

Analysis of PASS theory-based interventions for improving cognitive processing and learning: a narrative review

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Abstract

Objective: *The present narrative review focuses on the neurocognitive bases of the PASS theory of intelligence and analyzes studies that test three interventions based on this theory.*

Method: *A methodological analysis of these studies and the implementation details of the interventions was conducted. The analysis included 17 studies published between 2000 and 2019 that addressed the efficacy of PASS theory interventions for improving cognitive processing and reading and math skills.*

Results: *This analysis suggests that the interventions improved cognitive processing, specifically successive and simultaneous processing of information. These interventions also improved reading and math skills. The analysis of the interventions' implementation showed these academic skills and cognitive abilities improved when applied individually or in small groups. Furthermore, this efficacy remained even with a small number of sessions of short duration.*

Conclusions: *This review provides useful information to support professionals working with the school-aged population in the selection, development, and implementation of neuropsychological interventions based on the PASS Theory to improve cognitive functioning and learning.*

Keywords:

neuropsychological interventions, cognitive processes, PASS Theory

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Introduction

The foundations of modern neuropsychological interventions can be found in the early treatments for people suffering from neurological deficits or injuries¹, and rely primarily on cerebral plasticity mechanisms. Neuropsychological interventions have proven efficacious for improving functioning in different cognitive domains (e.g., attention, memory) in clinical and research settings². Clinicians implement these interventions to improve cognitive functioning and, as a result, improve general psychological functioning. These interventions have contributed significantly to the recovery of patients with alterations in cognitive processing that resulted from acquired or vascular brain injuries³. These strategies have also been proven to increase the functional performance of children in their daily lives and their home and academic environments³.

Recently, there has been increasing scientific evidence that supports the value of specialized neuropsychological interventions to address specific deficits and learning problems. However, it is a challenge to determine which of these interventions represents the most useful approach when offered to children with cognitive weaknesses and academic difficulties. There is a demand to evaluate existing neuropsychological interventions and select those most appropriate to provide services to students with special needs. The purpose of this narrative review is to analyze the methodological practices used by studies testing neuropsychological interventions based on the Planning, Attention, Simultaneous, and Successive Processing theory of intelligence (PASS)⁴, for which there is evidence of efficacy. A narrative review is a type of article that provides “summaries and evaluations of the findings or theories within a literature base”⁵ (p. 8). This type of article results more appropriate for this work because the emphasis is on the trends identified in the literature, and not on the systematic meta-analysis of the findings in the different studies. This review will offer psychologists and educators a guide in the selection and implementation of interventions to promote optimal development of cognitive processing and adequate acquisition of learning skills.

PASS Theory of Intelligence

The PASS theory of intelligence⁴ is based on Alexander Luria’s work on brain organization⁶. He proposed that the brain is organized into three functional and interrelated units that handle information. These units are: (a) attention, which regulates excitement and levels of alertness; (b) the successive and simultaneous processes, which deal with the reception, analysis, and storage of the information; and (c) planning, which is responsible for self-monitoring and the organization of all conscious activity⁶. All units represent a set of brain structures involved in different functions (i.e., dynamic functional system). Hence, cognition can be described as the interaction of these interdependent functional units⁷.

Luria’s description of the brain’s functional units serves as the basis for new perspectives of intelligence and, ultimately, PASS theory⁴. The authors of the PASS theory use Luria’s model of functional units to define the components of human intelligence as basic cognitive processes that underlie intelligent behavior⁸. These processes work interdependently and provide the means to act in the world and acquire knowledge. Despite the interdependence of the PASS processes, each one plays a unique role according to the demands of the task⁸. Planning allows individuals to select and develop the necessary strategies to solve problems. Attention is a mental process related to the orientation response and allows the individual to selectively focus on a certain stimulus while resisting distractions. Simultaneous processing is essential for the organization of information, in groups or as a whole, and requires visual-spatial abilities. Finally, successive processing is involved in the storage and use of organized stimuli in a specific temporal order. These four processes represent a fusion of cognitive and neuropsychological constructs that are strongly related to academic performance and behavior⁸.

The PASS theory goes beyond the conceptualization of intelligence as a general ability, proposing that it is better explained as the integration of basic and interdependent cognitive processes that drive behavior and intelligent thinking. The PASS theory is

operationalized through the Cognitive Assessment System (CAS2)^{9,10}, an instrument designed to evaluate the four PASS cognitive processes proposed in this theory. Studies conducted with the CAS2 have shown its validity and reliability with different populations^{11,12}. Research has found significant correlations between the CAS2 Full Scale and achievement measures (e.g., Naglieri & Rojahn¹³). Furthermore, Sepúlveda Miranda et al.¹⁴ demonstrated high correlations between PASS neurocognitive processes and academic skills. In that study, a regression analysis found that between 42% and 54% of academic achievement could be explained by the interaction of PASS neurocognitive processes. A similar study reported that the CAS2 Successive Processing Index resulted as a better predictor of receptive language abilities than the Spanish Wechsler Verbal Scale¹⁵.

Also, Kroesbergen et al.¹⁶ identified a relationship between specific PASS processes and early math skills among Italian and Dutch children. The CAS2 has been used to examine the relationship between executive functions and academic achievement from a developmental perspective, suggesting a domain-general relation between these variables¹⁷. Confirmatory factor analyses have shown that the architectural structure proposed in the PASS theory covers a variety of cultures with different linguistic characteristics⁷. Additionally, it has been useful for establishing cognitive profiles as well as identifying strengths and weaknesses in different clinical populations^{8,18-21}. These studies show the applicability of the PASS theory with people from different linguistic and cultural backgrounds.

Cognitive modification programs and specific guidelines for the development of neuropsychological interventions have been derived from the PASS theory. These have proven to improve cognitive processes functioning, behavior, and learning difficulties. They integrate neurological and cognitive dimensions proposed by Luria; based on his idea that learning is a socioculturally mediated phenomenon that can modify brain functioning and the cognitive processes emerging from it²². Luria's contributions, especially from the cultural historical approach, are applied to contemporary neuropsychology research and practice to reanalyze and re-

interpret different neuropsychological disorders²³. These fields incorporate this approach's concept of the social brain as a social and cultural regulator of brain function. This approach becomes even more important in the development of intervention strategies that consider the conditions and contexts in the development of children's cognitive processes. The PASS theory has been operationalized (i.e., CAS2) and has been useful for developing interventions²⁴. In the following section, some of these interventions were examined.

Interventions Based on the PASS Theory

The principal interventions based on the PASS theory are: (a) Reading Enhancement Program (PREP)²⁵; (b) Cognitive Enhancement Training (COGENT)²⁶; and (c) Helping Children Learn: Intervention Handouts for Use in School and at Home (HCL)²⁷. PREP is an intervention program that aims to improve simultaneous and successive processing of information, processes related to reading skills, in primary school-aged children who presented difficulties with reading, spelling, and reading comprehension^{8,24,28}. This program encourages students to become aware of their use of strategies to solve problems through verbalizations, but without explicit teaching strategies. This method was first supported by the work of Brailsford et al.²⁹, Kaufman and Kaufman³⁰, and Krywaniuk and Das³¹, who demonstrated that training of successive and simultaneous processes could result in better cognitive functioning and reading skills.

The PREP consists of ten tasks that address cognitive processes and reading skills. It has a global training component with strategies to promote simultaneous and successive processing, and a bridging component with tasks related to the school curriculum. These components are presented in three levels of increasing difficulty and are matched with the child's progress. Several studies that will be discussed in this paper have shown the efficacy of PREP as a cognitive remediation program to improve reading difficulties.

The COGENT is a child education program designed to improve cognitive functioning, phonological

awareness, and language. These abilities are specifically linked to literacy and school learning²⁶. The intervention consists of five activities or modules that include shapes, images, and toys to facilitate the association of words with literacy, comprehension, and cognitive ability. It is designed specifically for students ranging from 4- to 7-years-old with or without difficulties in these areas³². This program has proven to be a useful tool for educators, psychologists, and other staff under appropriate supervision in the development of reading and other related academic skills. COGENT can be implemented at school or home with groups of 10 children or less. It allows the child to internalize the strategies necessary for better cognitive processing and improve reading fluency and comprehension.

Finally, HCL is a manual that contains independent intervention guides related to the PASS theory²⁷. The manual includes 106 English and Spanish instructional guides for academic interventions that are supported by relevant yet limited scientific evidence⁸. The first part of the manual is designed for parents and educators and provides general information on the PASS theory, including case studies that illustrate how this theory can be used to understand and teach children with learning difficulties. The second part contains intervention handouts aimed at improving cognitive processing, reading skills, spelling, writing, mathematics, and test-taking strategies. Finally, the manual includes several handouts designed specifically to help children learn about their abilities.

Multiple studies have demonstrated the efficacy of PREP, COGENT, and HCL to improve cognitive functioning and academic skills. However, it is important to analyze the intervention components used in these studies to determine which implementation strategies are more effective.

To address this gap in knowledge, the research questions that guided this narrative review were: (a) What are the research methods used to study the efficacy of PASS-based interventions? and (b) What are the implementation strategies followed in these studies to test the efficacy of these interventions?

Method

Studies on the Efficacy of Interventions Based on the PASS Theory

In this section, 17 studies published between 2000 and 2019 in various countries were analyzed, including Canada, Spain, the United States of America, Greece, India, and Puerto Rico. In the process of identifying the articles, theses, and dissertations described in this review, different online databases and a special issue of a psychology journal dedicated to the PASS theory were consulted. The chosen studies were published between 2000 and 2019, addressed the efficacy of PASS-based interventions, and selected because their content was based on the PASS theory. Most of the reviewed studies evaluated the effects of the intervention on PASS cognitive processes and reading and mathematics skills. Those reviewed were 11 journal articles, five doctoral dissertations, and one master's thesis. Please refer to the supplemental material for more details (Table S1).

Results

Methodological Analysis of Interventions Based on the PASS Theory

The studies were conducted with elementary and middle school children suffering diverse behavioral and learning problems (e.g. behavioral difficulties, attention-deficit/hyperactivity disorder, learning difficulties, mild intellectual disability). Only Hald's study³³ included children with other health problems and language disabilities.

The studies focused mostly on third and fourth graders, but others worked with students ranging from first to eighth grade. This tendency may be due to the emphasis on basic reading skills and the learning expectations at these grades. In Puerto Rico, for example, children are expected to master fundamental reading skills, such as phonics, word recognition, and fluency by third grade³², which will then allow them to focus on the acquisition of reading comprehension skills. Furthermore, this may explain why identification of learning difficulties, specifically in reading, tends to be more frequent in third grade.

Most of the studies reviewed employed quasi-experimental ($n = 9$) or experimental ($n = 4$) designs with pre- and posttest. Only two case studies (e.g., Báez Reyes³⁵; Medina³⁶) and two single-subject designs (e.g., Cordero-Arroyo et al.³⁷; Naglieri & Johnson³⁸) were identified. The studies designs were coded using the information reported in the articles. In most cases, only minor changes in wording were made to maintain consistency. If the design was not explicitly stated (i.e., Baker³⁹; Haddad, et al.⁴⁰; Hald³³; Hayward et al.⁴¹; Iseman & Naglieri⁴²; Mahapatra et al.⁴³; Naglieri & Johnson³⁸; Papadopoulos et al.⁴⁴; Pérez-Álvarez et al.⁴⁵), it was inferred considering the information provided in the methods section of the article (e.g., random assignment, group comparison, pretest and posttest administration, follow-up measures).

Most studies used the Cognitive Assessment System (CAS2) to assess cognitive processes and administered the complete extended battery, except for Baker³⁹ and Forget⁴⁶. These two studies only utilized the successive and simultaneous processes scales. Reading skills were most commonly assessed with different versions of the Woodcock-Johnson tests of academic achievement, alongside supplementary reading tests that focused on comprehension and phonology. Mathematics skills were assessed via different standardized instruments and worksheets constructed by the investigators using a curriculum-based measurement framework. The studies chosen for this review used various instruments to measure most skills, and the Spanish versions of the instruments were used in studies conducted with Spanish-speaking children. Most academic skills were measured with multiple standardized and non-standardized instruments.

Improvements in Academic Skills and Cognitive Processing

Another important consideration was whether the interventions improved academic skills and cognitive processing. Because meta-analysis is the preferred technique to determine the effects of interventions, the following discussion is based on the findings reported by the study's authors but

is not intended as an exhaustive analysis of the results of statistical procedures (e.g., effect size, p-values).

The PREP showed a positive impact on basic reading skills, reading comprehension, and reading fluency. Only two studies showed no impact on reading comprehension skills⁴⁷⁻⁴⁸ and one showed no impact on basic reading skills⁴⁸.

Furthermore, most of the studies showed that PREP had a positive impact on the PASS processes. Particularly, a greater impact was reported on successive and simultaneous processing, either at the subtest or scale level (i.e., PASS theory processes). Only the study by Pérez-Álvarez et al.⁴⁵ showed a positive impact on planning and attention and no impact on successive or simultaneous processing. The results by Pérez-Álvarez et al.⁴⁵ could be associated with the PREP's design, which promotes the development and appropriate use of strategies while focusing on successive and simultaneous tasks. The studies by Forget⁴⁶ and Janzen⁴⁸ showed no impact on any cognitive processes.

The COGENT intervention model was only used in the study by Hayward et al.⁴¹. The results showed that it had a positive impact on the cognitive processes of the PASS when used in conjunction with the PREP and helped improve basic reading skills in third-grade children when used on its own.

Studies that used Helping Children Learn interventions included the following modules: (a) Teaching Students About Planning, (b) Teaching Students About Attention, (c) Planning Facilitation for Math Calculation, (d) Strategies for Spelling, (e) Self-Monitoring for Planning and Attention Problems, (f) Stop and Think! Teaching Self-Control, (g) Promoting Good Listening, and (h) Using Plans to Overcome Anxiety. These handouts were used in English and Spanish, based on the language of the country where the study was conducted. The results demonstrated a positive impact of the HCL-based interventions on planning ability. Only the study by González Santiago⁴⁹ failed to show an impact on cognitive processes, since the observed differences in planning and attention were

not above those explained by practice effects according to the instrument's reliability indexes. Most studies also report a positive impact on basic and complex reading skills, except for the study by Janzen⁴⁸. Hald³³, Iseman and Naglieri⁴², and Naglieri and Johnson³⁸ evidenced a positive impact on mathematics skills.

In most cases, positive results were found for all or most measures, which suggests that outcomes were not merely due to how the academic skills were assessed, but reflect a general improvement in the skill. This provides support for the interventions' efficacy, which in turn highlights the PASS theory's appropriateness as a framework from which to derive academic interventions.

Analysis of the Implementation Components of Interventions based on the PASS

To know how to effectively select, develop, and implement these interventions, it is necessary to understand how they were implemented in the studies. The following components were included in this analysis due to their relevance to the mentioned intervention phases: (a) Which intervention, (b) PASS processes the intervention addressed, (c) Academic areas addressed, (d) Modality, (e) Person who implemented the intervention, and (f) Number of sessions, their frequency, and duration. The results of the analysis of these components are summarized in Table 1.

Intervention and PASS Processes

Most studies aimed to evaluate the effectiveness of the PREP (n = 11); one of these integrated the PREP and COGENT sequentially as the intervention program (e.g., Hayward et al.⁴¹). The remaining six used intervention handouts contained in the HCL manual. Because the majority of implemented the PREP, a clear emphasis on successive and simultaneous processing can be identified, even though most of these evaluated the intervention's impact on the four PASS processes. On the other hand, the HCL-based interventions emphasized planning ability. Only the study by González Santiago⁴⁹ addressed its impact on attention ability.

Academic Area

The academic area that received the most attention was reading (n = 12), which is consistent with the number of studies that implemented the PREP. This intervention focuses primarily on successive and simultaneous processing because research suggests that children with reading difficulties often have a specific cognitive limitation in these processes^{45,50}.

Modality

Most of the reviewed studies implemented the interventions on groups of children (n = 14), particularly those using the PREP (n = 9). In these cases, the interventions were administered to small groups, consisting of three to four children. Only two studies implemented the PREP individually (e.g., Medina Santiago³⁶; Pérez-Álvarez et al.⁴⁵). Medina Santiago³⁶ indicates that the individual modality is the most appropriate when working with children with attention deficit and hyperactivity disorder.

Person who Implemented the Interventions

Interventions were implemented by teachers, psychology and education graduate students, a certified teacher, and researchers in psychology and education. In four studies, the intervention was implemented by the researchers in collaboration with research assistants. In all cases, those who administered the intervention were trained before implementation. The studies by González Santiago⁴⁹, Mahapatra⁴³, and Pérez Álvarez et al.⁴⁵ did not specify who administered the intervention.

Frequency and Duration of Sessions

There was considerable variation in the duration of the interventions between different studies. Similarly, the total number of sessions and their frequency varied significantly. In most studies that used HCL-based interventions, sessions lasted 30-minutes. Those conducted by Cordero-Arroyo et al.³⁷, Iseman and Naglieri⁴², and Naglieri and Johnson³⁸, only 10 minutes of these 30-minute sessions were used to administer the actual intervention.

Table 1. Implementation components of interventions based on the PASS theory

Reference	Intervention	Impacted areas	Modality	Person who implemented the intervention	Session quantity	Session frequency (weekly)	Session duration (minutes)
Alfonso Gil et al., ⁴⁷	PREP	Successive and Reading	Group	Teachers	164	5	20 - 25
Báez Reyes ³⁵	PREP	Successive, Simultaneous, and Reading	Group	Researcher and assistants	15	3	60
Baker ³⁹	PREP	Successive and Reading	Group	Teachers	22 - 24	3 - 4	20 - 25
Chiyoko Harvey, 2000 ⁵⁶	PREP	Successive and Reading	Group	Researcher	45	-	30
Cordero-Arroyo et al. ³⁷	HCL	Planning, Attention, Successive, Simultaneous, and Reading	Individual	Researcher and assistants	22	2	30
Forget ⁴⁶	PREP	Successive, Simultaneous, and Reading	Group	Teachers	16	4	40
González Santiago ⁴⁹	HCL	No impact	Group	-	20	2	45 - 50
Haddad et al. ⁴⁰	HCL	Reading	Group	Teachers	8	2	30
Hald ³³	HCL	Planning and Math	Group	Researcher and assistants	6	2	30
Hayward et al. ⁴¹	COGENT y PREP	Planning, Attention, Successive, Simultaneous, and Reading	Group	Teachers	24	3	30
Iseman & Naglieri ⁴²	HCL	Math	Group	Teachers	10	2	30
Janzen ⁴⁸	PREP	Planning, Successive, Simultaneous, and Reading	Group	Assistants	15	2	60
Mahapatra ⁴³	PREP	Simultaneous and Reading	Group	-	15	-	60
Medina Santiago ³⁶	PREP	Successive, Simultaneous, and Reading	Individual	Researcher and assistants	20 - 30	2	45
Naglieri & Johnson ³⁸	HCL	Math	Group	Teachers	17	-	30
Papadopoulos et al. ⁴⁴	PREP	Successive, Simultaneous, and Reading	Group	Assistants	20	-	30
Pérez-Álvarez et al. ⁴⁵	PREP	Planning, Attention, Successive, and Simultaneous	Individual	-	15	-	45

Note. PREP = Reading Enhancement Program; COGENT = Cognitive Enhancement Training; HCL = Helping Children Learn: Intervention Handouts for Use in School and at Home.

Although the duration of the sessions is consistent throughout the different studies using HCL, there was significant variation in the total number of sessions, ranging from 6 to 22. Similarly, there were significant variations in the duration of the studies implementing the PREP, which ranged from 20 to 60 minutes. To determine their cost-effectiveness, the duration and number of sessions required for the intervention to have an effect must be taken into consideration. This is important since it represents a major factor that guides the decision-making process of psychologists when working with school populations.

It was observed that interventions with less sessions proved to be efficacious for improving reading and math skills, and the cognitive abilities proposed by the PASS, even when the session duration remained the same. For example, it was observed that 15 sessions of 60 minutes with the PREP, three times a week, can improve the successive and simultaneous processing and reading skills. Similarly, six 30-minute sessions with interventions from the HCL manual, twice a week, can improve planning skills and math skills.

Discussion Implications

This review has important implications for psychology and education because it is aligned with federal and state regulations that emphasize the importance of using evidence-based strategies and interventions. The United States Department of Education, in compliance with Every Student Succeeds Act⁵¹, requires the implementation of evidence-based interventions to effectively impact the teaching and learning processes in the schools⁵². For example, the Departamento de Educación de Puerto Rico promotes the use of interventions and strategies based on scientific research as part of its transition to the ESSA Law⁵³. Similarly, the American Psychological Association⁵⁴ states that psychological evaluations and interventions supported by science should be prioritized to promote effective psychological practice.

Adhering to the aforementioned regulations, the analysis conducted has important implications for professional training. Clinical and school psychology

curriculums should contemplate the inclusion of contemporary models that could guide the identification of children's needs and intervention efforts, following the most recent scientific evidence. Furthermore, incorporating some of these subjects to teacher-training programs would facilitate the collaboration between teachers and psychologists, which could improve intervention efforts and the outcomes of learning in the nation's schools.

This work has important implications for clinical and educational practice. Professionals working in clinical and school settings could incorporate the interventions described into their practice since these have proven to be efficacious—according to the authors—in addressing different cognitive and learning difficulties. Similarly, teachers could effectively implement HCL-based interventions in the classroom because these also have proven to be successful for improving academic skills in individual or small group modalities and do not require specialized training. Although the impact of HCL interventions has been shown to be greater for children with learning difficulties, incorporating these into regular-classroom instruction could also benefit the rest of the children⁴². The integration of this cognitive approach to learning encourages teachers to play a central and active role in intervention and progress monitoring processes. This could strengthen children's neurodevelopment and facilitate achieving learning outcomes.

Limitations and Recommendations

A major limitation of this narrative review is that no search strategy or specific selection criteria were established *a priori*; therefore, a systematic literature review is recommended to optimize the replicability of the findings. Even though the search criteria were not established *a priori*, the process by which we identified the studies was detailed to improve replicability. Additionally, two studies were found that tested the efficacy of the COGENT, yet only one of these was accessible. More studies that evaluate the effectiveness of COGENT for strengthening cognitive functioning in children at an early age are needed. Future investigations should also analyze the impact of PASS-based interventions

on all areas of cognitive functioning and academic performance (e.g., behavior, anxiety) previously reported, which would yield information about the generalization of the intervention's effect to other important outcomes. Another limitation of this review was the consideration of a single intervention model (i.e., PASS theory) only, and this has been criticized by Kavale and LeFevre⁵⁵ because it limits the interpretation of the findings. After all, they cannot be compared to the efficacy of other models. Future reviews should address this concern.

Finally, because this review focused on the methodological and implementation details of these interventions and not on their effectiveness, the effect sizes of the studies reviewed were not reported. Only the positive or negative impact of the intervention as reported by the authors of each study is mentioned. A meta-analysis is recommended to address this limitation and determine the effect sizes of these interventions. This would lead to increased comparability between studies and improve confidence in the findings.

Conclusion

The PASS theory states that intelligence is better understood as the interaction of basic psycholog-

ical processes that are themselves the result of brain functioning. This view based on a cognitive processing framework goes above and beyond traditional approaches to measuring intelligence that conceptualize it as a general ability and over-emphasize the difference between its verbal and non-verbal aspects⁷.

The analysis of the interventions based on the PASS theory provides evidence of the efficacy of these interventions for improving cognitive functioning. This effect was clearer on the successive and simultaneous processing of information. The results suggest the interventions also improved basic and complex reading skills (e.g., reading comprehension). The impact of PASS-based interventions on math skills through planning was also demonstrated. The findings suggest the interventions were productive, showing a reorganization of the cognitive abilities that underlie the learning of these skills. The effect of the interventions was also evidenced when implemented individually or in small groups and even for a small number of sessions of short duration. This suggests that implementing PASS interventions at an early age, based on the neurocognitive profile of children, could contribute to improving their cognitive processing and academic skills.

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Supplemental Material

Table S1. Studies on PASS theory-based interventions

Reference	Purpose	Design	Population	Instruments	Findings
Alfonso Gil et al. ⁴⁷	Assess the effects of the PREP-L on the cognitive process of successive coding and reading comprehension.	Quasi-experimental with pretest-posttest design and control group	Second grade Spanish speaking students at risk of reading difficulty (n = 29)	Cognitive Assessment System (CAS) Pruebas de evaluación de la comprensión lectora (ACL) Reading Enhancement Program (PREP)	Positive impact on successive processing No impact on reading comprehension
Báez Reyes ³⁵	Examine the capacity of bridge tasks of the PREP to promote cognitive modification of processes associated with the skills to learn to read.	Case study with pretest-posttest design	Spanish speaking eight to twelve-year-old students with reading difficulties (n = 5)	Cognitive Assessment System (CAS) Woodcock-Muñoz de Aprovechamiento Académico (WM) Reading Enhancement Program (PREP)	Positive impact on successive and simultaneous processing Positive impact on basic reading and comprehension skills
Baker ³⁹	Compare the effects of a phonetics program built by the teacher to the PASS program.	Experimental with pretest-posttest design and control group	Third grade English speaking students with reading difficulties (n = 38)	Cognitive Assessment System (CAS) Woodcock Reading Mastery Tests (WRMT) Phoneme Elision (PE) Reading Enhancement Program (PREP)	Positive impact on successive processing Positive impact on basic reading skills
Chiyoko Harvey ⁵⁶	To determine the efficacy of the PREP to improve cognitive processing, reading proficiency and perceived control.	Quasi-experimental with pretest-posttest design and non-equivalent control group	Title I English speaking students from first to third grade (n = 67)	Cognitive Assessment System (CAS) Harcourt Brace basal reading book Gates-MacGinitie Reading Test (GMRT) Word Pattern Survey (WPS) Student Perceptions of Control Questionnaire (SPOCQ) Reading Enhancement Program (PREP)	Positive impact on successive processing Positive impact on basic reading skills Positive impact on comprehension and vocabulary skills
Cordero-Arroyo et al. ³⁷	Determine the efficacy of an intervention based on the PASS theory for neurocognitive modification, specifically planning, and its impact on basic reading skills.	Single Subject Design with pretest-posttest design	Third grade Spanish speaking students with characteristics of inattention and hyperactivity and difficulties in reading (n = 3)	Cognitive Assessment System 2: Español (CAS2: Español) Woodcock-Muñoz de Aprovechamiento Académico Spelling worksheets Helping Children Learn (HCL)	Positive impact on planning, attention, successive and simultaneous processing Positive impact on spelling and basic reading skills

(continued)

Table S1. Studies on PASS theory-based interventions

Reference	Purpose	Design	Population	Instruments	Findings
Forget ⁴⁶	Investigate the relative effectiveness of the PREP program in increasing basic decoding skills in reading in Title I students, compared to conventional instructional techniques and methods.	Quasi-experimental with pretest-posttest design and non-equivalent control group	Title I English speaking students from third to fourth grade (in the reading program; n = 29)	Cognitive Assessment System (CAS) Woodcock Reading Mastery Tests (WRMT) Reading Enhancement Program (PREP)	No impact superior to the comparison intervention in cognitive processes Positive impact on reading fluency with the PREP and the traditional method
González Santiago ⁴⁹	Explore the possibility of neurocognitive modification in attention and planning processes in a sample of Puerto Rican children with Attention Deficit Hyperactivity Disorder (ADHD).	Quasi-experimental with pretest-posttest design	Spanish speaking six to nine-year-old students diagnosed with ADHD (n = 5)	Cognitive Assessment System 2: Español (CAS2: Español) Escala de Evaluación de la Conducta Perturbadora (EECP) Inventario de Comportamiento Escolar (IDC-E) Blood and saliva sample Helping Children Learn (HCL)	Impact similar to the practice effect in planning and attention
Haddad et al. ⁴⁰	Determine if an intervention designed to facilitate planning (<i>Planning facilitation</i> ^a) could have differential benefits in reading comprehension depending on the individual cognitive characteristics of the students.	Quasi-experimental with pretest-posttest design and control group	Fourth grade English speaking students (n = 45)	Cognitive Assessment System (CAS) Ekwall-Shanker Reading Inventory Fourth Edition (ERSI) Helping Children Learn (HCL)	Positive impact on reading comprehension
Hald ³³	Determine if two interventions based on the PASS (<i>Planning Facilitation Method</i> ^a / <i>Planning Facilitation and Math Instruction</i> ^b) would have different effects depending on the individual cognitive characteristics of the students.	Quasi-experimental with pretest-posttest design and control group	English speaking nine to 11-year-old students in fourth grade with difficulties in mathematics (n = 19)	Cognitive Assessment System (CAS) KeyMath-Revised (KM) Mathematics worksheets Helping Children Learn (HCL)	Positive impact on planning Positive impact on math skills

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Table S1. Studies on PASS theory-based interventions

Reference	Purpose	Design	Population	Instruments	Findings
Hayward et al. ⁴¹	Determine the effectiveness of the COGENT in Canadian students to improve cognitive and reading processes. Determine if the COGENT participants would benefit more from the PREP.	Quasi-experimental with repeated measures and control group	Third grade English speaking students with poor reading skills (n = 45)	Cognitive Assessment System (CAS) Woodcock-Johnson Tests of Achievement (WJ) Comprehensive Test of Phonological Processing (CTOPP) Cognitive Enhancement Training (COGENT) Reading Enhancement Program (PREP)	Positive impact on cognitive processes when both interventions were used Positive impact on basic reading skills, with the COGENT-COGENT and the COGENT-PREP
Iseman & Naglieri ⁴²	Examine the effectiveness of the <i>Planning-based strategy instruction</i> ^a to improve planning.	Experimental with Pretest-posttest design with and control and follow-up	10- to 15-year-old English speaking students with ADHD and learning difficulties (n = 29)	Cognitive Assessment System (CAS) Woodcock-Johnson Tests of Achievement (WJ) Wechsler Individual Achievement Test Second Edition (WIAT-II) Helping Children Learn (HCL)	Positive impact on math skills
Janzen ⁴⁸	Determine the efficacy of the PREP intervention to improve reading skills.	Experimental with repeated measures and control group	Third and fourth grade English speaking students with different levels of reading comprehension (n = 28)	Cognitive Assessment System (CAS) Canadian Test of Cognitive Skills (CTCS) Stanford Diagnostic Reading Test (SDRT) Word Probe (WP) Reading Enhancement Program (PREP)	No impact on cognitive processes (PASS) No impact on basic reading and comprehension skills
Mahapatra et al. ⁴³	Examine the effectiveness of a cognitive remediation program to improve reading comprehension in English of students whose primary language is not English.	Quasi-experimental with pretest-posttest design and control group	Fourth grade English Language Learners with significant difficulties in reading comprehension (n = 14)	Cognitive Assessment System (CAS) Woodcock Reading Mastery Tests (WRMT) Reading Enhancement Program (PREP)	Positive impact on simultaneous processing Positive impact on word reading and reading comprehension
Medina Santiago ³⁶	Implement the cognitive remediation program the PREP to children with difficulties of Reading and ADHD- Combined to improve reading proficiency.	Case study with pretest-posttest design	Seven- and 9-year-old Spanish speaking students with reading problems and ADHD-Combined (n = 5)	Cognitive Assessment System: Español (CAS: Español) Woodcock-Muñoz de Aprovechamiento Académico (WM) Reading Enhancement Program (PREP)	Positive impact on successive and simultaneous processing Positive impact on basic reading and comprehension skills

(continued)

Table S1. Studies on PASS theory-based interventions

Reference	Purpose	Design	Population	Instruments	Findings
Naglieri & Johnson ³⁸	Determine if an instruction designed to facilitate planning (<i>Planning Facilitation Method</i> ^a) would have differential effects depending on the cognitive characteristics of the PASS in each child.	Single Subject Design	Sixth to eight grade English speaking students with learning difficulties and mild intellectual disability (n = 19)	Cognitive Assessment System (CAS) Math worksheets Helping Children Learn (HCL)	Positive impact on math skills in the group with a planning cognitive weakness
Papadopoulos et al. ⁴⁴	Investigate a cognitive approach for the development of phonological skills and cognitive abilities related to reading.	Experimental with pretest-posttest design, control group and follow-up	Kindergarten English speaking students at risk of reading difficulties (n = 30)	Cognitive Assessment System (CAS) Rhyme Oddity Sound Isolation Phoneme Elision Reading Enhancement Program (PREP)	Positive impact on successive and simultaneous processing Positive impact on basic reading skills
Pérez-Álvarez et al. ⁴⁵	Investigate learning difficulties in elementary school children with regards to the PASS processes and determine the utility of the PASS-based intervention (PREP) within the follow-up period.	Quasi-experimental with pretest-posttest design and follow-up	English speaking students between 6 and 11 years with specific learning problems (n = 248)	Cognitive Assessment System (CAS) Reading Enhancement Program (PREP)	Positive impact on planning and attention, but there was no impact on successive and simultaneous processing

Note. ^aTeaching Students about Planning on HCL. ^bPlanning Facilitation for Math Calculation.