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Abstract

Objective: The current study investigated the internal structure and external relations of the Children's Psychological Processes Scale (CPPS). **Method:** Principal components analysis and exploratory factor analysis were conducted. Concurrent validity studies were also completed with the Behavior Rating Inventory of Executive Function (BRIEF) and Woodcock–Johnson III Tests of Cognitive Abilities (WJ III COG). **Results:** A general cognitive ability factor was identified that accounted for up to 85% of the scale's total variance. Exploratory factor analysis produced a three-factor solution that included general processing ability, executive functions, and visual-motor processing. Subscales comprising the CPPS executive functions factor were found to have high correlations with BRIEF composites and subscales. CPPS subscale correlations with comparable WJ III COG tests indicated that the majority of the CPPS subscales assess the same constructs as those measured by the WJ III COG. **Conclusion:** The results suggest that rating scale measures of cognitive and metacognitive processes assess the same latent factors and cognitive processes as performance-based measures. *(J. of Att. Dis. XXXX; XX(X) XX-XX)*

Keywords

ADHD, cognitive processes, executive functions, working memory

Introduction

Much has been written about the manifest and latent structure of human cognitive abilities. In his seminal review of factor-analytic studies of measured intellectual abilities more than 20 years ago, John B. Carroll (1993) documented extensive support for the general intellectual ability (GIA) factor historically referred to as "psychometric *g*" or "*g*." Carroll concluded that *g* accounted for much of the variance in intellectual and cognitive test batteries and that there were eight broad factors of intelligence that subsumed approximately 65 narrow abilities. Prior to the release of Carroll's work, Raymond Cattell (1971) had promoted an intelligence theory that disputed the existence and utility of *g* while emphasizing two primary cognitive ability factors: fluid (*Gf*) and crystallized (*Gc*) intelligence. Building on Cattell's theory, John Horn (1994) determined that available research supported the existence of at least six or seven additional broad ability factors beyond crystallized and fluid intelligence. Upon completion of his review, Carroll concluded that the extant factor-analytic evidence supported Cattell–Horn's *Gf-Gc* theory. Later, Woodcock (1994) and McGrew (2005) would integrate Cattell–Horn theory with Carroll's, resulting in a three-stratum theory of human cognitive abilities referred to as Cattell–Horn–Carroll (CHC) theory that has been widely applied to the structure, classification, and analysis of cognitive tests (Flanagan, Ortiz, & Alfonso, 2013). For example, the structure of the Woodcock–Johnson III Tests of Cognitive Abilities (WJ III COG; Woodcock, McGrew, & Mather, 2001) has been aligned with the CHC taxonomy.

In addition to psychometric CHC theory, Luria's (1970) neuropsychological theory of human cognitive processing has been the basis of instruments that focus on measuring cognitive "processes," rather than intellectual abilities. The Lurian approach encourages more direct measurement of neuropsychological "processes" that underlie performance on cognitive ability measures. Kaufman and Kaufman (1983) were the first to operationalize Lurian theory with the Kaufman Assessment Battery for Children (K-ABC), followed by Naglieri and Das (1997) with Cognitive Assessment System (CAS). Internal analysis of the CAS (Naglieri, 1999) provided support for the latent cognitive

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processing factors of successive processing, simultaneous processing, planning, and attention. Moreover, external validity studies of the CAS found that these processes were highly predictive of academic learning (Naglieri).

Executive Functions and Working Memory

More recently, there has been growing interest in the measurement of metacognitive abilities, more commonly referred to as "executive functions" (e.g., Delis, Kaplan, & Kramer, 2001). Executive functions include an array of mental processes responsible for cuing, directing, and coordinating perception, cognition, and emotion during purposeful, goal-directed, problem-solving behavior. Identifying the latent structure of executive functioning is ongoing, primarily due to the complexity of executive processing. For example, McCloskey and Perkins (2013) have proposed more than 30 executive functions. Nonetheless, during factor analysis, executive function subscales usually form only two or three factors (Gioia, Isquith, Retzlaff, & Epsy, 2002), and sometimes they coalesce into just one broad factor (Naglieri & Goldstein, 2013).

One of the key roles of executive functions is to "supervise" or "manage" cognitive and other psychological processes (Dehn, 2014). Accordingly, there is evidence that executive functions influence academic learning and performance (e.g., Locascio, Mahone, Eason, & Cutting, 2010). In addition, dysfunctions in the self-regulatory aspects of executive functioning are thought to account for ADHD (Barkley, 1997). Consequently, the measurement of executive functions has frequently focused on inhibition and other dimensions related to control of attention (Gioia, Isquith, Guy, & Kenworthy, 2000; Naglieri & Goldstein, 2013).

In addition to self-regulatory processes (SRP), executive assessment instruments usually include working memory, another key executive dimension. Working memory is the limited capacity to retain information while simultaneously processing the same or other information for a short period of time (Swanson, 2000). For example, working memory is required during inductive reasoning and when multitasking. According to Baddeley (2006), a central executive working memory plays a supervisory role over phonological and visual-spatial short-term memory components. Because it is also a core cognitive process, working memory plays a crucial role in all aspects of academic learning and performance (Gathercole, Brown, & Pickering, 2003). Moreover, working memory deficits have been implicated in ADHD. A significant portion of individuals with ADHD have working memory deficits (Alderson, Rapport, Hudec, Sarver, & Kofler, 2010). According to Rapport's model (Rapport et al., 2009), working memory deficiencies underlie the behavioral inhibition deficits that are the hallmark of ADHD.

Besides inhibition, other executive functions that are closely associated with working memory include shifting, updating, and control of attention (Unsworth, 2009). Some cognitive processes also have strong relations with working memory. Several studies reviewed by Krumm et al. (2009) have reported that working memory is an excellent predictor of fluid reasoning. Processing speed is another cognitive process that has high correlations with working memory (Dehn, 2008). Factor analysis of dedicated working memory measures usually results in a structure that conforms to Baddeley's tripartite model (Pickering & Gathercole, 2001). Consistent with the fact that the prefrontal cortex continues to develop into adolescence, the structure of working memory and executive factors vary by age (Johnson, Logie, & Brockmole, 2010). Other possible sources of variance by age include development of metacognitive strategies and levels of expertise.

Relations Between Rating Scales and Performance-Based Measures

Measuring executive functions with traditionally structured psychological scales presents challenges. For instance, performance can be confounded by the cognitive abilities required to complete a testing task. That is, a deficient cognitive process might lower performance on what is ostensibly a metacognitive, or executive, task. Furthermore, standardized testing procedures tend to support executive functioning through their structure, organization, and focused demands. For example, testing procedures typically reduce the need to inhibit distraction. The result is that direct testing of executive functions sometimes produces an overestimate of an individual's executive functioning in the classroom and real world (Gioia et al., 2002). These challenges led Gioia et al. (2000) to argue that a rating scale approach, such as the Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000), could be as reliable and valid a measure of executive functions, if not more so, as performance-based measures.

Support for this argument was provided by Toplak, Bucciarelli, Jain, and Tannock (2009) who discovered that BRIEF scores indicative of executive deficits were highly predictive of an ADHD diagnosis. Moreover, Toplak et al. reported significant associations between performance-based measures of executive functioning and parent and teacher ratings on the BRIEF. However, in predicting ADHD, the performance-based measures contributed little unique variance beyond the BRIEF scores. Additional support for the diagnostic validity of executive function rating scales was provided by Mahone, Martin, Kates, Hay, and Horska (2000) who discovered that parent ratings of executive functions are significantly correlated with the volume of frontal lobe gray matter.

Although there is some support for a rating scale such as the BRIEF measuring real world functioning better than direct testing, the more common claim is that cognitive and metacognitive rating scales assess the same constructs as performance-based tests. For instance, Alloway, Gathercole, Kirkwood, and Elliott (2009) reported that teacher ratings of working memory on the Working Memory Rating Scale (WMRS; Alloway, 2008) correlated highly with working memory tests. WMRS scores indicative of working memory deficiencies corresponded with lower working memory scores on direct measures of working memory, such as the Working Memory Index on the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV). The WMRS scores were also highly predictive of academic learning. However, such findings may be in the minority. In a review of the research, Normand and Tannock (2012) found only a modest relationship between ratings of working memory and performance-based measures of working memory. One explanation is that subtest performance demands may not engage the same set of abilities as those assessed by rating scales.

The Children's Psychological Processes Scale (CPPS)

Similar to the approaches of Gioia et al. (2000) and Alloway (2008), Dehn applied rating scale technology to a broader spectrum of cognitive and metacognitive processes through the development of the CPPS (Dehn, 2012). The CPPS is a standardized, norm-referenced teacher rating scale designed to assess 11 cognitive processes: attention, auditory processing, executive functions, fine motor, fluid reasoning, long-term recall, oral language, phonological processing, processing speed, visual-spatial processing, and working memory. The CPPS Executive Functions items broadly sample executive abilities while the Attention subscale focuses on inhibition and attentional control. In addition, the CPPS Working Memory subscale adheres to Baddeley's working memory model by including items that tap both short-term memory and executive working memory.

The web-based CPPS allows teachers to rate the frequency of observed problem behaviors that are thought to be manifestations of deficiencies in underlying psychological processes. The primary purpose of the CPPS is to identify psychological processing deficits in children referred for a learning disability (LD) evaluation. A study conducted during standardization found that the CPPS differentiates well between children with and without LD (Dehn, 2012).

Purpose of the Study

If the CPPS effectively measures the same cognitive and metacognitive processes assessed through traditional, direct testing procedures, then the CPPS subscales should have strong relations with direct measures of the same processes and the factor structure of the CPPS should be similar to those performance-based scales. Therefore, it is predicted that factor analysis of the CPPS will produce a latent general ability factor, as well as an executive factor comprised of subscales, such as attention and working memory, that are usually associated with executive functioning. It is also predicted that the CPPS subscales will correlate significantly with similar cognitive and metacognitive measures.

The primary purpose of the present investigation is to explore the factor structure of the recently released CPPS (Dehn, 2012). The secondary purpose is to evaluate the relations CPPS process scores have with corresponding direct measures of cognitive processes. The third purpose is to appraise the validity of the CPPS as a measure of executive functions, including working memory.

The specific research questions are as follows:

Research Question 1: Will a general cognitive ability factor emerge along with other cognitive and metacognitive factors that are typically identified in direct measures of cognitive and metacognitive abilities and processes?

Research Question 2: What are the relations between the CPPS processing subscales and direct, performance-based measures of cognitive abilities?

Research Question 3: Is there internal and external validity support for a CPPS executive functions factor that includes working memory?

Method

Participants

The sample for the factor-analytic studies consisted of the CPPS standardization sample of 1,121 participants drawn from the United States. The participants ranged in age from 5 through 12 years, with a median age of 8. They were rated by 278 teachers from 128 communities in 30 states and the District of Columbia. The sample's demographic characteristics closely approximated U.S. Census percentages. Males comprised 51% of the sample, while 49% were females. The racial/ethnic composition was as follows: African American 14.6%, White 76.2%, Asian 4.4%, Native American 1.2%, and Mixed/Other 3.6%. Of the White participants, 22.8% were Hispanic. Students with educationally recognized disabilities made up 8.5% of the sample, with 3.1% of the total sample having a specific LD and 1.5% having a diagnosis of ADHD. Parent education levels closely approximated U.S. Census data, as did urban versus rural residence.

For the external validity study with the BRIEF (Gioia et al., 2000), 33 teachers from across the U.S. completed both a CPPS and a BRIEF rating scale on one of their students. The student sample consisted of 17 males and 16 females, none of whom had a diagnosed disability. There were two participants from each of the fifth, sixth, and seventh grades and 5 to 6 students each from kindergarten through fourth grade. The overall academic skills of the sample were also well balanced, with 22 students ranked as average, 6 ranked below average, and 5 ranked above average. The racial/ethnic distribution was 24 White students, 6 African American, 2 Asian, and 1 Native American. Of the 24 White students, 7 were Hispanic.

Forty participants whose teachers completed CPPS ratings were tested with the WJ III COG (Woodcock et al., 2001). The students were recruited from six different schools located in a Midwestern community with a population of approximately 75,000. The student sample consisted of 22 males and 18 females. Participants ranged in age from 5 years, 6 months to 12 years, 11 months, with a mean age of 9 years, 6 months. Six of the 40 participants had a disability: 1 with ADHD, 1 with Asperger's, 1 with a traumatic brain injury, and 3 with a LD. The participants' overall academic skills, as ranked by their teachers, consisted of 18 with above average rankings, 16 with average rankings, and 6 with below average rankings. All the students were non-Hispanic Whites except for one student identified as "Other."

Instruments

CPPS. The CPPS (Dehn, 2012) is an Internet, web-based teacher rating scale designed to assess psychological processes related to academic learning in children ages 5 through 12 years. The CPPS consists of 121 items divided among 11 process subscales. The internal consistency reliability (Cronbach's α) estimates for the subscales range from .88 to .98, with the majority in the mid-90s. An interrater reliability study found a median coefficient of 76.5. Validity of the CPPS is supported by expert review, developmental evidence, and external and internal validity studies.

BRIEF. The BRIEF (Gioia et al., 2000) uses rating scale technology to measure executive functions in children ages 5 to 18. The BRIEF's teacher and parent rating forms consist of 86 items divided among eight scales that measure different aspects of executive functioning. Three scales (Inhibit, Shift, and Emotional Control) contribute to the Behavioral Regulation Index, which represents the ability to modulate behavior and emotions, and the remaining five scales (Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor) comprise the Metacognition Index, which is interpreted as the ability to cognitively self-manage tasks and actively problem solve in a variety of contexts. The BRIEF also has a global score known as the Global Executive Composite (GEC).

WJ III COG. The WJ III COG (Woodcock et al., 2001) consists of 20 cognitive tests (subtests) that are organized under three categories—verbal ability, thinking ability, and cognitive efficiency. The WJ III COG Extended Battery, an individually administered scale, produces seven broad factors consistent with the CHC taxonomy of cognitive abilities (Flanagan et al., 2013), and it also yields four clinical clusters—Phonemic Awareness, Broad Attention, Working Memory, and Cognitive Fluency. In addition to the factor scores and clinical cluster scores, individual WJ III COG test scores included in this study were Visual-Auditory Learning-Delayed Recall, Rapid Picture Naming, and Pair Cancellation.

Procedures

All standardization data were collected online via a secure Internet website during the winter and spring of 2011. Classroom teachers were recruited, and each was asked to complete CPPS rating scales on up to five of their students who met specified demographic criteria. After data collection was completed, intercorrelations among subscales were computed. Because of the novel, atheoretical approach of measuring cognitive processes through rating scale technology, there were no specific *a priori* hypotheses to evaluate. Therefore, exploratory factor analysis was selected to identify shared variance that could be attributed to underlying latent constructs. Principal components analysis (PCA) and maximum likelihood exploratory factor analysis, followed by oblique rotation of retained factors, were applied to the CPPS subscale intercorrelation/covariance matrices at each of the four norm age groups.

For the concurrent validity study with the BRIEF, teachers first completed an online CPPS rating form, followed by completion of a paper-and-pencil BRIEF within 30 days. For the WJ III COG study, experienced school psychologists administered the Extended Battery of the WJ III COG to students after their teachers had completed online CPPS rating forms. After data collection was completed, correlational analyses were conducted by comparing CPPS scores with the BRIEF and the WJ III COG scores.

Results

PCA

Regardless of the type of PCA conducted with the CPPS standardization data, a broad general dimension, which is typically interpreted as representing general intelligence (*g*) on cognitive scales, was the first factor to emerge. On the CPPS, this general factor is interpreted as representing General (psychological) Processing Ability (GPA). The emergence of a principal component is consistent with the high intercorrelations among all the CPPS subscales. The intercorrelations for the 7- to 8-year-old age group displayed

Table 1. CPPS Subscale Intercorrelations for 7 to 8 Years of Age (*n* = 384).

	AT	AP	EF	FM	FR	OL	LTR	PP	PS	VSP	WM
AT	1.00										
AP	.77	1.00									
EF	.93	.78	1.00								
FM	.61	.67	.64	1.00							
FR	.72	.83	.76	.57	1.00						
OL	.66	.84	.70	.61	.83	1.00					
LTR	.77	.91	.79	.62	.90	.86	1.00				
PP	.59	.79	.63	.66	.78	.80	.81	1.00			
PS	.72	.75	.78	.61	.80	.73	.82	.72	1.00		
VSP	.65	.80	.67	.73	.79	.75	.80	.81	.73	1.00	
WM	.85	.89	.88	.65	.90	.83	.93	.77	.85	.78	1.00

Note. AT= Attention; AP = Auditory Processing; EF = Executive Functions; FM = Fine Motor; FR = Fluid Reasoning; OL = Oral Language; LTR = Long-Term Recall; PP = Phonological Processing; PS = Processing Speed; VSP = Visual-Spatial Processing; WM = Working Memory.

Table 2. Subscale Loadings (Sorted by Median Loading) on the CPPS General Component.

Subscale	Ages 5-6 (*n* = 258)	Ages 7-8 (*n* = 384)	Ages 9-10 (*n* = 279)	Ages 11-12 (*n* = 200)	Median
Working Memory	.97	.95	.95	.95	.95
Long-Term Recall	.97	.94	.94	.94	.94
Auditory Processing	.95	.94	.94	.93	.94
Fluid Reasoning	.95	.91	.91	.91	.91
Oral Language	.91	.90	.90	.91	.91
Visual-Spatial Processing	.94	.87	.87	.85	.87
Processing Speed	.94	.83	.83	.89	.86
Phonological Processing	.90	.84	.84	.86	.85
Executive Functions	.91	.83	.83	.84	.83
Attention	.87	.80	.80	.83	.81
Fine Motor	.87	.70	.70	.72	.71
Total % of variance explained	85.71	78.55	75.13	76.99	

Note. Values are loadings on first principal component extracted via principal components analysis.

in Table 1 are typical of those for the entire sample. The intercorrelations in Table 1 range from .57 to .93. As reported in Table 2, this general latent factor accounts for the majority of the CPPS scale's total variance, more than 85% at ages 5 to 6. Except for Fine Motor, all of the subscales consistently load high (.70 or above) on this primary factor. Due to their high loadings on this general dimension, it is difficult for any of the CPPS subscales to demonstrate high subscale specificity; that is, it is difficult for any of the subscales to emerge as primarily independent measures.

Inspection of the eigenvalues (latent roots) from the principal components of a data set is typically used to ascertain the number of statistically and potentially meaningful dimensions to retain in subsequent common-factor or maximum likelihood factor analysis of the data. The PCA for each of the four age groups revealed one very large eigenvalue (9.43, 8.64, 8.26, 8.46, for ages 5-6 through 10-12), followed by a set of dramatically smaller second set of eigenvalues (0.56, 0.68, 0.89, 0.89, respectively). These results suggest that a single factor solution is the most parsimonious and plausible interpretation, although inspection of the scree plots suggested that a two- or three-factor solution was worthy of exploration.

Exploratory Factor Analysis

Given the eigenvalues obtained from the PCA, it was decided that two- and three-factor solutions would be extracted. Although the PCA results suggested the extraction of two factors at most, extracting one additional factor often helps clarify the primary factors of interest. Moreover, the extraction of more than one factor can often identify clinically meaningful dimensions. Given the unknown internal structure of the 11 CPPS subscales, this deliberately lenient factor extraction strategy was applied to the data for each of the four age groups. The results are reported in Tables 3 through 6.

Across all age groups, the first factor extracted in a two-factor solution was consistently defined by high factor

Table 3. Ages 5 to 6 Exploratory Factor Analysis Solutions.

Maximum likelihood two-factor oblique solution	1	2	Maximum likelihood three-factor oblique solution	1	2	3
Phonological Processing	**1.03**[a]	−0.15	Oral Language	**1.04**[a]	−0.07	−0.05
Oral Language	**1.02**[a]	−0.12	Long-Term Recall	**0.87**	0.12	0.03
Visual-Spatial Processing	**0.93**	0.00	Auditory Processing	**0.79**	0.14	*0.06*
Long-Term Recall	**0.91**	0.08	Phonological Processing	**0.64**	−0.10	*0.38*
Auditory Processing	**0.87**	0.10	Fluid Reasoning	**0.58**	0.18	0.25
Fluid Reasoning	**0.84**	0.14	Working Memory	**0.58**	*0.38*	0.09
Processing Speed	**0.68**	*0.30*	Processing Speed	**0.53**	*0.33*	0.14
Working Memory	**0.68**	*0.35*	Attention	0.01	**0.93**	0.05
Fine Motor	**0.58**	*0.31*	Executive Functions	0.16	**0.81**	0.05
Attention	0.03	**0.95**	Visual-Spatial Processing	0.09	0.00	**0.92**
Executive Functions	0.20	**0.82**	Fine Motor	0.09	*0.32*	**0.58**
% Common Variance Explained	73.50	26.50	% Common Variance Explained	49.80	27.60	22.70
Correlations between factors			Correlations between factors			
1	1.00		1	1.00		
2	.73	1.00	2	.76	1.00	
			3	.89	.71	1.00

Note. *n* = 258; Bold font designates primary subscale factor loadings ≥ .50; italic font designates secondary subscale factor loadings ≥ .30 and < .50.
[a]Heywood cases.

Table 4. Ages 7 to 8 Exploratory Factor Analysis Solutions.

Maximum likelihood two-factor oblique solution	1	2	Maximum likelihood three-factor oblique solution	1	2	3
Phonological Processing	**0.99**	−0.17	Working Memory	**1.03**[a]	−0.02	−0.06
Oral Language	**0.93**	−0.05	Long-Term Recall	**0.91**	0.18	−0.01
Long-Term Recall	**0.91**	0.07	Fluid Reasoning	**0.88**	0.18	−0.03
Visual-Spatial Processing	**0.87**	−0.02	Processing Speed	**0.79**	0.00	0.08
Fluid Reasoning	**0.86**	0.06	Executive Functions	**0.76**	−0.16	0.06
Auditory Processing	**0.82**	0.14	Attention	**0.75**	−0.13	0.00
Working Memory	**0.67**	*0.36*	Auditory Processing	**0.65**	0.11	0.19
Processing Speed	**0.63**	0.27	Oral Language	**0.62**	0.22	0.20
Attention	0.05	**0.92**	Fine Motor	−0.03	−0.10	**0.90**
Executive Functions	0.10	**0.90**	Visual-Spatial Processing	0.21	0.17	**0.66**
Fine Motor	*0.47*	0.26	Phonological Processing	0.27	0.27	**0.54**
% common variance explained	72.00	28.00	% common variance explained	69.70	5.70	24.60
Correlations between factors			Correlations between factors			
1	1.00		1	1.00		
2	.78	1.00	2	.35	1.00	
			3	.83	.26	1.00

Note. *n* = 258; bold font designates primary subscale factor loadings ≥ .50; italic font designates secondary subscale factor loadings ≥ .30 and < .50.
[a]Heywood cases.

loadings for all CPPS subscales except Attention and Executive Functions. The first factor is interpreted as representing GPA. The composition of the second factor in the two-factor solution was consistently defined (across all age groups) by high loadings of the Attention and Executive Functions subscales, with secondary moderate loadings for Working Memory, and occasional, salient secondary loadings for Processing Speed. Working Memory's loading on this second factor was only half the size of its loading on the GPA factor.

Table 5. Ages 9 to 10 Exploratory Factor Analysis Solutions.

Maximum likelihood two-factor oblique solution	1	2	Maximum likelihood three-factor oblique solution	1	2	3
Phonological Processing	**1.00**[a]	−0.19	Fluid Reasoning	**1.01**[a]	0.03	−0.17
Oral Language	**0.94**	−0.04	Long-Term Recall	**0.92**	0.13	−0.10
Visual-Spatial Processing	**0.91**	−0.06	Phonological Processing	**0.87**	−0.17	0.18
Fluid Reasoning	**0.85**	0.10	Oral Language	**0.87**	−0.02	0.09
Auditory Processing	**0.83**	0.15	Auditory Processing	**0.78**	0.15	0.07
Long-Term Recall	**0.81**	0.18	Processing Speed	**0.69**	0.14	0.07
Processing Speed	**0.69**	0.15	Working Memory	**0.67**	*0.38*	−0.02
Working Memory	**0.62**	**0.42**	Visual-Spatial Processing	**0.65**	−0.03	*0.41*
Fine Motor	**0.61**	0.06	Attention	0.04	**0.90**	0.06
Attention	0.04	**0.92**	Executive Functions	0.08	**0.88**	0.08
Executive Functions	0.09	**0.90**	Fine Motor	0.08	0.18	**0.76**
% common variance explained	73.00	27.00	% common variance explained	63.60	24.50	11.90
Correlations between factors			Correlations between factors			
1	1.00		1	1.00		
2	.70	1.00	2	.69	1.00	
			3	.56	.29	1.00

Note. n = 258; bold font designates primary subscale factor loadings ≥ .50; italic font designates secondary subscale factor loadings ≥ .30 and < .50.
[a]Heywood cases.

Table 6. Ages 11 to 12 Exploratory Factor Analysis Solutions.

Maximum likelihood two-factor oblique solution	1	2	Maximum likelihood three-factor oblique solution	1	2	3
Phonological Processing	**0.99**	−0.17	Fluid Reasoning	**1.01**[a]	0.02	−0.17
Visual-Spatial Processing	**0.95**	−0.14	Long-Term Recall	**0.96**	0.05	−0.06
Long-Term Recall	**0.86**	0.13	Oral Language	**0.84**	0.05	0.05
Oral Language	**0.85**	0.09	Phonological Processing	**0.82**	−0.15	0.27
Fluid Reasoning	**0.82**	0.14	Processing Speed	**0.79**	0.14	−0.03
Auditory Processing	**0.81**	0.15	Auditory Processing	**0.73**	0.15	0.14
Processing Speed	**0.73**	0.20	Working Memory	**0.67**	*0.37*	0.00
Fine Motor	**0.65**	0.04	Visual-Spatial Processing	**0.66**	−0.08	*0.41*
Working Memory	**0.62**	*0.42*	Attention	0.03	**0.93**	0.07
Attention	0.06	**0.93**	Executive Functions	0.10	**0.87**	0.04
Executive Functions	0.10	**0.90**	Fine Motor	0.09	0.22	**0.73**
% common variance explained	72.40	27.60	% common variance explained	63.40	24.60	12.00
Correlations between factors			Correlations between factors			
1	1.00		1	1.00		
2	.71	1.00	2	.72	1.00	
			3	.56	.27	1.00

Note. n = 258; bold font designates primary subscale factor loadings ≥ .50; italic font designates secondary subscale factor loadings ≥ .30 and < .50.
[a]Heywood cases.

The second factor, which is thought to represent SRP, is defined primarily by the Attention and Executive Functions subscales. The binding of the Attention subscale with the Executive Functions subscale was expected, given that self-regulation, a primary characteristic of executive functioning (McCloskey, Perkins, & Van Divner, 2009), underlies all of the observable behaviors expressed by the Attention items. The high correlations that both subscales have with the BRIEF (see Table 7) provide additional external validity support for the interpretation of this factor.

Table 7. Pearson Correlations Between CPPS Subscales and BRIEF Scales.

	Brief Scales										
CPSS Scales	Inhib.	Shift	Emot. Cont.	BRI	Init.	Work Mem.	Plan/Org.	Org. Mats.	Mon.	MI	GEC
AT	.69**	.45**	.57**	.61**	.76**	.81**	.83**	.81**	.67**	.83**	.85**
AP	.27	.09	.18	.15	.67**	.54**	.50**	.42*	.46**	.57**	.49**
EF	.71**	.48**	.58**	.61**	.80**	.81**	.85**	.77**	.71**	.85**	.86**
FM	.37*	.30	.42*	.32	.67**	.57**	.59**	.52**	.58**	.63**	.59**
FR	.29	.11	.10	.16	.71**	.59**	.58**	.40*	.56**	.63**	.52**
LTR	.33	.19	.22	.27	.77**	.65**	.64**	.50**	.56**	.70**	.60**
OL	.19	.06	.04	.06	.53**	.37*	.40*	.29	.39*	.44*	.36*
PP	.20	.09	.04	.08	.61**	.46**	.49**	.36*	.46**	.51**	.43*
PS	.28	.36*	.22	.28	.74**	.67**	.63**	.56**	.54**	.70**	.60**
VSP	.24	.26	.17	.17	.69**	.54**	.56**	.41*	.50**	.59**	.51**
WM	.53**	.35*	.39*	.39*	.86**	.81**	.81**	.69**	.71**	.84**	.78**
GPA	.41*	.28	.30	.31	.82**	.71**	.72**	.59**	.63**	.76**	.68**

Note. Correlations are between *T*-scores. Emot. Cont. = Emotional Control; BRI = Behavioral Regulation Index; Inhib. = Inhibit; Init. = Initiate; Work Mem. = Working Memory; Plan/Org. = Plan/Organize; Org. Mats. = Organization of Materials; Mon. = Monitor; MI = Metacognition Index; GEC = Global Executive Composite; AT= Attention; AP = Auditory Processing; EF = Executive Functions; FM = Fine Motor; FR = Fluid Reasoning; LTR = Long-Term Recall; OL = Oral Language; PP = Phonological Processing; PS = Processing Speed; VSP = Visual-Spatial Processing; WM = Working Memory; GPA = General Processing Ability.
*Significant at < .05. **Significant at < .01.

In all age groups except the 7- to 8-year group, a third minor factor was suggested that was consistently defined by the Fine Motor subscale. Across all three-factor solutions, the Visual-Spatial subscale often displayed a salient factor loading on this third factor. These results suggest that a visual-motor processing (VMP) dimension might be present when the Fine Motor and Visual-Spatial subscale scores group together and are discrepant from the subscales comprising the GPA and SRP factors.

When the three-factor solutions are considered, there is evidence for the three major factors of GPA, SRP, and VMP. However, there are some developmental exceptions (see Tables 3-6). (a) An interpretable three-factor solution emerged in all age groups except 7 to 8 years, where only two-factor solutions were interpretable (either GPA and SRP or GPA and VMP). In the three-factor solution at ages 7 to 8 years, the second factor (SRP) was considered an uninterpretable factor. (b) Whenever the SRP factor is clearly present, the Working Memory subscale has a significant secondary SRP factor loading. Its most significant loading is at ages 9 to 10. (c) With a three-factor solution, VMP always appears, but the association of Fine Motor with Visual-Spatial is stronger for the two younger age groups than for the two older groups. This most likely reflects age-related truncation of the Fine Motor subscale at the older age groups.

External Validity Support for the SRP Factor

The results of the correlation analyses based on the BRIEF and CPPS *T*-scores are reported in Table 7. The CPPS Attention, Executive Functions, and Working Memory subscales have the strongest relations with the BRIEF scales. Each of these three CPPS subscales has a significant correlation with every BRIEF scale and composite score. The CPPS Attention and Executive Functions subscales, which comprise the CPPS SRP factor, appear to be measuring similar behaviors and constructs as the BRIEF, as evidenced by correlations consistently ranging from .45 to .86, with most at .70 or above (see Table 7). There are also consistent significant relations between the remaining CPPS subscales and the BRIEF Metacognition Index. These other CPPS subscales do not correlate as strongly with behavioral and emotional control functions as reflected by the BRIEF scales in these domains, but they do have strong relations with all of the self-management and problem-solving functions included in the Metacognition Index. The only CPPS subscale that does not demonstrate consistently moderate to high correlations with the BRIEF metacognitive scales is the Oral Language subscale.

Relations Between CPPS Subscales and a Performance-Based Measure

The cognitive abilities assessed by the WJ III COG include a range of broad and narrow cognitive abilities, many of which correspond to the cognitive processes assessed by the CPPS. For example, both scales purport to measure fluid reasoning, working memory, and auditory processing. While these cognitive and processing abilities are assessed through performance-based procedures with the WJ III COG, they are evaluated indirectly through teacher ratings with the CPPS.

The CPPS/WJ III COG correlations are based on the respective scales age-partialled residual scores. The correlation coefficients between pairings of *W*-scores are reported in Table 8. Some of the notable findings include the following:

1. The pattern of CPPS correlations with the WJ III COG General Intellectual Ability (GIA-Extended) score is consistent with the fact that the GIA is a weighted score, with CHC factors that load higher on general intelligence (*g*) receiving higher weightings. For example, the CPPS Fluid Reasoning and Oral Language subscales have the highest correlations with GIA, consistent with the high loadings that the WJ III Fluid Reasoning and Verbal Ability clusters have on the WJ III GIA factor (Woodcock et al., 2001).
2. The eight CPPS subscales with the highest loadings on the CPPS general factor (see Table 2) have statistically significant correlations with the WJ III COG Verbal Ability cluster. Whereas, the three subscales with the lowest loadings on the CPPS general factor (Attention, Fine Motor, and Executive Functions) are not significantly related with the WJ III Verbal Ability factor.
3. All of the CPPS subscales have strong relations with Cognitive Fluency, defined as the ability to quickly and fluently perform simple to complex cognitive tasks.
4. The CPPS subscales and WJ III Clusters that measure what are thought to be the same constructs and that display statistically significant coefficients are as follows (see Table 8): Auditory Processing with Auditory Processing, Executive Functions with Broad Attention, Fluid Reasoning with Fluid Reasoning, Long-Term Recall with Rapid Picture Naming, Oral Language with Verbal Ability, Phonological Processing with Auditory Processing and Phonemic Awareness, Visual-Spatial Processing with Visual-Spatial Thinking, Working Memory with Short-Term Memory, and GPA with GIA-Extended. These correlations provide convergent validity evidence for the CPPS.
5. The CPPS subscale and WJ III Clusters that are thought to measure similar constructs and that do not have corresponding statistically significant coefficients are as follows: Attention with Broad Attention, Executive Functions with Pair Cancellation, Long-Term Recall with Long-Term Retrieval, Processing Speed with Processing Speed, and Working Memory with Working Memory.
6. The lack of relations between constructs that are not theoretically related, known as *discriminant validity evidence*, can also be gleaned from Table 8. CPPS and WJ III COG pairings that are not significantly related include the following: Auditory Processing with Fluid Reasoning, Processing Speed, and Pair Cancellation; Executive Functions with Auditory Processing and Phonemic Awareness; Fine Motor with GIA-Extended, Verbal Ability, Thinking Ability, Fluid Reasoning, Phonemic Awareness, Working Memory, and Visual-Auditory Learning-Delayed Recall; Long-Term Recall with Processing Speed and Pair Cancellation; Oral Language with Visual-Spatial Thinking and Pair Cancellation; and Phonological Processing with Processing Speed and Pair Cancellation.
7. The WJ III COG score with the fewest significant correlations is Visual-Auditory Learning-Delayed Recall. Only the CPPS Oral Language subscale has a significant correlation with this WJ III COG test.
8. Of all the CPPS subscales, Fluid Reasoning and Oral Language have more statistically significant relations (13 each) with WJ III COG clusters and tests than any other CPPS subscales.
9. Of all the CPPS subscales, the Attention subscale has the fewest statistically significant relations (only 4) with WJ III COG clusters and tests.

Discussion

The results of the PCA reveal that an underlying general factor accounts for the majority of variance (75%-86% depending on age level; see Table 2) in the CPPS 11 subscales. Fine Motor is the only subscale with just a moderate loading on this general factor, probably because fine motor abilities are less cognitive. The finding of strong positive intercorrelations across the 11 subscales (see Table 1) is similar to the positive manifold found on performance-based, cognitive measures (Floyd, Reynolds, Farmer, & Kranzler, 2013). The emergence of a strong general factor indicates that a general mental ability underlies individual differences on the cognitive processes tapped by the CPPS.

Like psychometric *g*, the nature of this latent factor is unclear, but given the processing focus of the CPPS, it is thought to represent GPA. The CPPS GPA does not seem to be exactly the same construct as *g*, given that it has only a modest correlation of .51 (see Table 8) with the GIA score on the WJ III COG. (GIA is an established measure of *g*; see Woodcock et al., 2001.) Perhaps, part of the differentiation between GPA and *g* can be attributed to the inclusion of more executive processing components in the CPPS than are found on most intellectual or cognitive instruments. The other hypothesis is that classroom learning behaviors may draw from a different type of general psychological ability.

High subscale specificity on the CPPS was not expected because there is not a one-to-one correspondence between a specific psychological process and a learning task or

Table 8. Pearson Correlation Coefficients Between CPPS and WJ III COG *W*-Scores.

	WJ III COG clusters																	
CPPS subscales	GIA EXT	VER	THK	COG EFF	CMP KNW	LT RET	VST	AUD	FLD REA	PRO SPD	STM	PHO AW	WM	BRD ATT	COG FLU	VAL DR	RPN	PR CAN
AP	**−.36**	**−.45**	.00	−.27	**−.52**	.01	**−.42**	**−.52**	.09	−.12	−.31	**−.44**	−.06	−.13	**−.65**	−.04	**−.76**	−.22
AT	**−.42**	−.29	−.19	**−.33**	−.32	−.08	.04	−.22	−.23	−.29	−.29	−.15	−.27	−.30	**−.51**	−.12	**−.44**	−.04
EF	**−.43**	−.23	−.26	**−.39**	−.26	−.18	−.13	−.02	−.28	**−.46**	**−.33**	.06	**−.40**	**−.48**	**−.37**	−.31	−.23	−.13
FM	−.33	−.31	.03	−.31	**−.47**	**−.14**	**−.47**	**−.44**	.18	−.24	**−.32**	−.28	−.15	−.29	**−.65**	−.18	**−.74**	**−.47**
FR	**−.68**	**−.51**	**−.48**	**−.42**	**−.55**	**−.43**	−.26	−.31	**−.40**	**−.35**	**−.42**	−.26	**−.41**	**−.47**	**−.55**	−.32	**−.44**	−.22
LTR	−.16	**−.46**	.13	−.10	**−.52**	.12	**−.47**	**−.50**	.27	.00	−.12	**−.44**	.10	.07	**−.61**	−.04	**−.80**	−.12
OL	**−.61**	**−.42**	**−.50**	**−.40**	**−.42**	**−.39**	−.12	−.21	**−.44**	**−.37**	**−.35**	−.21	**−.37**	**−.42**	**−.49**	**−.33**	−.28	−.18
PP	−.27	**−.52**	.13	−.30	**−.55**	.08	**−.58**	**−.62**	.33	−.10	**−.32**	**−.58**	.01	−.01	**−.69**	−.08	**−.88**	−.31
PS	−.28	**−.55**	.07	−.28	**−.62**	.07	**−.57**	**−.64**	.30	−.16	−.28	**−.59**	−.08	−.11	**−.67**	−.06	**−.82**	−.27
VSP	**−.46**	**−.45**	.00	**−.39**	**−.59**	−.11	**−.41**	**−.45**	.08	−.26	**−.42**	**−.35**	−.25	**−.38**	**−.59**	−.14	**−.71**	**−.42**
WM	**−.51**	**−.43**	−.27	**−.37**	**−.47**	−.21	−.22	**−.34**	−.20	**−.33**	**−.33**	−.27	−.29	**−.37**	**−.62**	−.24	**−.55**	−.19
GPA	**−.51**	**−.52**	−.14	**−.39**	**−.59**	−.13	**−.41**	**−.49**	−.04	−.29	**−.39**	**−.41**	−.23	−.31	**−.71**	−.21	**−.74**	−.28

Note: Bolded coefficients have a *p* value of less than .05. AP = Auditory Processing; AT = Attention; EF = Executive Functions; FM = Fine Motor; FR = Fluid Reasoning; LTR = Long-Term Recall; OL = Oral Language; PP = Phonological Processing; PS = Processing Speed; VSP = Visual-Spatial Processing; WM = Working Memory; GPA = General Processing Ability; GIA EXT = General Intellectual Ability (Extended); VER = Verbal Ability; THK = Thinking Ability; COG EFF = Cognitive Efficiency; CMP KNW = Comprehension-Knowledge; LT RET = Long-Term Retrieval; VST = Visual-Spatial Thinking; AUD = Auditory Processing; FLD REA = Fluid Reasoning; PRO SPD = Processing Speed; STM = Short-Term Memory; PHO AW = Phonemic Awareness; WM = Working Memory; BRD ATT = Broad Attention; COG FLU = Cognitive Fluency; VAL DR = Visual-Auditory Learning-Delayed Recall; RPN = Rapid Picture Naming; PR CAN = Pair Cancellation.

behavior. Completion of a performance-based, cognitive task typically requires several processes functioning in an integrated fashion. Similarly, completing ostensibly different learning tasks seems to depend on clusters of cognitive processes working in unison (Dehn, 2014). For example, reading comprehension and written language both place demands on executive functions, working memory, and processing speed. Apparently, the observed behaviors rated by teachers on the CPPS are the manifestation of several cognitive processes working together.

The results of the exploratory factor analysis indicate that the CPPS measures three meaningful, interrelated factors. After the primary factor (GPA), there is evidence for a second factor that is mainly comprised of the Executive Functions, Attention, and Working Memory subscales. This factor was named SRP because it seems to be primarily measuring the self-regulatory aspects of metacognition, such as self-monitoring and inhibition, that are involved in cognition and learning. The separation of the SRP factor from GPA is consistent with the theoretical division between cognitive processes and the executive functions that direct and manage these cognitive processes.

The high correlations that the CPPS Executive Functions, Attention, and Working Memory subscales have with the BRIEF factors and subscales provide external validity support for the SRP factor. Although the BRIEF is more of a multidimensional measure of executive functions, the CPPS SRP factor seems to measure the essence of executive functions. The CPPS SRP subscales appear to adequately sample all aspects of executive functioning included in the BRIEF (see Table 7). Thus, the CPPS could be used as a screener of executive functions, followed by the more in-depth BRIEF or similar broad executive functions rating scale whenever the CPPS produces clinically significant scores on the SRP subscales.

The CPPS Working Memory subscale aligns with both the cognitive GPA factor and the metacognitive SRP factor (see Tables 3-6). This dual alignment is consistent with Baddeley's division of working memory into executive and lower level (short-term storage) cognitive components. Apparently, working memory is both a core cognitive process and an executive function. On performance-based measures, working memory predicts a large portion of the variance in *g* (Giofre, Mammarella, & Cornoldi, 2013). When the CPPS rating scale is used for assessment, working memory displays the same relationship. Of all the CPPS subscales, Working Memory has the highest median loading (.95) on GPA. Nonetheless, it has moderate loadings (.3-.4) on the SRP factor. Evidence of the Working Memory subscale's strong connections with other executive functions can also be found in its relations with the BRIEF scores (see Table 7). Furthermore, the correlational data in Table 1 are consistent with research (reviewed in Dehn, 2008) that has identified the strong relations working memory has with the cognitive abilities of fluid reasoning, long-term recall, and processing speed.

When a three-factor solution was attempted, evidence for a Fine Motor factor was discovered with three of the four age groups (see Tables 3-6). The Fine Motor subscale probably demonstrates independence because motor abilities and skills can be separated from cognitive and metacognitive abilities. With the two younger age groups, Visual-Spatial Processing pairs with Fine Motor to form a factor that represents VMP.

Regarding the CPPS subscale associations with performance-based factors and tests, the majority of CPPS subscales have significant correlations and shared variance with corresponding WJ III COG tests (see Table 8). Interestingly, the eight CPPS subscales that comprise the GPA factor have high correlations with the WJ III COG Verbal Ability (crystallized intelligence) cluster, whereas the non-GPA subtests are not significantly related with Verbal Ability. This indicates that cognitive processes have strong relations with crystallized intelligence, but executive functions, attention, and fine motor processes do not. The fact that the CPPS Working Memory subscale does not correlate significantly with the WJ III COG Working Memory cluster should not be a cause for concern because the CPPS Working Memory subscale does correlate significantly with the WJ III COG Short-Term Memory cluster (short-term memory is part of working memory). This alignment is consistent with the CPPS Working Memory subscale being more of a cognitive than an executive measure (discussed previously).

Conclusion

Regarding the first research question, the latent structure of the CPPS is similar to direct cognitive ability measures in that a general factor accounts for most of the scale's variance. However, given the GPA's only moderate correlation with the WJ III COG GIA, the CPPS GPA and psychometric *g* do not appear to be the exactly the same construct. Nonetheless, the GPA score might be interpreted as a measure of general mental processing ability, with an emphasis on processing efficiency. Although they primarily tap a general latent factor, the 11 CPPS processing subscales should be separable, at least to some extent, in a clinical meaningful way.

A unique aspect of the CPPS compared with direct cognitive ability measures is the emergence of executive processes as a second-order factor. Performance-based scales typically identify secondary factors such as fluid reasoning, rather than an executive functions factor. However, this may occur because cognitive ability scales seldom attempt to measure executive processes. Because there are very few scales designed to measure both cognitive and metacognitive processes, the discovery of both a GPA and a self-regulatory factor in the CPPS is an important finding.

In regards to the second research question, most CPPS subscales appear to have moderate relations with corresponding WJ III COG tests. The findings provide some support for the claim that the CPPS is a valid measure of cognitive processes and abilities. In addition, the pattern of correlations between the two scales adds to the factor-analytic evidence that the CPPS discriminates well between cognitive and metacognitive (executive) processes.

Regarding the third research question, there is internal and external validity support for a CPPS executive processing factor. This second-order factor consists primarily of the Executive Functions, Attention, and Working Memory subscales. Although working memory is typically considered an executive process, on the CPPS working memory aligns much more strongly with GPA than it does with SRP. Consequently, Working Memory on the CPPS is thought to tap cognitive more than metacognitive (executive) processes.

The current findings have implications for using the CPPS, which is an observer-based rating scale that reflects behavioral difficulties of children with cognitive and metacognitive processing weaknesses. The CPPS' reliance on rating scale methodology offers the advantage of ecological validity because it captures mental processing in the classroom without the confounds introduced by standardized, structured procedures. The CPPS may also identify manifestations of underlying cognitive and metacognitive processing weaknesses more efficiently than direct, performance-based testing. Because the CPPS appears to be measuring similar constructs, its results may provide guidance regarding which potentially weak psychological processes should be assessed through direct, performance-based testing.

Limitations

There are a few limitations with the current investigation. First, a larger *n* would have enhanced the concurrent validity studies with the BRIEF and WJ III COG. Second, all of the samples should have included a higher percentage of participants with ADHD. Third, confirmatory factor analysis should have followed exploratory factor analysis. Fourth, a sample other than the CPPS standardization sample might have been used for the factor-analytic studies.

Future Research

Future investigations related to the research questions in this study should further explore these issues: (a) the relations between psychometric *g* and the general factor in cognitive and metacognitive (executive) rating scales, (b) the relations working memory has with both cognitive functions and executive functions, (c) the relations CPPS subscales have with other performance-based cognitive and metacognitive scales, (d) how well the CPPS predicts academic achievement, and (e) the factor structure of the CPPS using confirmatory factor analysis with a nonstandardization sample.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Dr. Dehn is the author of the Children's Psychological Processes Scale (CPPS), and he is also the co-owner of Schoolhouse Educational Services, the publisher of the CPPS.

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