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The Relation Between Cognitive Processes and Problem-Solving Performances of Preschoolers

Okul Öncesi Dönem Çocukların Bilişsel İşlem Düzeyleri ve Problem Çözme Performansları Arasındaki İlişki

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ABSTRACT: The aim of this study is to examine the relationship between the cognitive processing levels of preschool children and their problem-solving skills. The Cognitive Assessment System (CAS), developed by Naglieri and Das (1997) and adapted into Turkish by Ergin (2003), was used to determine the cognitive processing levels of children. A puzzle completion task was given to determine the problem-solving strategies of the participant children. The age range of 21 children in the study group was between 5 and 6, with an average age of 5.61. According to the coding of the researcher, 11 positive and 4 negative puzzle completion strategies that children used were determined. A canonical correlation analysis was conducted using positive and negative strategies as predictors of problem-solving skills to evaluate the multivariate shared relationship between cognitive processes and problem-solving. The results indicated that the explanatory percentage of the Planning dimension of cognitive processes on positive strategies was higher than the Attention, Simultaneous, and Successive dimensions.

Keywords: Cognitive processes, problem-solving, puzzle completion task, canonical analysis.

ÖZ: Bu çalışmanın amacı, okul öncesi dönem çocuklarının bilişsel işlem düzeyleri ile problem çözme becerileri arasındaki ilişkiyi incelemektir. Çocukların bilişsel işlem düzeylerini belirlemek için Naglieri ve Das (1997) tarafından geliştirilen ve Ergin (2003) tarafından Türkçe'ye uyarlanan Bilişsel Değerlendirme Sistemi (CAS) kullanılmıştır. Katılımcı çocukların problem çözme stratejilerini belirlemek için yapboz tamamlama görevi verilmiştir. Çalışma grubundaki 21 çocuğun yaş aralığı 5 ile 6 arasında olup ortalama yaşları 5.61'dır. Araştırmacının kodlamasına göre çocukların kullandıkları 11 olumlu ve 4 olumsuz yapboz tamamlama stratejisi belirlenmiştir. Bilişsel işlem ve problem çözme arasındaki çok değişkenli paylaşılan ilişkiyi değerlendirmek için problem çözme becerilerinin yordayıcıları olarak pozitif ve negatif stratejiler kullanılarak kanonik korelasyon analizi yapılmıştır. Sonuçlar, bilişsel süreçlerin Planlama boyutunun olumlu stratejiler üzerindeki açıklama yüzdesinin Dikkat, Eşzamanlı ve Ardıl Bilişsel İşlemler boyutlardan daha yüksek olduğunu göstermiştir.

Anahtar kelimeler: Bilişsel işlem, problem çözme, yapboz tamamlama görevi, kanonik analiz.

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Problem-solving is considered a skill that requires high-level cognitive competencies. The problem-solving process includes steps such as revealing the problem, analyzing the elements of the problem, producing solutions, deciding on the most appropriate solution, testing the solution, and evaluating the result (Bingham, 2016/1958). This research aims to evaluate the relationship between problem-solving and cognitive competencies of preschool children based on the accepted modern approaches to explain cognitive competencies.

Cognitive Processes

Compared to traditional intelligence tests, intelligence theories based on cognitive processes explain intelligence better (Fagan, 2000; Sternberg, 1988). Traditional intelligence tests appear to measure similar information as achievement tests (Naglieri & Bornstein, 2003). PASS theory, a neurocognitive intelligence theory that defines intelligence through four cognitive processes, reconceptualizes intelligence as cognitive processes (Das et al., 1994). This study evaluated cognitive functions using the Cognitive Assessment System (CAS), a measurement tool based on PASS theory. PASS Theory was created by Das et al. (1994), considering current theoretical and applied psychology studies of intelligence. It got this name by combining the first letters of the English spellings of the cognitive function areas defined as Planning, Attention, Simultaneous, and Successive. Das (2002) and Naglieri (1999) describe these components in detail. Accordingly, planning refers to the strategies and decisions that an individual uses while solving problems or achieving a goal (Das, 2002). Attention, on the other hand, is defined as a cognitive process that prevents an individual from focusing selectively or responding to attention-grabbing stimuli. In other words, the ability of the individual to focus on the elements that need to be focused and ignore the others is called attention (Das, 2002). The individual’s combining separate stimuli into a group or associating each element within a conceptual whole is defined as simultaneous operations (Naglieri, 1999). Simultaneous cognitive processing refers to the individual’s ability to relate parts of the stimulus in a comprehensible whole. Successive cognitive processes are defined as processes that put stimuli in a chain-like and special sequence (Naglieri, 1999).

According to the results of some studies in which the cognitive processing levels of preschool children were evaluated using the CAS scale, children’s cognitive processes are found to be related to children’s weight status and physical activity (Davis et al., 2015), early literacy skills (Enerem, 2018), behavioral problems (Aslan, 2009). Additionally, visual reading training programs (Ergin, 2015) and fine motor skill activities (Stewart et al., 2007) are effective in increasing preschoolers’ cognitive processes.

Problem-Solving in Preschoolers

Educators and researchers have seen problem-solving skills as critical skills that should be developed throughout life. There are different opinions about the content of problem-solving skills. Cicerone et al. (2000) conceptualized problem-solving skills as complex cognitive processes, including “executive function, reasoning, decision making, and the capacity for insight and awareness” (as cited in Chan & Fong, 2011, p.2024). On the other hand, problem-solving has also been defined as a complex cognitive process that includes problem identification, information processing, and planning (Argelagos & Pifarre, 2012; Chan & Fong, 2011; Fessakis et al., 2013; Kalyuga & Hanham, 2011). Individuals can plan to apply a solution to a particular problem after the information processing process. This planning process can happen once or several times. If individuals choose a suitable method, the problem can be solved instantly. However, if they cannot solve the problem, they can restructure their planning strategies or use trial-and-error methods until they solve the problem (Fessakis et al., 2013). Top-level self-regulation processes used to plan the solution of a problem include deciding which strategy should be used during problem-solving and monitoring the success of problem-solving (Sternberg, 1981).

Researchers have mostly focused on understanding the facilitating or destructive aspects of child-related individual variables (e.g., Berhenke et al., 2011) or parenting behaviors (e.g., Sun & Rao, 2012) that affect success in challenging problem-solving tasks. Since this article focuses on the characteristics of children, the relationship between different variables about children and problem-solving is discussed below. For example, the child's attention is related to the child's task persistence and effortful control (e.g., Gaiter et al., 1982; Kochanska et al., 2000). In addition, emotions play an important role in the problem-solving process. The positive effect of emotions can support attention and memory problem-solving (Carver & Scheier, 2000). The negative affectivity, on the other hand, increases cognitive load, impairs working memory, and is related to less deep strategy use (Turner et al., 1998). Campos et al. (1989) found that affectivity affects attention, self-regulation, problem-solving, and optimal functioning processes. Children who become excessively or emotionally disorganized may not fully engage with the task (Cole et al., 1994).

The literature discusses the importance of solitary play and single-use toys for competent problem-solving skills. For example, Rubin (1982) claims that nonsocial play is related to problem-solving skills. The relevant research indicates that children were more competent in problem-solving when they engaged in a task after playing with objects (Dansky & Silverman, 1973; Sylva et al., 1976). Toys that elicit individual play were often used in intellectually beneficial ways (Trawick-Smith et al., 2011). One of the intellectually beneficial toys is puzzles. Puzzles have been found to lead to problem-solving behaviors (Fleer, 1990; Kirova & Bhargava, 2002; Lloyd & Howe, 2003). Puzzles are named 'cognitively oriented' or 'closed-ended' materials. According to Lloyd and Howe (2003), single-use toys may help children develop problem-solving skills; however, the role of play materials alone in facilitating children's problem-solving skills needs to be investigated further.

The Current Study

This study aims to examine the relationship between the cognitive processing levels of preschool children and their problem-solving performance. Puzzles are among the favorite toys of children. However, limited research has been done on the cognitive processes used in the puzzle completion process (Doherty et al., 2021). This research primarily determines preschool children's strategies during the puzzle completion task. It also provides an example of how the puzzle completion task is a procedure that can be used to evaluate children's problem-solving skills and how performance on this task can be evaluated. It is thought that this research will contribute to the relevant literature by revealing the relationship between the strategies used by children during the puzzle completion task and children's cognitive processes.

Cognitive processes to be used during the puzzle completion task can be exemplified based on the PASS Theory. The planning process defines mental processes such as the child's determination of puzzle completion solutions, choosing among solutions, applying the chosen solution, and checking the effectiveness of the method he/she applies. Behaviors of controlling the urge to use strategy and act without careful thought while completing puzzles are components of the cognitive process called Planning. Planning processes include Attention, Simultaneous and Successive processes. Focusing on the puzzle task, resisting distraction, and maintaining focus indicate that the attention process is taking place. Simultaneous cognitive operations, on the other hand, is a mental process of bringing together separate stimuli as a whole. Simultaneous cognitive processes such as remembering the puzzle picture and visualizing the puzzle shapes are required in the puzzle completion task. The fourth cognitive operation of the PASS theory is the Successive Cognitive Process. This process, which defines the serial organization of speech sounds and the synthesis of separate vocal and motor stimuli in the form of successive sequences, is not a processing structure that children will need as much as other processes in the puzzle completion task.

Method

Model of the Research

This research was designed in a descriptive survey model, which aims to examine the relationship between the cognitive processing levels of 5- and 6-year-old children and the strategies they use in the puzzle completion task. Descriptive survey studies attempt to describe an event, individual, or object under their conditions and analyze data across a sample population at a certain point of time (Cohen et al., 2007).

Study Group

The research was carried out in a city located in the northwest of Turkey. First of all, two preschools were determined according to the principle of accessibility. Afterward, an information note containing the purpose and procedures of the research was prepared to share with the families, and this information note was delivered to the parents in the two selected preschools by the school administration and teachers. Phone calls were made with the families who volunteered to participate in the research, and an application calendar was created with the children of the parents who filled out the parental consent form. The participant group of the study consisted of 21 children (13 boys, 8 girls) with typical development. The age range of the participating children is between 5 and 6, with an average age of 5.61 (SD=.49).

Data Collection Tools

The Cognitive Assessment System (CAS), developed by Naglieri and Das (1997) and adapted into Turkish by Ergin (2003), was used to determine the cognitive processing levels of children. A puzzle completion task was given to determine the problem-solving strategies of the participant children.

Puzzle Completion Task

The method used by Fagot and Gauvain (1997) was adapted within the scope of this research. A commercial cardboard jigsaw puzzle, having 36 pieces of different shapes that must be fitted together, is used in the study. The chosen jigsaw puzzle is 20 x 22 cm in size and is suitable for children 5-6 years old. The puzzle is an underwater picture with various fish and undersea creatures. Before being used within the scope of this research, it was applied by the researcher with three children who were not included in the sample. The direction given by the researcher is: "There is a puzzle here. I wonder how you will complete it. While you work on it, I will watch you and record your moves. I expect you to do it as fast as you can". While the children were trying to complete the puzzle, the researcher recorded all the children's moves. The researcher gave no directions while the children were playing with the puzzle. Asking the children for tips, s/he said, "I'm very curious how you complete it. That's why I'm just watching you." After the application, the researcher coded these moves and determined the strategies used by the children. All notes and codes have been checked repeatedly and the list of strategies has been finalized.

Cognitive Assessment System (CAS)

It is a battery developed by Naglieri and Das in 1997, designed to evaluate the cognitive processing performance of children aged 5-17 years. It is based on the PASS Theory, defined by four cognitive processes: planning, simultaneous, attention, and successive. It was adapted into Turkish by Ergin (2003). The CAS scale consists of two forms: Standard Battery and Basic Battery. Each of the four scales in the standard battery, planning, simultaneous, attention, and successive, consists of three subtests. Each of these four scales in the basic battery consists of two subtests. Within the scope of this research, the 5-7 age form of the standard battery was used. There are three subtests for each cognitive domain in the standard battery; the total number of subtests is 12 (Naglieri & Das, 2014).

Planning Scale: Planning refers to children's mental processes about the solutions they create against the problems and how they apply and evaluate them. It consists of 3 subtests: Matching Numbers, Planned Codes, and Planned Connections. After implementing the planning subtests, the child is asked what kind of strategy s/he uses during the process. Simultaneous Scale consists of Nonverbal Matrices, Verbal Spatial Relations, and Figure Memory subtests. Simultaneous cognitive processes help the individual to associate the individual elements as a conceptual whole in his mind and to associate the stimulus parts understandably. Attention Scale: Attention is a mental process that focuses the individual against stimuli and provides selective cognitive activity. The Attention Scale consists of three subtests: Expressive Attention, Number Detection, and Perceptual Attention. The three subtests of the Successive Scale are Word Series, Sentence Repetition, and Speech Rate (5-7). Successive cognitive processes are mental processes to understand the serial organization of events and make sense of stimuli in a specially ordered chain (Naglieri & Das, 2014). This test was administered and scored by a practitioner with a CAS practice certificate within the scope of this research.

Data Collection

The researcher participated in the certification program for the CAS test. After obtaining the CAS implementation certificate, an application was made to obtain the necessary ethical documents to run the research. Afterwards, an informative text about the research was prepared, and families with preschool children were reached. A phone call was made with the families who volunteered to participate in the research, information was given about the details of the research, a consent form was sent to the families, and the implementation schedule was determined. The applications were carried out in a room designed for children. The children were informed in terms of the research scope, and consent was obtained from the children. Two of the children did not want to participate in the study. Then, the study was conducted with the 21 children who volunteered to participate in the research. The practices within the scope of the research were carried out one-on-one with the participant children. First, the CAS test was applied, and the puzzle completion task was started when the application of the test was finished. The CAS scores of the children were calculated within a few days after each application, and the CAS test family report was prepared and conveyed to the families. The application of CAS took approximately 75-90 minutes, and the puzzle completion task lasted an average of 35 minutes. While 13 children who participated in the research completed the Puzzle, eight children stated that they wanted to leave it unfinished after a certain period.

Ethical Procedures

Ethics committee approval has been given by the Social and Human Sciences Ethics Committee before the application. Within the scope of the research, an information form, a parent consent form, and a child consent form were prepared and distributed. The children were the ones who voluntarily participated. The collected data has been stored under the principle of confidentiality. Family reports were created about the results of the CAS test. Family interviews were conducted within a few weeks following the implementation, and these reports were delivered to the families.

Data Analysis

While evaluating the normality assumptions, ±2 criteria for skewness and ±7 criteria for kurtosis were used (Curran et al., 1996). Accordingly, it was concluded that the data showed a normal distribution. According to the results, it was determined that the data showed normal distribution (Table 1).

Table 1

Normality Distribution

	Skewness	Kurtosis	Mean	SD
Planning	.319	-.375	95.85	16.36
Simultaneous	.338	.225	102.42	13.85
Attention	.305	.443	104.19	11.46
Successive	-.103	-.757	97.09	12.78

Table 2

Intercorrelations and Descriptive Statistics of Study Variables

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Planning	1																	
2	Simultaneous	.45*	1																
3	Attention	.64**	.36	1															
4	Successive	.46*	.45*	.36	1														
5	P.S.1	.03	-.30	-.18	-.08	1													
6	P.S.2	-.02	.23	.31	-.08	.12	1												
7	P.S.3	-.06	-.02	-.01	-.19	.24	.44*	1											
8	P.S.4	-.02	-.23	.04	.02	.35	-.03*	.53*	1										
9	P.S.5	-.09	-.28	-.44	-.28	.14	-.19	.21	-.12	1									
10	P.S.6	.41	.24	.09	.57**	.06	-.28	-.62**	-.43*	-.17	1								
11	P.S.7	.06	-.56**	-.12	-.10	.51*	-.37	-.30	.18	.07	.25	1							
12	P.S. 8	-.02	-.48*	-.53*	-.09	.23	-.56**	-.46*	-.29	.10	.38	.66**	1						
13	P.S. 9	-.09	-.04	.12	-.32	-.30	.41	.44*	-.25	.25	-.48	-.37	-.31	1					
14	P.S.10	.19	-.24	.23	.43	.23	-.31	-.22	.27	-.46*	.38	.66**	.38	-.31	1				
15	N.S.1	.44*	.53*	.00	.25	-.18	-.13	-.14	-.58**	.21	.35	-.30	.02	.05	-.22	1			
16	N.S.2	.37	.64**	.19	.32	-.24	-.05	-.42	-.53*	.21	.62**	-.34	-.02	-.24	-.26	.52	1		
17	N.S.3	.36	.11	-.10	.44**	.12	-.36	-.52*	-.48*	.25	.90**	.28	.42	-.36	.17	.44	.52*	1	
18	N.S.4	.01	.02	-.12	.25	-.18	-.33	-.90**	-.36	-.23	.55**	.34	.26	-.33	.26	.04	.33	.44*	1

Descriptive statistics are displayed in Table 2. The positive and negative strategies used by the children during the puzzle completion task were observed and noted by the researcher. Accordingly, 11 positive strategies and 4 negative strategies were listed. As one of the positive strategies, strategy number 11, “combined two pieces,” was used by all children, and it was excluded from the analysis. The list of positive and negative strategies and the distribution of how many children use this strategy are presented in Table 3.

Figure 1

Negative Strategy Example

Figure 2

Positive Strategy Example

Table 3

List of Positive and Negative Puzzle Completion Strategies

		Used		Not Used	
		f	%	*f*	%
P.S. 1	Checked the picture from the puzzle box before starting	6	28.6	15	71.4
P.S. 2	Checked the picture from the puzzle box after a while	12	57.1	9	42.9
P.S. 3	Spread out all the pieces in the box on the table and turning the pieces over	10	47.6	11	52.4
P.S. 4	Sorted by color	16	76.2	5	23.8
P.S. 5	Combined the patterns	20	95.2	1	4.8
P.S. 6	Tried to combine taps and blanks	13	61.9	8	38.1
P.S. 7	Started from above or below	2	9.5	19	90.5
P.S. 8	Spoke to himself/herself	4	19.0	17	81.0
P.S. 9	Asked the researcher about clues	12	57.1	9	42.9
P.S. 10	Found the corner pieces at first	4	19.0	17	81.0
P.S. 11	Combined two pieces	21	100	0	0
N.S. 1	Locate the middlers on the edge or corner pieces in the middle	10	47.6	11	52.4
N.S. 2	S/he combined the wrong pieces even if colors and shapes do not fit	11	52.4	10	47.6
N.S. 3	Tried to combine 2 pieces of unmatching color	12	57.1	9	42.9
N.S. 4	Researched the pieces out of the box one by one	10	47.6	11	52.4

Note: P.S.=positive strategy, N.S.=negative strategy

Results

Preliminary Results

Results from bivariate correlations (Pearson) showed that Planning was positively related to Simultaneous (r =.45., p<0.05), Attention (r =.64, p<0.01), Successive (r =.46, p<0.05), and Negative Strategy 1 (r =.44, p<0.05). Although Simultaneous was positively correlated to Successive (r =.45, p<0.05) and Negative Strategy 2 (r =.64, p<0.01), it was negatively correlated with Positive Strategy 7 (r =-.56, p<0.01) and Positive Strategy 8 (r =-.48, p<0.05). Attention was negatively correlated with Positive Strategy 8 (r =-.53, p<0.05). Successive was positively related to Positive Strategy 6 (r =-.57, p<0.01) and Negative Strategy 3 (r =-.44, p<0.01).

Also, a t-test analysis was conducted to test whether the cognitive processes skills differ between the children who completed the puzzle and the ones who would like to stop working on it before it is completed. Planning t (19) =.23, p=.81; simultaneous t (19) =1.63, p=.11; attention t (19) =.71, p=.48; and successive t (19) =.75, p=.45 scores do not differentiate in terms of puzzle completion status.

Canonical Correlations Analyses

A canonical correlation analysis was applied using positive and negative strategies as predictors of problem-solving skills to evaluate the multivariate shared relationship between two variable sets (i.e., strategies and cognitive abilities). It was running separate models for positive and negative puzzle completion strategies to examine their unique contributions to display.

First, a canonical correlation analysis was conducted using ten positive strategies as predictors of problem-solving skills to evaluate the multivariate shared relationship between two variable sets (positive strategies and cognitive abilities). The results are indicated in Table 4. The analysis yielded four functions with squared canonical correlations (R_c^2) of .955, .797, .527, and .278 for each successive function. The full model across all functions was statically significant by considering Wilks's λ = .003 criterion, F (40, 28.40) = 2.55, p = .005. Wilks' λ represents the variance not explained by the model. Thus, 1-λ describes the full model effect size of an r2 metric. In this study, the r2 type effect size was found to be .99 for the four canonical function sets. This result indicates that the full model explains approximately 99% of the variance shared between the variable sets. The dimension reduction analysis allows the researcher to test the hierarchical arrangement of functions for statistical significance (Sherry & Henson, 2005). As noted, the full model (functions 1 to 4) was not statistically significant; however, the explained variance (R_c^2) for each function was above 20%, implying the practical significance of each function. The standardized canonical function coefficients and structure coefficients for Functions 1 to 4 are presented in Table 4. The squared structure coefficients and the communalities (h2) across the four functions for each variable are also given.

Table 4

Canonical Solution for Positive Strategies and Children's Cognitive Processes Skills

	Function 1			*Function 2*			*Function 3*			*Function 4*			
Variable	*Coefficient*	r_s	r_s^2(%)	*Coefficient*	r_s	r_s^2(%)	*Coefficient*	r_s	r_s^2(%)	*Coefficient*	r_s	r_s^2(%)	h^2(%)
Positive S1	-.18	-.11	1.21%	-.27	.40	16.00%	-.28	-.03	0.09%	.67	.32	10.24%	27.54%
Positive S2	-.98	.10	1.00%	.20	-.55	30.25%	.71	.18	3.24%	-1.26	.01	0.01%	34.50%
Positive S3	1.57	-.09	0.81%	.20	-.15	2.25%	-1.11	-.03	0.09%	.97	.23	5.29%	8.44%
Positive S4	-1.88	-.04	0.16%	.31	.17	2.89%	1.17	.32	10.24%	-2.01	.07	0.49%	13.78%
Positive S5	-.78	-.30	9.00%	.78	.35	12.25%	.14	-.40	16.00%	-.53	.46	21.16%	58.41%
Positive S6	.28	.45	20.25%	.41	.45	20.25%	-.01	-.19	3.61%	-1.01	-.45	20.25%	64.36%
Positive S7	1.67	-.09	0.81%	.11	.75	56.25%	.01	.39	15.21%	1.65	.26	6.76%	79.03%
Positive S8	-2.05	-.41	16.81%	.35	.60	36.00%	.24	-.09	0.81%	-1.67	-.03	0.09%	53.71%
Positive S9	-.73	-.16	2.56%	-.30	-.45	20.25%	.86	.22	4.84%	-.29	.29	8.41%	36.06%
Positive S10	-.17	.26	6.76%	.53	.55	30.25%	.53	.58	33.64%	-.33	-.13	1.69%	72.34%
R_c^2			95.53			79.75			52.74			27.83	
Planning	-.52	-.91	82.81%	-.76	-.20	4.00%	.61	.11	1.21%	-.87	-.33	10.24%	98.91%
Simultaneous	-.21	-.66	43.56%	.82	.47	22.09%	.74	.47	22.09%	.33	.32	0.01%	97.98%
Attention	-.26	-.77	59.29%	.74	.33	10.89%	-1.05	-.50	25.00%	-.07	-.18	5.29%	98.42%
Successive	-.24	-.68	46.24%	-.61	-.33	10.89%	-.35	-.11	1.21%	.91	.63	0.49%	98.03%

Note. Structure coefficients (r_s) greater than |.45| are underlined. Communality coefficients (h^2) greater than 45% are underlined. Coefficient = standardized canonical function coefficient; r_s= structure coefficient r_s^2= squared structure coefficient; h^2= communality coefficient.

Another canonical correlation analysis was run using four negative strategies as predictors of problem-solving abilities to evaluate the multivariate shared relationship between two variable sets (negative strategies and cognitive abilities). The analysis yielded four functions with squared canonical correlations (R_c^2) of .639, .562, .087, and .003 for each successive function.

Table 5

Canonical Solution for Negative Strategies and Children's Cognitive Processes Skills

	Function 1			*Function 2*			
Variable	*Coefficient*	r_s	$r_s^2(\%)$	*Coefficient*	r_s	$r_s^2(\%)$	$h^2(\%)$
NS1	-.46	<u>-.63</u>	39.69%	-.42	<u>-.66</u>	43.56%	83.25%
NS2	-.88	<u>-.74</u>	54.76%	.32	-.33	10.89%	65.65%
NS3	.66	.04	0.16%	-.96	<u>-.89</u>	79.21%	79.37%
NS4	.12	.09	0.81%	.19	-.13	1.69%	2.50%
R_c^2			63.99			56.24	
Planning	.05	.35	12.25%	1.04	<u>.52</u>	27.04%	39.29%
Simultaneous	1.09	<u>.93</u>	86.49%	-.12	.16	2.56%	89.05%
Attention	-.01	.28	7.84%	-1.02	-.24	5.76%	13.60%
Successive	.42	.09	0.81%	.43	<u>.49</u>	24.01%	24.82%

Note. Structure coefficients (r_s) greater than |.40| are underlined. Communality coefficients (h^2) greater than 40% are underlined. Coefficient = standardized canonical function coefficient; r_s= structure coefficient r_s^2= squared structure coefficient; h^2= communality coefficient.

Wilks's λ = .143 criterion, F (16, 40.35) = 2.24, p = .01 indicated that the full model across all functions was statistically significant. For the set of two canonical functions, the r^2 type effect size was .856, which indicates that the full model explained about 85% of the variance shared between the variable sets. The dimension reduction analysis allows the test of the hierarchical arrangement of functions for statistical significance (Sherry & Henson, 2005). As noted, the full model (functions 1 to 2) was not statistically significant; however, the explained variance (R_c^2) for functions 1 and 2 was above 20%, implying the practical significance of these two functions. The last two functions only explained 8% and .03% of the variance, indicating a lack of contribution to the shared variance. Table 5 indicates the standardized canonical function coefficients as well as the structure coefficients for Functions 1 and 2. The squared structure coefficients and the communalities (h^2) across the two functions for each variable are also given.

Discussion and Conclusion

The current study examined the relationship between the cognitive processing levels of preschool children and their problem-solving skills using a jigsaw puzzle completion task. The positive and negative strategies used by preschool children during the puzzle completion task were determined by the researcher's observation. Then, the relationship between these strategies and the cognitive processing levels of the children was examined by canonical correlation analysis. Puzzles are very popular toys among both girls and boys, regardless of gender. As the literature indicates, puzzles are referred to as toys that support the development of problem-solving skills. However, a very limited number of resources can be reached regarding the strategies children use while playing with puzzles. In this sense, this research is thought to contribute to the limited literature on puzzles.

Strategies that can facilitate the solution while completing the puzzle are called positive strategies. A total of 11 positive strategies were coded based on the observations made by the researcher while the children were trying to solve the puzzle. One of the positive strategies, "Combined two pieces," was used by all the children participating in the study. "Combined the patterns" is a positive strategy used by 20 children. In addition to these, positive strategies such as "Sorted by color," "Tried to combine taps and blanks," "Checked the picture from puzzle box after a while," and "Asked the researcher about clues" are strategies used by more than 50% of children. When the strategies used by children were examined, it was seen that the strategies used by children were similar to those mentioned in the literature. For example, Fleer (1990) stated that children can develop common strategies through scaffolding in puzzle-solving tasks. Among the strategies suggested by Fleer (1990) and used by children in this research matched the following; "*Discussing the puzzle picture before it is dismantled," "Turning the pieces over so that the design of the picture is clearly presented," "Discussing the colour, patterning or shape of the border...", "…asking the child to look for a piece with that colouring or patterning", "Examining puzzle pieces already inserted and discussing the shape of the gaps…" and "Modelling to the child puzzle solving through verbalizing thinking and problem-solving strategies used "(*pp.76-77). Research done with preschool children indicated that each age group (3-, 4-, and 5-year-old children) completed the puzzle more quickly when a guide picture was present (Doherty et al., 2021). The same research results indicate that in the task of completing the puzzle, an enhanced understanding of meta-representation will contribute to the understanding that pictorial elements can come together to form an image and may provide additional strategies for putting the pieces together by trial and error.

Then, the relationship between positive strategies and children's cognitive processing scores was examined (Table 4). Accordingly, the explanatory power of Function 1 for Canonical Solution for Positive Strategies and Children's Cognitive Processes Skills is 95.53. Since Function 1 is the most explanatory function, examining the relationship between positive strategies in this set and children's cognitive processing scores deserve to be discussed. According to this result, there is only a relationship between Positive Strategy 6 (Tried to combine taps and blanks) and children's cognitive processing levels (Planning, Simultaneous, Successive, Attention). No relationship was found between Positive Strategy 1 (Checked the picture from the puzzle box before starting), Positive Strategy 3 (Spread out all the pieces in the box on the table and turning the pieces over), and Positive Strategy 4 (Sorted by color) and children's cognitive processing scores in any function. As expected, the explanatory percentage of planning on positive strategies was higher than the other three cognitive process subscales. Accordingly, the assumption that the Planning component is directly related to the puzzle completion task used as a problem-solving task and the strategies used during the puzzle completion task has been confirmed. The planning process defines mental processes such as the child's determination of puzzle completion solutions, choosing among solutions, applying the chosen solution, and checking the effectiveness of the method he/she applies.

The results of the canonical correlation analysis that was conducted using four negative strategies as predictors of problem-solving abilities to evaluate the multivariate shared relationship between negative strategies and cognitive abilities indicated that attention is not related to any of the negative strategies. Also, the results of the same analysis indicated that "Negative strategy 4: Researched the pieces out of the box one by one" is not related to the cognitive processes scores of the participant children. Since there was no research examining the relationship between cognitive processes and the puzzle complete task, it was not possible to compare the results with the results obtained in different cultures and with different sample groups.

Limitations and Suggestions

The limitations of the present study one should consider when interpreting the results. The data was collected at one point in time. So, the results cannot determine causality. Second, the number of participants was limited to 21 children. Since the implementation of data collection tools in the research was long and the research had to be completed within the scope of a project, the number of participants was limited. In addition, the puzzle completion task was started immediately after the CAS application, with the children's consent. However, the long duration of the applications may have affected the puzzle completion performance of the children. In addition, children's puzzle completion strategies were recorded and coded by the researcher. Considering the study limitations, it can be stated that the generalizability of the results is not possible. It is recommended that future studies using similar designs on this subject be conducted with more participants, that children's puzzle completion performances be evaluated at different times, and that different researchers code puzzle completion strategies.

Children's puzzle completion strategies may be affected by variables other than cognitive processes. For example, jigsaw puzzle plays in young children relate to visual perception, eye-hand coordination, social development, and the development of specific mathematical concepts (Fleer, 1990), spatial abilities (Levine et al., 2012; Young et al., 2014) and general and pictorial metarepresentational development (Doherty et al., 2021). It is recommended that future studies examine the relationship between puzzle completion strategies and cognitive processes by controlling these variables.

Conflicts of Interest

The author declares that she has no conflict of interest.

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