

University Students' Cognitive Bias in the Context of Their Analytical Thinking Skills: A Reliability and Validity Study

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Abstract

This study aimed to develop a reliable and valid scale to reveal the cognitive biases of university students in context of analytical thinking skills. During scale development process, firstly, a 5-point Likert type scale pre-trial form consisting of 60 items was created. The pre-trial form was applied to 450 students in Afyon Kocatepe University. Both exploratory (EFA) and confirmatory factor analysis (CFA) were used. According to analyzes, the scale consists of 5 sub-dimensions and 25 items. In the exploratory factor analysis, it was seen that the items had a factor load of .55 to .81. It was determined as 51.818% of the variance value determined for the whole scale. CFA result $\chi^2=614$; RMSEA=0.0540; SRMR=0.0540; CFI=0.885 and TLI=0.870 has reached acceptable compliance values with. Cronbach's alpha was calculated as 0.76. Approximately 30 days after developing the scale, test-retest reliability analysis was performed with 40 participants ($r=0.869$; $p<.05$). The findings show that a valid and reliable measurement tool has emerged. The scale was named as “The Scale of Cognitive Bias in the Context of Analytical Thinking Skills”.

Keywords: Analytical Thinking, Cognitive Bias, Scale, University

DOI: 10.29329/ijpe.2022.439.14

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INTRODUCTION

The term cognitive bias was first used in the 1970s to describe people's patterns of systematic but supposedly flawed responses to judgement and decision problems (Wilke & Mata, 2012). Cognitive biases arise because human cognition cannot correctly process all available information (Kruglanski & Ajzen, 1983). When individuals cannot adequately interpret and use the existing information, they produce various cognitive biases for reasons such as persuading themselves and others, analyzing the situation or concluding. According to Bazerman and Moore (2012), people use some simplification strategies or applicable rules (called heuristics) in the decision-making process. These heuristic methods are standard rules that indirectly direct the thoughts of individuals. They are mechanisms for individuals to cope with the complex environment surrounding their decisions. While they often seem helpful, using cognitive biases can sometimes lead to severe errors because cognitive biases are a thinking process that prevents individuals from reasoning and provides practicality for the moment and conclude various situations without evaluating them in depth.

Cognitive bias is not a qualified decision-making process. Individuals who use cognitive biases do not seem very willing to be open-minded. Instead, individuals have an unconscious tendency to search or process information with cognitive biases (Schmutte & Duncan, 2014). Heuer (2007) likens cognitive bias to a kind of illusion. It can be persuasive even in seemingly clear cases. In this case, cognitive bias alone does not produce a correct decision or result. Therefore, it is challenging to overcome cognitive bias. People do not always act rationally. Many people feel capable of making rational decisions. However, they sometimes tend to prejudge various situations based on cultural norms and beliefs. Sometimes they are presented with too much information, or they may want to make a quick decision. This may cause them to rely on cognitive shortcuts (rules of practice) known as heuristics. Biases are normal processes designed to make quick decisions. Prejudices are unconscious, automatic and uncontrollable, and there is no magic solution to overcoming these reflexive movements. However, knowing their effects, when and where they apply, and some basic structured techniques can help mitigate their negative consequences (Bazerman & Moore, 2012; Schmutte & Duncan, 2014).

According to Benson (2016), cognitive biases help us address four different problems. The first is how to combat information overload. When individuals encounter too much information, their brain use tricks to select the information they will use the most. The second problem is that some situations faced by individuals do not have enough meaning. Individuals try to make sense of what they perceive in such situations. To solve the problem, they fill in non-significant gaps using their imagination or pre-existing knowledge. The third problem is the need to act quickly. From time to time, individuals may have to make quick decisions in situations they encounter. In such situations, they use cognitive biases. The fourth problem is about which of the many information an individual should remember.

According to Benson (2016), cognitive biases also have some disadvantages besides the advantages mentioned above. Above all, individuals cannot see and remember everything. Some of the information they filter is useful and important. Searching for meaning can evoke illusions. Sometimes individuals imagine details filled with assumptions and construct meanings and stories that are not there. Quick decisions can be wrong. The decisions and reactions we make quickly are often unfair, self-serving, and inefficient. Individuals' memories strengthen mistakes from time to time. Some things they remember later may be more biased and hurt their thinking more.

Duncan Pierce (n.d.) classified and explained cognitive biases under various subtitles. The first of these is the social and group effect. This is social and group prejudices involving relationships with other people. The other subtitle is the attitude towards risk and probability. These biases affect how individuals make decisions in situations where there is a risk or in uncertain situations. Decisions can have an impact on planning and decision-making activities. Another bias is remembering, recognizing and seeking information. Internalized information can significantly influence existing ideas in individuals. An individual may overlook an element that is considered essential by others.

There are also cognitive biases about how activities are noticed and evaluated. Another bias Pierce addresses is the evaluation of information. Information is guided by the information available to individuals. When information is available and sufficiently evaluated to allow for action, other cognitive biases may have an effect on, perhaps delay or prolong, actions taken. Once the action has been taken, evaluating the effectiveness of what has been done may also be biased and affect the decision-making process.

Similarly, Benson (2016) divided cognitive biases into four categories. One hundred seventy-eight cognitive biases are listed under these categories. The first category addressed is "too much information". This title mainly covers the cognitive tricks that individuals apply to filter most of the information they encounter in complex environments. For example, among too many elements, individuals focus specifically on unfamiliar elements, make situational changes, and focus on details that confirm their previous beliefs. Another category relates to the fact that the available data makes little sense. The third category relates to the rapid movement of individuals. For example, individuals prefer simple options over complex or ambiguous options. The last category is about having too much information to remember.

Halvorson and Rock (2015) divided prejudices into five categories. The first of these is similarity. It includes similarity biases based on the ideas or actions of other people, such as competitors or colleagues. For example, if individuals in one group believe in a topic, others in the other group also believe in the same topic or vice versa. The second category includes prejudices related to the unwillingness or laziness of individuals to spend the effort required to carry out a careful analysis. An example of this situation is belief bias. Individuals with this type of cognitive bias do not focus on the logic of a situation or the decisions made about a situation. Instead, they focus on the decisions that have been made, whether to agree or support them. Another category is experience. They are prejudices that result from overconfidence in individuals' perceptions or experiences. For example, false consensus (exaggerating the universality of one's own beliefs or judgments, attributing them to others in the absence of any evidence for them) or illusion of transparency (a tendency to exaggerate the extent to which an individual's mental state and insights are accessible to others). The other category was handled as the distance category. Depending on the concept of intimacy, it is the prejudices associated with the excess or low amount of information. These types of prejudices are related to the emotional comfort of individuals and the emotional comfort they feel towards familiar situations. The last category is the security category. These biases are related to an innate tendency to avoid risk or loss. Individuals with this type of prejudice take little or no action regarding their decisions.

The common point of all the above classifications is that cognitive bias affects the decision-making process of individuals from various aspects. Researchers from different disciplines (Caputo, 2013; Thompson, 2013; Zur, 1991) have discussed the concept of cognitive bias in order to understand how cognitive bias can improve decision-making skills in their fields. Caputo (2013), interested in the negotiation process and politics, claims that cognitive misperceptions can significantly bias human behaviour when making judgments and decisions, which is not valid in negotiations. Zur (1991) stated that cognitive biases could affect how we perceive the actions of enemies. Research has shown that the enemy's hostile actions are more likely to be attributed to natural features, while positive, conciliatory or peaceful actions are related to situational factors. In other words, when the enemy act peacefully, they are compelled to do so not by their own choice but by external circumstances. When they act aggressively, it is due to personal choice or characteristic behaviour (Zur, 1991). Thompson (2013) states that people do not like to make decisions. He expresses that individuals have some habits and like to think automatically. For this reason, he emphasizes that individuals generally avoid making choices and push them to stress. It means that those who work in the real estate sector generally understand this situation and use it for their benefit. For example, because buying a house is extremely important and hard to reverse, sensible people should look at many options and consider them very carefully. An excellent real estate agent will show clients a few expensive and not-so-nice houses and then some much nicer ones for about the same price. Many buyers will respond by stopping their calls and jumping into negotiations. Individuals' sensitivity to "bargaining" is one of the cognitive tools

used to simplify their choice situations. All these studies in different fields express cognitive bias as a systematic (that is, non-random and therefore predictable) deviation from rationality in reasoning or decision making (Blanco, 2017). Cognitive bias is defined as errors in judgment, memory, decision making, evaluation, and other cognitive processes, usually occurs when personal beliefs and preferences are expressed with different evidence (Cherry, 2018).

Cognitive bias is irrational behaviour with predictable consequences. It has been suggested that cognitive biases underlie many beliefs and behaviours that are dangerous or problematic for individuals, such as superstitions, pseudoscience, prejudice, poor consumer choices (Ariely 2009). Cognitive biases have been defined as a general feature of cognition. Therefore, they are common and can be observed in a wide variety of fields and tasks. For example, cognitive biases may even underlie highly societal issues such as prejudice and racial hatred (Hamilton & Gifford 1976; Blanco, 2017). It is not strange that researchers are trying to find ways to overcome cognitive biases. Some say that to get rid of cognitive biases, individuals need to be motivated to perform at their best. Others argue that some strategies should be taught in order to change the heuristics that cause cognitive biases. It states that critical, analytical and reasoning skills should be developed to eliminate the negative aspects of cognitive biases in a group (Larrick, 2004). When cognitive biases control individuals, their ability to make logical judgments is limited, and facts are left behind certain beliefs. For this reason, the types of thoughts necessary to keep it under control can be put to work.

Analytical thinking is the process of actively and skillfully conceptualizing, applying, analyzing, synthesizing and evaluating the information generated by observation, experience, thinking, reasoning or communication (<https://www.dictionary.com/browse/critical-thinking?s=t>). This definition can be considered a comprehensive one as it covers various perspectives on analytical thinking. It includes both thinking dispositions and cognitive skills. Facione (1990) characterizes analytical thinking as a purposive, self-regulating judgment that results in interpretation, analysis, evaluation, and inference, as well as the evidential, conceptual, methodological, criterion-based, or contextual evaluations on which that judgment is based. Analytical thinking is considered a powerful resource and an essential skill for survival and success in the complex 21st-century world (Pellegrino & Hilton, 2012). It is an essential requirement in many dynamic and rapidly changing professional environments such as medicine and economics. A lack of analytical thinking skills can lead to biased reasoning and ultimately erroneous decisions with severe consequences (Croskerry, 2003; Klebba & Hamilton, 2007; Smith, 2003). Therefore, education has an essential role in developing students' analytical thinking, and the training of analytical thinking skills is essential to reduce biased reasoning (Facione, 2009; Niu et al., 2013; Paul, 1990). In this sense, education needs to develop analytical thinking. It has been observed that the acquisition of analytical thinking skills generally leads to better learning and transfer of trained tasks (Helsdingen et al., 2011). It facilitates students' assessment of their own skills. It makes own thinking and knowledge more accessible and usable (Billing, 2007; Celuch & Slama, 1998; Paul, 2005).

While there are good reasons to see analytical thinking as an expected outcome of education, situations that are explicitly taught are unfortunately not so obvious. According to Larrick (2004), instead of aiming to identify and demonstrate biases and thinking misconceptions, researchers should pay more attention to finding effective analysis techniques and strategies. Learning how to avoid reasoning by having cognitive biases, that is, thinking training can form the basis for rational thinking (Stanovich, 2011). The ability of individuals to think analytically can contribute to making much more rational decisions by preventing the formation of cognitive biases. Cognitive biases can affect people's behaviour and decisions about their use. However, it is noteworthy that studies with cognitive bias are in the fields of finance and psychology. However, it is extremely important for their learning experiences that students analyze their situations well, make healthy decisions without acting with any prejudice, and manage the problem-solving process well. Research in different fields such as finance, education, and politics shows that cognitive biases negatively affect the development of the decision-making process. For example, McCann (2014), in a study on finance, stated that managers with cognitive biases have difficulty in making decisions, and that they often cannot make independent decisions. Again, in the study conducted by the Joint Commission (2016) in the field of health, it is

stated that many of the patients with cognitive biases delay the treatment process, and some even give up the treatment process. Today, this situation can be handled with a much more recent example. Recently, the cognitive biases developed by anti-vaccine people towards the Covid-19 vaccine negatively affect their decision about the vaccine, and they cannot think clearly about the positive features of being vaccinated. Smith (2015) stated that good marketers should be skilled in eliminating the cognitive biases of their customers; otherwise, they cannot be effective in the customers' decision-making process. Dror, McCormack, and Epstein (2015) focused on how to handle cognitive biases in the legal system and emphasized that the problem could be eliminated by improving thinking styles. This situation reveals once again the importance of individuals to stay away from cognitive biases that disrupt their thinking systems so that they can make logical decisions, analyze their situation well, and follow the problem-solving steps. It can be an effective way for university students, who are in a critical period in their education life, to be away from cognitive biases in the decisions they will take for the future and benefit from some types of thinking in combating this. The best way to reduce and eliminate cognitive biases is to be aware of cognitive biases. In this context, this study aims to develop a valid and reliable measurement tool that can be used to reveal the cognitive biases of university students in the context of their academic thoughts.

METHODOLOGY

In the research, sequential explanatory design, one of the mixed research methods, was used to develop the Cognitive Bias Scale in the Context of Analytical Thinking Skills. In this design, qualitative data is collected and analyzed first. Quantitative data is then collected and analyzed (Tashakkori & Teddlie, 2003; Creswell, 2005). Creswell (2005) stated that this design also allowed the development of a standardized data collection tool. In this study, a literature review was first carried out, and then the views of students obtained from the open-ended questions were analyzed. Findings obtained by evaluating the answers to the questions were used as a source for creating the scale items in the item pool. The study was designed with this method since it aimed to develop a measurement purpose to reveal the cognitive biases of university students in the context of analytical thinking skills.

Study Group

The trial applications of this study, which aims to develop a scale that reveals the cognitive biases of university students in the context of analytical thinking, were carried out in the 2020-2021 academic year. The study group of the research was determined by the typical case sampling method, one of the purposive sampling methods. According to Patton (2005), typical situations are situations that contain information at a level that can explain the generally examined event or phenomenon among the many similar ones in the universe. For these reasons, the study group of the research consists of 451 students who continue their undergraduate education at Afyon Kocatepe University. According to Cornish (2006), for the sample size in factor analysis studies, "50" is very bad, "100" is terrible, "200" is medium, "300" is good, "500" is very good and "1000 and more" is excellent. In this framework, it is thought that 451 samples will be sufficient for the 60-item trial scale. The personal information of the students is given in Table 1:

Table 1 Demographic Information of Participants

Variables		N	%
Gender	Female	319	70.7
	Male	132	29.3
Grade	1st Grade	240	53.2
	2nd Grade	112	24.8
	3rd Grade	57	12.6
	4th Grade	42	9.3
Age	17-19	119	26.4
	20-22	264	58.5
	23 and above	68	15.1

As seen in Table 1, 319 (70.7%) female students and 132 (29.3%) male students participated in the study. Of these students, 240 (53.2%) were in their first year, 112 (24.8%) were in their second year, 57 (12.6%) were in their third year, and 42 (9.3%) were in their fourth year. Again, 119 of the participating students are in the 17-19 age range, 264 are in the 20-22 age range, and 68 are 23 years old and over.

Scale Development Process

In this research, which is a scale development study aiming to reveal the cognitive biases of university students within the framework of academic thinking skills, first of all, the relevant field was scanned to establish the theoretical ground (Bilton, 2010). Based on the "Cognitive Bias Codex", categorized by Buster Benson and designed by John Manoogian in 2016, cognitive biases encountered in the educational process and the context of analytical thinking are listed, and key concepts are formed. Many articles have been written based on these key concepts. According to Tezbaşaran (2007), while writing the scale items, care should be taken that the number of items planned to be included in the scale should be three or four times if possible. For this reason, an item pool consisting of 60 items was created.

In order to ensure the content validity of the resulting 60-item scale, the opinions of 2 experts working in the field of Afyon Kocatepe University Curriculum and Instruction were consulted. In addition, to reveal its intelligibility in terms of language and expression, the opinions of a Turkish teacher working in a secondary school affiliated with the Ministry of National Education were taken. In these evaluations, the 6th item of the draft scale was "I remember information that is interesting and funny to me more easily." It was stated that it would be more meaningful to express the expression as two different items, and it was emphasized that the words "interesting and funny" express different situations. Again, it was stated that it would be more appropriate to include the sentences with the negative suffix on top of each other, and necessary corrections were made in this regard. Then, a preliminary experiment was carried out with 15 university students from different grade levels. After the pre-test, the draft scale was applied to the sample group to analyze its validity and reliability. This draft scale was designed in a 5-point Likert type, and the item ranges were determined as "strongly agree (5), agree (4), slightly agree (3), disagree (2), strongly disagree (1)".

Data Acquisition and Analysis

The trial phase of this scale, which was designed to reveal the cognitive biases of university students in the context of analytical thinking, was carried out in the spring semester of the 2020-2021 academic year. Before the scale was implemented, application approval was obtained from Afyon Kocatepe University Social and Human Sciences Scientific Research and Publication Ethics. The draft scale was applied to university students voluntarily. The data obtained were transferred to the computer environment, and positive items were graded starting from 5 and negative items starting from 1. In other words, items 3, 8, 15, 24, 47, 48, 51, 53, 57 and 59 are reverse coded. Exploratory factor analysis and confirmatory factor analysis were used for the data obtained from the draft scale. Kaiser-Meyer-Olkin (KMO) analysis was used to determine the suitability of the scale for factor analysis, and Barlett's analysis test was used to determine the suitability of the sample size (Büyükoztürk, 2012). The Cronbach's Alpha coefficient determined the reliability of each sub-dimension and the full scale.

FINDINGS

In this section, the analyses made to determine the scale's psychometric properties, which is intended to be developed to reveal the cognitive biases of university students in the context of analytical thinking, are included. The first thing to be done during developing a measurement tool is to determine the factor loads with exploratory factor analysis. The next step is to perform confirmatory factor analysis to determine to what extent the items obtained by this analysis are sufficient for

construct validity. Worthington and Whittaker (2006) emphasize that exploratory and confirmatory factor analyzes are necessary to determine the construct validity of a measurement tool.

Of course, before proceeding to the factor analysis stage, the Kaiser-Meyer-Olkin (KMO) and Barlett tests were applied to determine the suitability of the scale for factor analysis, the distribution of data, and the sample size. The data relating to this are given in Table 2:

Table 2 KMO and Barlett Test Results

Kaiser-Meyer-Olkin		.862
Bartlett Test	Chi-square	8714.600
	df	1770
	p	.000

According to Table 2, the KMO value was found to be .862. This value shows that the data are suitable for factor analysis. According to Tabachnick and Fidell (2001), a value of .60 and above is considered sufficient for factor analysis. As a result of the Barlett test, the chi-square value was 8714.600; It was calculated as $df=1770$ and $p=.000$. According to Gorsuch (1997), these values indicate the suitability of the data for factor analysis.

Findings Obtained from Exploratory Factor Analysis

Factor analysis was carried out to determine the factors of the Scale of Cognitive Bias in the Context of Analytical Thinking of University Students and the items included in these factors. Exploratory factor analysis, which is performed to gather the variables that measure the same structure or quality and explain them with a few factors, deals with whether the feature to be measured can be expressed with a few basic factors (Gürbüz & Şahin, 2014). There are seven different factor extraction methods in exploratory factor analysis. These are principal component analysis method (PCA), principal axis factors analysis (TEA), maximum likelihood analysis (MR), image-factor analysis (IF), unweighted least-squares analysis (LDL), generalized least squares analysis (GEK), and alpha analysis (AF). The most commonly used factor extraction method is principal component analysis (Gorsuch, 2008; Henson & Roberts, 2006; Hogarty et al., 2005; Kline, 2011; MacCallum & Tucker, 1991). In this study, the factors were determined by principal component analysis. Because of principal component analysis, is aimed to extract the maximum variance from the data set with each component. In other words, a large number of variables can be summed by decreasing them under a smaller number of components. These few variables play an important role in explaining the full scale. Maximum likelihood analysis has been used a lot in factor analysis studies in recent years. The maximum likelihood analysis is expected to reveal how many factors were determined in the hypotheses established at the beginning of the study (Cudeck & O'Dell, 1994). However, in this study, there was no initial number of factors determined. The main goal is to develop a measurement tool that can reveal individuals' cognitive biases by reducing them to a small number of factors. In the factor analysis, the Varimax rotation technique was applied in order to gather the items that are highly correlated with each other (Tavşancıl, 2019). The purpose of factor rotation is to provide conceptual significance. No new factors are obtained by factor rotation. Factor rotation is done only to provide a better interpretation of the obtained factors. With factor rotation, the structure determines which variables are more related to which factor (Gorsuch, 2008). In the first factor analysis, the first-factor number of the scale was 16 and the total variance value was calculated as 58.787%. When the items in these 16 factors are examined, it is seen that some items are included in more than one factor and also the factor loads are high. Among these items, the difference between the factor loads is less than .10 and the items with factor loads less than .40 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 20, 21, 22, 23, 28, 29, 30, 32, 36, 37, 39, 42, 43, 44, 46, 53, 54, 56, 59, 60) were excluded from the scale by testing one by one. After these items were removed from the scale, a Scree plot based on their eigenvalues was also used to determine the number of factors healthily. The graphic related to this is in Figure 1:

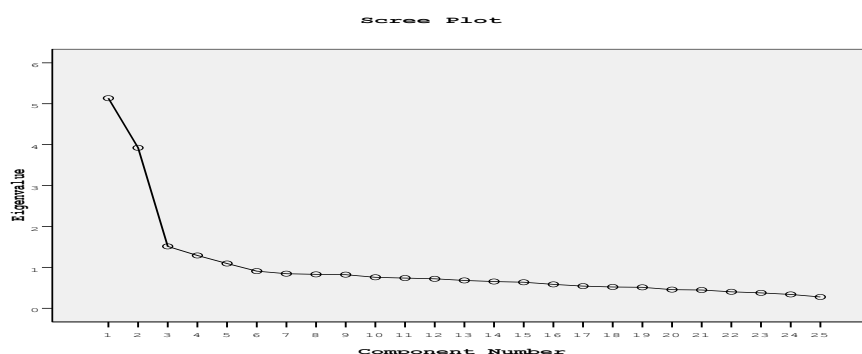


Figure 1 Stacking Graph of Factor Eigen Values

As shown in Figure 1, as a result of the factor analysis, a measurement tool consisting of 25 items was obtained. Having five breaking points gives an idea about the dimensions to be included in the measurement tool. The total variance of these items and factors was calculated as 51,818%. The eigenvalues, variance percentages and total variance percentages related to this are given in Table 3:

Table 3 Variance Table of the Scale of Cognitive Biases of University Students in the Context of Analytical Thinking

Factors	Initial Eigenvalues			Total Factor Loads			Factor Load Rotated Total		
	Total	% Variance	% Cumulative	Total	% Variance	% Cumulative	Total	% Variance	% Cumulative
1	5.135	20.539	20.53	5.135	20.539	20.539	4.589	18.356	18.356
2	3.922	15.688	36.22	3.922	15.688	36.227	2.327	9.309	27.665
3	1.512	6.050	42.27	1.512	6.050	42.277	2.186	8.745	36.411
4	1.291	5.164	47.44	1.291	5.164	47.441	2.186	8.743	45.153
5	1.094	4.376	51.81	1.094	4.376	51.818	1.666	6.664	51.818

As seen in Table 3, three factors emerged as a result of the exploratory factor analysis. The variance explanation percentages of these three factors were calculated as 18.356%, 27.665%, 36.411%, 45.153% and 51.818%, respectively. In studies conducted in social sciences, a value between 40% and 60% of the total variance rate is considered sufficient (Tezci, 2016). Accordingly, it is seen that the total variance value of the Scale of Cognitive Bias in the Context of Academic Thought of University Students is sufficient. The factor loadings of the items in the scale, in other words, the data on the rotated components matrix, are given in Table 4:

Table 4 Rotated Components Matrix Table of the Scale of Cognitive Bias in the Context of Analytical Thinking of University Students

Item No	Factors				
	1	2	3	4	5
Item45	.747				
Item35	.699				
Item24	.685				
Item47	.670				
Item57	.647				
Item48	.645				
Item16	.644				
Item33	.630				
Item34	.593				
Item49	.556				
Item41		.714			
Item58		.651			
Item38		.640			
Item40		.619			
Item50		.593			
Item27			.723		

Item31	.642	
Item26	.634	
Item25	.609	
Item17		.815
Item18		.804
Item19		.674
Item51		.665
Item55		.646
Item52		.630

While applying exploratory factor analysis, axis rotation is applied to ensure that the factors obtained are independent and make clear and meaningful comments. With this application, while the load of an item on one factor increases, the load on the other factor decreases. Thus, it is determined in which factors the items give a high correlation (Büyüköztürk, 2012). For this purpose, the rotation process was applied to gather the items that have a high correlation with each other in a factor. As seen in Table 4, the factor loads of 25 items in the measurement tool vary between .55 and .81. This shows that 25 items in the measurement tool are also qualified to be included in the scale.

Findings Related to Reliability Analysis

In order to determine the reliability of the Scale of Cognitive Biases of University Students in the Context of Academic Thinking, first of all, item-total correlation analysis was applied, which determines the relationship between the scores obtained from the items belonging to the measurement tool and the total score obtained from the test. In addition, to determine the item discrimination power regarding the scale's reliability, the t-test based on the difference between the lower and upper group averages (based on the internal consistency criterion) was applied to 25 items in the scale. The difference between the t-test and the mean of the independent groups for each scale item of the 27% top and bottom groups at the two ends of the scores obtained from the measurement tool was examined. The findings obtained from these analyzes are given in Table 5:

Table 5 Findings Related to Item-Total Correlation and t-Test for 27% Sub- and Super-Groups

Factors	Item No	Item-Total Correlation Values		t-Test Values for 27% Lower and Upper Groups	
		r value	p-value	t value	p-value
Factor 1	Item45	.507	.000	3.764	.000
	Item35	.404	.000	0.640	.000
	Item24	.439	.000	2.743	.000
	Item47	.434	.000	3.336	.000
	Item57	.382	.000	2.662	.000
	Item48	.390	.000	2.737	.000
	Item16	.360	.000	1.828	.000
	Item33	.382	.000	2.206	.000
	Item34	.354	.000	1.441	.000
Factor 2	Item49	.348	.000	1.105	.000
	Item41	.386	.000	4.135	.000
	Item58	.318	.000	3.504	.000
	Item38	.373	.000	5.819	.000
	Item40	.397	.000	5.890	.000
	Item50	.354	.000	5.802	.000
Factor 3	Item27	.424	.000	6.751	.000
	Item31	.366	.000	5.593	.000
	Item26	.440	.000	6.690	.000
	Item25	.359	.000	6.011	.000
Factor 4	Item17	.523	.000	7.089	.000
	Item18	.547	.000	7.661	.000
	Item19	.396	.000	5.437	.000
Factor 5	Item51	.385	.000	17.497	.000
	Item55	.321	.000	21.315	.000
	Item52	.321	.000	13.339	.000

As seen in Table 5, the item-total correlation coefficients of the University Students' Cognitive Prejudices in the Context of Academic Thinking Scale varied between 0.31-0.54 and the correlation coefficients of all items were significant. The fact that these correlation coefficients are positive and significant indicates that the items exemplify similar behaviours and the test's internal consistency is high. It is stated that items with an item-total correlation of 0.30 and higher are highly discriminatory, items between 0.20 and 0.30 can be included in the test or should be corrected in mandatory situations, and items less than 0.20 should be discarded from the test (Büyüköztürk, 2012). Accordingly, it is seen that the discrimination of the items in the Scale of Cognitive Bias in the Context of Academic Thinking of University Students is good. It is seen that the discrimination of the items in the scale is at a reasonable level.

On the other hand, as a result of the t-test for the 27% lower and upper groups given in Table 5, it is seen that the mean score difference of all items is significant. To determine the reliability of the scale, the Cronbach Alpha reliability coefficient was calculated. The results obtained are listed in Table 6:

Table 6 Cronbach Alpha Values

Factors	Cronbach alpha (α)
Factor 1	0.85
Factor 2	0.75
Factor 3	0.70
Factor 4	0.75
Factor 5	0.75
Total	0.76

As seen in Table 6, the reliability values of the sub-dimensions of the University Students' Cognitive Prejudices in the Context of Analytical Thinking vary between 0.70-0.85. The total reliability of the scale was calculated as 0.76. The reliability coefficient, which is a measure of the consistency of the scores of the items with the total test scores, is "not reliable" if it is between 0.00-0.40, "low reliability" if it is between 0.40-0.60, "highly reliable" if it is between 0.80 and 1.00. It is "highly reliable" (Akgül & Çevik, 2003; Kalaycı, 2008). Considering the reliability value of the scale both based on factors and on the basis of total points, it is seen that it is pretty reliable.

Table 7 Pearson Correlation Analysis Results Between Factors

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	TOPLAM
Factor 1	1	*.395	*.326	*.374	*.370	*.745
Factor 2	*.395	1	*.347	*.321	*.309	*.371
Factor 3	*.326	*.347	1	*.475	*.378	*.456
Factor 4	*.374	*.321	*.475	1	*.320	*.369
Factor 5	*.370	*.309	*.378	*.320	1	*.333
Total	*.745	*.371	*.456	*.369	*.333	1

According to Table 7, there is a positive and significant relationship between the factors of the scale. According to Büyüköztürk et al. (2013), it is stated that the correlation coefficient is "weak" if it is less than 0.30, "moderate" if it is between 0.30-0.70, and "high" if it is more significant than 0.70. Accordingly, it can be mentioned that there is a moderately positive relationship between the factors of the scale. It also shows that the five factors of the scale are in the same structure. This shows that the total score can be calculated over the factors in the scale.

Findings on Confirmatory Factor Analysis

Confirmatory factor analysis is used to test whether there is a sufficient relationship between the determining factors, which variables are related to which factors, whether the factors are independent of each other and whether the factors are sufficient to explain the model (Özdamar, 2004). In this context, a five-dimensional model was created due to the exploratory factor analysis of the

Scale of Cognitive Bias in the Context of Analytical Thinking of University Students. This model was tested with confirmatory factor analysis. Descriptive statistics for confirmatory factor analysis are given in the table below (Table 8):

Table 8 Confirmatory Factor Analysis Values of University Students' Cognitive Bias Scale in the Context of Analytical Thinking

Factors	Items	Values	St. Error	95% Confidence Interval		Z	p
				Lower	Upper		
Factor 1	Item45	0.710	0.042	0.627	0.792	16.84	.001
	Item35	0.575	0.044	0.488	0.661	13.05	.001
	Item24	0.615	0.039	0.537	0.693	15.48	.001
	Item47	0.543	0.035	0.473	0.614	15.17	.001
	Item57	0.587	0.042	0.505	0.670	13.99	.001
	Item48	0.558	0.041	0.476	0.639	13.48	.001
	Item16	0.529	0.040	0.450	0.609	13.07	.001
	Item33	0.558	0.044	0.471	0.645	12.57	.001
	Item34	0.529	0.044	0.486	0.561	10.65	.001
Factor2	Item49	0.542	0.050	0.443	0.642	10.68	.001
	Item41	0.596	0.055	0.448	0.704	10.78	.001
	Item58	0.632	0.057	0.520	0.745	11.04	.001
	Item38	0.487	0.047	0.495	0.579	10.33	.001
	Item40	0.513	0.053	0.408	0.619	10.55	.001
Factor 3	Item50	0.657	0.052	0.555	0.759	12.62	.001
	Item27	0.591	0.038	0.515	0.667	15.26	.001
	Item31	0.490	0.040	0.410	0.570	10.58	.001
	Item26	0.537	0.034	0.468	0.605	15.37	.001
Factor4	Item25	0.421	0.045	0.433	0.509	10.36	.001
	Item17	0.658	0.033	0.585	0.731	17.62	.001
	Item18	0.661	0.034	0.593	0.729	19.06	.001
Factor5	Item19	0.409	0.035	0.439	0.578	11.47	.001
	Item51	0.495	0.048	0.400	0.591	10.17	.001
	Item55	0.397	0.045	0.408	0.587	10.72	.001
	Item52	0.489	0.054	0.481	0.596	10.91	.001

According to Table 8, as a result of the first level confirmatory factor analysis of the University Students' Cognitive Bias Scale in the Context of Analytical Thinking, factor loads were found to range between .397 and .710 and all items were significant. In addition, the covariances among the factors of the scale were examined and the findings are given in Table 9:

Table 9 Factor Covariances of University Students' Cognitive Bias Scale in the Context of Analytical Thinking

		Value	SH	95% Confidence Interval		Z	p
				Lower	Upper		
Factor 1	Factor 1	1.000 ^a					
	Factor 2	0.421	0.062	.319	.243	1.95	.001
	Factor 3	0.468	0.056	.379	.157	4.73	.001
	Factor 4	0.428	0.054	.334	.122	4.21	.001
	Factor 5	0.495	0.066	.426	.163	4.40	.001
Factor 2	Factor 2	1.000 ^a					
	Factor 3	0.452	0.057	.339	.565	7.84	.001
	Factor 4	0.403	0.056	.292	.514	7.12	.001
	Factor 5	0.493	0.067	.360	.625	7.27	.001
Factor 3	Factor 3	1.000 ^a					
	Factor 4	0.625	0.044	.537	.713	7.99	.001
	Factor 5	0.577	0.062	.454	.700	9.19	.001
Factor 4	Factor 4	1.000 ^a					
	Factor 5	0.479	0.062	.347	.591	7.53	.001
Factor 5	Factor 5	1.000 ^a					

According to Table 9, the covariance values between the factors of the Scale of Cognitive Biases of University Students in the Context of Analytical Thinking were significant ($p < .05$), and there was a positive correlation between the factors. The covariance values between the factors vary between 0.421 and 0.625. This shows that the five-factor structure of the scale is confirmed.

In the next step of the confirmatory factor analysis, the University Students' Cognitive Biases Scale fit indices in the Context of Analytical Thinking were examined. While there is no consensus on which index will be accepted as a standard when deciding whether the model created by confirmatory factor analysis is compatible with the theory, various fit indices such as χ^2 , χ^2/df , GFI, CFI, TLI, RMSEA, RMR and SRMR are used (Munro, 2005). ; as cited in Çapık, 2014). In this context, the fit indices for the scale are; $\chi^2=614$, $df=265$, $\chi^2/df=2.316$; RMSEA=0.0540; SRMR=0.0682, CFI=0.885; TLI = 0.870. If the chi-square/degree of freedom (χ^2/df) value is less than 5, the model is considered a good fit, and if it is less than 3, the model is considered a perfect fit. Since this value obtained by confirmatory factor analysis is less than 3, it is seen that the scale has a perfect fit. For RMSEA, which is the model's error (mismatch) index, 0.08 is accepted as an acceptable fit, and less than 0.05 is considered a perfect fit. Considering the RMSEA value of this scale, it is seen that the scale has a perfect fit. In addition, SRMR values lower than 0.08 are accepted as acceptable fit. CFI and TLI values between .95 and 1.00 are indicated as a perfect fit and between .90 and .95 as acceptable fit. It is also stated that the TLI value is accepted as a threshold value up to .80 (Byren, 1998; Hu & Bentler, 1999; Marsh et al., 2006; Kline, 2011; Çokluk et al., 2012; Yaşlıoğlu, 2017). Accordingly, the Path Diagram of the model created for the Cognitive Bias Scale in the Context of Analytical Thinking of University Students is given in Figure 1 below:

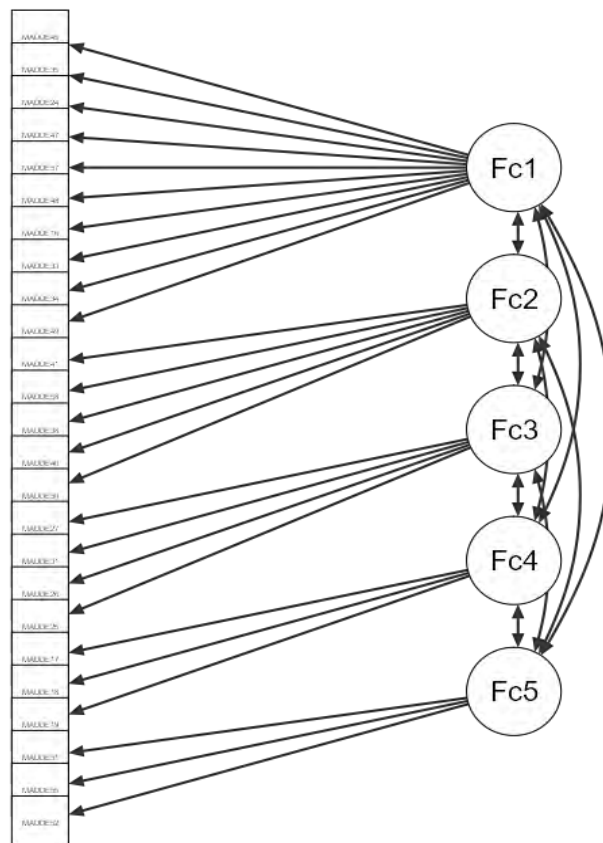


Figure 2 Path Diagram

According to the model given in Figure 1, the University Students' Cognitive Prejudices Scale in the Context of Analytical Thinking consists of 5 factors and 25 items. As a result, confirmatory factor analysis findings confirmed that the model created was at an acceptable level.

Findings Related to Test-Retest Analysis

Calculation of the correlation coefficient between two measurement values by applying a developed measurement tool to the same sample group, under the same conditions, continuously or in a specific time interval, is a type of analysis for the scale's reliability. The recommended timeframe ranges from 15 to 30 days. Thus, the test-retest reliability value of the scale is calculated by looking at the correlation between the two applications (Seçer, 2015; Tavşancıl, 2019). The most important point to note here is that the time interval does not adversely affect the reliability of the measurement tool. While the time in between makes it easier for the participants to recall; The prolongation of the time in between may cause some changes in the measured properties, thus not providing the same conditions for two measurements (Tavşancıl, 2019). In order to examine whether the "Cognitive Bias Scale of University Students in the Context of Analytical Thinking" consists of five factors, changes depending on time, test-retest analyzes were conducted with 40 participants and a strong positive correlation was found between the two applications ($r=0.869$). For the invariance over time, the mean scores obtained from the first and second applications administered with a 4-week interval were compared with the dependent groups' t-test, and no statistically significant difference was found between the two mean scores ($t=0.946$; $p>0.00$). In addition, the Cronbach alpha coefficient was found to be 0.74 in the test-retest group. In each test-retest analysis, a person's first and second application scores were compared. Data regarding these are given in Table 10:

Table 10 Test-Retest Analysis Values of the Scale of Cognitive Biases of University Students in the Context of Analytical Thinking

N=30	Practice I	Practice II
Mean	85.60	88.59
Standard deviation	14.73	12.02
Median	169.3	171.6
Minimum Score	70	115
Maximum Score	100	125
Correlation	0.869	
t value	0.946	
p-value	0.08>0.05	
Cronbach Alpha	0.74	

CONCLUSION AND DISCUSSION

In the rapidly developing and changing world, this change has affected educational paradigms, and learning environments have become more complex. The basis of this situation lies in the fact that individuals encounter much more information than their minds can control. Every day, individuals are faced with much information that they need or do not need, necessary or not necessary. Minds, on the other hand, develop some shortcuts as a defence mechanism within this information density. While many of the shortcuts can be helpful, some can cause problems in the decision-making process. Shortcuts that cause such problems are called cognitive biases.

Individuals who have to solve a complex problem under challenging conditions can intuitively produce several solutions because the minds of individuals tend to use solutions based on previous experiences, intentions or intuitions in the problem-solving process. All of these are not only an excellent approach to problem-solving but also a quick, sometimes good and sometimes insufficient solution suggestion. These are normal responses to probability, frequency, and prediction, not exceptional responses to excessive complexity or information overload problems. In other words, they are cognitive biases. Gazel (2014) defines the term cognitive bias, which he calls cognitive bias, as irrational/irrational behaviour that leads to misperception, misinterpretation, negative reaction or

showing. In general, prejudices are helpful; They enable us to make quick and efficient judgments and decisions with minimal cognitive effort. Nevertheless, they can also blind a person to new information. Not recognizing this impact on individuals' choices and decision-making processes can undermine the quality and accuracy of the analysis. So what should be done? Individuals may not be able to change and erase any traces of prejudice in their minds, but being aware of cognitive limitations can help reduce their negative effects (Kahneman & Frederick, 2005). In this context, this study aims to develop a measurement tool that will help to reveal the cognitive bias processes of university students within the framework of analytical thinking. It is thought that individuals who are aware of their cognitive biases can manage their decision-making processes much better.

In the research, a field survey was conducted within the scope of cognitive bias and how these biases can be handled within the framework of analytical thinking. In line with the theoretical information obtained from the field survey, 10 open-ended questions were determined to ask the students before creating an item pool. Due to the Covid-19 epidemic that broke out as of March 2020, open-ended questions were directed to 40 students online. In line with the data obtained from both the field survey and the answers to open-ended questions, it was deemed appropriate to create three times the number of items planned to be in the scale, and 60 items were written. Before applying any statistical process to the items in the item pool, the opinions of 2 field experts and 1 language expert were taken. Necessary corrections were made in line with expert suggestions. In the next step, a preliminary application was carried out with 15 students, and the draft scale was given its final shape. Necessary ethics committee approvals were obtained before the application.

After the draft measurement tool was applied to the sample group, the suitability of the obtained data and sample group size for factor analysis was tested with KMO. A KMO value greater than .60 (KMO=.862) and a significant Bartlett test result ($p < .05$) indicate the suitability of the available data for factor analysis. In the bias scale development study conducted by Sklad and Diekstra (2014), the KMO value was .53 and the Bartlett test result was found to be significant ($\chi^2(253)=766.50$, $p < .001$). Although the KMO value was slightly below the required standard, the measurement tool development process continued.

In the next step, exploratory factor analysis was performed, revealing how many factors the data set consisted of. Items with item loads less than .40 and the same items with loads less than .10 on different factors were removed from the draft measurement tool one by one. After the principal components analysis, it was seen that the draft measurement tool consisted of five factors and a total of 25 items. The total variance explanation rate of the measurement tool was determined as 51.818%. In studies conducted in social sciences, it is generally accepted that a value between 40% and 60% of the total variance is sufficient (Büyüköztürk, 2012; Tezci, 2016).

For this reason, it can be stated that the factors of the measurement tool are sufficient to represent the total variance. Sklad and Diekstra (2014) calculated the total variance as 59.7% in the bias scale development study. Toplak et al. (2011) mentioned some difficulties developing a measurement tool for cognitive bias in their study. While developing a measurement tool on this subject, it is necessary to know that cognitive bias has two different types of tasks. Some cognitive biases are measured with one or more equivalent items. For example, a gambler's cognitive bias can be judged by a single problem such as "When playing slot machines, people win something 1 time out of 10". However, Julie won her first three games. So what are Julie's chances of winning the next time she plays?

Similarly, base rate omission, sunk cost bias, and belief bias are often measured in one or more comparable items. In other words, a separate score can be calculated for the biases considered, and a total score can be obtained from the measurement tool. The factors obtained in this study can reveal different cognitive biases and a total score can be obtained from the measurement tool.

Another situation claimed by Toplak et al. (2011) is that Likert-type instruments, like the measurement tool developed in this study, cannot be developed to reveal some cognitive biases. Some

cognitive biases are typically manipulated among subjects and are evidenced by the influence of a normatively irrelevant factor. For example, the framing effect is often achieved by presenting a gain and a loss version of the same decision problem to two different groups (Tversky & Kahneman, 1981). Therefore, to reveal individuals' cognitive biases, situations are needed by revealing such thoughts of individuals, not items (Parker & Fischhoff, 2005). However, in this study, the results obtained from the field scanning and the application of the draft measurement tool, especially before the development of the draft measurement tool, were that the cognitive biases of individuals against certain situations could be revealed not only by the creation of certain situations.

The reliability coefficient of this study, which aims to develop a measurement tool to reveal the cognitive biases of university students in the context of analytical thinking, was calculated as .76. The measurement tool development study conducted by Toplak et al. (2011) calculated the internal consistency of composite scores for fifteen cognitive biases as .484 (Cronbach alpha). Similarly, Aczel et al. (2015) similarly calculated the reliability coefficient as .23 for one factor and .37 for the other factor in their study. These studies revealed that the factors measuring the same cognitive bias were unreliable, and it was deemed appropriate to evaluate the factors based on their total scores rather than considering the factors separately. Bruine de Bruin et al. (2020), on the other hand, aimed to develop a measurement tool that deals with how cognitive biases affect the decision-making process. Reliability values in the seven sub-dimensions of the 6-point Likert type scale varied between .54 and .77. In this study, it is seen that the reliability values of the factors vary between .70 and .85. This shows that the factors of both measurement tools are reliable in revealing different types of cognitive biases in the context of thinking types. Teovanović et al. (2015) stated that they calculated the reliability value greater than .70 in measurement tools in which seven cognitive biases were factors.

The aim of the study by Peter et al. (2013) is to create a new scale that evaluates thinking errors commonly seen in psychosis and assumed to play a role in the formation and maintenance of the disorder. The prepared Cognitive Bias Questionnaire (CBQp) consists of 30 items. The scale showed good internal consistency and test-retest reliability, with scores remaining constant over time in both healthy controls and psychosis patients. After confirmatory factor analysis of the scale, which consisted of seven factors with exploratory factor analysis, it was seen that two factors could not be used, and the reliability coefficients were unacceptable. They also stated that there was a high level of correlation between the remaining factors of the scale.

Cognitive biases are universal human cognitive tendencies that emerge very early in life and continue throughout our lives (Samuels & McDonald 2002). Cognitive biases can help us quickly filter and process large amounts of information using heuristics or rules of thumb. These cognitive biases and heuristics often operate below the user's awareness and are, therefore, quite difficult to overcome. In their study, Kliegr et al. (2018) studied 20 cognitive biases that they believe may affect human judgment and the interpretation of rules discovered by machine systems. In this study, they discussed how each bias can arise in the context of machine learning and how system designers can adopt bias reduction techniques defined in the cognitive science literature.

A study by Kim and Yang (2020), it is aimed to develop a thinking process model that reveals cognitive bias by analyzing students' cognitive biases while processing experimental manuals. The results showed that four paradigm categories (causal conditions, phenomena, interactions and contextual conditions) and fifteen concepts were derived. In the research, it is seen that students exhibit bias in following the instructions given to them due to the effect of causal conditions. In this case, causal and contextual conditions can be considered in a guideline to be developed. Thus, cognitive bias among students can be reduced and ultimately help them to conduct accurate experiments. Therefore, it is essential to know the cognitive biases of the students during the decision-making process or the completion of a task assigned to them and to overcome the cognitive biases by taking the necessary steps in this direction.

Castro et al. (2019), in their study on the cognitive biases of university students, aim to relate the issue of prejudice to the training of psychologists, as it has a strong influence on people in the role

of supporting society. The participants of the study are 198 psychology students from three universities in southern Chile. Two cognitive tasks created by Kahneman and Tversky were used as data collection tools in the research. The results obtained from the study show that there is a high level of cognitive bias in student groups. The two assessed tasks show differences between universities regarding cognitive confirmation bias in subtask 1 and task 2. Likewise, there are differences by age and gender. As a result of the research, it was concluded that future psychologists need to strengthen their reasoning skills in the initial training to develop decision-making skills in the professional field.

Rivas (2008) emphasized that people tend to make quick decisions in different situations, ignoring that they are chosen by choosing an alternative to others, stating that the ongoing situation will only have meaning. This tendency, called cognitive bias, is often inaccurate and leads to error. Having an initial idea of how the world works or having an image of others does not mean not studying new information. Instead, information is assimilated into pre-existing ideas and further reinforced (Martín & Alvarez, 2000). In other words, individuals' cognitive biases may seem to enable instant decisions to be made quickly, but this is considered a problem if it prevents the acceptance of new information or research and examination. As a result, when individuals want to make rational decisions, they have to control their cognitive biases, spend the decision-making process efficiently, and analyze their situation well. In this case, they need to know their cognitive biases to manage the process. With this study, a valid and reliable measurement tool was developed that can be used to determine cognitive biases in the context of analytical thinking. In possible future studies, applications to overcome the determined cognitive biases can be carried out.

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APPENDIX

Item No	Items
1	I accept or reject anything my friends accept or reject without question.
2	I believe in the first truth found in any decision-making situation.
3	When I encounter a new situation, I keep my current situation, I don't want to learn anything new.
4	I don't notice changes in something I know.
5	I do not consider simple-looking solutions when solving a problem or learning a subject.
6	I am not interested in evidence and details that confirm my belief in a situation.
7	When I see a different version of a subject that I knew before, I think it is wrong to accept this change.
8	In a situation where I am torn between two options, I believe in the correctness of the option I have chosen without seeking any proof.
9	I convince myself that the solution proposals I put forward in a problem situation are more correct than the solution proposals of others.
10	I notice the faults of others rather than my own.
11	I retain information I have learned or a problem I have solved in a different way than when I experienced it.
12	I store a subject in my mind in a different way than it is.
13	When trying to remember a subject I learned, I add to it from myself.
14	I learn by listing a newly learned information in keywords in order to remember it more easily.
15	I create new stories to complete the missing data in a situation, I complete it myself.
16	When I learn new information, I look for evidence that proves the accuracy of the information.
17	When I encounter a new situation or attempt to solve a problem, I stay in control so that I don't make mistakes.
18	In order to reach a solution in case of a problem, I go to information diversity and do research from different sources.
19	In a problem-solving situation, I conduct research to confirm or prove my initial decisions.
20	Every piece of information I have learned is very valuable to me.
21	I believe that the information I have learned will fill my knowledge gaps.
22	I take a positive approach to a new subject that I have learned.
23	I have trouble remembering the subjects I love.
24	I start with the closest and most accessible information to focus on a topic or problem.
25	I try to shape the past and the future with the thoughts I have now.