	Ages and admin time	Format and cost	Skill measu-red	SLI perfor-mance relative to TD peers	Authors and year
and compa-rison group						
Visual scanning task – *complex visual searching task* Groups: autistic, SLI and compa-rison group	Identifying a target symbol inserted in a matrix of 25 symbols; Pressing key if detection of target and press another key if no detection	7-21	Computer -based	EF, PS	NSD between SLI and comparison groups	Noterdaeme et al. 2001.
The FOCUSED task – *simple visual discri-mination task* Groups: SLI and TD	Moving a joystick in the direction that the target is pointing	7:1-15:7 Approx. 10-15 min.	Computer -based	PS	TD had higher perfor-mance than SLI	Schul et al. 2004.
The SHIFT task – *simple visual discri-mination task* Groups: SLI and TD	Basic procedure is the same of the FOCUSED task, but this includes three blocks of 128 trials, with breaks between them	7:1-15:7 Approx. 20-30 min.	Computer -based	AF, VD	NSD in perfor-mance accuracy; TD had faster RT than SLI	Schul et al. 2004.
Nonverbal-auditory sustained selective attention task Groups: SLI and TD	Pressing of a button when a target sound is heard among other environmental stimuli	4:0-5:7 24 min.	Computer -based; Sony Forge 7.0; Direct RT Precision Timing software	SA	SLI < TD under high load conditions; similar perfor-mance under low load conditions	Spaulding, Plante, and Vance 2008.
Visual sustained selective	Visualization of animation sequences of	4:0-5:7 24 min.	Computer -based; Fireworks	SA	Similar performance between	Spaulding, Plante, and Vance 2008.

Task	Brief description of task	Ages and admin time	Format and cost	Skill measured	SLI performance relative to TD peers	Authors and year
attention task Groups: SLI and TD	a plane and pressing the button when target animation is seen		MX 2004 program; Direct RT Precision Timing software		groups under both load conditions	
Go No-Go – *nonlinguistic task* Groups: SLI and TLD	Pressing of a button on a response box (GO) when they see a shape with a vertical line and withhold a response (No-GO) when they see a shape with a horizontal line	10-12 Variable	E-Prime software	IC	SLI resembled that of children with TLD who were on average 3 years younger	Tropper 2009.

Of the 38 tasks, processing speed was the most measured competency, identified by 26 of the studies. This competency was often measured by the response time to stimuli ranging from visual scanning, visual discrimination, visual and auditory attention, mental rotations, visual search, visual and auditory detection, and motor tasks among others. The other competencies were used by fewer studies, ranging from 0 to 6 studies.

Following the review of the selected articles, a thorough review of existing nonlinguistic assessment tools was performed. These tools were grouped according to the languages in which they are available, the age range assessed by the tools, the administration time for each tool, the format; be it paper-and-pencil format or computer-based, the qualifications required for administration (and whether or not SLP's and teachers are eligible), the evaluated competencies of interest (as described in the test manuals) as well as the authors and the year in which they were published. The tests have been listed in alphabetical order. It should be noted that some of the tests require some instructions to be given verbally by the examiner, but the responses given by the subjects are always non-verbal.

Table 2.0 List of Available Nonlinguistic Cognitive Assessment Tools

AF: Attentional Functions; C: Categorization; EF: Executive Functions; FR: Fluid Reasoning; L: Literacy; Mat: Mathematics; MS: Memory Skills; P: Planning; SA: Sustained Attention; VMD: Visual-motor deficits; VSP: Visuospatial Processing; WM: Working Memory

Test (non-verbal)	**Administra-tion time**	**Format**	**Qualification**	**Evaluated nonlinguistic competency and age range**	**Authors and year**
Alloway Working Memory Assessment 2 – 2nd ed. (AWMA-2) **Language**: English	Screener: 5-10 min; Short form: 10-15 min; Long form: 30 min.	Fully automated (Q-global web-based)	CL3 **SLP: yes** **Teacher: yes**	MS 5-79	Alloway 2012.
Automated Working Memory Assessment – (AWMA) **Languages**: English, Dutch, Irish, Italian, Japanese, Korean, Mandarin, Portuguese, Romanian, Spanish	Screener: 5-7 min; Short form: 10-15 min; Long form: 45 min.	Computer based assessment or scorebook	CL3 **SLP: yes** **Teacher: yes**	MS 4-22	Alloway 2007.
Berry-Buktenica Develop-mental Test of Visual-Motor Integration, Sixth Edition	10-15 min.	Handscored	B, Q1, Q2 **SLP: yes** **Teacher: no**	VMD 2:00-99:11	Beery, Norman, Buktenica, Beery 2010.
Cambridge Neuro-psychologi-cal Test Automated Battery – (CANTAB) **Language:** English	Approx. 10 min. per test (25 tests); Varies according to specific test and level of impairment	Computer software	Health sciences diploma **SLP: yes** **Teacher: no**	AF, EF, MS, PS, VSP 4-90	Cambridge Cognition Ltd. 2013.
Comprehen-					

Test (non-verbal)	**Administra-tion time**	**Format**	**Qualification**	**Evaluated nonlinguistic competency and age range**	**Authors and year**
sive					
Test for Nonverbal Intelligence – 2nd ed. (CTONI-2) **Languages**: English, French, Spanish, Chinese, Tagalog, Vietnamese, German and Korean.	60 min.	Handscored	Levels B, Q2 **SLP: yes** **Teacher: no**	C, FR 6-89	Hammill et al. 2008.
Kaufman Assessment Battery for Children: Core Battery (CHC model) – 2nd ed. **Language:** English	25-70 min.	Paper-and-pencil	Levels C, Q2 **SLP: yes** **Teacher: no**	FR, MS, VSP 3-18	Kaufman and Kaufman 2004.
Leiter International Performance Scale – 3rd ed. (Leiter-3) **Languages**: English and Swedish	20-25 min.	Handscored or software	Level B **SLP: yes** **Teacher: no**	AF, FR, MS 3-75	Roid et al. 2013.
Leiter International Performance Scale-Revised– (Leiter-R)	20-25 min.	Handscored or software (administration and scoring)	Level B **SLP: yes** **Teacher: no**	AF, FR, MS 2-20	Roid and Miller 1997.

Test (non-verbal)	**Administra-tion time**	**Format**	**Qualification**	**Evaluated nonlinguistic competency and age range**	**Authors and year**
Language: English					
Raven's Coloured Progressive Matrices – (CPM) **Languages**: English, French, German, Italian, Japanese, Portuguese (Brazilian), Spanish, and Swedish	15-30 min. (Individual or group)	Handscored or online	Level B **SLP: yes** **Teacher: no**	FR 5-11; the elderly	Raven 2003.
Reynolds Intellectual Assessment Scales – (RIAS) **Languages**: English and Spanish	Approx. 30-35 min. - 4 subtests	Paper-and-pencil	Level C **SLP: no** **Teacher: no**	MS 3-94	Reynolds and Kamphaus 2003.
Shipley-2 – 2nd ed. **Language**: English	20-25 min.	Handscored	Level B **SLP: yes** **Teacher: no**	FR 7-89	Shipley 2012.
Stanford-Binet Intelligence Scales – 5th ed. (SB-5) **Language:** English	5 min. per subtest - 4 *verbal* - 4 nonverbal	SB5 *ScoringPro* Soft ware	Level B **SLP: yes** **Teacher: no**	FR, VSP, WM 2-75+	Roid 2003.

Test (non-verbal)	**Administra-tion time**	**Format**	**Qualification**	**Evaluated nonlinguistic competency and age range**	**Authors and year**
Test of Everyday Attention for Children – (TEA-Ch) **Language**: English	55-60 min.	Handscored	Levels B, Q1, Q2 **SLP: yes** **Teacher: no**	SA 6-15:11	Manly et al. 1998.
Test of Nonverbal Intelligence – 4th ed. (TONI-4) **Languages**: English, French, German, Spanish, and Chinese, Vietnamese, Korean and Tagalog	15-20 min.	Handscored	Levels B, Q2 **SLP: yes** **Teacher: no**	FR 6:0-89:11	Brown, Sherbenou, and Johnsen 2010.
Tower of London-Drexel University – 2nd ed. (TOLDX) **Language**: English	10-15 min.	Handscored	Level C **SLP: no** **Teacher: no**	AF, EF 7+	Culbertson and Zillmer 2005.
Universal Non-verbal Intelligence Test – (UNIT) **Language**: English Wechsler	10-35 min. - 3 batteries	Handscored or software	Level B **SLP: yes** **Teacher: no**	FR, MS 5:0-7:11	Braken and McCallum 1996.
Weschler	60-90 min.	Paper-and-	Level C	FR, PS, WM	Wechsler

Test (non-verbal)	**Administra-tion time**	**Format**	**Qualification**	**Evaluated nonlinguistic competency and age range**	**Authors and year**
Intelligence Scale for Children – 4th ed. (WISC-IV) **Language**: English		pencil	**SLP: no** **Teacher: no**	6:0-16:11	2002.
Weschler Preschool and Primary Scale of Intelligence – 3rd ed. (WPPSI-III) **Languages**: French, English, Dutch, Finnish, Italian, Japanese, Lithuanian, Mandarin, Slovenian, and Swedish	a) 30-45 min. b) 60 min.	Paper-and-pencil	Level C **SLP: no** **Teacher: no**	AF, FR, PS a) 2:6-3:11 b) 4:0-7:7	Wechsler 2002.
Wisconsin Card Sorting Test – (WSCT) **Languages**: French, English, and Spanish	20-30 min.	Paper, Computer based	Level C **SLP: no** **Teacher: no**	EF 7-89	Grant and Berg 2003.
Woodcock Johnson III Test of Cognitive Abilities	Approx. 5 min. per test (7 tests) Total 35-40 min.		Level B **SLP: yes** **Teacher: no**	AF, FR, P, PS, VSP, WM 2:0-90+	Woodcock McGrew, and Mather 2007.

A total of 19 nonlinguistic tests with varying degrees of qualification levels were identified. Of those 19 tests, 15 can be administered by speech-language pathologists, only 2 tests can be administered by teachers. Various competencies can be assessed by the 19 tests, however, only those that measure the nonlinguistic cognitive skills shown to date to be impaired in children with PLI were identified. Unlike the task distribution, most of the assessment tools tap into several nonlinguistic cognitive abilities. However, memory, be it working memory or general memory skills, were the most frequently measured cognitive abilities assessed by 11 tools. It should be noted that some of the abilities measured by the tasks were not specifically measured by the tools such as: temporal resolution abilities, cognitive flexibility, visual discrimination, and inhibitory control. The same can also be said about some of the tasks. The following abilities were only measured by the assessment tools but not the specific tasks: planning, fluid reasoning and categorization.

Discussion

After completing the search for nonlinguistic cognitive tasks, it became evident that most of the 38 tasks were not readily available to clinicians or teachers with the exception of a visuo-spatial working memory task that can be downloaded for free from the Internet. However, there is still some debate as to whether or not it should be used as a PLI diagnostic tool. Furthermore, many tasks require software programs that are very costly like for example E-Prime (Psychology Software Tools, Inc. 2013), which can cost over a thousand dollars. Similarly, DirectRT (Empirisoft Corporation. 2011) can also cost close to a thousand dollars.

Although the iPad (Apple 2013) or other android tablet applications have not been clinically tested, they could offer an alternative method to assessing some of the nonlinguistic cognitive skills mentioned in this paper. For example, the iPad application “Check Your Reaction” by Apogee Studio (2013) is available at a very low cost and could potentially be used as a cognitive task requiring inhibition such as the Go No-Go task. However, the use of this application would require further research in order to determine its specificity and sensitivity in the identification of PLI among children. Such work is currently on going.

Using some of these tasks with certain complementary tests should facilitate the assessment of bilingual children by providing teachers, speech-language pathologists, psychologists and other professionals, an assessment battery founded on evidence-based practice. The results of the large majority of the studies conducted using these various nonlinguistic cognitive measures all show that children with PLI perform significantly worse than their typically developing peers. This reinforces the importance of using such tasks in everyday clinical practice or in the classroom. As far as establishing a standard assessment protocol, the authors feel that this is not necessary given the extensive selection of these tests and tools. However, it is important to ensure that most of the nonlinguistic cognitive abilities discussed in this paper be assessed either via a task or an assessment tool. Clinicians should establish their own protocol by using the tests that are available to them and by adding additional tasks or tests to complete their nonlinguistic cognitive battery.

Unlike the tasks, many tests are readily available to speech-language pathologists and other clinicians. However, it should be noted that the tests mentioned in table 2.0. are often used as inclusionary or exclusionary criteria for the selection of participants in certain researches. They are not necessarily used to rule out the presence of PLI, but rather to rule out the presence of a frank cognitive impairment. Yet, clinicians can use many subtests as part of a larger assessment battery to determine the presence of PLI. Many of the tests have subtests that can be used for the assessment of specific nonlinguistic cognitive skills. For example, the Attention Sustained subtest of the Leiter International Performance Test-Revised (Leiter-R; Roid and Miller 1997) is a paper-and-pencil task that can be completed in approximately 5 minutes and can serve as an important diagnostic tool in combination with other tests. By using many of these tests, clinicians can better assess children’s nonlinguistic cognitive ability as well as measure progress following linguistic and nonlinguistic intervention.

In the absence of assessment tools or tasks, certain exercises are available at a low cost and can be used on a daily basis with all children. For example, the Locutour Multimedia Attention and Memory: Volume II software package (Scarry-Larkin and Price 2007) includes many different computer-based games that are designed to improve memory and attention. This is only one example of many tools that can be used to work on cognitive skills. In fact, tangible games can also be used in order to work on memory, attention, information processing, among others (Ebert, Rentmeester-Disher, and Kohnert 2012). These games can be used regardless of whether or not the child has been identified as having a cognitive deficit. Lastly, tablet applications designed for improving cognition are being created every day and offer an alternative way to work on these skills (see Robillard and Mayer-Crittenden *in press* for a review). Perhaps clinicians and teachers should look at adopting some of these activities in their daily interventions in order to enhance or improve existing cognitive abilities.

Because many of the tests require a certain qualification for administration, SLPs and teachers could recommend that children be assessed by a psychologist in the specific areas of memory, attention, processing speed, information processing, executive functions, fluid reasoning, among others. This would give insight on a bilingual child's cognitive abilities without focusing on a particular language. In some parts of Canada, many psycho-educational assessments tend to focus on literacy, numeracy, oral communication, general attention and memory. When a child is bilingual, these assessments often need to take place in both languages. It is therefore possible that other more subtle cognitive skills are not included in the standard psycho-educational assessment protocol. By requesting that specific abilities such as nonlinguistic processing speed, executive functioning, cognitive flexibility, categorization, verbal working memory (phonological loop) be evaluated, based on our every day observations, these could then be assessed by a qualified psychologist who, in turn, could provide the teacher or SLP with a detailed cognitive portrait of the child, along with the more traditional psycho-educational assessment. This would enable the SLP or the teacher to directly focus on those abilities and provide the child with adequate support in order to enhance learning in the areas of numeracy, literacy and oral communication in one or both languages spoken by the child.

Future Research

Future research is needed to investigate how children with PLI score on some of the above-mentioned measures and assessment tools in comparison to typically developing children at different ages. Further, the sensitivity and specificity of the tasks and the assessment tools should be determined in order to better identify monolingual and bilingual children with PLI. In addition, since most of the tasks are very experimental in nature, more research needs to be conducted with user-friendly nonlinguistic tasks that can easily be used by clinicians and teachers.

Conclusion

This paper set out to establish a protocol for the assessment of monolingual and bilingual children suspected of having a PLI. In total, 15 tests which assess nonlinguistic competencies reportedly impaired in children with PLI were found and can be administered by SLPs. Further, 38 tasks were also found. However, many tasks were similar, with had a highly experimental research component and required specialized equipment or training in order to use them. Consequently, many of these tasks could be very expensive to administer. Only a select few were available online for free. This is not surprising given the relatively recent use of these tasks in the literature. To overcome this challenge, certain tasks could be found in the form of tablet applications. However, further research is required in order to determine how children with PLI perform in comparison to their typically developing peers. Nonetheless, the list of tasks found in the literature opens new doors not only for assessment protocols but also for possible models of intervention. Evidenced-based practice on nonlinguistic competencies shortfalls in bilingual children with PLI suggests that language intervention should also target underlying nonlinguistic competencies. Although very little research has been conducted in this field, new research is currently underway.

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