Open Education Studies

Sensorimotor and Cognitive Profile Test: School-entry Profile and Raven Matrices

--Manuscript Draft--

Manuscript Number:	
Full Title:	Sensorimotor and Cognitive Profile Test: School-entry Profile and Raven Matrices
Short Title:	
Article Type:	Research Article
Keywords:	Cognitive Profile; Sensorimotor; Raven Matrices; educational technologies; learning interventions,
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Suggested Reviewers:	
Opposed Reviewers:	

Sensorimotor and Cognitive Profile Test: School-entry Profile and Raven Matrices

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Abstract.

The potential of technology to enhance educational intervention cannot be overstated. Despite the emphasis on considering assessment of sensorimotor aspects together with cognitive aspects, teachers tend to ignore sensorimotor. One of the reasons for teachers to ignore the sensorimotor areas is the lack of comprehensive testing tools that combine the two aspects. As a result, in the present study, we aimed at using the newly developed Sensorimotor and Cognitive Profile Test (SCPT) to create a school profile and test the validity of the tool. We used 1050 children to create the school profile and tested the validity of the tasks from SCPT by correlating its tasks with those from the Raven Matrices.

Results show that SCPT can provide teachers with students' profiles based on their sensorimotor and cognitive characteristics. Also, the tasks from the SCPT correlated strongly with those from the Raven Matrices. Based on this, we argue that the SCPT is a valid tool that teachers can use for assessing the sensorimotor and cognitive abilities of their learners. Therefore, teachers whose schools participated in the project should use the created profile to develop relevant interventions for their learners. Furthermore, we call for educators around the world to use the SCPT for assessing learners.

Keywords: Cognitive Profile, Sensorimotor, Raven Matrices, educational technologies, learning interventions,

1 Introduction

Both sensorimotor and cognitive areas determine the potential abilities of an individual to learn including learning of 21st Century skills such as creativity and communication. Several studies show that poor development in sensorimotor areas interferes with a person's ability to control himself and interact with others(Diamond, 2013; Jorquera-Cabrera et al., 2017; Purpura et al., 2022; Shi & Feng, 2022). On the other hand, Cognitive areas influence memory, attention and reasoning, all of which are learning ingredients and enhance skills such as critical thinking, creativity and communication (Hill et al., 2021; Shi & Feng, 2022; Staff, 2018). Recall, the majority of these skills are highly valued in the 21st Century. According to Reed (2020), oral communication (28 %), written communication (23%), collaboration (22%), and problem-solving (19%) are the highly rated skills in the 21st Century. Consequently, sensorimotor and cognitive profile tests are crucial for determining relevant interventions to support learners to reach their potential learning capabilities to cope with the survival demands in the 21st Century era. As Shi and Feng (2020) encapsulate, "Therefore, studying the cognitive development and enhancement strategies of children and adolescents is not only a prerequisite for their healthy physical and mental but also an important guarantee for building an "Intellectual Superpower"..." These tests are more emphasized to children than adults because children's brains are at a critical age of development (Shi & Feng, 2022). As the adage goes, "The bad beginnings make the bad endings" Therefore, children have become the subject of cognitive and sensorimotor profile tests for learning improvement purposes.

However, traditional profile test practices prioritized cognitive areas while ignoring sensorimotor areas. This has been influenced by the dominance of theories such as the Neural Computational theory of Cognition that viewed cognitive development as independent (Piccinini & Bahar, 2013). Unfortunately, Cognitive profile tests alone may compromise interventions for children to improve their learning abilities because they are less comprehensive. Embodied cognition theory states that mind, body and surroundings are interrelated (Kosmas & Zaphiris, 2018; Krawczyk, 2018; Shapiro & Stolz, 2019; Weisberg & Newcombe, 2017). Staff (2018) argues that the revelation brought by embodied cognition that sensorimotor and cognitive areas share resources proves the significance of considering sensorimotor profiles in supporting children to learn. This is alluded to by Shi and Feng (2022, p.11) who posits, "The relationship between motor skills and brain of children and adolescents provides a new perspective for the reform of the physical education curriculum." Also, Piaget's sensorimotor development stages show how children's interaction with their environment through their senses improves their cognitive development. For instance, the permanence stage indicates how children come to understand the existence of objects that are ought of their sight (Mcleod, 2023; Shapiro & Stolz, 2019), which implies the cognitive role of abstract concepts. Therefore, incorporating sensorimotor profile tests in cognitive profile tests for learning intervention is gaining the attention of researchers.

Studies that have considered sensorimotor profile tests concur with embodied cognition theory. For instance, Shapiro and Stolz (2019) reported two studies (Gerofsky, 2011, and Walkington et al., 2014)) that noted the influence of gesture in solving mathematics problems among college and grade 8 and 11 students. In addition, Bartoli et al. (n.d) observed identical twins who were presented with visual-motor tasks and noted that these twins were getting better in the visual-motor task with increasing age. Furthermore, Hill et al., (2023) examined the sensorimotor and cognitive abilities of children aged 7 -10 years. They noted that sensorimotor aspects (tracking, aiming and steering) and cognitive aspects (forward and backward digit recall, inhibition control

and speed processing) were related and both correlated positively to age factor. Thus, the significance of incorporating sensorimotor profile tests in cognitive profile tests for learning intervention.
Despite the potential of sensorimotor profile tests to transform our interventional practices, schools have rarely embraced them. This could be influenced by a lack of comprehensive profile testing tools (that combine sensorimotor and cognitive tests) and/or a lack of confidence in the newly developed tools for cognitive and sensorimotor profile tests. Kosmas and Zaphiris (2018) argue that changes in education practices to comply with the Embodied Cognition framework will be possible only if there is technological innovation and evidence to support the theoretical framework. As a result, in the present study, we present the school profile we created using the online version of the Cognitive and Sensorimotor Profile Test (CSPT) tool. Also, we examine the correlation of the results from CSPT with Raven Matrices to establish the validity and reliability of the CSPT tool that we used. We believe that the findings from this study will motivate educators to consider the sensorimotor profile tests and convince them to use the CSPT.

2. Methodology

2.1 Study Context

The study was conducted in public schools in Hungary involving school teachers and school children who were in the first grade by the year 2022.

2.2 Sample and Sampling Techniques

We selected 52 schools from the area of the Diocese of Vác. Thus, small villages, small towns and big cities, as well as schools in Budapest participated in the research. The selected schools are run by the state, churches or some foundations. The main selection aspect was the school's intention to participate. Teachers, who had a first-grade class, were instructed by the school management to participate in the research. This procedure was our intentional goal to create a natural situation where teachers are not necessarily committed to the use of new methods. The study involved 1050 children from the first grade in all the schools that were involved in the study. The age of students who were involved in the study ranged from 5 to 10 as shown in the Table 1, but practically the main range of age is from 6 to 8. Although the number of children in the schools were more than the ones we included in the study, we could

only work with students who were available at schools during the study project. Thus, convenience sampling technique was employed.
Furthermore, teachers who participated in the study were only those who taught in the relevant grade from the participating schools. Therefore, we used a purposive sampling technique to select teachers because the main criterion was to be a teacher for the first grades in the participating schools. Based on this criterion 95 teachers participated in the present study because not all the classes had two teachers due to the lack of teachers in Hungary.

Table 1
The age of students involved in the study

Age	5	6	7	8	9	10	Sum
Number of children	1	387	606	43	12	1	1050
%	0,10	36,86	57,71	4,10	1,14	0,10	100,00

2.3 Testing Procedures

The test for both sensorimotor and cognitive abilities was conducted by teachers in their relevant schools using the online version of the tool. Before teachers conducted the test, they were trained on how to administer the test, and what is the tester's attitude during the testing. Having satisfied with the acquired knowledge of using the tool, we allowed them to proceed with the testing exercise. This testing exercise took place within schools from September to November 2022. Although the tool allows students to be tested anywhere (at school and home), we opted to conduct the test at school to avoid any differences in the circumstances.
Both sensorimotor and cognitive areas were tested using various tasks as shown in the following sub-sections.

2.3. Cognitive and Sensorimotor Testing

Cognitive tasks measure auditory memory, working memory, speech sound differentiation, speech comprehension, abstract thinking, and sensing quantities. The tool provides tasks that can assess various sensorimotor areas namely sequential processing, body schema, spatial orientation, balance, and visuomotor speed. The tasks take 2x45 minutes or less to be completed. However, it is not obligatory to complete all the tasks. In this sense, the teacher can decide how long children should take to work on a certain task.

In this study, we focused on the areas that are highly relevant at the beginning of the first grade. Namely sensorimotor tasks (Spatial sequence, Time sequence, Language sequence, finding animals in order, Identification of body parts, Identification of fingers, balancing on one leg, knocking – with the left hand with the right hand, and alternately, Eye movement control), and measures of cognitive development (Digit Span, Digit Span backwards, Speech comprehension, Speech sound differentiation, Figures, Comparison of quantities) as illustrated in Figure 1.

Mod	Name of the test	Description of the task	Test indicators	Measured area
Sensorimotor development				
sequential processing	Spatial sequence	Subjects build according to a pattern from squares and rectangles.	number of correct answers	spatial sequential processing
	Time sequence	Subjects arrange jumbled pictures according to the order in which the events occurred.	number of correct answers	temporal sequential processing
	Language sequence	Subjects point to pictures starting with the letter 'sh' have to be identified.	number of correct answers	phonological awareness
	Finding animals in order	Subject click on windows of a house in the order in which animals appeared beforehand.	number of correct answers	spatial temporal processing
body schema, spatial orientation	Identification of body parts	Subjects point given body parts on a girl's picture, and a boy's face.	number of correct answers	body schema
	Identification of fingers	Subjects touch the fingers of the hand seen on the screen with their corresponding finger.	number of correct answers	finger awareness
balance	Balance - open - right	Subjects balance on right leg with eyes open.	time in secundum	sensorimotor integration
	Balance - open - left	Subjects balance on left leg with eyes open.	time in secundum	sensorimotor integration
	Balance - closed - right	Subjects balance on right leg with eyes closed.	time in secundum	sensorimotor integration
	Balance - closed - left	Subjects balance on left leg with eyes closed.	time in secundum	sensorimotor integration
visuomotor speed	Knocking - left	Subjects knock on a sign as fast as possible using left hand finger.	number of knocking	visuomotor speed
	Knocking - right	Subjects knock on a sign as fast as possible using right hand finger.	number of knocking	visuomotor speed
	Knocking - alternate	Subjects knock on a sign as fast as possible using alternately the hands.	number of knocking	visuomotor speed
	Eye movement control	Subjects have to find the pigs among 45 different animals arranged in rows, and columns	time in secundum	visuomotor efficiency
Cognitive development				
auditory	Digit Span	Increasing number sequencies has to be repeated.	number of correct sequences	auditory memory
	Digit Span backward	Increasing number sequencies has to be repeated backwards.	number of correct sequences	efficiency of working memory
verbal	Speech comprehension	Subjects hear sentences and have to find which of three pictures the given sentence is about	number of correct answers	speech comprehension
	Speech sound differentiation	Subjects hear two words and they have to judge whether they are the same or different.	number of correct answers	speech sound discrimination
visual	Figures	A piece of series of figures is missing. Subjects choose from four figures the [illegible]	number of correct answers	figural abstraction
	Comparison of quantities	Subjects decide which quantity is more or same. Some tasks are given visually some verbally.	number of correct answers	sense of quantity
Mod	Name of the test	Description of the task	Test indicators	Measured area

Figure 1: Sensorimotor and cognitive areas measured and their indicators

2.4. Raven Matrices Testing

Children participating in the research were administered the Coloured Raven Matrices Test by their teachers. During the preparation, teachers learned the traditional way of taking this test, but the data were collected through the online interface designed for this purpose.

The Coloured Progressive Matrices (Raven, Court, and Raven, 1995) are widely used to measure non-verbal intelligence and are one of the best general intelligence tests that give an overall score. In such a scoring system, one point is assigned to each correct item, no matter what kind of cognitive process the item contains. Accordingly, the correct answers are derived from a single factor, which is Spearman's general intelligence. Though new research, such as Smirni (2020), suggests that Raven’s tasks focus on several cognitive areas, in our research, we use the Raven Matrices to measure the traditional non-verbal intellectual ability to test our other results through a traditional indicator. Here we compare Raven data to our test results and use them in the analysis of our test, and the first graders’ cognitive profile. Later, we will further analyze the results of the Coloured Raven Matrices.

2.5 Data Collection Methods

All data from the Sensorimotor and Cognitive Profile Test, as well as the Coloured Raven Matrices, were collected in the same server through the online interface designed for this research.

2.6 Data Analysis Methods

Data analysis and preparation were performed using open-source Python libraries (most notably, pandas, numpy, statsmodels, seaborn). The initial step involved data preparation, which started with filtering out tests by students outside the desired age range and filtering out retakes of tests, keeping only the first tries for all. All variables were normalized to the 1-5 scale such that 3 stands for all values at most 1 standard deviation away from the mean, 2, and 4, stand for deviations between 1 and 2 standard deviations away from the mean downwards and upwards respectively, and 1 and 5 stand for values that are more than 2 standard deviations lower, respectively higher, than the mean. The distribution of all variables was inspected using histograms, violinplots and boxplots, and Pearson's correlation coefficients were then calculated to measure the strength and direction of the relationship between pairs of variables. Using a combination of exploratory factor analysis and cognitive considerations, a set of variables was chosen as indicators and grouped into five broad and several more specific classes of indicators. Polar charts were compiled using Plotly (https://plotly.com/python/) to visualize different groups', classes' and students' profiles given the selected indicators.

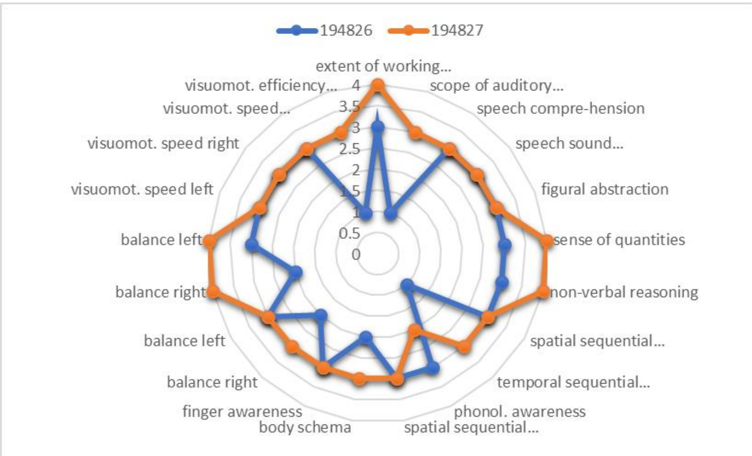
3. Results

The present was guided by two main objectives: to create a school profile and examine the correlation between the results from our test tool and those from Raven Matrices. In this section, we present results based on themes drawn from the two objectives. Thus, we organize the results in two subsections-school profile and correlation between SCPT and Raven Matrices' results.

3.1 The School Profile

Data analysis indicates that the SCPT can provide teachers with students' profiles for sensorimotor and cognitive abilities. For instance, in Figure 2, the profiles of two students are presented in a way that the teacher can access the development level of various aspects related to sensorimotor and cognitive development.

Figure 2 *Illustration of the two students' profiles from the School Profile*



original points	age	test name	Digit Span	Digit Span	Speech compreh	Speech sound	Figural abstracti	Compar. quantitie	Coloured Raven	Spatial sequence	Time sequence	Language sequence	Finding animals	Identif. of body	Identif. of fingers	Balance open	Balance open	Balance- closed	Balance open	Knocking left hand	Knocking right	Knocking alternate	Eye moveme
	6	**194826**	1	0	5	18	10	3	19	9	6	4	3.56	4	7	5	50	4	6	44	42	27	131
	7	**194827**	4	3	5	19	7	4	28	12	23	1	4.21	5	10	55	31	21	22	34	37	33	33
Categories	age	Ability area	extent of working memory	scope of auditory memory	speech compre- hension	speech sound discriminat ion	figural abstractio n	sense of quantities	non-verbal reasoning	spatial sequential processing	temporal sequential processing	phonol. awareness	spatial sequential processi	body schema	finger awareness	balance right	balance left	balance right	balance left	visuomot. speed left	visuomot. speed right	visuomot. speed alternate	visuomot. efficiency direction
	6	**194826**	3	1	3	3	3	3	3	3	1	3	3	2	3	2	3	2	3	3	3	3	1
	7	**194827**	4	3	3	3	3	4	4	3	3	2	3	3	3	3	3	4	4	3	3	3	3

Source: (Author, 2023)

*3.2 **The Correlation between the SCPT's and Raven Matrices' Results***

Data analysis indicates that there is a strong correlation between the results from SCPT and those from the Raven Matrices. However, the level of correlation differed from one aspect to another. For instance, it was observed that the temporal sequence task from the SCPT had the strongest correlation with the alignment of images of temporally consecutive events as shown in Figure 3.

Figure 3

Correlation between tasks from SCPT and those from Raven Matrices

Test names and indicators		Correlations with the Coloured Raven Matrices score
Temporal sequence	correct answers	0.4701
Spatial sequence	correct answers	0.4235
Figural abstraction	correct answers	0.3330
Digit Span backward	longest sequence	0.3157
Finding animals in order	correct answers	0.3099
Speech sound discrimination	correct answers	0.3002
Comparison of quantities	correct answers	0.2966
Identification of body parts	correct answers	0.2613
Speech comprehension	correct answers	0.2537
Digit Span backward	longest sequence	0.2458
Identification of fingers	correct answers	0.2276
Language sequence	correct answers	0.2182

Source: (Author, 2023)

Key: Darker grey ones are sensorimotor tasks

4. Discussion

One of the results from the present study is that using SCPT enables educators to create the school profile based on students' sensorimotor and cognitive abilities. This implies the possibilities of SCPT to enhance teachers to develop the most comprehensive intervention for supporting students. Studies have shown that educators can successfully help students learn if they provide support that caters for the needs of their cognitive and sensorimotor development (Staff, 2018; Shi & Feng, 2022). Based on this, teachers should be supported to use the SCPT in their classroom to assess holistically the readiness of their learners to learn and find the best way to support them.

This result resonates to some extent with results from previous studies such as (Hill et al., 2023) in which the correlation between sensorimotor and cognitive abilities with age is reported. The similarities between this study with the previous one is that they all consider sensorimotor to be as influential as cognitive aspects to students' ability to learn. However, the present study went far by introducing a new testing tool and creating a school profile for the schools whose learners were involved in the project.

Moreover, it has been observed that the results from the SCPT correlate strongly with those from the Raven Matrices. This means that assessment tasks from the SCPT are as valid as other tasks from the more trusted test. The correlation of our test results with those from Raven Matrices may raise confidence among potential users of our developed testing tool. Therefore, it is expected that SCPT will be adopted by various educators in their educational contexts to assess learners' cognitive and sensorimotor abilities.

The present study is similar to some extent to previous studies (Hill et al., 2023; Shapiro & Stolz, 2019; Shi & Feng, 2022) that consider the significance of sensorimotor abilities in the same way as cognitive abilities to students' learning. Nevertheless, the present study is unique in the sense that it introduces a new tool for facilitating the assessment of sensorimotor and cognitive abilities simultaneously. Based on this, it went far from rating sensorimotor as a significant aspect of learning to providing the means to harness its potential to support learning. In other words, this study enhances practices for incorporating sensorimotor in assessing students' abilities rather than the knowledge about the potential of sensorimotor. Therefore, the present study enhances comprehensive interventions by introducing the testing tool to those who would wish to use it and providing school profiles to teachers whose schools participated in the project.

Also, the study adds value to the tool by validating it by correlating its results with Raven Matrices' results. Given that the SCPT is new to many practitioners in the world, some might have doubted the validity of its tasks. This could make some educators hesitate to use the tool in their classroom. However, the fact that the tool has been validated using the more trusted test, it is likely that educators will adopt it unquestionably.

This aligns with Kosmas and Zaphiris (2018) who argue that technological innovations become influential in educational contexts if they are accompanied by evidence Therefore, this gives value to the test.

5. Conclusion and Recommendations

The results from this study show that SCPT can facilitate teachers to create school profiles for the sensorimotor and cognitive abilities of their learners. Also, the results show that test tasks from SCPT correlate strongly with the tasks from the Raven Matrices. Therefore, the study contributes to educational intervention to incorporate sensorimotor in assessing students' readiness to learn by introducing and validating the tool for creating the school profile. Based, on these results, we call for educators to consider the use of SCPT in their schools to enhance the assessment of learners' cognitive and sensorimotor abilities. Furthermore, we urge teachers in schools whose profiles were created in this project to develop interventions based on the indicators of learners' development related to both sensorimotor and cognitive areas.

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