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# Multidimensional Scaling of the Cognitive Assessment System-Second Edition: Implications for the Structural Validity of PASS Theory and Its Application in School Psychology

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## ABSTRACT

This study applied multidimensional scaling (MDS) to the Cognitive Assessment System-Second Edition (CAS2) to investigate the structural validity of PASS theory (Planning, Attention, Simultaneous, Successive) across two age groups (5–7, 8–18 years) in the normative sample ($N = 1342$). MDS is a statistical technique that creates a visual map showing similarities and differences between objects in a visual array of the distances between them. Accordingly, MDS offered a spatial representation of subtest relationships, revealing near-perfect model fit for both groups. Results indicated some clustering of Planning and Attention measures, partially supporting prior findings that these constructs may be psychometrically fused. Expressive Attention displayed atypical spatial placement from ages 8 to 18, suggesting factorial complexity beyond those linkages. A radex-like structure emerged, with cognitively complex tasks centrally located and more differentiated configurations observed in older participants, consistent with the developmental mutualism hypothesis. Findings highlight persistent challenges in cleanly separating PASS processes, with implications for CAS2 interpretation and intervention design. MDS proved a valuable complement to factor analysis, offering nuanced insights into test dimensionality and the ongoing debate over the validity of PASS theory.

The administration and interpretation of cognitive tests remains an important fixture of school psychology training and practice, and a nontrivial portion of the professional literature is devoted to debates on how various measures should be employed and interpreted (Benson et al. 2019). According to Kamphaus et al. (2018), clinical assessment has been marked by a series of four waves where different epistemological assumptions have been debated which has culminated in the current era of the "fourth wave" where contemporary interpretive approaches are informed mainly by theory. From this perspective, our understanding of individual differences is largely based on a psychometric approach which "attempts to measure performance along dimensions which are purported to constitute the psychological domain" (Taylor 1994, 185). In the appraisal of intellectual functioning, the rise of the Cattell–Horn–Carroll theory (CHC; Schneider and McGrew 2018) exemplifies this approach. However, before the formal origination of CHC theory at the turn of the century, instrumentation inspired by alternative theories were popular among practitioners. Most notably Planning, Attention, Simultaneous, and Successive (PASS) theory and the Cognitive Assessment System (CAS; Naglieri and Das 1997a).

## 1 | Origins of PASS Theory and the CAS

The PASS Theory of Intelligence is often cited as providing foundational support for the CAS as well as a host of CAS/

**Summary**

- Results indicate that the CAS2 appears to be more strongly aligned with PASS theory than the previous version of the test based on the alignment produced from multidimensional scaling analyses.
- Planning and Attention measures show overlap, though the strength of those associations appears to differ by age.
- CAS2 measures appear to become more differentiated with age supporting the mutualism hypothesis.

PASS-related clinical guidebooks and intervention materials (e.g., Das 1999; Naglieri and Pickering 2010; Naglieri and Otero 2017). In fact, the origins of PASS theory and its relations to early attempts to validate CAS measures were elaborated in a standalone text several years before the actual publication of the instrument (see Das et al. 1994). The PASS model is rooted in the conceptualization of cortical functioning described by the Soviet neuropsychologist Alexander Luria (1973).[1] Luria proposed that human cognition operates through three distinct yet interconnected brain systems, each contributing to four core psychological processes. These systems, known as functional units, support separate but interdependent components of mental activity: Unit 1 (brainstem and associated structures) regulates arousal and tone; Unit 2 (posterior cortex: occipital, parietal, temporal lobes) receives, processes, and stores sensory information; and Unit 3 (frontal lobes) programs, directs, and verifies behavior. On the CAS, these units are best represented in the form of the four primary scales (Planning, Attention, Simultaneous processing, and Successive processing) which are the focal point of clinical interpretation.

Planning is a neurocognitive ability involving the use of strategies and self-monitoring to guide goal-directed behaviors (Goldberg 2009). Attention is used to selectively focus on a particular stimulus while inhibiting responses to other competing targets. Simultaneous processing involves the integration of stimuli into a gestalt, while Successive processing is used to arrange information in a specific sequence in which each part has a defined order. It should be noted that while the functional units are thought to represent distinct areas of the brain, no cortical region functions in isolation. Further, Naglieri (1997) described that "PASS processes are dynamic in nature, respond to the cultural experiences of the individual, are subject to developmental changes, and form an interrelated (correlated) interdependent system" (p. 250). Consequently, it was suggested at the time of its publication that the primary purpose of the CAS was to afford users with PASS scales designed to cohere with an alternative conceptualization of intelligence which could be used to generate more useful profiles of individual strengths and weaknesses for academic remediation (Naglieri and Das 1997b). Nevertheless, the CAS has been subjected to rigorous research criticism since its inception likely because PASS Theory fundamentally challenges conventional representations of the structure of intelligence (e.g., CHC) underlying most ability measures used by contemporary practitioners. Further complicating the matter is the fact that Luria's theories were largely derived from qualitative clinical observations of patients which researchers (e.g., Spiers 1982) have argued is difficult to capture in the conventional psychometric approach to test validation which has long been used in school psychology.

## 2 | Concerns Regarding the Structural/Theoretical Validity of the CAS

Upon its publication in 1997, initial reviews of the CAS were largely laudatory noting the novelty of the measures, embedded strategy assessments throughout the instrument, potential for reduced bias due to the exclusion of prior knowledge, and the PASS theoretical foundation itself (Nishanimut and Padakannaya 2014). Despite these strengths, questions soon emerged about the fidelity of the measurement model on which the instrument was based. As previously described, the psychometric representation of the PASS model was developed in concert with the CAS and supported by factor analytic evidence reported in the CAS *Interpretive Handbook* (Naglieri and Das 1997b). Specifically, a four-factors model (PASS) was compared to several competing models via confirmatory factor analysis (CFA) with the PASS model cohering with publisher theory and judged to be superior to rival models though it was not disclosed whether the PASS model was correlated or uncorrelated. Further, exploratory factor analysis (EFA) and CFA results did not consistently support the preferred PASS model across the age range, instead seemingly supporting an alternative (PA)SS model at different ages which would render preferred interpretive strategies for the instrument moot. Thus, independent scholars soon raised questions about what the CAS measured and whether PASS theory was viable from a psychometric perspective.

Referencing previous results that raised questions about the structural validity of the PASS model in preliminary versions of the CAS (e.g., Kranzler and Weng 1995) and the failure to explicate a hierarchical model accounting for the influence of general factor of intelligence, Kranzler and Keith (1999) re-analyzed the CAS normative data using CFA. While fit statistics generally supported an oblique four-factors PASS model across different age groups, the authors concluded that a correlated factors model is inherently agnostic and affords no explanation for why latent factors may be correlated. It should be noted that subsequent factor-analytic research affirms the contention that correlated factors models are rarely justified in intelligence test research (Gignac and Kretzschmar 2017). Accordingly, Kranzler and Keith endorsed a hierarchical model with the Planning and Attention factors collapsed ($r = \sim 0.90$) into a third-order Planning/Attention dimension loading directly on a hierarchical *g* factor. Further, they provided alternative explanations for interpreting PASS scores aligning with what eventually became CHC theory. From these results, the authors concluded that the CAS was best explained by an alternative model containing a theoretically inconsistent factor fusing the Planning and Attention dimensions together which would call into question the veracity of PASS theory entirely.

In a spirited rebuttal, Naglieri (1999) noted that Kranzler and Keith seemingly relied on selective interpretation of isolated fit statistics at the expense of others indicating the preferred PASS model was superior (see Lai and Green 2016 for an explanation of why this is potentially problematic). Further, questions were raised about a series of problematic loadings observed in the preferred alternative hierarchical model (i.e., Heywood cases) which would seemingly render it untenable as an explanation for the data. Additionally, a host of other forms of validity evidence were highlighted to support the construct validity of PASS scores. In an equally spirited rejoinder, Keith and Kranzler (1999) supported their original results, correctly asserting that structural validity precludes establishing broader construct validity for PASS scores. That is, factor analytic results provide the statistical rationale for the specification and interpretation of test scores, and without this evidence, the results from other external predictive validity studies remain ambiguous (McGill et al. 2021). However, the issues raised in the rejoinder by Naglieri (1999) were not replicated in subsequent CFA investigations by Kranzler et al. To wit, Kranzler et al. (2000) found evidence supporting the same alternative (PA)SS (i.e., CHC) model in a later CFA investigation featuring a clinical sample which did not did not contain any discernable evidence of model misspecification.

In sum, the broader question of what the original CAS measures is largely left to the eye of the beholder. Disagreements on the matter seem to largely be an issue of theoretical divergence (fourth wave) in which one camp prefers a CHC version of the world as evidenced by a later joint-CFA of the CAS with the WJ-III, suggesting[2] that the CAS should be interpreted predominately from a CHC lens (Keith et al. 2001). Conversely, it also stands to reason that the CAS may be a complexly determined test given the neurocognitive focus of the measures and that utilization of more constrained EFA techniques allowing the data to "speak for itself" (Carroll 1985, 26) may be preferred for adjudicating the issue.

To wit, in one of the few EFAs of the CAS than can be found in the independent literature, Canivez (2011) re-evaluated the normative data using recommended EFA procedures which included the Schmid–Leiman orthogonalization procedure for approximating a hierarchical structure (SL; Schmid and Leiman 1957). Though the results of necessary extraction tests were not reported, if conducted, EFA results generally supported a four-factor PASS structure albeit one that defies simple structure and thus rendered easily distorted in CFA where potential cross-loadings usually default to zero (Asparouhov and Muthén 2009). Canivez noted specifically that the Expressive Attention appeared to be a problematic indicator with equal variance explained by the Planning and Attention factors. Of note, the variance explained by the general factor via the SL procedure was manifestly weaker than estimates obtained from other intelligence tests lending some support to the contention that the CAS can be interpreted at the PASS scale level as designed (i.e., Naglieri 1997).

Further complicating the matter, Naglieri et al. have consistently argued that the CAS/PASS theory does not adhere to a traditional hierarchical conceptualization of intelligence and that approximating presumed PASS abilities according to such a structure distorts the uniqueness of those constructs. For example, Papadopoulos et al. (2025) suggest that CAS/PASS abilities represent evidence of dynamic mutualism. That is, different cognitive abilities (such as vocabulary, reasoning, and memory) develop in a reciprocal and self-reinforcing manner, meaning improvement in one area directly causes growth in another. Thus, instead of a single, innate general intelligence factor driving all abilities, this theory posits that a general intelligence *emerges* as a byproduct of these numerous positive interactions during development (Gignac 2014). If accepted, it would seemingly render the previous factor analytic criticisms moot.

## 3 | CAS2 Development and Validation

The Cognitive Assessment System-Second Edition (CAS2; Naglieri et al. 2014a) represents the first revision of the original version of the measurement instrument since its publication in 1997. Naglieri et al. (2014b) correctly note that "The analysis and interpretation of the results of an entire literature are before the status test's validity can be known with a degree of certainty, making the study of any test's validity an ongoing process" (p. 71). Accordingly, the CAS2 validation plan used feedback from the CAS as a blueprint for how to improve the test. Most notably, "A major effort was made to strengthen the factor structure and improve reliability and validity" (Naglieri et al. 2014b, ix). This core revision goal is not surprising given the unresolved debate about the internal structure of the CAS. To accomplish this goal, alterations were made to item content, length, and administration time for several subtests and Speech Rate was replaced by a Sentence Repetition task.

Information supporting the structural validity of the CAS2 is provided in the Technical Manual and mainly consists of a series of CFAs across four age brackets. Inspection of the fit statistics reported in the Technical Manual indicate that a four factor PASS model generally provided the best fit to the normative data; however, that model was virtually indistinguishable from the alternative (PA)SS model proposed by Kranzler and Keith (1999) at ages 8–10 and none of the models explored at ages 14–18 afforded adequate fit. Further, no results from hierarchical models were reported (as per Canivez 2011), if explored, although the CAS2 yields an omnibus full-scale composite that would imply that very interpretive/theoretical structure (McGill and Dombrowski 2016).

Like the CAS, the CAS2 appears to be a complicated instrument that defies easy identification in terms of what it measures lending support to critics that charge that the instrument fails to align with PASS theory or that PASS theory itself is not a viable explanation for the data (e.g., Kranzler et al. 2000). Unfortunately, few independent structural validity investigations of the CAS2 appear to have been furnished in the professional literature in the years since its publication. Instead, users are left mostly to rely on repatriations of CFA results or theoretical expositions supporting a four (correlated) factors model (PASS) extrapolated from the normative data as per the Technical Manual (e.g., Naglieri and Otero 2024). While a correlated factors model may be preferred for the instrument, it is worth noting that the model was found to be statistically indistinguishable and, in some cases, inferior to alternative hierarchical and bifactor structures featuring only three group-specific factors for the CAS2 in a recent CFA by Papadopoulos et al. (2025). Further, Gignac and Kretzschmar (2017) note that correlated factors models often obscure dimensional complexity in ability measures such as the CAS2 complicating confident clinical interpretation of scores. Accordingly, it remains an open question as to what the CAS2 measures and how that instrument should be interpreted like its predecessor.

## 4 | Structural Validation and Valid Alternatives to Factor Analysis

Despite its advantages (e.g., Greene et al. 2023), it has been argued that relying solely on factor analysis may be problematic and assessment researchers have been encouraged to consider using alternative multivariate techniques that may better disclose relationships among psychological variables (McGrew et al. 2023; Revelle 2024). One multivariate alternative that has been successfully applied to intelligence tests such as the CAS2 (e.g., Meyer and Reynolds 2018) is multidimensional scaling (MDS). MDS is a statistical technique that allows users to visualize correlational relationships in space (i.e., a two-dimensional map) to better ascertain potential structural relationships that may not be easily recovered by conventional factor analysis techniques. Particularly those that are more restrictive (e.g., CFA) and rely on users to specify any parameters that may depart from a preferred simple structure a priori. As an unrestrictive exploratory technique, MDS allows users to discover similarities and differences between objects that can lead to more effective modeling in CFA when the underlying data may depart from the desired simple structure.

MDS is used to represent variables in space with distances corresponding to proximities measured among the variables. These spatial relationships are mapped onto a two-dimensional or three-dimensional plane and visually inspected for theoretical consistency. If indicators that are assumed to measure a common psychological dimension (i.e., Processing Speed) are grouped together in a common space, that dimension may be regarded as a viable construct in the data for further explication. Additional features in the data may also be ascertained. For instance, variables that are located closer to the center of the figure are regarded as more cognitively complex than variables located farther away and radex structures are frequently applied to these data that permit these types of analyses (e.g., Marshalek et al. 1983).[3] Published studies applying MDS to cognitive test scores have been relatively scarce in the school psychology literature and mostly limited to tests ascribing to some variant of CHC Theory (e.g., McGill 2020; Meyer and Reynolds 2018).

## 5 | Purpose of the Current Study

While PASS theory is intuitively appealing, it is largely derived from investigations of the structure of various iterations of the CAS, now in its second edition. While questions remain about the structural validity of the original version of the target measure which would seem to call into question the veracity of PASS theory in general, pertinent investigations on the CAS/CAS2 have relied exclusively on the use of conventional forms of factor analysis (e.g., Canivez 2011; Kranzler and Keith 1999; Papadopoulos et al. 2025). Accordingly, the present study examines whether the application of MDS reveals a pattern of relationships among CAS2 measures, featuring data from the nationally representative normative sample, that cohere with those suggested by PASS theory. This information is important as it undergirds the interpretive strategies that are the bedrock of proposed clinical applications for the instrument (e.g., Georgiou et al. 2021; Otero and Naglieri 2023). It is believed that these results will be instructive for furthering our understanding of the instrument as well as PASS theory and its proposed clinical applications that may very well have relevant international applications, given the instrument and its related remedial instructional program has been adapted for use in eight languages and are widely used in other countries such as Greece (Papadopoulos 2013).

## 6 | Methods

### 6.1 | Participants

Summary data for the current investigation was obtained from participants in the CAS2 norming sample that included 1342 children and adolescents aged 5–18 years. According to the Technical Manual (Naglieri et al. 2014a), this sample was obtained using a stratified proportional sampling plan designed to accord with 2011 US Census estimates. Inspection of the demographic data reported in the Technical Manual reveals that the data for the norming sample was consistent with the US population parameters for age; parental education; gender; and age, race, and region. There were ~100 participants in each of the 11 age groups reported. Note that while such groups are described and specified throughout various sections of the Technical Manual, summary data (e.g., correlation matrices) are only provided for groups aged 5–7 and 8–18 that are the focus of the current study.

### 6.2 | Measurement Instrument

The CAS2 is a norm-referenced measure designed to measure PASS neurocognitive abilities of individuals aged 5–18 years. A conceptual organization of the test and its accompanying scores is outlined in Table 1. The CAS2 consists of 13 subtests that can be combined into an eight-subtest core battery (Planned Codes, Planned Number Matching, Matrices, Verbal–Spatial Relations, Expressive Attention, Number Detection, Word Series, Sentence Repetition [ages 5–7], Sentence Questions [ages 8–18]), or a 12-subtest extended battery (Planned Connections, Figure Memory, Receptive Attention, Visual Digit-Span) featuring an additional subtest for each of the PASS scales. The core subtests combine to yield four PASS-derived scales and an omnibus full scale composite score (FS) which the Technical Manual describes as providing “an index of the overall level of an individual's cognitive functioning” (p. 10).

Although several supplemental composite scores derived from reconfigurations of core and supplemental subtests are provided to users, they do not contribute to PASS measurement and are not featured in CAS2 theoretical/structural models depicted in the Technical Manual and thus are not the focus of this study (Canivez 2025). All subtests are expressed as scaled scores ($M = 10$, $SD = 3$), and all scales and composites are expressed as standard scores ($M = 100$, $SD = 15$). Average reliability coefficients for the PASS scales and FS range from 0.86 to 0.95. Validity evidence is provided in several forms in the CAS2 manual and independent reviews are available (e.g., McGill 2015).

### 6.3 | Data Analyses

Data analyses for the study involved several steps. First, proximity matrices were derived from CAS2 normative sample participants aged 5–18 for the various 12 subtest extended battery configurations using best practice recommendations (e.g., Revelle 2013). This involved extracting and analyzing the correlation matrixes from the Technical Manual for children and adolescents ages 5–7 and 8–18, respectively (Naglieri et al. 2014b).[4] Second, correlation matrices were transformed into proximity matrices using the following formula:

$$\text{Distance}_{ab} = \sqrt{2(1 - r_{ab}}$$

Where $\text{Distance}_{ab}$ and $r_{ab}$ represent the distance between the two variables and the correlation between them, respectively. This transformation allows for a geographic representation of intercorrelations in space in keeping with the law of cosines governing the relationship between both indices (Bailey et al. 2021). The resulting matrices were then subjected to nonmetric MDS[5] analyses using the *MASS* and *Vegan* packages in the R Statistical System (R Developmental Core Team 2025). Finally, Shepard diagrams (Shepard 1962) were constructed to evaluate the overall fit of the models and to determine whether a two-dimensional MDS model yielded an acceptable fit to the data. A Shepard plot is a diagnostic tool that visualizes the relationship between the original dissimilarities in the data and the distances between points in the MDS solution and allows for the calculation of several relevant MDS fit indices which are described below.

**TABLE 1** | Theoretical structure for the cognitive assessment system-second edition (CAS2).

| Scale | Core subtests | Expanded subtests |
|---|---|---|
| Planning | Planned codes | Planned number matching |
| | Planned connections | |
| Attention | Expressive attention | Receptive attention |
| | Number detection | |
| Simultaneous | Matrices | Figure memory |
| | Verbal–spatial relations | |
| Successive | Word series | Visual-digit span |
| | Sentence repetition (5–7) | |
| | Sentence questions (8–18) | |

*Note:* Selected CAS2 subtests can be reorganized to form a variety of supplemental composite scores which are not the focus of the current investigations, as they do not contribute to the PASS conceptual model.

## 7 | Results

Overall model fit for the MDS maps at ages 5–7 and 8–18 was assessed via multiple indices. $R^2$ represents an overall goodness of fit test with values $> 0.90$ indicating good fit. Both $R^2$ values (0.99 and 0.99) for each of the age groups indicated that a two-dimensional model was tenable for the data (Kruskal and Wish 1978). As a result, both Shepard plots demonstrated exceptionally tight clustering indicative of a near-perfect solution. Conceptually STRESS is an index of mismatch between the original distances specified in the proximity matrix and the

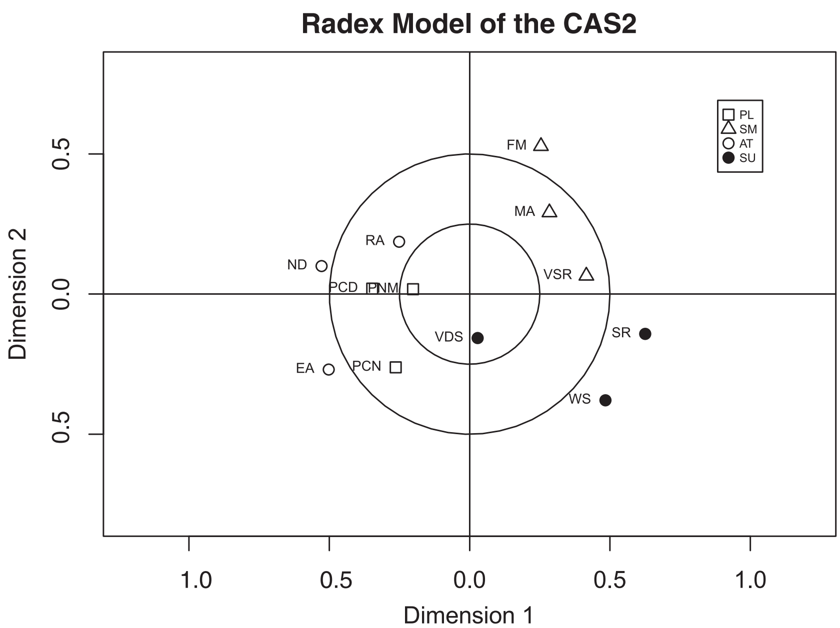


**FIGURE 1** | 2-D Nonmetric MDS map for the CAS2 for ages 5–7. To interpret MDS results, focus on the relative distances between points on the plot, where closer points indicate more similar objects. Also, look for patterns and clusters, which reveal "structure" in the data. AT = attention, EA = expressive attention, FM = figure memory, MA = matrices, ND = number detection, PCD = planned codes, PCN = planned connections, PL = planning, PNM = planned number matching, RA = receptive attention, SM = simultaneous, SR = sentence repetition, SU = successive, VDS = visual-digit span, VSR = verbal–spatial relations, WS = word series.

transformed data and represents the inverse of $R^2$. Given the fact that STRESS levels approached zero, the explication of rival one- and three-dimensional maps was not deemed necessary.

The resulting MDS maps for the 12 subtest extended battery configurations for ages 5–7 and 8–18 are displayed in Figures 1 and 2, respectively. In the two-dimensional nonmetric map for ages 5–7 STRESS was 0.01, with 99% dispersion accounted for. The map for ages 5–7 shows subtests clustered around in a center point, mostly the Planning and Simultaneous subtests. The Sentence Repetition and Word Series subtests appear on the lower right side of the figure furthest out on the periphery, making the map a bit difficult to interpret. A visual inspection of the array indicates that all CAS2 subtests are graphically designed according to their assigned PASS scale, except for Expressive Attention and Planned Connections, which both reside in the lower left quadrant, thus potentially co-mingling the Planning and Attention scales. Interestingly, Visual-Digit Span is located near the center of the radex indicating that it is the most cognitively complex of all the measures (Marshalek et al. 1983). It is the only measure demonstrating this degree of complexity. As in, it appears to be equally aligned with aspects of Planning and Attention.

Another MDS with the extended subtest configuration for ages 8–18 (STRESS = 0.01) is shown in Figure 2. The tests are more dispersed from the center, though mostly located next to their respective CAS2 scales. Similarly, while Simultaneous and Successive measures continue to reside in mostly independent quadrants on the right side of the map, Planning and Attention measures are more co-mingled than at ages 5–7, almost suggesting a fusion (e.g., Keith and Kranzler 1999). Nevertheless, the location of Expressive Attention (Attention) is located independent of that cluster suggesting at the bottom of the left side of the map near the convergence with the right side suggesting that it may contain enough specificity to standalone as a unique entity.

## 8 | Discussion

As surveys continue to indicate that school psychologists spend a disproportionate amount of their time administering and interpreting cognitive tests such as the CAS2 (Hunt et al. 2023), verifying the construct validity of the scores which are the focal point of clinical interpretation for these measures is paramount. Results from the present study suggest that the CAS2 shows stronger alignment with PASS Theory than previous editions of the test, though issues with disentangling Planning and Attention remain. While the present study focuses exclusively on the CAS2, it is worth noting that it can be argued that CASS/PASS theory has done more to usher in the modern era of cognitive profile analysis and strengths and weaknesses approaches to specific learning disability identification (PSW) than any comparable development (McGill, Dombrowski, and Canivez 2018). To wit, the first formal PSW model was articulated in the *Essentials* series accompanying the publication of the CAS, long before that model came to be a staple in school psychology training and practice. While certainly, there are other comparable instruments that have far more market share and clinical use, many practitioners likely employ interpretive practices inspired by the instrument and its accompanying literature. Not surprisingly, CAS/PASS Theory continues to be a featured topic in contemporary conferences and professional development proceedings across the world.

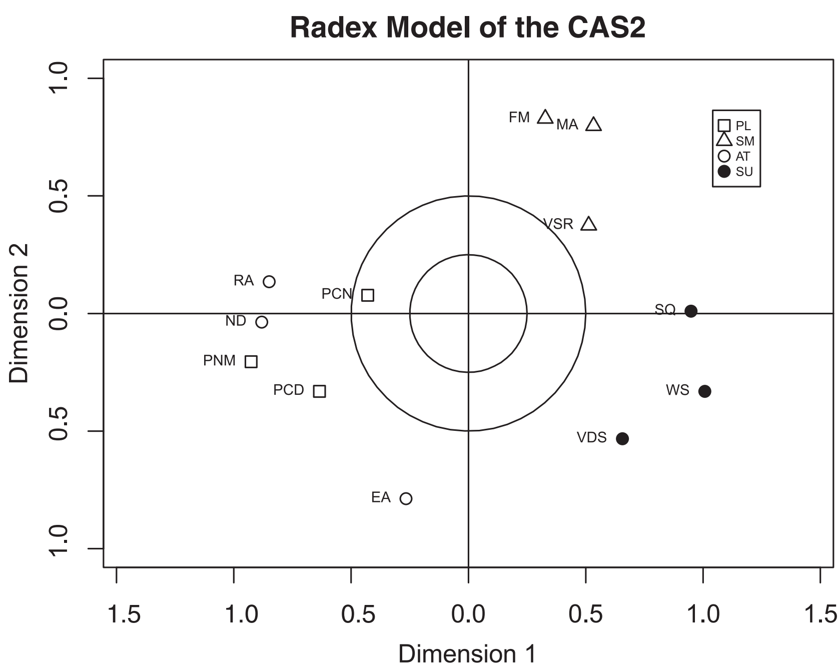


**FIGURE 2** | 2-D Nonmetric MDS map for the CAS2 ages 8–18. To interpret MDS results, focus on the relative distances between points on the plot, where closer points indicate more similar objects. Also, look for patterns and clusters, which reveal "structure" in the data. AT = attention, EA = expressive attention, FM = figure memory, MA = matrices, ND = number detection, PCD = planned codes, PCN = planned connections, PL = planning, PNM = planned number matching, RA = receptive attention, SM = simultaneous, SQ = sentence questions, SU = successive, VDS = visual-digit span, VSR = verbal–spatial relations, WS = word series.

MDS was used as an alternate multivariate procedure for investigating the interrelations among CAS2 scores. Results are interpreted within the context of the radex model and CAS/CAS2 factor analyses. The present study represents the first application of MDS to the CAS2, offering a novel visual representation of the relationships among its subtests across two developmental age groups. The results suggest that a two-dimensional MDS solution provides an exceptionally strong fit for the CAS2 data at both ages 5−7 and 8−18, as indicated by near-perfect $R^2$ values and minimal STRESS indices. These results provide strong evidence that the correlational structure of the CAS2 can be meaningfully represented in a spatial format, which, in turn, allows for an inspection of patterns that may not be readily observable through conventional factor analytic methods or descriptive examination of the correlation matrices provided in the Technical Manual.

Several notable patterns emerged. First, in both age groups, the Planning and Attention subtests were more closely clustered than originally anticipated under PASS theory which coheres with prior independent factor analytic results. This was particularly evident in the older age group, where Planning and Attention measures appeared to co-mingle to the extent that they almost formed a fused cluster. This pattern generally mirrors the findings of Kranzler and Keith (1999), whose CFA work suggested that these two constructs were highly correlated ($r \approx 0.90$) and perhaps best conceptualized as a single higher-order dimension. It should be noted that the latent correlations between Planning and Attention reported in the CAS2 Technical Manual ranged from 0.77 to 0.92 which is not in and of itself indicative of isomorphism per se. Nevertheless, the persistence of this configuration across alternative analytic approaches such as MDS underscores the possibility that the Planning-Attention distinction in PASS theory *may* be psychometrically tenuous. However, prior factor analytic results also contained clear evidence of local mis-fit when explicating a fused higher-order dimension, suggesting that retention of a (PA)SS model is not as straightforward as has been conveyed in the literature.

Despite the general co-location of most subtests in accord with their assigned PASS distinction, Expressive Attention consistently demonstrated a degree of spatial separation from its assigned PASS factor. This finding is important for two reasons. First, it lends credence to earlier observations (e.g., Canivez 2011) that Expressive Attention may function as a cross-loaded or construct-ambiguous measure. However, at ages 8–18 it migrated significantly away from those same measures suggesting that it is likely factorially complex and perhaps even developmentally variant. As Dombrowski et al. (2019) have shown with the WISC-IV, a single problematic indicator with ambiguous alignment can de-stabilize parameter estimates resulting in paradoxical factor analysis results that evade replication. While it remains to be seen whether Expressive Attention is the lone source of CAS/CAS2 interpretive confusion, the present results indicate that CAS2 is a complicated instrument to interpret. Accordingly, this dimensional complexity needs to be accounted for in future restricted CFA analyses in which complex relationships such as these are rarely modeled effectively (Revelle 2024).

## 8.1 | Paradox of Expressive Attention and PASS Theory

It is worth noting that the Expressive Attention test on the CAS2 is essentially a reparameterization of the classic "Stroop" task in which the assessment of visual and verbal interference is considered a measure of behavioral inhibition. While theoretically located in the Attention scale, inhibition is a facet that has also been associated more broadly with executive functioning (i.e., it is a scale provided in most executive functioning rating scales in school psychology). As Naglieri and Otero (2011) freely acknowledge, "the essential dimension of planning as defined by Naglieri and Das (1997b) is very similar to the description of executive functioning provided by others" (p. 323). So, this overlap should not be surprising.

So, should a (PA)SS model be preferred as per Keith and Kranzler (1999)? Not necessarily. It may very well be the case that collapsing Planning and Attention may be overly draconian and it would essentially upend PASS Theory as postulated on the CAS2 entirely as the present results support *some* differentiation of those indicators. Yet, a more compelling case will need to be made that those constructs are separable to the point of assigning interventions linked specifically to those scales in future revisions to the theory and the test given such overlap is well known with respect to conventional neurocognitive measures (Bowden 2017; Lezak et al. 2012).

Clinicians would do well to keep in mind that while CAS/PASS Theory is reported as being Luria-inspired, Luria's greatest contributions to neuropsychology were the qualitative idiographic observations and assessments of patients which helped to reject long-standing localization of brain function doctrine (Ardila 1992). CAS/PASS theory is best represented as an attempt to psychometrically model the functional units previously described which are highly interrelated. Put simply, Expressive Attention may be *the* issue, but it is an issue that complicates the CAS/PASS applications in school psychology until it is fully resolved theoretically and psychometrically.

## 8.2 | Evidence for Dynamic Mutualism?

Additionally, the maps revealed a consistent radex-like structure (Marshalek et al. 1983), with more complex tasks (e.g., Visual Digit Span [ages 5−7]) located centrally, and simpler or more specialized tasks positioned toward the periphery. This supports the notion, long established in cognitive ability research, that task complexity and centrality are closely related, and that subtests may be arranged based on their theoretical alignment as well as their degree of complexity. What both MDS solutions make clear is that there are few CAS2 measures that are centrally located which is not consistent with previous MDS results from other competing measures like the WISC-V which feature most tests closer to the center of the radex (i.e., Meyer and Reynolds 2018). These observations are consistent with the results of a hierarchical EFA of the previous version of the measurement instrument conducted by Canivez (2011) which found that the CAS general factor was manifestly weaker than comparable indices from other tests. While explicit independent hierarchical structural analyses of the instrument are needed, what can be discerned from available CFAs reported in the Technical Manual and elsewhere (e.g., Papadopoulos et al. 2025) is that the CAS2 appears to show a stronger alignment with PASS theory than its predecessor. Though the present results indicate that questions regarding the Planning-Attention distinction remain, suggesting interpretive strategies that focus exclusively on using these scales as markers for individual strengths and weaknesses and linkages for remedial academic and behavioral interventions require additional information to be justified.

Nevertheless, a casual inspection of the maps reveals age effects with CAS2 measures more centrally located at ages 5–7 and evidence of substantially more dispersion in the older group suggesting that the measures show greater uniqueness of differentiation across the age span. As an example. Visual–Spatial Relations and Planned Number Matching migrate from the center of the map at ages 5–7 to the periphery at ages 8–18 suggesting a degrade in cognitive complexity for those measures across the age span. This observation is consistent with the mutualism hypothesis which suggests that the uniqueness of abilities is strengthened over time due to dynamic relationships between different abilities supporting their growth (Gignac 2014). Albeit descriptively. Further, the mutualism hypothesis suggests that it is these beneficial interactions produced from the environment that are responsible for positive manifold and not *g*. While scholars have long posited that there are age dedifferentiation effects associated with cognitive abilities (Breit et al. 2022), adjudication of the mechanism responsible for these effects and the nature of *g* are beyond the scope of the present study as MDS and simple correlated factors CFA models are not designed to explicate a hierarchical general factor whether believed to be present or not in the data. Whereas a radex model may help in terms of supporting visualization of these data, it is no substitute for directly evaluating more complicated latent structures directly particularly when longitudinal conjectures are invoked (Watkins et al. 2023). Accordingly, school psychologists should be wary of any attempts to establish assessment to intervention linkages which, to this point, are advanced on solely a theoretical basis absent empirical falsification (Ramminger and Jacobs 2024).

### 8.3 | Implications for Clinical Practice

These findings carry both theoretical and applied implications. Theoretically, they contribute to the longstanding debate regarding the structural validity of PASS theory as operationalized in the CAS and CAS2. While PASS theory is grounded in a neuropsychological model (Luria 1973) and emphasizes separable cognitive processes the MDS evidence here supports the contention that at least some of these processes; particularly, Planning and Attention appear to be somewhat difficult to disentangle psychometrically which replicates in part concerns originally raised by Keith and Kranzler (1999) which suggested that those scales were indistinguishable from each other on the CAS. While such isomorphism is not as apparent here, there is clearly overlap among the measures indicating that isolating and amplifying those scales for clinical interpretation may not be wholly justified.

Applied implications for practitioners include the need for caution when interpreting scale-level results, especially if using them to guide individualized interventions as suggested in the CAS/PASS literature. If Planning and Attention are not clearly distinct in measurement, profile-based interpretations that assume their independence may be unwarranted. However, it remains unclear whether this overlap is due to shared processes among some of the subtests or is driven by shared variance that is attributable to a common latent dimension (e.g., Planning-Attention factor) that has yet to be satisfactorily explained in previous factor analytic investigations (e.g., Canivez 2011; Kranzler and Keith 1999).

These cautions are especially prescient for the CAS2, given that it is one of the few instruments in which its developers offer a host of intervention materials and remedial programs that are associated with PASS theory in general and the CAS/CAS2 more specifically. First, it is worth noting that this assessment to intervention linkage represents one of the few coherent aptitude by treatment (ATI) research programs of its kind in contemporary assessment practice. By comparison, similar linkages are suggested for other ability measures and competing theories (e.g., CHC; Mascolo et al. 2014) but they are mostly backed by assertions or extrapolations from research summaries (Schneider and Kaufman 2017). While scholars continue to debate the efficacy of this program of ATI research, a recent meta-analysis by McNulty et al. (2024) evaluating outcomes of CAS/PASS-inspired math and reading intervention yielded a moderately positive (0.64) effect size overall indicating that empirical proof of concept for this approach is not entirely wanting. To be clear, this is not an endorsement of this approach but merely an acknowledgment of the existence of information that some clinicians may find more persuasive.

The study also highlights the value of alternative multivariate techniques, such as MDS, for examining test structure, as they help to uncover underlying relationships among variables from a different vantage point. Unlike CFA, which constrains loadings and may obscure cross-loading relationships when they are present, MDS provides a more flexible visual inspection of the correlational landscape. In this case, MDS confirmed certain CFA-derived conclusions (e.g., Planning-Attention overlap) but also revealed nuances such as subtest-specific separations that may inform future test revisions. This methodological complementarity underscores the importance of not relying solely on a single analytic framework in structural validation or broader construct validity research (McGrew et al. 2023).

### 8.4 | Study Limitations

This study is not without limitations that should be considered when interpreting the results. The most important limitation is the use of an archived standardization sample. Although psychometric analyses with these same data provided the evidentiary basis for the interpretive procedures that were recommended to users in the Technical Manual (Naglieri et al. 2014b), additional research to determine if these results are invariant across different clinical samples and/or settings would be instructive for furthering our understanding of relations between CAS2 variables. More specifically, additional EFA/CFA research comparing the rival bifactor and/or hierarchical models featuring the presumed CAS2 first-order structure are needed to fully discern the unique contributions of the PASS scales from possible higher-order dimensions as implied by the provision of the FS composite, particularly given the apparent complexity in some of the measures involved (Reise et al. 2013).

Such analyses were not reported, if conducted, in the Technical Manual and independent investigations of the CAS2 measurement model apart from the present investigation have been noticeably absent since its publication. This is an issue plaguing the development of CAS/PASS theory in general, as a majority of studies furnished to support those assessments to intervention linkages appear to be produced by one or members of the same allegiance network. This is merely an observation that has also been noted for other rival theoretical paradigms (e.g., CHC).

While MDS is useful for visually representing presumed structural relationships at a first-order level, it is not a method which permits the explication of higher-order constructs (e.g., general intelligence). While PASS theory suggests that traditional conceptualizations of *g* are likely misguided, the present MDS results are not instructive for adjudicating that issue. Further complicating the matter, the only factor analytic study conducted to date on the CAS2 normative sample featuring hierarchical and bifactor models found that such models were virtually equivalent to the preferred correlated factors model (see Papadopoulos et al. 2025). While these results as well as prior CAS EFAs (e.g., Canivez 2011) suggest that the manifest influence of a CAS\PASS general factor is likely weaker than traditional conceptualizations of *g*, the existence of such a latent dimension on the instrument would likely temper some of the PASS-derived treatment recommendations that have long pervaded the literature and workshop circuit where such information is discussed.

## 9 | Conclusion

As the ultimate responsibility for appropriate test use and interpretation lies predominantly with the test user (Weiner 1989), clinicians using the CAS2 in clinical evaluations must seriously consider the present and other available information to make informed decisions about which CAS2 scores have satisfactory reliability, validity, and utility. The results from the present study demonstrated both convergence and divergence with the theoretical structure posited in the manual and in subsequent validation studies in the professional literature (e.g., Papadopoulos et al. 2025). This conflicting pattern of results will likely engender continued discussion about the utility of the instrument regardless of the structural improvements associated with the revision. In the end, the present results illustrate well that school psychologists must carefully evaluate the evidence presented, or not, to support laudatory claims, particularly when it involves issues such as aptitude by treatment interactions (a long, controversial topic). Strong claims require strong evidence, and when such claims are linked to a particular theory and/or test, then establishing clear and convincing evidence of construct validity becomes paramount. As always, School psychologists should integrate test results with broader clinical judgment and advocate for local validation of intervention effectiveness rather than sole reliance on cognitive test profiles generated from any test via the use of multi-method, cross-informant assessments in practice.

### Endnotes

[1]The Simultaneous-Successive processing dichotomy was first discussed by Das et al. (1975) and later incorporated as part of the theoretical structure of the original K-ABC (Kaufman and Kaufman 1983). Interestingly, Naglieri was among the cadre of graduate students at the University of Georgia that worked under Alan Kaufman to develop that measure.

[2]There appears to be evidence of local fit violations in some of the models in the form of out of bounds parameter estimates as well disclosed use of constraints to prevent other estimates from being rendered impermissible to arrive at these conclusions which are not regarded as factor-analytic best practice (Brown 2015). Further, it also assumes that the WJ-III measures the hypothesized CHC constructs in question. Independent examinations suggest otherwise (see Dombrowski and Watkins 2013).

[3]Radex refers to the application of centrality measures (e.g., concentric circles) to an MDS solution which permit speculation about the "cognitive complexity" of measures. A typical MDS solution simply features measures in space with no additional visual aids or features. Within the literature, the application of these features is referred to as "Radex modeling" even though it is simply MDS.

[4]Correlation matrices for the normative sample were not included in initial versions of the manual which was subsequently amended.

[5]As an alternative, metric MDS preserves the Euclidean distance between objects and is preferred only when such distances have meaning (e.g., distances between cities on a map).

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