

Differences in the Cognitive Processes of Autism Spectrum Disorder Students in Understanding Mathematical Problems Based on the Level of Intelligence

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Abstract. *The purpose of this study is to determine differences in the cognitive processes of autism spectrum disorder (ASD) students in understanding mathematical problems based on different levels of intelligence. The subjects of this study consisted of 3 ASD high school students who had high, medium and low intelligence respectively. Data obtained through task-based interviews using triangulation. ASD subjects with a high intelligence level (ASDH) received information by reading the problem softly, applying voice pressure to certain words, interspersed with laughing and smiling to themselves, repeating certain words and muttering to say an unclear sentence. Whereas ASD subject with a medium intelligence level (ASDM) received information by reading the problem out loud with a rather rapid intonation of voice, without any eye contact with blank eyes. Whereas ASD subject with a low intelligence level (ASDL) received information by reading the problem rather loudly and reading piecemeal sentences. ASDH subject can store information and call back in three forms of visual representation, images, verbal and symbols. Information recalled by ASDM subject in two forms of visual representation, images and verbal. Information recalled by ASDL subject is only in one form of visual representation, in the form of images. ASDH subjects were able to understand well the meaning of the symbols that exist in the problem, while ASDM and ASDL subjects were not able to understand it. ASDH and ASDM subjects can understand well the adequacy of information in the problem, while ASDL subjects are unable to understand it. ASDH subjects were able to reduce information in the questions, while ASDM and ASDL subjects were not able. ASDH and ASDM subjects were able to understand well the patterns of the images in the problem while ASDL subjects were not able to understand them.*

Keywords: *Cognitive Processes, autism spectrum disorder, intelligence level, understanding mathematical problem*

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I. Introduction

Cognition is a mental activity that exists in the human brain. The mental activity starts from how information is received by the senses (sensory register), how the information is filtered and passed on to the brain by sensory registers, processed and stored in the brain and then called back [1].

The process of filtering information is carried out because the information received by the senses is very much, so it is necessary to selectively select some of the information aimed at so that the information can be received properly and effectively. To be able to selectively choose the process of focusing attention on that information called attention. Furthermore, some of the information that has been filtered by the sensory register will be passed on to the brain and processed. In processing the information there is a process of perception or giving meaning (interpretation) by using the prior knowledge possessed. Because the knowledge possessed by each person is different, each person's perception of an information can also be different.

After the process of perception, the next stage of internal representation is the process of cognition in constructing information which will then be stored in memory and at any time can be recalled. Everyone always experiences such a process, when an information is obtained. If the information obtained in the form of problems that must be resolved, the higher the level of cognition, because the process is carried out and the results are used as a basis for making decisions in solving problems.

One type of problem is a problem in the field of mathematics. The ability to solve problems is an important component of mathematical competence. The National Council of Teachers of Mathematics stated that problem solving must be a focus in learning mathematics because it includes skills that are an important part of daily life. Good problems give students the opportunity to strengthen and expand their knowledge and to stimulate new learning [2]. Neef et al [3] state that problem solving (mathematical problems in the form of stories) is one of the challenging tasks for many students, especially students with cognitive difficulties because it requires not only mathematical skills, but also reading comprehension, reasoning, and the ability to change words and numbers into the appropriate operations.

How can a mathematical problem be faced with someone who has social interaction and communication disorders such as children with autism or autism spectrum disorder (ASD)? According to Young Seh Bae [4] in his dissertation stating that, solving mathematical problems in the form of stories in students with autistic disorders is still rarely studied in depth despite serious increases in population prevalence in these students. Thus in-depth research is needed about the cognitive processes of ASD children in solving mathematical problems. In this study specifically discusses the process of cognition in understanding mathematical problems, while the subject is distinguished based on different levels of intelligence.

1.1 Mathematical problem

A problem usually contains a situation that encourages someone to solve it but does not know directly what to do to solve it. If a problem is given to a child and the child immediately knows how to solve it correctly then the problem cannot be said to be a problem for the child. It can be concluded that a mathematical problem will become a problem in learning mathematics if the problem can be solved by means of non-routine settlement procedures and requires the organization of some other knowledge.

The National Council of Teachers of Mathematics [2], states that: good problems give students the opportunity to strengthen and expand their knowledge and to stimulate new learning. Most of the mathematical concepts can be introduced through problems based on experiences that are known to students that are derived from students' lives or from mathematical contexts. However, problem solving is a challenging task for many students, especially for students with cognitive difficulties because it requires not only mathematical skills, but also reading comprehension, reasoning, and the ability to turn words and numbers into appropriate operations [3].

Polya [5] proposed 4 phases in solving a problem, namely: (a) Understanding the problem (understand the problem); (b) Devise a plan, (c) Carry out the plan (carry out the plan), and (d) Look back. Understanding the problem to be solved is a very important step in solving the problem. Understanding the problems encountered will facilitate the resolution of these problems. Without understanding the problem well, a person will experience difficulties or even will not be able to solve the problem at hand. In this step the ability to see the relationship between data and conditions that exist or are available and those that are not known or asked for is needed. The completion plan that was made beforehand was carried out carefully at each step. In the step of re-checking carried out to ascertain whether the settlement is in accordance with what is desired in the problem or not. If the results obtained are not appropriate, it is necessary to double-check every step that has been done to get the desired results. From the results of the inspection, it is known that the step is not appropriate. Thus, improper steps can be corrected again.

1.2 Students with autism spectrum disorder (ASD)

The term autism was first coined by Eugen Bleuler, a psychiatrist and psychologist from Switzerland in 1912 who referred to "an escape from reality". Autism comes from the Greek word "autos" which means self. This term refers to schizophrenia disorders, withdrawing from the extremes of social life [7]. In the mid-20th century doctors, psychiatrists and psychologists began to research and try to define a group of children who have developmental abnormalities (abnormal development) including Leo Kanner. Leo Kanner [8] was the first to formally publish autism. He wrote that autistic children are "have come into the world with innate inability to form the usual biologically provided affected contact with people". The disability in question is in the form of delayed speech, lack of vocabulary, inability to use language for communication, the desire to be alone and the ability to connect objects in their environment only when they want. Kanner [8] based on psychoanalytic theory said that the condition of this autistic child may be due to the care of an old man who is cold, stiff and perfectionist.

Kanner [9] found children who had a different set of behaviors which later was called the syndrome of early childhood autism. Furthermore, he also discovered several common characteristics of children with autism, namely: extreme autistic aloneness, an obsessive desire to maintain equality, extraordinary ability to memorize, and the limited types of activities carried out spontaneously.

In the same period, Hans Asperger, a psychiatrist from Viennese Austria, discovered several children who had the same behavior called Asperger's Syndrome [10]. He also explained that these children have deficiencies in social and emotional relationships, lack feelings with others, use less language, but some were found to have talents in mathematics and science. Asperger also said that maybe the cause of autism had something to do with genetics. To deal with children with autism, Asperger offers to use a treatment and education approach.

1.3 Cognition processes and intelligence level

Autism spectrum disorder (ASD) is a type of autism that has different characteristics from other types of autism. This type of autism is more common than other types of autism. Symptoms of keautirannya appear when a newborn child is characterized by inability or lack of eye contact with others, less reacting to stimuli, like to be alone, less able to have reciprocal social and emotional relations. But like other types of autism, people with autism are found from mild, moderate to severe. Severe ASD will experience severe obstacles in communication and imagination, do not like to hear loud noises, are not sensitive to pain or fear, persist in routine activities, behave repetitively and stereotypically and throw tantrums or cry for no apparent reason (tantrum).

This type of autism is usually referred to as infantile autism or true autism or childhood autism because it is experienced by children from infancy. Unlike the Asperger syndrome, which generally has average or even higher intelligence, this type of autism is found in children with low to high intelligence. Based on the results of Joseph & Tager's research [11], found that cognitive development of ASD children is not evenly distributed. In this study, 120 subjects with autistic children consisted of 108 boys and 12 girls, 73 preschoolers and 47 school ages. In this study it was also found that nonverbal abilities were better than verbal abilities. Harris et al [12] in his study found that, "cognitive skills have been found to influence the age of diagnosis for ASD and the severity of autistic symptoms. Children with higher IQs are more likely to be identified at a later age. Children with below normal IQ exhibit more autistic symptoms verall, including more social problems. That is, cognitive abilities influence the age of diagnosis for ASD and the severity of autistic symptoms. Children with higher IQs are more likely to be identified in old age. Children with IQs below normal show more severe symptoms of autism, including more social problems.

Furthermore, the results of Long & Gurka's research [13] found differences in language skills in children with ASD (autis spectrum disorder) which were more inhibited than in children without ASD and there were slight differences in the cognitive abilities of children with and without ASD. The study sampled 147 ASD children aged 16-38 months who were referred to a diagnostic clinic for development evaluation.

According to Mayer [14], that the process of cognition experienced by someone when solving a mathematical problem are: (1) interpreting: understanding every sentence in the problem), (2) recalling: recalling the factual knowledge needed in solving problems, (3) organizing: building a coherent representation of key information in a problem called conceptual knowledge, (4) planing: designing a completion plan, (5) producing: implementing a plan called procedural knowledge. Cognitive abilities have a close relationship with intelligence even though they are not the same thing. Nickerson, Perkins and Smith believe in some abilities that can represent human intelligence, namely: (1) ability to classify patterns, (2) ability to modify behavior adaptively, (3) ability to think deductively, (4) ability to think inductively (generalization), (5) the ability to develop and use conceptual models, (6) the ability to understand / understand.

According to Latham [15] said that cognitive abilities are brain-based skills and mental processes that are needed to carry out any task and have more to do with the mechanism of how a person learns, remembers, and pays attention to than the actual knowledge has been learned. Furthermore Latham [15] also said that IQ, or Intelligence Quotient, generally describes scores on tests that measure a person's cognitive abilities compared to the general population. IQ tests are designed to measure a general ability to solve problems and understand concepts. There is a high positive correlation between IQ and success in school and work, but there are many,

many cases where IQ and success are incompatible. Latham [15] also added that a person's cognitive abilities can be trained or improved, while intelligence is a relatively static test score into adulthood.

II. Methodology

2.1 Participant of the research

The subjects in this study consisted of 3 high school students with ASD who respectively had high, medium and low IQ scores. They get intensive therapy for emotional control and currently they are in an inclusive school with special assistance from a teacher accompanying children with special needs.

2.2 Ethics/permissions

The researchers obtained permission from the Ministry of Education and Culture and relevant schools. Pseudonyms have been used to protect the identities of the participants who were free to withdraw from the research without fear or prejudice at any time.

2.3 Setting and design of the research

The research took place in a private high school in East Java Province in Indonesia. The subject with high intelligence level attended a private high school in an inclusive education setting. The subjects with medium and low intelligence level attended a public high school. The school was located in an area of the city. At the school, a certified educator provided support services for students with ASD.

The research approach was done in a flexible and evolving style in accordance with the circumstances in the field. Adjustments were made for the factors that affected the results of the study. The results of the study cannot be generalized, but only reflect actual phenomena in the field according to the research objectives. This research focused on a student with autism spectrum disorder, so this research is a case study. The approach is categorized as qualitative, while this type of research is descriptive explorative research [14]. The qualitative data on the general form of words was derived from observations, interviews or documents. Qualitative data has advantages compared with quantitative data; for example, qualitative data is richer in terms of descriptions and explanations [15].

2.4 Instruments and its validation

In accordance with the type of the research (qualitative), the main instrument in this research was the researcher's observations, while the auxiliary instrument was in the form of mathematical problem test instruments and instrument-guided interviews. As a main instrument, the researchers acted as a planners, collectors, analyzers, interpreters and reporters of the research results. Thus, the researchers have to be objective, responsive and neutral.

Mathematical problem test instruments were processed by experts through content validation to validate the construction of problems, materials and language in the problems. The validators were two mathematics teachers and two mathematics specialists from a university. The topic in the problems is arithmetic sequence.

2.5 Data collection and analysis procedures

The data collection in the research was conducted consecutively, one at a time. The data collection was done by using task-based interviews with a think-aloud method. The subject of this research worked on mathematics problems by writing answers on the answer sheet provided and revealing what he was thinking at that time by narrating out loud. If the subject did not reveal his thought processes, the researchers would ask probing open-ended questions to elicit a response. All activities of the subject at the time of understanding mathematical problems were recorded with a video recorder. The think-aloud method can be effectively applied to gain the data of a qualitative research. In this research, the participant has to speak aloud any words that they are thinking when they complete the task. Think-aloud research methods have a strong theoretical basis with a valid source of data about what is in participant's mind during the language-based activities

III. Results

3.1 Autism spectrum disorder student with high intelligence

Subjects receive information by reading questions by making a quiet voice, applying sound pressures to certain words, reading questions with a flat expression, at certain times interspersed with laughing on their own, smiling to themselves, repeating certain words (repetitive) and muttering to say an unclear sentence. The subject has saved important information in the problem and recall them. The information is obtained by the subject of the sentence or picture in the problem. The stored information is recalled in four forms of visual representation properly because the form of the representation accurately describes the content of the problem. The four forms of visual representation are: (a) visual representations in the form of images, (b) two verbal representations, and (c) visual representations of tribal symbols. The subject considers the information stored and recalled as important information because through this information the problem can be solved. Then the subject calls back information that has been stored in its long-term memory by linking it to information that has just been received. The information recalled is information about the concept of the line.

The subject understands well what is known in the problem because the subject has revealed most of what is known in the problem. The reason the subject believes that this is what is known in the problem is because it determines the pattern and is clearly visible in the problem. The subject understands well what is asked in the problem because the subject has mentioned exactly what was asked in the problem. The reason the subject believes that it is what is asked in the problem with the reason because it is listed in the problem and the question is relevant to what is known in the problem. The subject can understand well the meaning of the notation in the problem. The subject can understand well the adequacy of the information contained in the problem with the reason that the information in the problem can be used to solve the problem. The subject is able to reduce the sentence in the problem. Figure 1 below is a scheme of the subject's cognition process at the stage of understanding the problem.

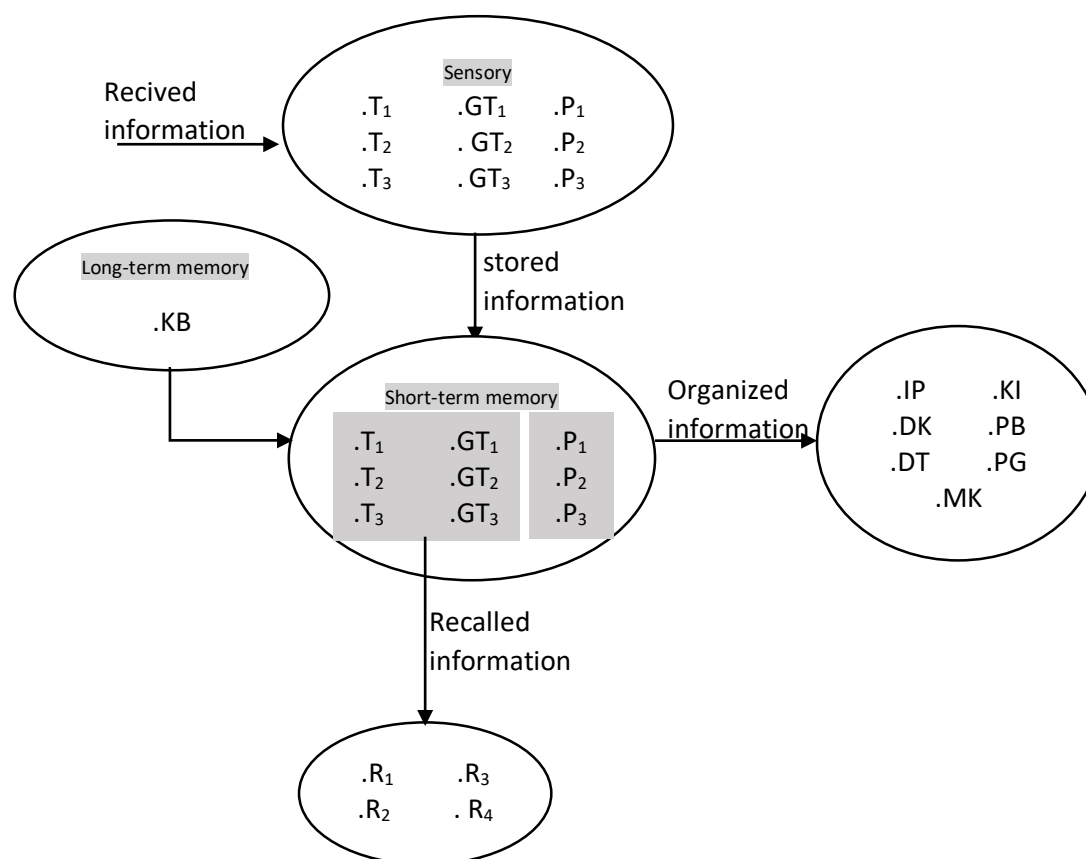


Figure 3.1 The scheme of the cognitive process of ASD subjects with a high level of intelligence in understanding the problem

T ₁	:	Information about 3 matchsticks needed to make a level 1 triangle
T ₂	:	Information about 9 matchsticks needed to make a level 2 triangle
T ₃	:	Information about 18 matchsticks needed to make a level 3 triangle
GT ₁	:	Draw the first level triangle
GT ₂	:	Draw the second level triangle
GT ₃	:	Draw the third level triangle
P ₁	:	Question about how many matchsticks are needed to form the 5th level triangle?
P ₂	:	Question about how many matchsticks are needed to form the 10th level triangle?

P ₃	:	Question about how many matchsticks are needed to form the n-th level triangle?
KB	:	Sequence concept
R ₁	:	The pictorial representation
R ₂	:	Verbal representation
R ₃	:	Verbal representation with difference between adjacent tribes
R ₄	:	Symbol representation
S	:	Understand the symbols in the problem
IP	:	Determine information that is important in the problem
DK	:	Understand the known
DT	:	Understand what is being asked
PB	:	Understanding the pattern of ranks
PG	:	Understand triangle 1, 2, and 3 level triangle patterns
KI	:	Understand the adequacy of information
MK	:	Reducing the known

3.2 Autism spectrum disorder student with medium intelligence

The subject receives information by reading the questions aloud. The subject reads the entire sentence in the question with a quick intonation of voice with a flat expression. The subject reading questions starts from the beginning of the sentence in the problem, sees the picture in the problem and then reads the question in the problem. When reading the questions, the subjects did not make eye contact with the researchers. The subject looks still with blank eyes after finishing reading the questions.

The subject has saved the information in the problem and recall them. The information is recalled in two forms of visual representation, namely: (a) visual representation in the form of images accompanied by symbols, and (b) verbal representations. The subject considers the information stored and recalled as important information because it can be used to determine the pattern of the sequence. Then the subject calls back information that has been stored in its long-term memory by linking it to information that has just been received. The information recalled is information about the concept of arithmetic sequence and pattern of the sequence.

The subject understands well what is known in the problem because the subject has revealed most of what is known in the problem. The reason the subject believes that it is what is known in the problem with the

reason that what is known is clearly seen in the problem and determine the pattern of the sequence. The subject understands well what is asked in the problem because the subject has mentioned exactly what was asked in the problem. The reason the subject believes that this is what is asked in the problem with the reason because it is listed in the problem. The subject is not able to understand well the meaning of the symbol in the problem. The subject can understand well the adequacy of the information contained in the problem with the reason that the information in the problem can be used to solve the problem. The subject has a good understanding of the pattern of differences between adjacent tribes. Figure 2 below is a scheme of the subject's cognition process at the stage of understanding the problem.

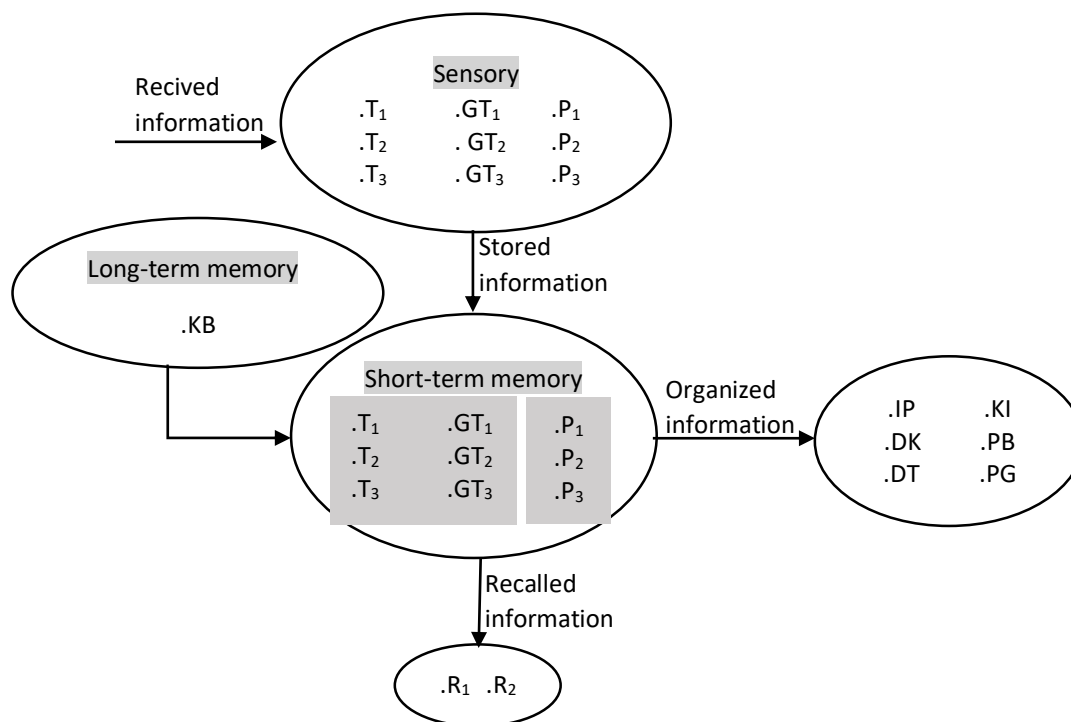


Figure 2 The scheme of the cognitive process of ASD subjects with a medium level of intelligence in understanding the problem

T ₁	:	Information about 3 matchsticks needed to make the first level triangle
T ₂	:	Information about 9 matchsticks needed to make the second level triangle
T ₃	:	Information about 18 matchsticks needed to make the third level triangle
GT ₁	:	Draw the first level triangle
GT ₂	:	Draw the second level triangle
GT ₃	:	Draw the third level triangle
P ₁	:	Question about how many matchsticks are needed to form the 5th level triangle?

P ₂	:	Question about how many matchsticks are needed to form the 10th level triangle?
P ₃	:	Question about how many matchsticks are needed to form the n-th level triangle?
KB	:	Sequence concept
R ₁	:	The pictorial representation
R ₂	:	Verbal representation
S	:	Understand symbol in the problem
IP	:	Determine information that is important in the problem
DK	:	Understand the known
DT	:	Understand what is being asked
PB	:	Understanding the pattern of ranks
PG	:	Understand triangle 1, 2, and 3 level triangle patterns
KI	:	Understand the adequacy of information

3.3 Autism spectrum disorder student with low intelligence

Subjects receive information by reading questions in a rather loud voice with a flat expression, reading from what is known in the problem and stops until what is known in the problem has been read all. The subject continues reading the first part that is asked in the problem then stops. The subject continues reading the last part asked in the problem. When reading the questions to completion the subject did not make eye contact with the researcher.

The subject saves and recalls the information. The subject saves and summons information in the form of visual representation in the form of images properly because the form of the representation accurately describes the content of the problem. The subject can understand what is known in the problem because the subject has revealed most of what is known in the problem. The subject can understand what is asked in the problem because the subject has mentioned correctly what is asked in the problem. Figure 3 below is a scheme of the subject's cognition process at the stage of understanding the problem.

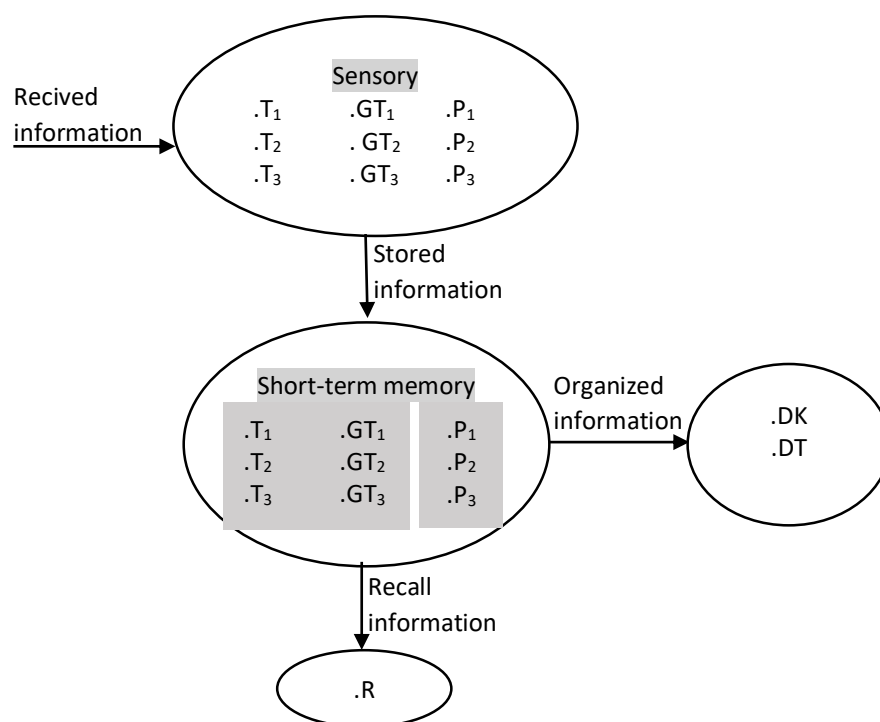


Figure 3 The scheme of the cognitive process of ASD subjects with a high level of intelligence in understanding the problem

T ₁	:	Information about 3 matchsticks needed to make a level 1 triangle
T ₂	:	Information about 9 matchsticks needed to make a level 2 triangle
T ₃	:	Information about 18 matchsticks is needed to make a level 3 triangle
GT ₁	:	Draw the first triangle
GT ₂	:	Draw the second triangle
GT ₃	:	Draw a third triangle
P ₁	:	Question about how many matchsticks are needed to form the 5th level triangle?
P ₂	:	Question about how many matchsticks are needed to form the 10th level triangle?
P ₃	:	Question about how many matchsticks are needed to form the nth level triangle?
R ₁	:	Visual representation of images

DK	:	Understand the known
DT	:	Understand what is being asked

IV. Discussion

At the stage of receiving information, ASD characteristics of the three subjects were seen. These characteristics include flat expressions or blank eyes, at certain moments interspersed with laughing and smiling to themselves, repeating certain words (repetitive) and muttering say an unclear sentence.

The three subjects stored important information from within the read problem, but the difference was during the process of recalling the information. ASD subjects with a high level of intelligence, able to call information in 4 different forms of representation. ASD subjects with moderate intelligence are able to call information in 2 different forms of representation. ASD subjects with low levels of intelligence are able to call information in 1 different form of representation. ASD subjects with a high level of intelligence and are able to recall information stored in their long-term memory. The information is relevant to the information inside that has just been received. However, ASD subjects with low levels of intelligence were unable to do it. The three subjects were able to determine what was known and what was asked in the problem, but only ASD subjects with a high and moderate level of intelligence were able to name the reason. Only ASD subjects with a high level of intelligence are able to understand the notation in the problem well.

The results of the study are consistent with research conducted by Whitby and Mancil [16] which shows that the ability to read, write and mathematics in ASD students with HFA is directly proportional to their IQ level. This is also in line with the results of research conducted by Dickerson and Colhoun [17] who examined the profile of ASD students which showed that ASD students were strong in the fields of reading, writing and mathematics and their abilities were in line with their IQ levels, whereas they were weak in the field attention and social interaction.

V. Conclusion

Based on the results of this study it can be concluded that the differences in the IQ level of ASD students affect their cognitive processes, especially in understanding mathematical problems. In learning in class, the teacher should pay attention to the level of intelligence. Teachers should not regard ASD children as one another. The fact is that ASD children are often considered to be retarded children and even classified as children with mental disorders, because some ASD children who have not been able to control emotions are still often in a tantrum.

The ASD characteristics that appear should be understood by the teacher such as: not making eye contact, not being able to interact, sometimes smiling and laughing to themselves, sometimes muttering, flat expressions and blank eyes. The teacher should not let ASD children withdraw from the class, because ASD children tend to be preoccupied with themselves. Interference with communication and communication is the main cause of

difficulties in learning in the classroom, so some learning strategies that emphasize interaction activities between ASD students without ASD should be done.

The process of receiving different information between ASD with high, medium and low intelligence levels can be used as a reference for teachers in providing assistance when students read. ASD students with low levels of intelligence who read tend to be piecemeal in need of a co-teacher who is constantly reminding and encouraging that students want to read in full. The information stored by the three subjects is almost the same, but what looks different is the process of recalling information. ASD students with a high level of intelligence are able to call information in 4 forms of representation, ASD students with a level of intelligence are able to call information in 2 forms of representation and ASD students with a low level of intelligence are only able to call information in 1 form of representation. This can be used as a reference for teachers to provide illustrations either through pictures or the media of the questions given. ASD students with low levels of intelligence who cannot recall relevant information from long-term memory require emphasis in giving apperception at the beginning of learning. A significant difference between ASD students with low intelligence levels and ASD students with high intelligence levels, especially in understanding patterns requires more assistance for ASD students with low intelligence levels.

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VII. Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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