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Knowledge Base Development Framework with Fuzzy Preference Based on Group Decision Maker

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ABSTRACT

The knowledge base is a critical component in building intelligent systems, especially those related to systems that require expertise. However, one of the problems experienced is when collecting expert knowledge from more than one person. This knowledge is different from each expert that makes opinions and perceptions result in different decision results, and not necessarily, the decision can be accepted by other experts, in this case, psychologists. As a result, decision-makers have difficulty making the right decisions. This study developed a framework and strategies to build a knowledge base from several experts -with fuzzy preferences using a qualitative approach. Developing a framework for determining symptoms and disorders in children was taking a sample. Determining symptoms and disorders in children sometimes requires more than one expert in decision-making. Experts in this case act as decision-makers in giving preference to the symptoms. The result gives 20 symptoms with five behavior disorders in children that often occur. The data of symptoms and disorders obtained formed as much as 19 knowledge in IF-THEN with different weights. In the future, expert system machines can use this knowledge base collection by adding inference methods.

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1. INTRODUCTION

Expert Systems are computer systems that can imitate or replicate tasks based on human intelligence and make decisions exactly as skilled humans do in the Artificial Intelligence (AI) domain. An Expert can solve complex problems by utilizing knowledge and information from their area of expertise. This information provides the basis for program design with rule-based problem-solving skills. Expert systems use precise data about a field to gain competence as human experts. Area expert system is a sub- field of artificial intelligence that has achieved great success in many domains. Currently, various topic areas such as medicine, chemistry, geology, law, politics, economics, and control systems use expert systems. In addition, potential applications of expert systems are made in any area (Cooke, N. J., 2014).

Expert systems are developed to deal with and solve complex problems by cognitive thinking about knowledge, expressed mainly as If-Then rules through predictable procedural code. AI programs that achieve competency at the expert level in solving problems in some task areas by conveying a certain level of knowledge about specific tasks are termed expert systems, knowledge-based systems, or rule-base (Mijwil, *et al*., 2021).

The process of solving such problems is considered an iterative procedure in which a decision maker (DM) interacts with a computer system in order to analyze multicriteria decision options and make the best choice according to his/her preferences (Nelyubin, *et al*., 2018, Nelyubin, *et al*., 2019). In practice, it is often impossible to obtain accurate estimates of quantitative parameters that reflect decision-makers preferences. Therefore, the most promising are methods of multicriteria analysis using incomplete, inaccurate, and fuzzy information about preferences.

The criteria importance theory makes it possible to correctly consider qualitative (non-numerical) information about the DM's preferences, mainly information about the relative importance of criteria. Within this theory, unique methods have been developed that allow conclusions to be drawn on decision-making based on incomplete information on the preferences of the DM. In addition, methods for obtaining and using fuzzy information about preferences are currently being developed (Nelyubin, *et al*., 2018, Nelyubin, *et al*., 2019, Liu, et al., 2020).

The knowledge base is the heart of the Expert System. They use heuristic knowledge as well as recognized scientific ideologies and computational algorithms. The domain knowledge of an expert system is organized in the knowledge base. This module is critical that the successful practice of the plan depends on the excellence and dependability of the knowledge confined (Imanov, E., & Daniel, E. 2019). When building an expert system, a knowledge base search process is needed. A knowledge base is a key to all intelligent systems. The knowledge base contains facts and rules to understand and resolve a problem.

However, one of the problems experienced is when collecting expert knowledge from more than one person. This knowledge is different from each expert that makes opinions and perceptions result in different decision results, and not necessarily, the decision can be accepted by other experts, in this case, psychologists. As a result, decision- makers have difficulty making the right decisions.

A knowledge base includes declarative knowledge refers to facts or information stored in the memory that is considered static. Declarative knowledge, also referred to as conceptual, propositional, or descriptive knowledge, describes things, events, processes, attributes, and relations. Moreover, procedural knowledge deals with the info about the sequence of action. There are various techniques of representation and organization of knowledge base. The most widely used are:

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- Semantic Networks
- Frames
- Logic
- Rules

The knowledge base is denoted in the production rules technique, If-Then rules, which are very influential and frequently used to represent knowledge. The knowledge base can be updated and extended. However, this is difficult due to insufficient access to specialists, practitioners, and health facilities. For this reason, the Rules are used in this study to represent the Knowledge Base (Diefenbach, et al., 2019 & Arbaiy, et al., 2018).

One of the cases that an intelligent system can solve, is discovering behavior disorders in children. Behavioral disorders tend to be more common in children because children experience growth and development during childhood. Therefore, behavioral disorders in children need to be investigated because behavioral disorders in children must be immediately identified and then carried out with appropriate treatment to not continue into adulthood.

Behavioral disorders are disturbances in behavior and emotions that can occur to a person. People's behavior can be said to deviate or experience interference if they deviate from conduct considered normal by adults according to age and sex. Deviations occur with high frequency and intensity. Variations take place over a relatively long time.

This development of children makes the need for research on behavior disorders that occur in children. The reason is that this disorder must be known immediately and then carried out with appropriate treatment so that it does not continue into adulthood. The handling will be more difficult if it has been carried to maturity.

Therefore, this knowledge base's construction can provide information about any symptoms categorized as behavioral disorders in children. If there is a behavior disorder in children, parents can immediately overcome them.

Determining symptoms and disorders in children requires more than one expert in decision-making. This study develop a framework and strategies to build a knowledge base from several experts using fuzzy preferences based on the group decision-maker. Developing a framework for determining symptoms and disorders in children was taking a sample.

2. METHODS

2.1 Data and Variable Selection

In this study, the data collected in the form of data on symptoms and disorders obtained from the results of literature studies and interviews with several experts, in this case, is a psychologist. The psychologist chose data on symptoms and disorders because this psychologist is in direct contact with behavioral disorders in children, used as a source of knowledge. Interviews were conducted with two psychologists in two places to obtain information about symptoms and behavioral disorders in children (Rehman, et al., 2021).

First, psychologists who served in hospitals and psychologists who served in schools for children with special needs. Data are distinguished above:

- Primary Data: This study was information collected from sources or the experts, and the data are from symptoms and types of disorders in children. Data also from other information related to behavioral disorders.
- Secondary Data: Collected in this study were obtained from the results of literature studies on previous research.

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2.2 Knowledge Acquisition

Knowledge acquisition is a step that the expert system must take to build a knowledge base. The acquisition includes collecting, transferring, and changing from the problem-solving ability of an expert or a documented source of knowledge to a computer program that aims to improve or develop the knowledge base. In other words, this knowledge acquisition is one of the steps taken to incorporate the knowledge obtained from the expert (Choi, S. Y., & Kim, S. H., 2021). Acquiring knowledge apart from experts can also be done from other sources such as parents, the social environment, or teachers. Based on reference (Zhai et al., 2021), are four stages in knowledge acquisition. The stages knowledge acquisition can be seen in **Figure 1**.

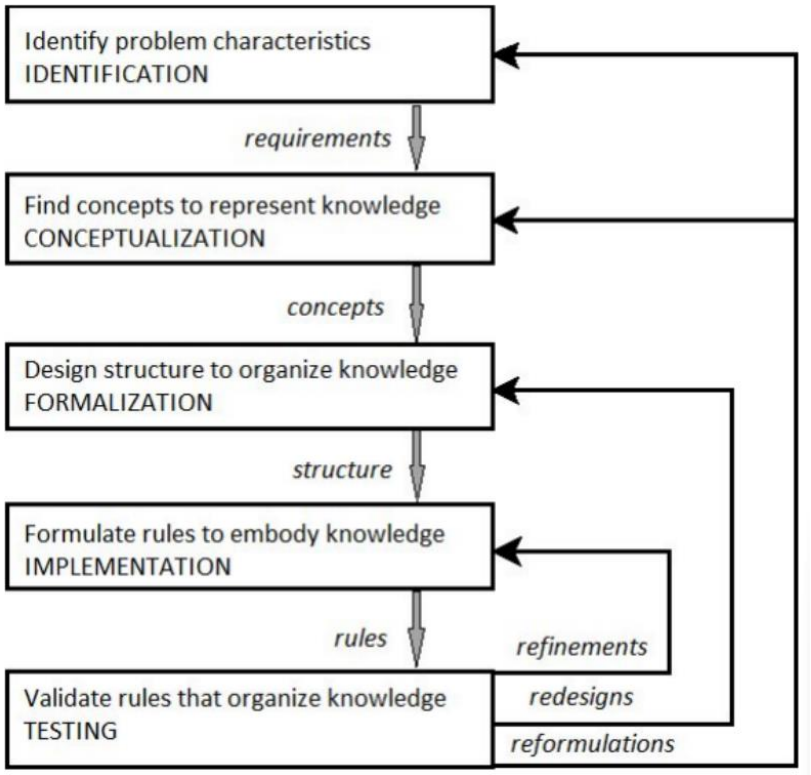

Figure 1. Knowledge Acquisition Stages.

2.2.1 Identification

Identification is carried out by raising the problem of behavioral disorders in children. The main discussion is research and determining the source of knowledge, namely an expert or, in this case, related to the topic discussed is a psychologist and conducting literature studies on manuscripts, journals, or books related to the lifted problem. In the process of obtaining information in the form of symptoms and behavioral disorders in children, interviews were conducted with two psychologists in Pontianak. rom Sungai Bangkong Regional Mental Hospital, and Sekolah Luar Biasa (SLB) Bina Anak Bangsa. They are Patricia Elfira Vinny S.Psi, M.Psi and Reni Herawati S.Psi, M.Psi, respectively.

2.2.2 Conceptualization

This section explains how concepts represent knowledge. In this study, knowledge is built from the preferences given by several experts. Decision makers (experts) will play a role in giving their preferences related to the diagnosis. Preference is given to features (symptoms

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or signs) under certain conditions and to disorders under certain conditions. This section details the data that has been determined by experts, such as grouping and selecting which symptoms are included in behavior disorders in children. The basic concept of a fuzzy decision support system is the relationship between elements in the set. In using fuzzy preference order in group decision making, fuzzy preference ordering as a fuzzy binary relation, satisficing reciprocity and max-min transitivity and developing group fuzzy preference order. Applicable when individual preferences are represented by utility functions, developing a method for analog group decision process with extended contributory rules (Akram, M., & Bibi, R., 2023). In this stage, two experts working separately to produce fuzzy preference relation named C1 and C2.

2.2.3 Formalization

At this stage, a structural design is carried out to organize knowledge. The design of this structure is like grouping the symptoms and then determining how to build a knowledge base. Understand how the concept of the group decision model is used.

2.2.4 Implementation

Several steps can be taken to get a knowledge base in this implementation stage. The knowledge base will later build a rule-based knowledge base. Each rule has the same antecedent according to the relationship between the features given, and each feature is related using the AND operator (Kusumadewi, S., & Wahyuningsih, H., 2020). Implementation is done by formulating and calculating behavioral disorder data that has been obtained from experts. There are several steps to get the knowledge base. First, this knowledge base is built on a rule-based basis. Each rule has the same antecedent according to the relationship between the given features, and each component is related using the AND operator (Xu, Y., Li, C., & Wen, X., 2018). Expert representation, in this case, is to determine the preference value. An expert will provide initiation of the symptoms that may appear. The knowledge base that will be built is based on the results of the preference values obtained from the experts, then followed by changing the expert preference values into a fuzzy preference relation matrix.

After that, the aggregation is carried out with the OWA operator, who will then be quantified with QGDD.

3. RESULTS AND DISCUSSION

3.1. Implementation

Perform formulation and calculation of behavioral disturbance data that has been obtained from experts. Expert representation, in this case, is to determine preference value. An expert will initiate the symptoms that may arise. The knowledge base that will be built is based on the results of the preference values obtained from the experts, then proceed by changing the expert preference values into a fuzzy preference relation matrix (Zhou, et al., 2017). After that, the aggregation is carried out with the OWA operator who will then be carried out the quantification process with QGDD.

In this group decision model, the decision-maker will provide a preference value to provide the importance of an alternative among other alternatives. Several preference formats can be used to provide preference values. Still, the preferred format used in this study is the utility vector format (Yang, et al., 2020). The preference of decision-makers will be given in the same format as fuzzy, namely values with a membership degree of 0 to 1. This preference value is given based on the importance of each symptom to a given disorder. This preference relation

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is made as a matrix by transforming the expert's preference value. Expert preference value changes into a fuzzy preference relation matrix, and the following formula is used:

$$P_{ij}^{k} = \frac{(u_i^k)^2}{(u_i^k)^2 + (u_j^k)^2}; 1 \leq i \neq j \leq m \quad (1)$$

In this case, P is the matrix, and U is the value of a column and raw. OWA operator is an effective method used to aggregate fuzzy preference relations (Yang, et al., 2020). This aggregation operator is used by considering the preference value given by the decision-maker. The way the OWA operator works is to aggregate the response values given by decision-makers who have previously been sorted based on the value of the responses given. The way to calculate the weight of the OWA operator is by using the fuzzy Q meter, which is a measure proportional non-decreasing formulated by:

$$Q(r) = r^{1/2} \quad (2)$$

Where Q is criteria or experts, Q can calculate OWA weights. This weight will later be used to calculate the Pc matrix as an aggregation matrix with the formula shown in the following equation:

$$w_i = Q(\frac{i}{n}) \quad Q(\frac{i \quad 1}{n}); i = 1, ..., n \quad (3)$$

Furthermore, calculate preference value to show of information used in decision making problems, especially when collecting an expert's choice into group choices. QGDD or Guided Dominance Degree quantifier is used to select alternatives by considering the aggregation matrix that has been obtained from the decision-maker (Yu, D., & Fang, C., 2023). This operator will quantify an alternative's dominance to other alternatives (Tapia, et al., 20217). The formula used in this QGDD operator is:

$$QGDD(Pcjn)iQij = \varphi, = 1 \quad (4)$$

The framework of building this knowledge can be seen in **Figure 2**.

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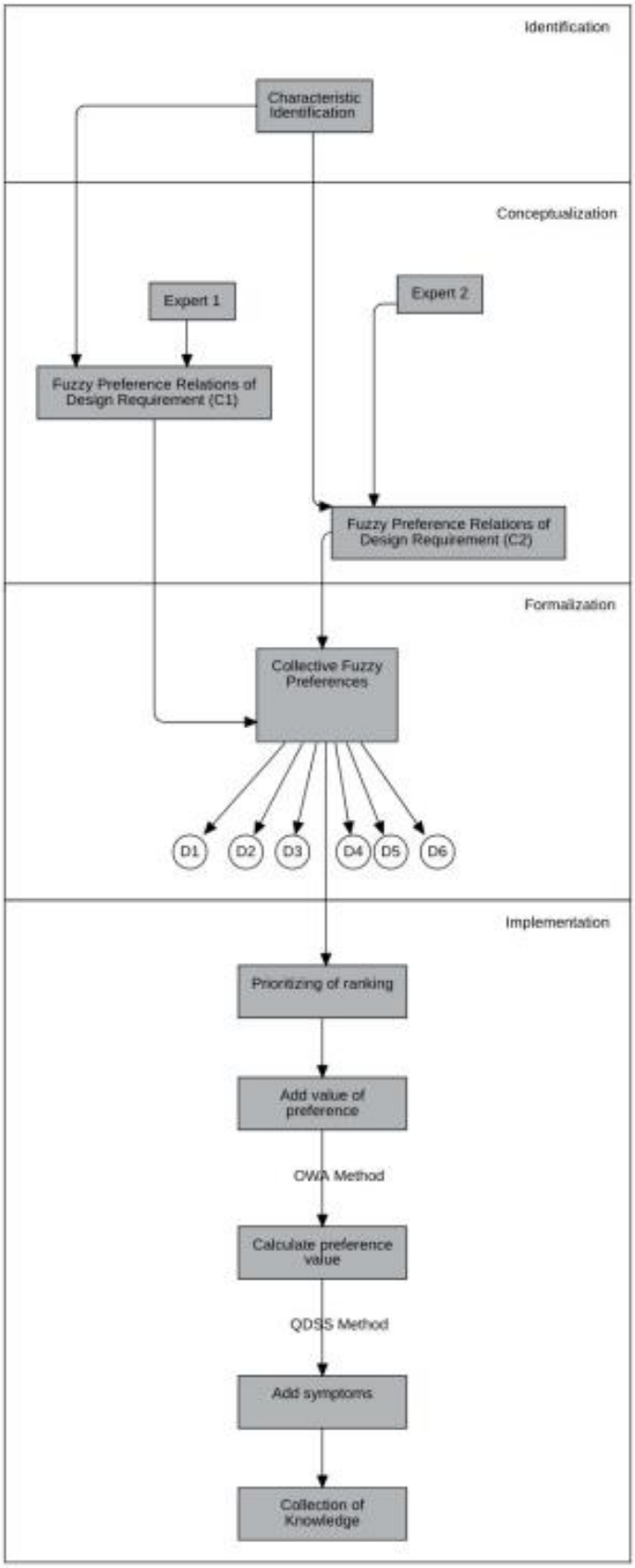

Figure 2. Knowledge Framework.

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3.2 Result

In this study, data collected in the form of symptom and disorder data obtained from the results of literature studies and interviews with several experts, in this case, are psychologists who have direct contact with children who have behavioral disorders.

3.2.1 Knowledge Based

Determining the knowledge base with this group decision model requires knowledge that comes from one person. Based on the literature studies and interviews with experts, there were 20 symptoms with five behavioral disorders in children. The collected symptom and disorder data can be made into a decision table with a relationship between symptoms and disorders. A table listing symptoms and disorders can be seen in **Table 1** and **Table 2** below:

Table 1. List Of Symptoms.

Code	Symptoms
S001	Easy to get angry
S002	Loves to use physical violence
S003	Uncontrolled behavior
S004	Aggressive, even hurt yourself
S005	Difficulty focusing or concentrating
S006	Don't stop talking
S007	It is difficult to sit still for long periods of time
S008	Frequently breaking the rules
S009	Often blames others for their own mistakes
S010	Often argue with older people
S011	It's easy to lose your temper or act impatiently
S012	Have cruel behavior towards others even towards animals
S013	Lied often
S014	Often bully others
S015	Lacking empathy for other people
S016	Frequent verbal attacks
S017	Wanting something in a tantrum
S018	Cannot reveal to adults what they want
S019	Likes to force things away from others
S020	Tend to impose their will

Table 2. List Of Distraction.

Code	Nuisance Name
P001	Temper Tantrum
P002	ADHD (Hyperactivity)
P003	ODD
P004	Conduct Disorde
P005	Aggressiveness

Furthermore, the preference value is transformed into a fuzzy preference relation using equation one, and then the fuzzy preference relation matrix is obtained as follows can be seen in **Figure 3**:

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$$P1 = \begin{bmatrix} 0{,}50 & 0{,}86 & 0{,}50 & 0{,}86 & 0{,}50 & 0{,}96 \\ 0{,}13 & 0{,}50 & 0{,}13 & 0{,}50 & 0{,}13 & 0{,}80 \\ 0{,}50 & 0{,}86 & 0{,}50 & 0{,}86 & 0{,}50 & 0{,}96 \\ 0{,}13 & 0{,}50 & 0{,}13 & 0{,}50 & 0{,}13 & 0{,}80 \\ 0{,}50 & 0{,}86 & 0{,}50 & 0{,}86 & 0{,}50 & 0{,}96 \\ 0{,}03 & 0{,}20 & 0{,}03 & 0{,}20 & 0{,}03 & 0{,}50 \end{bmatrix} \quad P2 = \begin{bmatrix} 0{,}50 & 0{,}80 & 0{,}50 & 0{,}80 & 0{,}50 & 0{,}80 \\ 0{,}20 & 0{,}50 & 0{,}20 & 0{,}50 & 0{,}20 & 0{,}50 \\ 0{,}50 & 0{,}80 & 0{,}50 & 0{,}80 & 0{,}50 & 0{,}80 \\ 0{,}20 & 0{,}50 & 0{,}20 & 0{,}50 & 0{,}20 & 0{,}50 \\ 0{,}50 & 0{,}80 & 0{,}50 & 0{,}80 & 0{,}50 & 0{,}80 \\ 0{,}20 & 0{,}50 & 0{,}20 & 0{,}50 & 0{,}20 & 0{,}50 \end{bmatrix}$$

Figure 3. Relation Matrix Preference

The aggregation process is carried out to form an aggregation matrix based on equations 2 and 3. The OWA weight 1 is 0.70, and OWA weight 2 is 0.29. After the OWA aggregation matrix was calculated, it was found that the matrix is not consistent. The matrix must be transformed. A matrix can be said to be consistent if xij + xji = 1. After obtaining a consistent matrix, then qualification with QGDD is carried out. Six symptoms affect the first disorder. the final weight value is obtained as follows C1 = 0.7822, 0.4861, 0.7822, 0.4861, 0.7822, 0.3160. This weight value will become the knowledge base's weight and can then be used as a weight for the inference process.

The number of rules or rules that will be generated on the knowledge base is the same as the number of symptoms that are alternatives. For example, in the first disorder, there are six symptoms, then in the first disorder, this will produce six knowledge with the same symptoms but have different weights.There are the same weight values in some conditions because the two experts' preference values are the same, the elimination of the same weight.

The results of calculations that have been done before, as many as 19 knowledge in the form of IF-THEN is formed. Knowledge in the form of a rule is then called the knowledge base. The knowledge base that is formed already has some rules explicitly arranged and related to which this knowledge base can be used to think that can be used in expert systems, especially in knowledge-based systems.

3.2.2 Testing

Testing is done by matching the resulting knowledge base with actual cases. This test is called a case study. A method that is applied to understand individuals more deeply. It is to collect and understand the individuals being studied and the problems faced so they can be resolved. This case test was conducted by providing a questionnaire to teachers and parents of children with behavioral disorders. Parents or teachers will fill out a sheet containing symptoms and disorders. These symptoms will be filled in according to the actual condition of the child. Apart from case analysis, this knowledge base's validity was also tested using other methods, namely triangulation, and member checks. Triangulation checks data from various aspects, namely source, technique, and time. In contrast, a member check is a data checking process carried out by experts as data providers to determine whether the study results agree[21]. Test cases were carried out on ten children with the following test result data.

Based on the results of case tests on ten children shown in figure 3, there is a match between the knowledge base built and the child's actual condition. The truth of this knowledge base is tested based on the validity test in which the triangulation process is carried out. Member checks are made to the experts so that the knowledge base built has valid information or data

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4. CONCLUSION

Based on the results, the analysis can conclude that we can use the preference values of the two experts to build a knowledge base using a framework built. In addition, we have 20 symptoms and five disorders collected from 19 knowledge. As it is depicted in Figure 4. In addition, the tests conducted on ten children who tend to have behavior disorders show a match between the symptoms that occur in these children and the symptoms generated on the knowledge base. In addition, this study also obtained performance values in the form of weights generated on the rule. The weight can be used for the inference process in an expert-based system. In the future, expert system machines can use this knowledge base collection by adding inference methods can be seen in **Figure 4**.

No	Age	Gender	SYMPTOMS																				Distraction
			S001	S002	S003	S004	S005	S006	S007	S008	S009	S010	S011	S012	S013	S014	S015	S016	S017	S018	S019	S020	
1	11 years	Male	√	√	√	√							√						√	√			Temper Tantrum
2	9 years	Male	√	√							√		√					√			√	√	Aggressiveness
3	10 years	Female	√		√	√							√						√	√	√	√	Temper Tantrum
4	8 years	Female	√		√	√	√												√	√		√	Temper Tantrum
5	12 years	Male	√	√														√			√	√	Aggressiveness
6	10 years	Male			√		√	√	√	√			√										ADHD
7	8 years	Male	√	√	√	√													√	√			Temper Tantrum
8	6 years	Female	√							√	√	√	√									√	ODD
9	5 years	Male			√		√		√	√	√		√						√				ADHD
10	3 years	Female			√		√		√				√										ADHD

Figure 4. Testing of Ten Children

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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