SCREENING OF SCHOOL READINESS SKILLS: A REVIEW OF THE LITERATURE

FNAL REPORT

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FINAL REPORT

CONTENTS

ACRONYMS

ADHD	Attention-Deficit Hyperactivity Disorder
BSID	Bayley Scales Of Infant Development
CDA	Care for Development Appraisal Tool
CSR	Cognitive Self-Regulation
DRC	Democratic Republic Of The Congo
ECD	Early Childhood Development
HTKS	Head-Toes-Knees-Shoulders
IQ	Intelligence Quotient
KABC-II	Kaufman Assessment Battery for Children
LMTF	Learning Metrics Task Force
MDAT	Malawi Developmental Assessment Tool
NELP	National Early Literacy Panel
NICHD	Eunice Kennedy Shriver National Institute of Child Health and Human Development
PIPS	Performance Indicators in Primary Schools
PK	Pre-Kindergarten
PPVT	Peabody Picture Vocabulary Test
RAN	Rapid Automatized Naming

EXECUTIVE SUMMARY

Ensuring that children are successful in school is one of the main tasks of an education system. Although widely recognized that learning begins in the home where children acquire many important skills (Irwin, Siddiqi, Hertzman, 2010), a seamless transition to formal schooling is necessary for academic success. School readiness refers to a child's preparedness to benefit from instruction. Children who have developed cognitive, behavioral, and emotional skills needed to learn and function in school are usually successful (Anderson et al., 2003; Boocock, 1995; Rafoth, Buchenauer, Crissman, & Halk, 2004) regardless of where they live. Data from studies in Brazil (Victora, Victora, & Barros, 1990), Guatemala (Gorman & Pollitt, 1996; Stith, Gorman, & Choudhury, 2003), Jamaica (Walker, Chang, Powell, & Gratham-McGregor, 2005), Philippines (Daniels & Adair, 2004; Mendez & Adair, 1999), and South Africa (Liddell, & Rae, 2001) demonstrated a positive association between early cognitive ability and academic performance in primary school and beyond. This evidence supports the use of screening measures to identify children who may need additional interventions to succeed in primary school.

The Learning Metrics Task Force (LMTF), a collaborative group led by the UNESCO Institute of Statistics and the Brookings Institute, identified global Ready-to-Learn indicators. These indicators are 'measures of acceptable levels of early learners and development across a subset of domains by the time a child enters primary' (Learning Metrics Task Force, 2013, p. 13). They recommend holistic measurement across seven domains. Four of these domains (social/emotional, literacy and communication, learning approaches and cognition, and numeracy and mathematics), are closely linked to academic success. Physical well-being, necessary for optimal learning, is also included among the domains (Issacs & Oates, 2008).

Previous studies have demonstrated that education interventions have the most direct impact on academic outcomes. The association between participation in Early Childhood Development (ECD) and cognitive development that prepares children to succeed in school has been used to advocate for the implementation of early childhood programs (Boocock, 1995; Krishnaratne, White, & Carpenter, 2013) and the development and use of school readiness screenings. Results from studies indicate that enrollment in ECD programs has a direct impact on primary enrollment and reduced drop-out (Krishnaratne et al, 2013), child behavior (Hamadani, Hudsa, Khatun, & Grantham-McGregor, 2006; Kagitcibasi, Sunar, Bekman, Baydar, & Cemalcilar, 2009; Klein & Rye 2004; Magwasa & Edwards, 1991), intelligence (Grantham-McGregor, Powell, Walker, Chang, Fletcher,1994), and later academic outcomes (Grantham-McGregor et al.,1994; Walker et al., 2010). Moreover, ECD programs which provide direct learning experiences to children and their families, target younger, disadvantaged children, are of longer duration and intensity, and integrate family support, health, and nutrition are the most effective. However, despite strong evidence on the importance and effect of ECD programs, global coverage is low (Engle et al., 2007).

Another approach to positively impact educational outcomes is to address children's health and nutrition needs. Health and nutrition programs implemented to temper the effect of illness and undernourishment on academic outcomes have had mixed results (Baker-Henningham & Boo, 2010; Krishnaratne et al, 2013). School feeding programs have had a positive impact on enrollment, attendance, and drop-out rates but only small effects on learning outcomes. Results of health interventions are also mixed. Grantham-McGregor & Ani (2001) found that the evidence for the effect of iron treatment on cognitive performance and educational attainment was inconclusive. Results of studies of the effect of malaria treatment have also been mixed. A study in Kenya found that treatment increased students' sustained attention but not educational attainment (Clarke & Royer, 2008) whereas a similar study in Sri Lanka (Fernando et al., 2006) found increased educational attainment among children who had been compliant in their treatment. A missing component in these studies is an assessment of the quality of instruction. Health interventions tend to impact cognitive skills but not

academic skills, suggesting that attention to health issues which affect cognitive skills is necessary in order to ensure that children are able to benefit from enhanced education programs.

Finally, combined nutrition and educational interventions resulted in improved mental and motor development (Grantham-McGregor, Powell, Walker, & Himes, 1991; Waber et al., 1981). Outcomes improve with greater duration (McKay, Sinisterra, McKay, Gomez, & Llireda, 1978). Although evidence exists that both nutrition and health impact children's cognitive development and their ability to learn, few longitudinal studies have been conducted that carefully examine the causal relationship among health, cognition, and learning (Griffiths, 2013). Understanding the relationship among these factors can provide the evidence needed to develop holistic interventions that maximize the effect of the interventions on student outcomes. However, until ECD programs are implemented universally, the screening of students prior to primary school entry can provide teachers with data on their cognitive and academic skills as the basis for development of more targeted instruction.

A review of the literature was conducted to identify measures predictive of later academic outcomes when administered prior to the initiation of formal schooling. Age at school entry varies by country; therefore, studies were included if the first assessment was conducted prior to or at the beginning of the child's first year of formal schooling and subsequent assessments were conducted at least one year later. Identified studies used predictor measures in four areas: academic, language, behavior, and cognitive. Outcomes measures were academic. Consistent with conclusions of multiple meta-analyses, measures of academic skills, particularly of emergent literacy skills, were most predictive of later reading ability, a common outcome measure. However, numeracy skills, rapid automatized naming, self-regulation, and executive function also contribute to student success. In an effort to identify measures that would not be confounded by lack of educational opportunity, measures that assess precursor skills and predict academic achievement (Glover & Albers, 2007), as well as those that are brief, easy to use, and provide information useful in planning instruction (Schatschneider, Petscher, & Williams, 2008) were selected for further examination. A second search was conducted to identify validation studies. These studies, conducted in various countries and in various languages, were used to determine whether the targeted measures were reliable and valid when implemented in non-Western contexts. Although the studies were often conducted with older children, they provide evidence that these measures can be used reliably in various contexts and languages. The purpose of this review is to identify early childhood assessments in various domains that can be used to reliably differentiate between children who are likely to benefit from instruction and those who are not, unless provided with interventions that address their cognitive and behavioral needs in addition to developing their academic skills.

SELECTION CRITERIA

Five criteria were applied in the selection of measures.

1. They had to assess a skill or domain that is predictive of later academic achievement.
2. They had to be appropriate for children who have not begun formal schooling.
3. They had to be easy to develop and adapt to different contexts and languages.
4. They had to be easy to administer.
5. They had to make a unique contribution to ensure that the resulting battery of assessments is efficient.

After reviewing studies that used measures that fit these criteria, a battery to assess three domains was identified. Measures that assess language, executive function, and speed of processing were selected.

LANGUAGE

Language skills are primarily measured in two ways. Assessment of vocabulary depth (how well a child knows a word) and breadth (how many words a child knows) provides an index of the child's general language knowledge. Specific aspects of language can also be examined. The most common language skills measured are phonological awareness, syntactic awareness, semantic awareness, and morphological awareness. Of these, phonological awareness has the most research support and is consistently found to predict the acquisition of later word reading skills. One reason for this phenomenon is that most of the research conducted has been in alphabetic languages. Phonological awareness skills have emerged as a predictive skill in every alphabetic language in which it was studied (Ziegler & Goswami, 2005).

Across languages, the hierarchy of skills is also consistent (e.g. Alcock, Ngorosho, Deus, & Jukes, 2010; Cho & McBride-Chang, 2005; de Jong & van der Leij, 1999; Holopainen, Ahonen, & Lyytinen, 2001; and Tolchinsky, Levin, Aram, McBride-Chang, 2012). Large unit skills such as blending and segmenting of compound words and blending and segmenting words at the syllable level emerge prior to formal reading instruction while skills at the phoneme level, such as blending and segmenting, develop with formal reading instruction. Across languages that differ in the depth of the orthography and phonological structure, children with normal developmental trajectories develop syllabic awareness at about age three-to-four and onset-rime awareness by age four-to-five (for a review of the research see Ziegler & Goswami, 2005). Phoneme awareness usually develops when children are taught to read (Alcock, Ngorosho, Deus, & Jukes, 2010; Ziegler & Goswami, 2005).

Therefore, measures of syllabic awareness are most appropriate for a battery that will be administered prior to formal schooling. This clear demarcation between skills that develop prior to and after instruction make it an ideal task for this battery. Two tasks which were used in a number of studies are recommended for the initial battery, a Word Oddity task in which children are asked to identify a word in a set of three that does not begin with the same sound as the other two. The second, Syllable Segmentation, requires children to segment two-syllable words.

EXECUTIVE FUNCTION

The ability to behave appropriately in a school setting is critical to school success. When children enter school, they are expected to quickly learn and follow the behavioral expectations of school such as following directions and not speaking out of turn. They also have to attend to the teacher and suppress distractors. Children who have acquired executive function skills are more likely to succeed in making a seamless transition to the classroom setting. Executive function includes three dimensions: working memory, inhibitory control, and cognitive flexibility (Center on the Developing Child at Harvard University, 2011). The acquisition of these skills, often thought to be the biological foundation of school readiness in early childhood, is essential (Blair, 2002). These processes are evident in children's ability to self-regulate their behavior and emotions. To screen children's ability in this domain, two tasks are recommended: the Head, Toes, Knees, Shoulders task and Peg Tapping (Diamond & Taylor, 1996). Both of these tasks are brief and assess children's control over the three processes.

RAPID AUTOMATIZED NAMING

Rapid automatized naming (RAN) is a measure of processing speed. Tasks of naming speed assess the rate at which a child can produce a verbal label for a common visual stimulus (Vukovic & Siegel, 2006). Task development and administration is based on a task introduced by Denckla and Rudel (1974). Commonly-used stimuli include colors, objects, letters, or digits. Although RAN letters or numbers are more predictive than RAN objects or colors, the latter are recommended for this battery based on previous experiences with early grade assessments in which many children are likely unable to identify even five letters or numbers prior to formal schooling.

I. INTRODUCTION

Improving quality and access to primary education has been the focus of governments, educators, and administrators in developing countries and the donor community for at least 15 years. As a result of concerted attention, universal attendance has seen large increases in countries with low enrollment rates. Total enrollment in primary education in the developing world reached 90 percent in 2011 (http://www.acdi-cida.gc.ca/acdi-cida/acdi-cida.nsf/en/JUD-13175929-H9K retrieved February 2014). The quality of reading instruction is also improving in countries as diverse as Egypt (https://www.eddataglobal.org), Malawi, Zimbabwe, and Pakistan (Save the Children, 2014b) that have instituted systematic reading programs. Despite promising results in some contexts, in others the rate of improvement is well below what would be expected even after taking into consideration the challenges faced by educators in many countries: large class sizes, poorly-prepared teachers, insufficient materials, and inadequate instruction. In addition to these school level factors, child-level factors also impact learning. Malnutrition and poor health are associated with negative academic outcomes (Grantham-McGregor et al., 2007; Halliday et al., 2012) as are underdeveloped executive function skills and the ability to process information efficiently (Saez, Folsom, Al Otaiba, 2012; Walker et al., 2007). Understanding how these child-level factors may mediate or moderate the effect of reading interventions may be the missing link to improving child academic outcomes in developing countries.

Although no universally-accepted theories of cognitive development exist, three prominent theories of sociocultural, core knowledge and information processing all posit that the interaction between nature and nurture is essential for cognitive development. That is, everyone is born with genetically-predisposed innate characteristics that define both human and individual potential. Children have innate cognitive capacities as a product of the human evolutionary process; these include the capacity to develop language, social cognition, use of numbers, and categorization of objects (Carey & Spelke, 1996). These universal aspects of human cognition arise early in infancy, have neurophysiological correlates, are cross-culturally uniform, and are the basis for more complex thinking skills (Carey & Spelke, 1996). Culture itself determines which objects are worthy of being categorized or counted, which sounds result in communication, and which people should be cared for (Bowman, 1994). Although, the rate at which specific cognitive skills develop may vary across cultures, all are available to support children's learning (Fischer & Silvern, 1985). Further, because of the high level of plasticity exhibited by humans, children can develop skills when provided the opportunity. Developmental plasticity refers to changes in neural connections during development that result from interactions and learning (Fischer & Silvern, 1985).

Numerous reports (AIDSTAR-One, 2011; Britto, 2012; Engle et al., 2007; Irwin, Siddiqi, Hertzman, 2007; Krishnaratne, White, & Carpenter, 2013; Myers, 2008; Nonoyama-Tarumi & Ota, 2010; UNICEF, 2011; Walker et al., 2011) have examined the role of school readiness in developing countries. Across the reports, consensus emerges that a holistic approach which incorporates measures across several domains is the most appropriate in these environments. 'School readiness' has traditionally been used to describe a child's readiness to perform school tasks. A child who is prepared to benefit from a school environment has acquired basic skills and knowledge in domains such as language, motor development, general knowledge, and problem solving. A child with these skills is more likely to acquire academic knowledge and skills in content areas. Assessments of school readiness are used to determine if children have prerequisite skills in five domains: (a) physical well-being and motor development, (b) social and emotional development, (c) approaches to learning, (d) language usage, and (e) cognition and general knowledge (Learning Metrics Task Force, 2013). Measures in these domains are usually based on normative samples of children and serve as the basis for standardized assessments of development.

Readiness can also refer to a child's readiness to learn. This model assumes that the child's neuro-system is developing appropriately and that he or she will be able to develop the various skills required to succeed in school given the opportunity and an appropriate educational experience.

Neurophysiological maturation impacts adjustment to school due to the influence on executive functions such as being able to regulate behavior and control emotions (Blair 2002). The goal of a screening battery under this model is to determine whether or not the child's neuro-system is intact. To make this determination, cognitive processing, metalinguistic, and self-regulation abilities of children as well as their attitude toward learning are examined. This approach acknowledges the interrelationships between skills and behaviors across domains of development and learning (Schoen & Nagle, 1994). Children's cognitive processes can be developed with appropriate interventions.

To gain a better understanding of why some children benefit from improved instruction while others do not, identification of the skills and abilities that facilitate learning is critical. Furthermore, screening measures that accurately differentiate students who are ready to learn from those who are not ready are needed. Effective screening measures are typically brief, easy to use, and provide information that can be used to plan instruction (Fuchs & Fuchs, 2006; Schatschneider, Petscher, & Williams, 2008). They are most useful if they are also predictive of future learning (Glover & Albers, 2007; Meisels, 1999).

II. ASSESSMENTS

Two types of assessments are commonly used with preschool children. Developmental screening tests measure a child's attainment of motor, communication, sensory, or cognitive skills. Results provide an objective description of the child's abilities and deficits. Children's scores are compared either to a norming sample or to a set of criteria to determine whether or not they have attained specific milestones that indicate the likely continuance of maturation and learning at the expected rates. Theories of child development characterize human development as a maturational process in which the progressive development of physical, motor, cognitive, and communication skills enables children to perform increasingly more complex tasks as they grow older. Further, by the time they begin school, most children have "mastered their home languages, established appropriate social relationships with their families and neighbors, learned a variety of category and symbol systems, and developed the ability to organize and regulate their own behavior in situations that are familiar to them" (Bowman, 1994, p.1). Cultural differences dictate that assessments of early childhood development should be adapted to the contexts in which they will used and further, both criterion and norm referenced tests should be validated.

If learning is defined as acquiring knowledge or developing the ability to perform new behaviors then all children are able to learn because they have the capacity to integrate their innate abilities with their sensory motor skills. They use these skills to perceive the world and cognitive skills provide them a means to process the sensory information. Thus all children are able to learn. However, the extent to which school expectations are aligned with the knowledge and skills that children possess will determine whether or not they are judged to be ready for school. To succeed in school, children have to be able to adapt their knowledge and behavior to a school environment and academic tasks. Therefore, to succeed children must not only possess these cognitive characteristics but must be able to use them flexibly to succeed in new environments.

Readiness tests determine a child's relative preparedness to participate in the classroom (Meisels & Atkins-Burnett, 2005). When used with all students, readiness screening measures can be used to identify children who require further evaluation to determine their need for additional support or early intervention (Meisels & Fenichel, 1996). Universal screening involves the use of low-cost tools that can be administered quickly to gather data on each child in the classroom.

Most early childhood developmental assessments have been developed and normed in Western countries. Although they can be useful in some contexts, assessments that more closely follow the developmental trajectories of children in developing countries may be more useful in tracking child

development and predicting future outcomes in those contexts. The Malawi Developmental Assessment Tool (MDAT), technically sound and culturally relevant for African settings (Gladstone et al., 2010), was developed to provide an alternative to traditional developmental assessments. The measure has 136 items in four domains: gross motor, fine motor, language, and social skills and was found to have predictive validity to two school-age psychological tests. Preschool children were assessed within one year of being discharged from the hospital and again at least two years later. Results indicate that the MDAT global score predicted scores on the second edition of the Kaufman Assessment Battery for Children (KABC-II) planning subtests: a) Test of Variables of Attention, b) attention-deficit hyperactivity disorder (ADHD) score and prime signal detection, and c) Achenback child behavior checklist external symptoms total (Boivin, Vokhiwa, & Magen, 2013). Despite the predictive validity and technical adequacy of the measure, the authors recommend its use for research rather than routine developmental assessment until resources are available for universal screening of children.

Another measure developed in Africa is the Kilifi Developmental Inventory (Abubaker et al., 2007) that focuses on loco-motor, eye-hand coordination, and psychosocial skills in children aged six to thirty-five months. The measure reliably discriminated among children with HIV infection and HIV-exposed or a control group in Kenya.

The Zambian Child Assessment Test is a multiple-domain assessment of preschool children in the Zambian context. It combines existing and new child development measures in the following domains: nonverbal cognition, receptive and expressive language, fine motor skills, information processing, and executive function (Fink, Matafwali, Moucheraud, Zuilkowski, 2012). Language skills were assessed with the Peabody Picture Vocabulary Test (PPVT), a test of receptive vocabulary, which has been used in a number of countries in various languages (Fink et al., 2012) including a previous study in Zambia. Expressive language was assessed by asking children to respond to two questions. Other subtests included Object RAN to assess information processing and the Pencil Tapping Test to assess attention. The Pencil Tapping Test was developed in Kenya (Brooker et al., 2010). At the end of the session, assessors completed a task orientation questionnaire that has been shown to be predictive of both cognitive and socio-emotional outcomes (Fink et al., 2012).

The School Readiness Assessment (Save the Children, 2013) is used to assess three and half to six year-old children. Sixty-six items assess children's physical, emergent language and literacy, math and numeracy, and socio-personal development. A shorter version with 25 items has also been developed and recently, cognitive measures have been added to the battery. The assessment has been used across six countries with consistent results. During the Senegal pilot, measures that assess phonological awareness, information processing, sustained attention, visual attention, and executive function were included. For the Mali pilot, the RAN battery with colors and objects was replaced with RAN animals. Additionally, a digit span measure was added to assess auditory attention. Demographic information on the pilot participants was not available. To date, no predictive validity data is available for the assessment but some of the individual components such as phonological awareness, RAN, and the sustained attention task, pencil tapping, have been validated.

The Care for Development Appraisal Tool (CDA) (Rafique & Nadeem, 2011) was designed to monitor child growth and development during the first three years of life to identify delays and possible areas of early intervention in young children. The test was validated in Pakistan. The tool can be reliably administered by trained community-based workers making it ideal for use in difficult and remote areas.

The PIPS (Performance Indicators in Primary Schools) assesses early reading and math development, executive function, and personal and social development in children between four to seven years. Teachers measure children individually with PIPS to track their progress throughout the primary years in cognitive measures as well as personal, social, and emotional development. To date, the measure has only been administered in English speaking countries but is being expanded for use in low-income

countries. The measure has been found to be predictive of reading ability at five and 16 years of age (Tymms & Bailey, 2013).

Several comprehensive assessments have been adapted for use in Africa. The most commonly used are the Griffiths Mental Development Scales (Griffiths, 1984), the Bayley Scales of Infant Development (BSID 1969, BSID II, 1993, and the BSID III 2006), and the Mullen Scales of Early Development (Mullen, 1995) (Kammerer, Isquith, & Lundy, 2013). The BSID has been used in South Africa, Uganda, the Democratic Republic of the Congo (DRC), and Tanzania with mixed results. The tool was appropriate for South Africa but the test was not discriminative enough at the low end in Uganda. The variability may have been due to the different levels of adaptation across contexts (Kammerer et al, 2013). The Griffiths Mental Development Scale has been used in South Africa after undergoing modifications but no normative data for Africa exists. Although the Mullen has only been used in Uganda, it has a wider age range and a less intense administration training requirement than the BSID (Kammerer et al, 2013); therefore, if the measure is reliable in other contexts, it may be a better option for assessment.

A recent meta-analysis examined the cognitive and academic outcomes of 23 health and nutrition interventions in school-aged children (Gee & Adelman, 2013). All assessments were developed and normed in Western countries. The most common tests used were:

- Wechsler Intelligence Scale for Children;
- Wide Range Achievement Test, 3rd Edition;
- Kaufman Assessment Battery;
- Peabody Picture Vocabulary Test;
- Raven's Colored Progressive Matrices.

Subtests were more predictive than the entire battery and these measures were more predictive of later cognitive skills than academic skills. Subtests demonstrated some cognitive impact in 11 studies. Of the six studies that measured achievement, only two demonstrated a significant impact. The use of standardized measures is viable in developing countries but attention to the contextual adaptation and cultural relevance is essential.

III. REVIEW OF RESEARCH

Results from meta-analyses and longitudinal studies with preschool children indicate that both academic and behavioral skills contribute to positive academic outcomes. For example, Scarborough (1998) examined the findings of 61 studies that used a wide variety of measures in kindergarten to predict reading achievement in first and second grade. Measures were divided into three categories: processing of print, oral language proficiency, and non-verbal abilities. Results indicate that letter identification and phonological awareness were predictive of word level skills while vocabulary, sentence recall, and concepts of print predicted comprehension skills. Perceptual skills, motor skills, and speech perception were the least predictive of later reading outcomes.

Ten years later, the National Early Literacy Panel (NELP; 2008) conducted a meta-analysis of approximately 300 predictive studies that examined the relation between a skill measured in preschool or kindergarten and reading outcomes such as word decoding, reading comprehension and spelling in primary school. All the studies included in the meta-analysis were conducted with children learning to read an alphabetic language. Similar to Scarborough's findings, the results of this meta-analysis indicate that children's skills related to print knowledge (e.g., alphabet knowledge, print concepts), phonological processing skills (i.e., phonological awareness, phonological access to lexical store, phonological

memory), and aspects of oral language (e.g., vocabulary, syntax/grammar, word knowledge) were independent predictors and had medium-to-large predictive relationships with later measures of literacy development. Measures of alphabet knowledge, phonological awareness, rapid automatized naming, writing or writing one's name, and phonological memory not only correlated with later literacy but also maintained their predictive power even when the role of other variables, such as IQ or socioeconomic status were accounted for. This indicates that these six measures may be suitable in contexts were children's experiences prior to school entry vary greatly.

A more recent meta-analysis of 70 longitudinal studies conducted by La Paro and Pianta (2000) that included more than 3,000 children, examined the degree to which assessments predicted children's social/behavioral and academic/cognitive competence during the transition to school (from preschool to kindergarten and from kindergarten to first and second grade). Assessments were divided into those that tested performance in cognitive/language development including literacy skills, intellectual functioning, and knowledge of vocabulary, colors, and fine motor skills and those that assessed social competence or problem behavior such as cooperation with peers or adults, following directions, attention, and aggression. Results showed that assessments of preschool children's functioning in the two broad areas of academic/cognitive and social/behavioral development predicted only a small to moderate portion of variability in similar outcomes in the early school years. Effect sizes were similar to those found by Scarborough (1998).

Duncan et al., (2007) used six longitudinal data sets to examine the relationship between three key elements of school readiness: school-entry academic, attention, and socio-emotional skills, and later school reading and math achievement. Across all six studies, the strongest predictors of later achievement are school-entry math, reading, and attention skills. A meta-analysis of the results shows that early math skills had the greatest predictive power, followed by reading and then attention skills. In contrast, measures of socio-emotional behaviors were insignificant predictors of later academic performance, even among children with relatively high levels of problem behavior. However, note should be made that the predictive relationships found were weaker than those found in other studies. Less powerful, but also consistent, predictors across studies were early language and reading skills such as vocabulary, knowing letters, words, and beginning and ending word sounds.

The difference in predictive power between this meta-analysis and others may be due to the combination of a wide range of reading skills as predictors. The authors found that attention skills were modestly but consistently associated with achievement outcomes. Stronger attention skills may help children remain engaged in academic activities. This finding is similar to that of other studies that have shown the important associations of attention skills with school success, independent of cognitive and/or language ability (Alexander, Entwisle, & Dauber, 1993; Howse, Calkins, Anastopoulou, Keane, & Shelton, 2003; McClelland et al., 2000; Yen, Konold, & McDErmott, 2004). However, child level characteristics such as chronic illness and malnutrition can moderate the effect of attention skills. That is, children with chronic illnesses such as malaria may not benefit from self-regulation instruction needed to improve academic outcomes until the effects of the illness have been addressed (Jukes et al., 2006). This point is particularly salient in developing countries where many children are chronically ill. In order for children to benefit from improved literacy instruction even when it includes self-regulation to improve attention skills, health concerns may have to be addressed simultaneously.

The predictive validity of different measures in preschool may vary depending on the nature of the sample, the length of follow-up, and the outcome domain (Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004). Measures of reading are often used as an outcome measure of academic achievement so the consistent findings of the predictive ability of early reading measures on later academic outcomes is not surprising. Over the past three decades, many different skills have been proposed to explain how children learn to read; however, three skills consistently emerge as the strongest predictors of reading: phonological awareness, print knowledge, and oral language (Lonigan, 2006; Lonigan, Schatschneider, &

Westberg, 2008; Whitehurst & Lonigan, 1998). Similar to results with older children, data from studies with preschool children reveal a strong relationship between preschool children's levels of reading-related skills and their levels of reading-related and reading skills in elementary school (e.g., Anderson et al., 2003; Boocock, 1995; Lonigan, Burgess, & Anthony, 2000; Rafoth et al., 2004; Storch & Whitehurst, 2002) indicating that the precursor developmental skills underlying the acquisition of reading are developed early and can therefore be assessed before school entry. Children, who have not had the opportunity to interact with print prior to school entry, may lack print knowledge, but most will have acquired oral precursor skills such as phonological awareness and oral language (Snow, Griffin, & Burns, 2005) since all children participate in a particular language community and the grammar and social rules of the child's linguistic community shape his or her language abilities (Rogoff, Gauvain, & Ellis, 1984).

IV. PREDICTIVE SKILLS

To determine the predictive validity of specific skills, a review of literature was conducted in which the following key terms were used to identify the initial set of studies: cognitive measures, predictors, academic success, preschool, and early childhood. Abstracts were reviewed to ensure that the studies met the inclusion criteria. Studies that met all the criteria included measures of language, behavior, executive function, rapid automatized naming, or early literacy or numeracy skills as predictors. Outcome measures reported various literacy skills. After a review of studies and elimination of specified early literacy skills from consideration, the factors of language, executive function, and rapid automatized naming emerged as the most empirically supported. Additionally, each of these areas makes a unique contribution to the determination of a child's readiness to learn and are all responsive to remediation in the classroom.

LANGUAGE

General language ability is related to learning. Prior to entering school, children will have developed phonological awareness, several thousand vocabulary words, and an understanding of the grammatical and discourse rules of the language they speak (Snow, Griffin, & Burns, 2005). Although general vocabulary knowledge is important, that capacity is difficult to measure well especially with young children; therefore vocabulary is often measured by examining children's acquisition of sub-skills such as morphological and orthographic awareness. Measures of these sub-skills provide more targeted information about children's language acquisition than measures of receptive and expressive vocabulary. Also useful is evaluation of the development of children's meta-linguistic skills. Meta-linguistic skills are related to but are not the same as language acquisition (Tumner, Herriman, & Nesdale, 1988). Children who have developed meta-linguistic skills are able to not only use language but also reflect on and manipulate its structural features. The four skills commonly categorized as meta-linguistic are: word awareness, phonological awareness, syntactic awareness, and pragmatic awareness. Children with more advanced general language ability tend to have more advanced meta-linguistic ability (Bowey & Patel, 1988). Therefore, children's meta-linguistic ability may serve as an index of their general language ability. Of the meta-linguistic skills studied, phonological awareness (PA) has emerged as the most stable and robust indicator of later reading ability for children between four and six years old (Cho & McBride-Chang, 2005; de Jong & van der Leij, 1999; Holopainen, Ahonen, & Lyytinen, 2001; Tolchinsky et al, 2012).[1]

1. No predictive studies were found of data from developing countries supporting the use of phonological awareness as a predictor of later reading ability.

A. Oral Language

The classification of reading as a language-based skill is widely accepted. Also true is the fact that children with oral language deficits in preschool are at greater risk for reading failure than children who have adequate language skills. Measures of oral language such as vocabulary, syntax, and idiomatic comprehension also predict reading achievement but account for less variance than measures of meta-linguistic skills (Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Manis, Lindsey, & Bailey, 2004; Proctor, Carlo, August, & Snow, 2005). Oral language was found to play a bigger role in later literacy achievement when it was measured using more complex measures that included grammar, the ability to define words, and listening comprehension than when measured using only simple vocabulary knowledge.

Bianco et al. (2012) conducted a three-year longitudinal study examining the relationships between oral language development, early training, and reading acquisition on word-identification and reading-comprehension tests with a sample of 687 French children. Hierarchical linear models showed that both phonological awareness and oral comprehension at the age of four years were relevant to reading acquisition two years later. Similar to Scarborough's (1998) findings these two broad skills explained separate parts of the variance on the outcome measures while revealing opposite effects: phonological skills explained more of the variance for alphabetic reading skills and oral comprehension explained more of the variance of reading comprehension. Roth, Speece, and Cooper (2002) also found differential effects for measures of semantic abilities. Children's oral definitions and word retrieval at kindergarten predicted second grade reading comprehension while phonological awareness predicted single word reading at first and second grades. Therefore, determining which predictive measures are most appropriate is dependent on the outcome measure of interest.

B. Meta-linguistic Skills

Children acquire metalinguistic skills early; those skills and visual capabilities may be influenced by the writing system of their culture (Tolchinsky et al, 2012). Researchers examined patterns of performance in phonological awareness, naming of letters, morphological awareness, and visual-spatial relations, in five-year-old native speakers of Spanish (n = 43), Hebrew (n = 40), and Cantonese (n = 63) and their concurrent relationship to word writing and word reading. The writing systems in these languages represent three major categories, alphabetic (Spanish), abjad (Hebrew), and morpho-syllabic (Chinese). The authors found that phonological awareness, letter naming, and perception of visual-spatial relations differed across groups, whereas morphological awareness showed a similar level of attainment in all three languages. This finding implies that although children may develop similar metalinguistic skills, the rate at which they acquire them and their importance to later reading is impacted by the structure of the language. Morphological awareness was consistent across the three languages and therefore may be a skill that can provide comparable cross-linguistic data but to date measures of morphological awareness are not as predictive as phonological awareness tasks. Cunningham and Carroll (2013) found that children with weak phonological processing at kindergarten and first grade showed weaker phonological awareness and morphological awareness three years later, demonstrating the possibility of phonological processing as a precursor skill. In another study (Kirby, Deacon, Bowers, Izenberg, Wade-Wolley, & Parrilla, 2012) of first to third grade English speaking students, that sought to identify the amount of variance provided by morphological awareness above and beyond phonological awareness, the researchers found that at grade one, morphological awareness made no significant contribution to measures of non-word decoding, word reading, text reading speed, or passage comprehension. However, by grade three, effects were significant and ranged from three to nine percent on all outcome measures. Thus, identifying the outcome variables of interest is an important first step in identifying the appropriate predictor measures.

Of the meta-linguistic skills that have been studied, phonological awareness has the largest evidence base. Phonological awareness, the ability to discriminate and manipulate the sounds of spoken language is

critical to early reading achievement in alphabetic (Bowey & Patel, 1988; de Jong & van der Leij, 1999; Ehri et al., 2001; Holopainen, Ahonen, & Lyytinen, 2001; Liberman, 1973; Wagner and Torgesen, 1987), abjad (Hebrew), and morpho-syllabic (Chinese) languages (Tolchinsky et al., 2012). It predicts mono-lingual children's word decoding skills (Bradley & Bryant, 1985; Cunningham & Carroll, 2013; Torgesen, Wagner, & Rashotte.1994; Wagner & Torgesen, 1987) and bilingual children's reading skill within and across languages (August, Calderon, & Carlo, 2001; Cisero & Royer, 1995; Comeau, Cormier, Grandmaison, & Lacroix, 1999; Durgunoglu et al, 1993; Lindsey, Manis, & Bailey, 2003).

Development of phonological awareness tasks lies on a continuum. Word-level skills develop first, followed by syllable-level skills, onset/rime-level skills, and lastly by phoneme-level skills (Anthony, Lonigan, Driscoll, Phillips, & Brugess, 2003). Children develop these skills gradually during early-to-middle childhood (Anthony & Francis, 2005; Anthony et al, 2003; Lonigan et al., 1998; NELP, 2008). As children get older, their phonological awareness skills increase in complexity and more importantly, the skills become more stable, making assessment more reliable. However, the amount of information gained from these measures decreases once children learn to read (Torgesen, 1999; Wagner et al., 1997) because phonological awareness and reading have a reciprocal relationship and are highly correlated; initially phonological awareness influences beginning reading but once children begin to read, reading influences phonological awareness. This is an important point because children in developing countries often begin to read much later than children in more developed countries. Therefore, the window for assessing and instructing children is driven by the onset of reading instruction rather than a specific age or grade level. All children should receive instruction in phonological awareness in their first year of schooling.

Phoneme segmentation is the single best predictor of reading achievement by the end of kindergarten and the end of first grade (Share, Jorm, MacLean, & Mathews, 1984) but prior to instruction, skills at lower levels are more appropriate. Several research studies have found that large unit, syllable or onset/rime tasks are more appropriate for children who have not started formal schooling. For example, Liberman, Shankweiler, Fischer, and Carter (1974) found that 50 percent of four- and five-year-olds could segment words at the syllable level but none could segment words at the phoneme level whereas 17 percent of five-year olds and 70 percent of six-year-olds could accomplish the task, demonstrating the developmental nature of different skills. Even when different tasks are used to assess a skill, the developmental sequence of skills is still found. Using a less stringent task, Fox and Routh (1975) asked three-to-six-year old children to say 'just a little bit' of a monosyllabic word that was presented orally. Three year olds could segment some words into onset and rime while five-year-old children could segment over half of the words into onset and rime.

Prior to instruction in reading, measures of phonological awareness at the syllable or onset/rime level are the most predictive of later reading of words. However, once reading instruction has been initiated, the grain size or unit that emerges as most predictive varies by language. Phonemic awareness, the ability to manipulate words at the phoneme level, is most predictive in alphabetic languages but larger units such as syllables and onset/rime are more predictive in other languages. For example, tasks at the syllable level are more predictive in Korean (Cho & McBride-Chang, 2005), Chinese (Chung & Ho, 2010), Cantonese (Tolchinsky et al, 2012), and Spanish (Tolchinsky et al, 2012). Both syllable and phoneme-level awareness skills were needed in Kannada (Reddy & Koda, 2012). Although different tasks were used in Hebrew and Danish, phoneme level tasks were the most predictive in those languages also.

Phonological awareness, assessed by final phoneme isolation, was responsible for development of reading in Hebrew (Tolchinsky et al, 2012). Lundberg, Olofsson, and Wall (1980) meanwhile found that phoneme reversal at kindergarten was the most predictive of first grade reading abilities while segmenting words into syllables with concrete materials was the least predictive in Danish. Rhyme awareness and phoneme judgment may be too easy for grade one students learning in transparent orthographies, an important consideration since many languages spoken in sub-Saharan Africa have

transparent orthographies. Findings also indicate that in developing phonological awareness measures, the structure of the language must be taken into account.

C. Measures

Measures of phonological awareness vary by the size of the unit of interest. MacLean, Bryant, & Bradley (1987) found that three-year old children can reliably detect rhymes; additionally they ascertained that this ability predicts later performance on subsequent metalinguistic skills and aspects of early reading. However, due to differences in language structures, development of parallel rhyme measures may be challenging across languages. Other equally predictive PA tasks may be easier to adapt across languages. For example, the oddity task requires children to identify one word in three choices that is different in one characteristic from the other two. This measure has been used with children as young as three years-old in English, Dutch, German, and Chinese languages (De Jong & van der Leij, 2003; Ho and Bryant, 1997; Siok & Fletcher, 2001; Wimmer, Landerl, & Schneider, 1994). The oddity task has also been included in the extended version of the Early Grade Reading Assessment and used with children in kindergarten through sixth grades in developing countries. Validation studies have been conducted in Arabic, Bangla, Spanish, Portuguese, and Chichewa.[2]

A second measure of phonological awareness is syllable deletion. For this measure, children are asked to delete a syllable or phoneme from a word and say the remaining sound sequence. Just as with the oddity task, the syllable deletion task is reliable with preschool-aged children and has been used in Malawi as part of the EGRA battery.[3]

D. Implications for Instruction

Since the more complex phonological awareness skills only develop after reading instruction begins, their development is dependent on the type of instruction received. The National Reading Panel found that reading instruction emphasizing explicit, synthetic phonics such as blending and segmenting words is more conducive to the development of phonemic awareness. Children who have not developed lower-level phonological awareness will need explicit instruction to develop those skills. Additionally, phonological awareness instruction should continue after reading instruction begins as the combination of these two components, phonological awareness and reading instruction, increases reading rates (Brady, Fowler, Stone, & Winbury, 1994). Although differences exist in the types of phonological awareness skills needed based on the orthographic structure of the language, all children will benefit from PA instruction in their first year of school.

EXECUTIVE FUNCTION

The ability to perform executive function tasks predicts children's early school success (Blair & Razza, 2007; Espy et al., 2004). More specifically, positive associations between young children's executive control and both early math and literacy achievement have been found by a number of researchers (Bull, Espy, & Wiebe, 2008; Bull & Scerif, 2001; Duncan et al., 2007; Gathercole, Brown, & Pickering, 2003; Matthews, Ponitz, & Morrison, 2009; Welsh et al., 2010). Executive function includes working memory, inhibitory control, and cognitive flexibility, which work together in the performance of everyday tasks and in academic settings (Chiappe, Hasher, & Siegel, 2000). For example, children who enter formal schooling without the ability to pay attention, remember instructions, or demonstrate self-control have more difficulty in elementary school and throughout high school (McClelland et al., 2007; NICHD Early Child Care Research Network, 2003). In particular, the attention aspect of self-regulation has received increasing consideration as a predictor of later achievement (Duncan et al., 2007). One longitudinal

2. EGRA; https://www.eddataglobal.org

3. Ibid: https://www.eddataglobal.org

study (McClelland et al., 2000) found that that children's attention-span persistence at age four significantly predicted math and reading achievement at age 21 and the odds of completing college by age 25. More importantly, the level of young children's executive function has been shown to account for variation in an intervention's effectiveness and can even mediate the effectiveness of an intervention on academic achievement (e.g., Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008; Raver et al., 2011) making this a useful screening measure. For example, in a study of the effect of book exposure, researchers found that book exposure predicted vocabulary and letter knowledge but short term memory predicted vocabulary over and above book exposure (Davidse, de Jong, Bus, Hujibregs, & Swaab, 2011). Because these skills are predictive of later academic outcomes, are context free, can be assessed early, and improve with instruction, they are very useful to assess children's readiness to learn prior to school entry. In this section, studies that have examined the impact of one or more cognitive processes on later learning outcomes are discussed

A. Memory

Memory is categorized as long-term, short term, and working memory. Each of these makes a unique contribution to learning. Long term memory is not usually examined as a predictor of learning; however both short term and working memory skills are predictive of learning outcomes. Short-term memory is the ability to hold a small amount of information in an active, readily-available state for a short period of time while working memory refers to the ability to temporarily store and manage information required to carry out a task. Children's working memory becomes more accurate during early childhood (Blair & Razza, 2007; Carlson, 2005). Working memory difficulties have been shown to affect students' reading and mathematics outcomes (Gathercole & Alloway, 2008).

Two studies found that phonological working memory was predictive of later skills. Nevo and Breznitz (2011) used a battery of assessments to determine the state of children' working memory skills, IQ, language, phonological awareness, literacy, rapid naming, and speed of processing at six years of age (before reading was taught) to predict reading abilities (decoding, reading comprehension, and reading time) a year later. Among all working memory components, phonological complex memory contributed most to prediction of all three reading abilities. Adding an assessment of phonological complex memory to more common measures before formal reading instruction begins might be a better estimate of children's likelihood of future academic success. Similarly, Preßle, Krajewski, & Hasselhorn (2013) investigated the relevancy of visual or phonological working memories as precursor skills at school entry. A sample of 92 children was tested on cognitive measures as well as quantity–number competencies and phonological awareness tasks. After school entry, the precursor skills were assessed again. The findings indicate that children who had reduced phonological working memory capacity before school entry had weaker phonological awareness skills at the beginning of school, indicating a need for targeted instruction in this area.

B. Attention

Research has shown that signs of attention and impulsivity can be detected and therefore measured in children beginning at two and half years old and that these skills will continue to develop until reaching relative stability between the ages of six and eight (Olson, Sameroff, Kerr, Lopez, & Wellman, 2005; Loher & Roebers, 2013). Studies linking attention with later achievement are less common but the evidence is consistent, suggesting that the ability to control and sustain attention as well as participate in classroom activities predicts achievement test scores and grades during preschool and the early elementary grades (Alexander et al, 1993; Sáez et al., 2012).

Self-regulation is the ability to monitor, assess, and regulate one's attention, thoughts, and behaviors in order to achieve a goal (Field, Martin, Miller, Ward, & Wehmeyer, 1998; Schunk & Ertmer, 2000). Children control their behavior to achieve goals in two ways: (1) by inhibiting behaviors that will impede a goal and (2) by performing behaviors that align with the goal.

Children are born with the neurological underpinnings for self-regulation; development of these skills is the result of the interaction between brain activity and experience (Blair, 2002; Huttenlocher, 2002). Across cultures, preschool aged children are able to use cognitive strategies to control their behavior and adopt the social standards of their community (Flavell, Miller, & Miller, 2002; Vygostky, 1986). Further, skills tend to stabilize as children get older. Kalpidou, Power, Cherry, & Gottfried (2004) found that five-year old children worked on tasks and maintained focus longer than three-year olds. Therefore, in terms of capacity, children across cultures are able to develop self-regulation skills. However, parental and community expectations shape children's behavior. For example, Keller et al. (2004) found differences in children's level of regulation among Cameroonian Nso, Costa Rican, and Greek toddlers. Finally, children with strong behavioral self-regulation are able to apply rules and standards of behavior in multiple contexts (Baumeister & Vohs, 2004). Students who are able to adapt their behavior across contexts are less likely to experience difficulty in learning the school norms needed to succeed in school. Since attention regulation is necessary for learning, lack of self-regulation skills puts children at risk for poor academic achievement.

The term self-regulation is used to refer to a number of skills:

- Attention-focusing is the capacity to attend to and sustain focus on a learning task. This increases the likelihood that the students will be able to use the information during practice and retain it (Garon, Bryson, & Smith, 2008; Gathercole et al., 2008).
- Inhibitory control is the ability to suppress inappropriate behaviors and thoughts that may distract children from instruction (Sáez et al., 2012).
- Attention-shifting is the ability to shift focus appropriately within a given learning task and from one task to another as situations demand.
- Organization of skills is the ability to follow directions, engage in planning, and organize sequences of behavior.
- Sustained attention is the ability to direct and focus cognitive attention on a specific task over an extended period of time and is necessary for information processing. The ability to sustain attention varies with age. Students who are able to sustain attention are more likely to avoid careless mistakes, follow instructions, complete school work, ignore distractions, and engage in goal-directed activity (Sáez et al., 2012).
- Focused attention, a short-term response to stimulus, may increase the amount of time that children participate in learning activities, thereby promoting their academic skills (Duncan et al. 2007).
- Selective attention allows students to efficiently process relevant information with minimal interference from irrelevant information (Lavie, 2000).

To determine the significance of inclusion of attention in a model for prediction of emergent literacy in pre-kindergarten (PK) and subsequent reading abilities in kindergarten, Dice and Schwanenflugel (2012) assessed the skills of 250 children attending public pre-kindergarten and kindergarten. Structural equation modeling was used to analyze data. Early literacy was used as a mediator between early attention and later decoding. Results suggest that attention in preschool is related to the development of early literacy skills. The authors suggest that attention in early childhood should be considered an important part of literacy development and should be considered in the development of interventions to increase literacy outcomes.

Similarly, Turner, Lipsey, Fuhs, Vorhaus, & Meador. (2012) conducted a series of studies to construct and validate a direct assessment battery for learning-related executive function for preschool children.

They examined associations between interactive processes of early childhood classrooms and gains in children's cognitive self-regulation (CSR) across the preschool year and in kindergarten. They included measures that met the following criteria: (1) exhibited variability and growth from the beginning to the end of preschool; (2) showed joint variation but not complete co-linearity with other executive function measures; (3) predicted academic achievement and growth in achievement; (4) converged with teacher ratings of classroom behaviors reflective of executive function; and (5) were easily administered in preschool settings. The authors included measures of attention focusing, inhibitory control, impulsivity, attention shifting, working memory, and organizational skills. Academic achievement outcomes measures assessed a number of areas included in the Woodcock Johnson III assessment (Woodcock, McGrew, & Mather, 2001): Applied Problems, Quantitative Concepts, Picture Vocabulary, Letter-Word Identification, and Oral Comprehension. The final battery included the following six measures: Peg tapping, Head-Toes-Knees-Shoulders, Dimensional Change Card Sort, Backward digit span, copy design, and Kansas Reflection-Impulsivity Scale for Preschoolers. Using this battery, the authors found that performance at the beginning of pre-kindergarten predicted achievement at the end of both pre-kindergarten and kindergarten. Gains made on self-regulation assessments across the pre-kindergarten year predicted gains in both PK and kindergarten achievement.

Memory and self-regulation work together. Attention-memory behaviors bolster reading performance because they strengthen a students' ability to remain focused on relevant aspects of reading instruction, guarding against forgetting and aiding in mentally organizing learning opportunities (Garon et al., 2008; Gathercole et al., 2008).

C. Measures

Children's executive function and self-regulation abilities can be assessed directly or through observations scales. Teacher or parent observation scales such as the Child Behavior Rating Scale are often used and are predictive of emergent academic skills but do not fit the criteria for this review.

The Head Toes Knees Shoulder task has been widely used and is also a consistent predictor of emergent mathematics, vocabulary, and literacy (Matthews, Ponitz, & Morrison, 2009; Turner et al., 2012). Von Suchodoletz et al., (2012) examined the validity of Head-Toes-Knees-Shoulders (HTKS) with 412 children from Germany and Iceland and the concurrent validity of the measure with academic tasks. Children were between 46 and 86 months old. Due to differences in school leveling, children in the German sample were in their second or third year of preschool, while children in Iceland were in either preschool or their first year of compulsory education. Results demonstrated variability consistent with previous research indicating that the measure was valid for children in Germany and Iceland. Additionally, German children who scored higher on HTKS scored higher on the academic outcome measures (vocabulary, reading, and mathematics subtests of the German version of the Kaufman Assessment Battery for Children, 2006). Results varied by age for the Icelandic sample. HTKS was related only to vocabulary but with first grade children, HTKS was related to phonological awareness and single word reading. Similarly, Wanless et al. (2011) assessed 3- to 6-year old children with HTKS in four cultures (China, South Korea, Taiwan, and United States) to determine the relation between HTKS and early mathematics, vocabulary, and literacy skills. Higher scores on HTKS were related to higher scores in mathematics, vocabulary and early literacy in the countries in which those skills were measured.

It is important to note that in the Wanless et al. study and a similar study in the United States. (Connor et al., 2010), first grade students scored near the ceiling level. Similar patterns may emerge in developing countries limiting the utility of the measure beyond the first year of compulsory schooling.

Peg tapping is a variation of the pencil tapping task (Brooker et al., 2010) that was developed in Kenya and has been use in Zambia, Mali, and Senegal. Similar to HTKS, this task assesses inhibitory control, sustained attention, and cognitive flexibility. However, this task is less complex than the HTKS task

because only two variations exist, one where the teacher taps once and the student taps twice and another where the teacher taps twice and the student taps once. The HTKS task has four variations that can be implemented simultaneously and as previously noted, grade one children were scoring at near ceiling levels; therefore, children may reach ceiling level sooner with an easier task.

D. Implications for Instruction

Cognitive self-regulation is the ability to deliberately control the quality, sequence, and persistence of task-related behavior and thoughts. Some research evidence suggests that cognitive self-regulation among pre-kindergarten children may be second only to emergent literacy and math skills as predictors of later reading and math achievement; therefore, the development of these skills for school entry is important for children.

Teachers play an important role in helping children develop self-regulation skills. Effective classroom management and specific teacher practices such as task orienting, behavior management, individualized instruction, and teacher re-directs (Sáez et al. 2012) can help students learn to attend to what is important. Children in first grade can be taught to self-regulate their behavior. Self-regulation has been defined as the skill characterized by the ability to monitor, assess, and regulate one's own behavior (Field, Martin, Miller, Ward, & Wehmeyer, 1998; Hallahan & Sapona, 1983; Schunk & Ertmer, 2000). Self-regulation consists of many strategies (components) such as self-goal setting, self-monitoring, self-instructions, self-evaluation, and self-reinforcement (Schunk & Ertmer, 2000). Initially, teachers manage goal-directed learning through instructional routines that foster student self-regulation. Self-regulation tasks scaffold children as they learn to manage their own behavior. In previous studies, self-regulation has typically demonstrated stronger effects on academic achievement when used in combination with other instructional strategies (Gersten, Fuchs, Williams, & Baker, 2001); therefore, implementation of these strategies should be integrated with academic learning tasks.

RAPID AUTOMATIZED NAMING (RAN)

RAN was first established as a predictor of reading achievement in the 1970s (see Denckla & Reudel 1974, 1976). This research was extended through the 80s and 90s (Blachman, 1984; Stanovich, 1981; Vellutino et al., 1996; Wagner, Torgesen, & Rashotte, 1994; Wolf, Bally, & Morris, 1986) and has additionally been extended to several alphabetic languages (de Jong & van der Leij, 1999; Georgiou, Parilla, & Papadopoulos, 2008; Holopainen, Ahonen, & Lyytinen, 2001; Parilla, Kirby, & McQuarrie, 2004; Wagner & Torgesen, 1987). RAN assessment is beneficial because it can identify children who are likely to have difficulties before reading instruction begins and, because it is an underlying process of efficiency, has likely importance for reading in every language (Heikkia, Narhi, Aro, & Ahonen, 2009).

Four types of RAN measures are used in studies across languages: colors, objects, letters and digits. Alphanumeric RAN (digit/letter naming) is more predictive than non-alphanumeric RAN (color and object) (Bowey, McGuigan & Ruschena, 2005; Felton & Brown, 1990) in single language studies particularly when assessed prior to school entry; however, five-year old children name objects and colors faster than letter and numbers. This pattern changes after children begin school and children have been introduced to letters and numbers (Schatsneider et al., 2004). In a longitudinal study of RAN performance, Mazzocco and Grimm (2013) found that the largest decline in response time occurred between kindergarten and grade one. Letter recitation ability declined the quickest followed by numbers and then colors, supporting the notion that instruction impacts children's performance on RAN letters.

Over the last 30 years, researchers have found RAN measures to be predictive of later reading. Studies examining the predictive value of RAN measures have found that RAN measures are only predictive to grade two (Pennington, Cardoso-Martins, Green, & Lefly, 2001; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997; Vukovic, Lesaux, & Siegel, 2003; Wolf, Bally, and Morris, 1986). Blachman (1984) found within-grade prediction of rapid naming tasks to reading and reading readiness tasks and first grade

reading achievement for kindergarten and first grade students respectively. Similarly, Manis, Seidenberg, and Doi (1999) found that grade one measures of RAN contributed to grade two measures of reading and Neuhaus and Swank (2002) noted that rapid letter naming was a significant predictor of word reading.

Although RAN measures have been implemented in over 15 languages with different scripts (Norton & Wolf, 2012), few have conducted predictive studies. Recently, RAN letters and digits measures in Arabic were developed and validated by Abu-Hamour (2013). The measures were reliable and predicted word reading at third grade. Torppa, Lyytinen, Erskine, Eklund, Lyytinen, (2010) found that Finnish children who were identified as dyslexic in second grade were slower on RAN objects at age three than their non-dyslexic peers.

Finally, a strong relationship exists between RAN and phonological awareness but the relationship changes over time. Initially, PA has a stronger relationship with word reading; however, once children are proficient in phonological awareness, the relationship between RAN and reading becomes stronger. Children who learn to read in languages with more transparent orthographies shift from phonology earlier than those learning to read in less transparent orthographies (Vaessen, Bertrand, Denes, Blomert, 2010). Because of the relative importance of these two skills varies by language, inclusion of both types of measures in a preschool battery is important.

A. Measures

RAN measures visual-verbal processing speeds. Five stimuli are presented in random order in a linear five by ten array (Denckla & Rudel, 1974) and the measure is timed. Students are asked to name the stimuli as fast as possible and time is recorded from the point when the child names the first stimulus until the sheet is completed. Presentation of the stimuli to the child on a separate sheet before beginning the task ensures that the child knows the name of the five stimuli. If children cannot name the letters or digits, the use of color or object stimuli is appropriate. Four types of stimuli are used: colors, objects, letters, and digits.

B. Implications for Instruction

Although no specific interventions to remediate slow naming speed exist, children who are slow usually benefit from additional repetitions and with sufficient practice can meet criterion (Levy, Bourassa, & Horn, 1999). If teachers are aware early of those children who have difficulty, they can plan additional practice and monitor students until they learn the content. This will be true for content such as letter names and sounds, high frequency words, or number facts. Instruction should focus on helping children build automaticity with the components of reading. The components may vary depending on the structure of the language. In agglutinated languages, the focus might be on morphology or orthographic patterns. In alphabetic languages, focusing on letter/sound relationship is more appropriate initially.

V. PROGRAM IMPLICATIONS

Two implications for programming surface from this review. The first is that a screening battery administered prior to school entry that assesses skills essential to success in school can provide teachers with information that would inform planning of more effective instruction. Al Otaiba and Fuchs (2006) found that children who are unresponsive to instruction even when it is provided in small groups have difficulty with phonological awareness, RAN, and with regulation of attention and behavior. This would indicate that children with difficulty in one or more of these areas are unlikely to benefit from regular classroom instruction; a plausible explanation for the lack of expected progress by some children even after reading instruction has improved.

In developing countries, the relationship between these early skills and later reading outcomes is further complicated by environmental and health factors that impact children's cognitive development. Additionally, evidence from education, health, and nutrition interventions indicates that all impact academic outcomes. As noted previously, the implementation of either health or nutrition interventions without attending to instruction has limited impact on academic outcomes although some cognitive skills often improve. One approach is to provide comprehensive interventions. Health and nutrition interventions are needed to improve cognitive skills. Improved cognitive skills serve as the foundation for learning academic skills. The combination of interventions will have to be differentiated across countries to respond to the specific learning situational needs of children. A second approach is to provide more comprehensive education interventions that support development of children's cognitive skills in addition to providing content instruction. For example, in areas where children are likely to have difficulty with attention, self-regulation can be added to an educational intervention. Empirical data is needed to determine whether education interventions alone can address children's cognitive skill deficits when they are the result of illness or malnutrition.

Results of literacy research also have implications for teacher training. Current efforts to improve literacy programs focus extensively on components of reading instruction. This review points additionally to the importance of ensuring that children also develop self-regulation skills. As is the case in other areas, some children will develop these skills with little effort while others will require explicit instruction and support. The research also highlights the importance of consistent classroom management, which reinforces appropriate classroom behaviors. The final component of the battery, RAN, will provide teachers with information regarding which children may need additional practice in self-regulatory behaviors. In combination with children's reading scores, RAN will provide teachers with more precise data for grouping students who may need varied amounts of practice for mastery.

Finally, given the dearth of predictive research from developing countries that examine the skills and knowledge needed by preschool children to succeed in primary school, and the child and family level factors that impact the development of cognitive and metalinguistic skills, determining rates of growth in these areas is essential.

VI. RECOMMENDATIONS

Screening measures should identify children who are at-risk for learning to read. Although children need to develop many skills, the most effective measures are those that assess skills predictive of later learning and can be remediated in the classroom. The proposed battery of measures includes assessments of skills in three areas: language, executive function, and rapid automatized naming. These skills are innate; therefore, found in children in all contexts. Further, all of these skills develop prior to school entry, can be assessed reliably in preschool aged children, and can be remediated in children who have not adequately developed the needed skills. Current assessments focus on academic content, namely early reading skills. The inclusion of these measures would provide additional information on precursor skills.

Each of the three measures identified have been included in other assessment batteries. For example, the Zambian Child Assessment Test (Fink et al., 2012), and School Readiness Assessment (Save the Children, 2014) included a RAN measure and pencil tapping as part of a larger battery. The School Readiness Assessment also included a phonological awareness task. If cost-efficiency is a goal, these three measures may provide information similar to that obtained by longer and more expensive assessment batteries. However, empirical studies are needed to determine the value added of these measures over the use of academic measures alone and to determine whether a battery of three measures can provide data as reliable as that provided by longer batteries. For an initial battery of assessment, the following skills are recommended:

A. Language

Two tasks are recommended to assess phonological awareness: a word oddity task and syllable segmentation. The word oddity task requires that children identify the word in a set of three that does not begin with the same sound as the other two. This is a versatile task because the level of difficulty can be adjusted by changing the target. For example, the easiest form of this task is to ask children to identify the word that does not rhyme with the others. But the target can also be a specific sound at the beginning, the middle, or end of a word. The versatility this task offers is beneficial given the evidence of differences in the predictive value of different tasks across languages. The second task, syllable segmentation, requires children to segment two-syllable words. The ability to segment words is important to reading development and focusing on the syllable as the unit which is developmentally appropriate for preschool children.

B. Executive Function

Executive function includes three dimensions: working memory, inhibitory control, and cognitive flexibility (Center on the Developing Child at Harvard University, 2011). These skills are interrelated and can be assessed with the Head-Toes-Knees-Shoulders (HTKS) task which has been used in various countries reliably (von Suchodoletz et al., 2012; Wanless et al., 2011). A second measurement tool is Peg Tapping (Diamond & Taylor, 1996) that assesses the same three executive function domains as the HTKS. Peg tapping is similar to The Pencil Tapping Test developed for first graders in Kenya (Brooker et al., 2010). Descriptions of HTKS and Peg Tapping are included in Appendix A.

C. Rapid Automatized Naming

Rapid automatized naming (RAN) is a measure of the speed of processing. Commonly used stimuli include colors, objects, letters or digits. Although RAN letter or numbers is more predictive of reading ability than RAN objects or colors, the latter are recommended for this battery. To be effective, children have to be familiar with the five items used as the stimuli; therefore RAN colors or objects will be most effective in developing countries. A sample is included in Appendix B.

APPENDIX A: MEASURES OF EXECUTIVE FUNCTION: HEAD-TOES-KNEES-SHOULDERS AND PEG TAPPING

HEAD TOES KNEES SHOULDERS (HTKS)

Description of the Instrument:

- Children are asked to play a game in which they must do the opposite of what the experimenter says. The experimenter instructs children to touch their head (or their toes), but instead of following the command, the children are supposed to do the opposite and touch their toes. If children pass the head/toes part of the task, they complete an advanced trial where the knees and shoulders commands are added. The HTKS task has been conceptualized by Ponitz, et al., (2008) as a measure of inhibitory control (a child must inhibit the dominant response of imitating the examiner), working memory (a child must remember the rules of the task) and attention focusing (must focus attention to the directions being presented by the examiner).

Base Reference/Primary Citation:

Ponitz, C. C., McClelland, M. M., Jewkes, A. M., Connor, C. M., Farris, C. L., & Morrison, F. J. (2008). Touch your toes! Developing a direct measure of behavioral regulation in early childhood. Early Childhood Research Quarterly, 23, 141–158. doi: 10.1016/j.ecresq.2007.01.004.

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HTKS TASK SCRIPT

Administer the task while seated; the child should stand, about 3 feet from you, throughout the entire task. The person symbol indicates to demonstrate the correct body motions.

If the child produces the correct response immediately, score the item "2". If they self-correct right away, without prompting, score the item "1". If they do not touch the correct part of their body at all, score the item "0".

Copy Practice:

Now we're going to play a game. The game has two parts. First, I want you to copy what I do. Touch your head.
Wait for the child to put BOTH his/her hands on head.

Good! Now touch your toes.
Wait for the child to put his/her hands on toes.

Good!
Repeat the two commands with motions again, or until the child imitates you correctly. *(keep having child copy)*

Touch your head.

Touch your toes.

Now we're going to be a little silly and do the opposite of what I say. When I say to touch your head, *instead* of touching your head, you touch your toes. When I say to touch your toes, you touch your head. So you're doing something different from what I say.

A1. What do you do if I say "touch your head"?

Circle child's response on the code sheet.

- If s/he hesitates or responds incorrectly, say:
Remember, when I say to touch your head, you touch your toes, so you are doing something different from what I say. Let's try again. Repeat A1 again.

If a child says an answer say: Show me

- If s/he responds correctly, say and proceed to A2:
That's exactly right.

A2. **What do you do if I say "touch your toes"?**

- If s/he hesitates or responds incorrectly, say:
Remember, when I say to touch your toes, you touch your head, so you are doing something different from what I say. Let's try again. Repeat A2 again.

- If s/he responds correctly, say and proceed to B2:
That's exactly right.

Circle child's response on the code sheet.

You may re-explain (use EXPLANATION above) up to three times in the TRAINING (A1-A2) and PRACTICE (B1-B4) sections. If you have already given two explanations during the TRAINING questions, then you may correct them only once more in the PRACTICE items. If the child cannot do the task after the third explanation, administer the 10 test items anyway.

PART I PRACTICE:

B1. Touch your head

B2. Touch your toes

B3. Touch your head

B4. Touch your toes

You may use any of the remaining retraining (up to 3 total on both rules and practice) on the practice:

Remember, when I say to touch your toes **(head)**, you touch your head **(toes)**, so you are doing something different from what I say. Let's try again.

PART I TESTING:

We're going to keep playing this game, and you keep doing the opposite of what I say.

If the child does not understand the task, you will have gone through the directions at most four times (once at the beginning, and up to three times in the TRAINING and PRACTICE sections). **DO NOT explain again after testing begins.**

1.	Touch your head
2.	Touch your toes
3.	Touch your toes
4.	Touch your head
5.	Touch your toes
6.	Touch your head
7.	Touch your head
8.	Touch your toes
9.	Touch your head
10.	Touch your toes

PART II TRAINING:

Administer Part II if child responds correctly to 5 or more items on Part I of the task, or if child is in kindergarten or beyond.

Ok, now that you've got that part, we're going to add a part. Now, you're going to touch your shoulders and your knees. First, touch your shoulders.
Touch your shoulders; wait for the child to touch his/her shoulders with both hands.

Now, touch your knees.
Touch your knees; wait for the child to touch his/her knees with both hands.

Repeat with four alternating commands (no demo) until the child has imitated you correctly or it is clear the child does not comprehend the task.

Touch your shoulders

Touch your knees

Touch your shoulders

Touch your knees

Ok, now we're going to be silly again. You're going to keep doing the opposite of what I say like before. But this time, you're going to touch your knees and shoulders. When I say to touch your knees, you touch your shoulders, and when I say to touch your shoulders, you touch your knees.

C1. What do you do if I say "touch your knees?"

- If response is correct, say and proceed to D1:

  Good job! Let's practice.

- If the response is incorrect, say and proceed to D1:

  Remember, when I say to touch your knees, *instead* of touching your knees, you touch your shoulders. I want you to do the opposite of what I say. Let's try again.
  Repeat C1 again.

If a child says an answer say:
Show me

PART II PRACTICE:

D1. Touch your knees

D2. Touch your shoulders

D3. Touch your knees

D4. Touch your shoulders

You may use any of the remaining retraining (up to 3 total on both rules and practice) on the practice:

Remember, when I say to touch your knees (shoulders), you touch your shoulders (knees), so you are doing something different from what I say. Let's try again.

- **If the child gets two or fewer correct, say:**

Remember, I want you to keep doing the opposite from what I say, but this time, touch your knees and shoulders.

Proceed to Part II test section. Do not explain any parts of the task again.

PART II TESTING:

Now that you know all the parts, we're going to put them together. You're going to keep doing the opposite from what I say to do, but you won't know what I'm going to say.

There are four things I could say.

If I say to touch your head, you touch your toes.
If I say to touch your toes, you touch your head.
If I say to touch your knees, you touch your shoulders.
If I say to touch your shoulders, you touch your knees.

Are you ready? Let's try it.

11.	Touch your head
12.	Touch your toes
13.	Touch your knees
14.	Touch your toes
15.	Touch your shoulders
16.	Touch your head
17.	Touch your knees
18.	Touch your knees
19.	Touch your shoulders
20.	Touch your toes

After the child completes the task, say:
Thank you for playing this game with me today!

HTKS RECORD FORM

*If the child produces the correct response immediately, score the item "2". If they self-correct (*see bottom of page 2) right away, without prompting, score the item "1". If they do not touch the correct part of their body at all, score the item "0".*

Part 1 TRAINING: (circle child's response)

			Retraining
A1. What do you do if I say "touch your head"?			
0 (head)	1	2 (toes)	_____
A2. What do you do if I say "touch your toes"?			
0 (toes)	1	2 (head)	_____

PART I PRACTICE: (circle child's response)

	Incorrect	Self-Correct*	Correct	Retraining
B1. Touch your head	0 (head)	1	2 (toes)	
B2. Touch your toes	0 (toes)	1	2 (head)	
B3. Touch your head	0 (head)	1	2 (toes)	_____
B4. Touch your toes	0 (toes)	1	2 (head)	

Retraining occurs only 3 times

PART I TESTING: (circle child's response)

		Incorrect	Self-Correct*	Correct
21.	Touch your head	**0 (head)**	**1**	**2 (toes)**
22.	Touch your toes	**0 (toes)**	**1**	**2 (head)**
23.	Touch your toes	**0 (toes)**	**1**	**2 (head)**
24.	Touch your head	**0 (head)**	**1**	**2 (toes)**
25.	Touch your toes	**0 (toes)**	**1**	**2 (head)**
26.	Touch your head	**0 (head)**	**1**	**2 (toes)**
27.	Touch your head	**0 (head)**	**1**	**2 (toes)**
28.	Touch your toes	**0 (toes)**	**1**	**2 (head)**
29.	Touch your head	**0 (head)**	**1**	**2 (toes)**
30.	Touch your toes	**0 (toes)**	**1**	**2 (head)**

Total Points:_____

Number of 1 responses:_____

NOTE

***Definition of self-correction**: Mark "self-correct" on both the training and testing portion if the child makes *any discernible* motion toward the *incorrect* answer, but then changes his/her mind and makes the correct response. Pausing to think, not moving, and then responding correctly does *not* count as a self-correction.

PART II TRAINING:

Administer Part II if child responds correctly to 5 or more items on Part I of the task, or if child is in kindergarten or beyond.

Circle child's response:

C1. **What do you do if I say "touch your knees?"** 0 (knees) 1 2 (shoulders)	**Retraining**

PART II PRACTICE:

	Incorrect	Self-Correct*	Correct	
D1. **Touch your knees**	0 (knees)	1	2 (shoulders)	**Retraining**
D2. **Touch your shoulders**	0 (shoulders)	1	2 (knees)	
D3. **Touch your knees**	0 (knees)	1	2 (shoulders)	
D4. **Touch your shoulders**	0 (shoulders)	1	2 (knees)	

PART II TESTING: (circle child's response)

		Incorrect	Self-Correct	Correct
31.	Touch your head	**0**	**1**	**2 (toes)**
32.	Touch your toes	**0**	**1**	**2 (head)**
33.	Touch your knees	**0**	**1**	**2 (shoulders)**
34.	Touch your toes	**0**	**1**	**2 (head)**
35.	Touch your shoulders	**0**	**1**	**2 (knees)**
36.	Touch your head	**0**	**1**	**2 (toes)**
37.	Touch your knees	**0**	**1**	**2 (shoulders)**
38.	Touch your knees	**0**	**1**	**2 (shoulders)**
39.	Touch your shoulders	**0**	**1**	**2 (knees)**
40.	Touch your toes	**0**	**1**	**2 (head)**

Total Points:_____

Number of 1 responses:_____

HTKS SCORING

Each item is coded as follows (Ponitz et al., 2008):

0 = Incorrect response
1 = Any motion to incorrect response, but self-corrected to end with correct response
2 = Correct response

Final Score:

The task has begins with 6 practice items and between the first and second set of items there are 5 more practice trials. The final score is the sum of the first six practice items and the 20 test items. (Range: 0-52)

PEG TAPPING

Description of the Instrument:

- The rules for the task were as follows: Immediately after the experimenter tapped once with a wooden dowel (*6* inches long, ¼ inch in diameter), the child was to tap twice with the dowel. Immediately after the experimenter tapped twice, the child was to tap once.
- The task was developed by Luria (1966) for his studies of study adult patients with frontal-lobe damage and first used in children by Diamond & Taylor (1996). The task requires both the ability to hold two things in mind, 1) rule to tap once when experimenter taps twice and 2) rule to tap twice when experimenter taps once, and the ability to exercise inhibitory control over one's prepotent behavior, the natural tendency to mimic what the experimenter does. Common errors include 1) comply with only one of the two rules, 2) tapping many times regardless of what the experimenter did and 3) doing the same thing as the experimenter, rather than the opposite.

Base Reference/Primary Citation:

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PEG TAPPING SCRIPT

MATERIALS: 1 wooden dowel (*6* inches long, ¾ inch in diameter).

INTRODUCE THE ACTIVITY AS FOLLOWS:

Hold the peg in one hand and tell child **We are going to play a new game.** Tap the peg one time on the table. Hand the peg to the child and tell him/her, **Now you tap one time on the table.** Continue practicing until the child only taps one time

Once the child has successfully tapped one time, take back the peg and tap two times on the table. Hand the peg back to the child and tell him/her, **Now you tap two times on the table.** Continue practicing until the child only taps two times.

PRACTICE:

RULE 1: **Great, now we are ready to play the game. When I tap one time** (tap one time and hand the child the peg) **I want you to tap two times.** Practice until the child is successful on two consecutive trials. Take the peg back and say,

RULE 2: **When I tap two times** (tap the peg two times on the table and hand it to the child) **I want you to tap one time.** Continue practicing until the child is successful on two consecutive trials. **Ready to play my game?**

PRETEST:

TRIAL 1: Tap one time and hand the peg over to the child to respond.

- If the child responds correctly, praise the child and proceed to Trial 2.
- If the child responds incorrectly or not at all, follow rules for Extended Practice.

TRIAL 2: Tap two times and hand the peg to the child to respond.

- If the child responds correctly again, praise the child and count these first two practice trials as trials 1 and 2 of testing. GO TO TRIAL 3.
- If child responds incorrectly or does not respond at all, follow rules below for Extended Practice.

Extended Practice: If the child responded incorrectly or not at all on either of the above trials, these trials are counted as practice. Remind the child of both rules, beginning with the first rule the child identified incorrectly. Then begin the pretest again. If the child is wrong on either of these two pretest trials, the instruction and pretest procedure can be repeated once more.

NOTE: THE PRETEST TRIALS ARE TRIALS 1 AND 2 ON THE SCORE SHEET. Record the child's answers for the pretest trials 1 and 2 on the score sheet. If the child gets both trials 1 and 2 correct, proceed to testing and BEGIN WITH TRIAL 3. If the child does not get both trials 1 and 2 correct after the third attempt of the pretest, proceed to Trial 3, but do NOT remind child of rules again.

TESTING: Administer the tapping in the order listed on the score sheet and record responses in the table. If the child taps other than 1 or 2 times, record the number of taps on the "other" line.

Do NOT give feedback to the child during or between trials.

PEG TAPPING CODE SHEETS

Trial	# Taps	Correct Response	Child Response (RECORD # OF TAPS)		Score (0-1)
1 (pretest)	1	2			
2 (pretest)	2	1			
3	2	1			
4	1	2			
5	2	1			
6	2	1			
7	1	2			
8	1	2			
9	1	2			
10	2	1			
11	1	2			
12	2	1			
13	2	1			
14	1	2			
15	1	2			
16	2	1			

PEG TAPPING SCORING

Each item is coded as follows:

0 = Incorrect number of taps

1 = Correct number of taps

Final Score:

Sum of all 16 items, children for whom the task was aborted received a score of -1.

APPENDIX B: MEASURE OF PROCESSING SPEED: RAPID AUTOMATIZED NAMING (RAN)

o	a	s	d	p	a	o	s	p	d
s	d	a	p	d	o	a	p	s	o
a	o	s	a	s	d	p	o	d	a
d	s	p	o	d	s	a	s	o	p
s	a	d	p	a	p	o	a	p	s

FIG. 9

6	4	7	9	2	4	6	7	2	9
7	9	4	2	9	6	4	2	7	6
4	6	7	4	7	9	2	6	9	4
9	7	2	6	9	7	4	7	6	2
7	4	9	2	4	2	6	4	2	7

FIG. 10

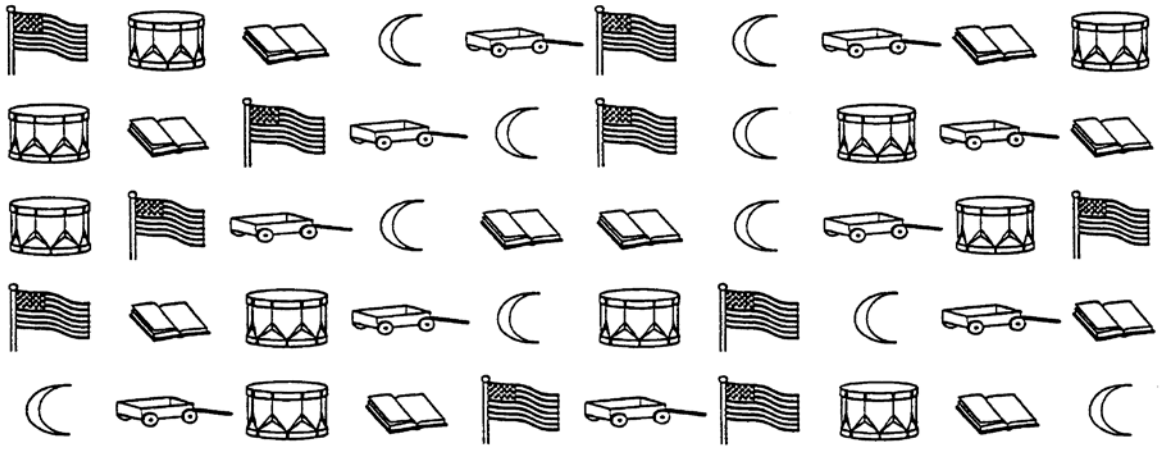

FIG. 11

APPENDIX C: REFERENCES

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