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Advancements in Understanding the Neurological Basis of Learning Disabilities through fMRI Studies

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ABSTRACT

Learning difficulties are conditions where students have difficulty receiving lessons and developing the potential that exists within them. Disabilities in one or more academic areas, such as reading, writing, mathematics, and spelling, as well as more general skills, such as listening, speaking, and thinking, can cause learning difficulties. While FMRI (Functional Magnetic Resonance Imaging) studies are used to study activities the human brain and understanding how the brain functions. This research was conducted with the aim of understanding the neurological basis of learning problems through fMRI studies. Using fMRI, researchers can see changes in brain signals that occur during mental activities, such as learning, and identify areas of the brain that are larger or smaller when processing information. The method used in this research is a quantitative method. This method is a way of collecting numerical data that can be tested. Data was collected through distributing questionnaires addressed to students. Furthermore, the data that has been collected from the results of distributing the questionnaire will be accessible in Excel format which can then be processed using SPSS. From the research results, it can be seen that this research can create better teaching methods and help students who experience learning difficulties improve students' abilities to the maximum, as well as help in developing more effective teaching strategies to improve students' learning abilities. From this study, researchers can conclude that Understanding the Neurological Basis of Learning Difficulties Through MRI Studies can be used to understand how the brain learns and to identify areas of the brain that are more active when processing information, thereby enabling students to learn better.

Keywords: *Difficulties, fMRI, Neurological*

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INTRODUCTION

Countries that prioritize education in their government programs will progress

and be able to compete internationally (Psaki et al., 2019). Countries that prioritize education will become leading nations in science, which in turn will become world leaders (Darwish et al., 2018). Not everyone can carry out reasonable educational or learning activities. Sometimes it goes smoothly, sometimes it doesn't, sometimes you can quickly understand what you are learning, and sometimes it feels very difficult (Mehmood, 2021).This is the reality that students often experience in their daily learning activities. No two people are the same, and these differences cause children to differ in behavior (Habibi & Zabardast, 2020). One term for learning difficulties is students who do not reach the expected learning level.

Each student has unique characteristics that correlate directly with their learning outcomes. These characteristics include intelligence, talent, motivation, thinking style, level of aspiration, perception, and attitude (Rao et al., 2019). In this way, teachers can ensure that the desired learning process can be achieved. In accordance with national education goals, students are part of the education system who are processed to become quality human beings (Marchini et al., 2018). There are several different ways to look at students, namely the social approach, the psychological approach, and the educational/pedagogical approach. In a psychological approach, students are developing creatures who have various human potentials that need to be developed through the educational process (Pastor et al., 2018). In the social approach, students are members of society who are prepared to become better members of society

Education prioritizes student activities in learning. When learning is carried out, the first thing to consider is the obstacles and difficulties faced by students (Du et al., 2020). Educational activities will focus on a child's needs rather than the desires of others if they can be known. The goal of education is to help students to develop fully according to their potential (Klein et al., 2022). Every student who experiences learning difficulties will show diverse (heterogeneous) phenomena. However, to more easily understand this variation, learning difficulties can be categorized into two types, namely internal learning difficulties, known as learning disabilities, and external learning difficulties, known as learning problems (Martins Pereira et al., 2021).

Learning disability or learning disability is a psychological syndrome that can cause learning difficulties (Robinson & Goodey, 2018). Symptoms that appear as signs of psychological abnormalities that cause learning difficulties in students are called syndromes (Maher et al., 2023). Learning being difficult is an invisible mistake. Learning disabilities cannot be physically identified, unlike individuals without learning problems. A situation where students show poor performance at school, such as getting low grades in all or most subjects at school, is known as general learning difficulties (Kamran et al., 2023). Often referred to as specific learning difficulties, a student shows significant difficulties in one of the subjects such as mathematics, geography, physics, or difficulty in writing (Sprunt & Marella, 2021).

Learning difficulties are problems experienced by students which are mainly

caused by neurological disorders that affect their ability to receive, process, analyze, or even store (Kauppila et al., 2021). Neurological factors are not the only cause of learning difficulties in students, but these problems can originate from problems with hearing, vision, motor skills, emotional barriers, or pressure from their environment (Phlypo et al., 2018). However, students who experience learning difficulties do not mean they are not intelligent, but rather that they have expertise in other fields. On the contrary, their condition prevents them from achieving like their peers their age, especially to meet school demands (Weigelt-Marom & Weintraub, 2018). Therefore, students who experience learning difficulties often show poor learning outcomes compared to their intellectual abilities.

The causes of students' learning difficulties are mainly caused by minimal brain disorders (DMO), damage to brain tissue due to disease, or disruption of brain function due to disorders that are periodic over a long period of time, such as epilepsy, as well as psychosocial factors (Moni et al., 2018). To understand the neurological basis of learning difficulties through fMRI studies, teachers must primarily use fMRI technology to understand how students' brains function when they experience learning difficulties (Hernandez-Saca, 2019). By using fMRI technology, teachers can understand how students' brain activity differs when they experience learning difficulties and how they overcome these difficulties. By using fMRI, teachers can understand how students' brains function when they face learning challenges and how to overcome these challenges (Bellacicco & Parisi, 2021). Thus, teachers can use strategies that are more appropriate to students' needs to deal with learning challenges.

The process of learning difficulties through FMRI (Functional Magnetic Resonance Imaging) studies is an approach used to understand the learning process and understand how the brain functions when students learn (Tu et al., 2020). In this analysis, fMRI was used to measure students' brain activity as they worked on various learning tasks. The results of this analysis can help teachers understand how students learn and discover the difficulties they face when learning (Riaz et al., 2020). Therefore, if a teacher wants to know a student's weaknesses, it really depends on the teacher's abilities. One of the teacher's abilities is being able to detect student learning problems and organize remedial teaching (Li et al., 2020). Apart from that, teachers can also identify problems with students' learning difficulties through daily teacher observations inside or outside the classroom, questions and answers, tests carried out by teachers, diagnostic tests, tests from books, assignments, and so on (Schneider et al., 2018).

The type of method used in this research is a quantitative method. This method is used so that the final results of the processed data can be known clearly and precisely regarding progress in understanding the neurological basis of learning difficulties through fMRI studies. The data collection process was obtained by the researcher from the results of the respondents' answers that the researcher had carried out. Researchers created a questionnaire with 10 questions, then distributed it via Goggle from. After the data is collected, the data will be calculated into a percentage

and presented in table form. In processing research data, researchers use SPSS software which aims to make it easier for researchers to process data, and the data results are more relevant. Furthermore, the researcher really hopes that the next researchers will research and study more deeply the progress in understanding the neurological basis of learning difficulties through fMRI studies.

RESEARCH METHODOLOGY

Research Design

This research uses a quantitative research design, which uses statistical processes to present data in the form of numbers. Researchers created twenty questions to collect information about the research to find out the results. Researchers will ask respondents to answer the questions asked, which will be presented in the form of tables and percentages (Plasman et al., 2022). The purpose of processing this data with the SPSS application is to compare the results of respondents' answers. After this comparison, researchers can provide solutions to any information they obtain about Progress In Understanding The Neurological Basis Of Learning Difficulties Through fMRI Studies.

Research Procedure

In this study, researchers investigated progress in understanding the neurological basis of learning difficulties through fMRI studies. The aim of the researcher is to investigate this so that the researcher can collect, analyze and provide understanding of the data that has been collected (Gorges et al., 2018). In making questions, the researcher used good language that was easy for respondents to understand when filling out the questionnaire distributed by the researcher later. This aims to ensure that respondents who provide responses to questions asked by researchers can be answered quickly. That way, it will be easier for researchers to examine the data being investigated regarding Progress in Understanding the Neurological Basis of Learning Difficulties Through fMRI Studies.

Research Subject

In examining progress in understanding the neurological basis of learning difficulties through fMRI studies, researchers of course determine the subjects for their research. In this research, the subject of this research is aimed at students from various educational institutions. Before distributing the questionnaire by the researcher, the researcher asked the respondents first to be willing to spend their time filling out the questionnaire that the researcher would distribute. The questionnaire each contains 10 questions about Progress in Understanding the Neurological Basis of Learning Difficulties Through fMRI Studies.

Research Ethics

After the researcher carried out several stages as previously explained, in conducting research, the researcher also paid close attention to ethics and manners in research. Researchers believe that ethics needs to be considered whenever and wherever, including in the research being conducted. This aims to gain trust and readiness from the respondents or those who are the objects of this research (Karns et

al., 2022). Furthermore, in this research, the researcher also explains information related to the research, one of which is information in filling out the questionnaire. This information is explained by the researcher so that the respondents are ready and willing to voluntarily provide responses and answers to questions asked by the researcher (Dreyer, 2021).

Data Collection and Analysis

Data collected by researchers in researching Progress in Understanding the Neurological Basis of Learning Difficulties Through fMRI Studies, will be processed into the SPSS application. Then the data that has been obtained will be presented by researchers in the form of tables and diagrams. The purpose of presenting it in table and diagram form is to be able to see a comparison of the results of research that has been carried out by researchers regarding progress in understanding the neurological basis of learning difficulties through FMRI studies. Next, the obtained data results are converted into percentages or averages. Then the data results will be tested again using the T-test.

Table 1 Categories of Progress in Understanding the Neurological Basis of Learning Difficulties Through fMRI Studies

No	Earning Category	Level of Education	Percentage (%)
1	Earning Category	Student	>90%
2	Strongly agree	Student	45-89%
3	Agree Disagree	Student	16-45%
4	Disagree Don't agree	Student	5-15%

Figure 1

Data Collection and Analysis Flow

Data Collection and Analysis Flow

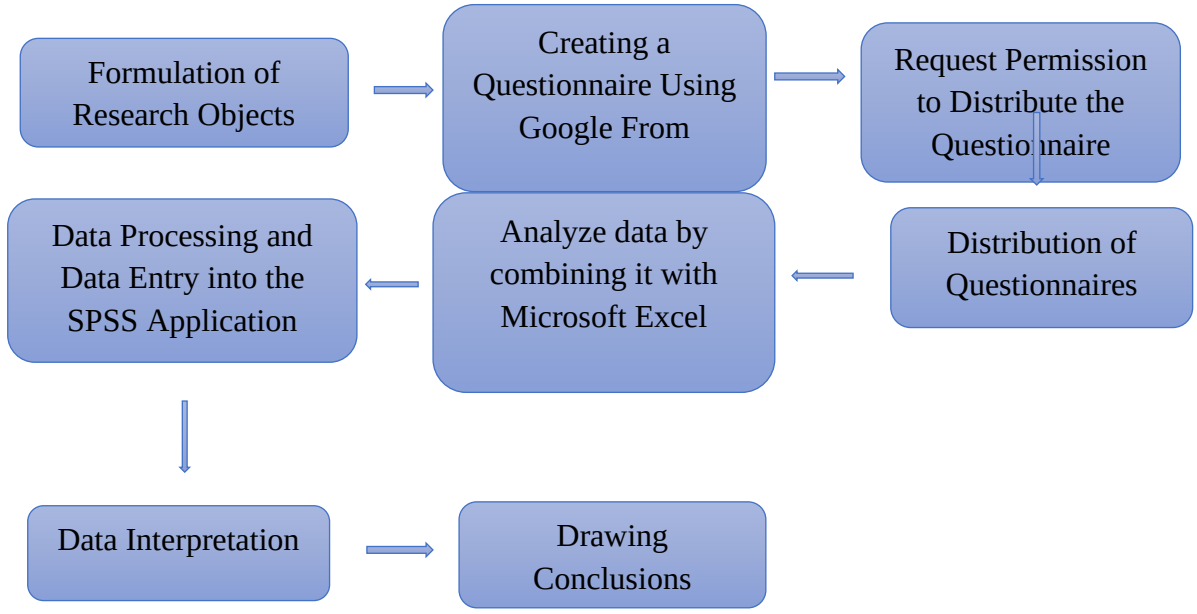

Figure 1 above shows how researchers collect and analyze research data. The results of data acquisition came from respondents' answers to the researcher's questions. Furthermore, in the quantitative research method, the researcher will also test again

using the T-test which will be used to enter research data into the SPPS application. The number of questions asked by the researcher was 20 questions, where each question was divided into ten questions with different questions. Only after the questionnaire has been distributed can researchers formulate and draw conclusions from the research object.

RESULT AND DISCUSSION

Progress in Understanding the Neurological Basis of Learning Difficulties Through FMRI Studies

The branch of medical science known as neurology deals with problems related to the nervous system. Doctors who specialize in this field are called neurologists, and they have the ability to diagnose, treat, and manage patients' neurological disorders. Some of the main parts of the nervous system include the cerebrum, brain stem, cerebellum, spinal cord, and spine. Each part carries out certain tasks to regulate various daily human activities. Some examples of the most common neurological disorders are Multiple sclerosis is a disease caused by viruses, the environment, or genetics which is characterized by tingling, numbness, or weakness in several parts of the body. If left untreated, this disease can attack the muscles, urinary tract, and cause thinking disorders. Alzheimer's is a disease that affects parts of the brain and spinal cord, causing memory and thinking problems.

Table 2
Summary of Percentage Results from Respondents' Answers

No.	Question	Strongly Agree	Agree	Somewhat Agree	Disagree
1	fMRI studies have helped researchers identify areas of the brain involved in memory and learning processes. It offers a picture of how the brain processes data and learns from experience.	40%	50%	5%	5%
2	fMRI can help discover activation patterns associated with certain learning problems, such as dyslexia, dyscalculia, and attention deficit hyperactivity disorder (ADHD).	30%	45%	20%	5%
3	fMRI studies have shown how the brain processes visual, auditory, and somatosensory information. This helps us understand how learning problems influence these processes.	43%	47%	8%	2%
4	fMRI has demonstrated the role of emotions in the learning process and shown how stress and anxiety can	45%	35%	7%	3%

	influence brain activity and negatively impact learning abilities.				
5	A better understanding of the neurological basis of learning difficulties may lead to the development of more specific and successful solutions to meet individual needs.	50%	25%	15%	10%
6	fMRI can be used to monitor the success of learning interventions and provide immediate feedback on how various teaching approaches affect the brain.	30%	50%	10%	10%
7	fMRI studies can help predict academic performance, enabling rapid intervention and support for students at risk of learning difficulties.	45%	35%	20%	0%
8	fMRI studies can predict academic performance and offer rapid support and intervention for students at risk of learning difficulties.	42%	35%	15%	8%
9	fMRI studies show that everyone's brain is different, and the way they learn is different. This understanding can help in developing a personalized learning approach.	38%	60%	2%	0%
10	fMRI shows that the brain has the ability to change and adapt, meaning that learning difficulties can be overcome with appropriate intervention.	52%	38%	7%	3%

Table 2 above shows the distribution of questionnaires that have been carried out by researchers. This questionnaire contains ten questions about progress in understanding the neurological basis of learning difficulties through fMRI studies. In addition, during the distribution of the questionnaire, the researcher presented a percentage of each response from the respondents. Therefore, respondents can choose to answer the researcher's questions by providing options such as strongly agree, agree, disagree, or disagree. And it can also be seen from the first question asked by researchers regarding fMRI studies that have helped researchers identify brain areas involved in memory and learning processes. It offers a picture of how the brain processes data and learns from experience., getting the highest score of 50% agree.

The second question about fMRI can help find activation patterns associated with certain learning problems, such as dyslexia, dyscalculia, and attention deficit hyperactivity disorder (ADHD), getting a percentage result of 20% less agree. The third

question regarding fMRI studies has shown how the brain processes visual, auditory, and somatosensory information. It helps us understand how learning problems influence these processes, scoring 47% in agreement. The fourth question on fMRI has shown the role of emotions in the learning process and shows how stress and anxiety can affect brain activity and have a negative impact on learning ability, getting a percentage gain of 35% agree. Next is the fifth question. A better understanding of the neurological basis of learning difficulties can lead to the development of more specific and successful solutions to meet individual needs. There are as many as 50% of the strongly agree option. Furthermore, the sixth regarding fMRI can be used to monitor the success of learning interventions and provide direct feedback on how various teaching approaches affect the brain, thereby improving the quality of school facilities, as many as 10% disagree.

The seventh question that fMRI studies can help predict academic performance, enable rapid intervention and support for students at risk of learning difficulties, received a percentage result of 35% of choices of the agree option. In the eighth question, fMRI studies can predict academic performance and offer support and quick intervention for students at risk of learning difficulties, also found in the agree option as much as 35%. Question nine about fMRI studies show that everyone's brain is different, and the way they learn is different. This understanding can help in developing a personalized learning approach, resulting in a percentage of 60% agreeing. For the last question regarding fMRI, it shows that the brain has the ability to change and adapt, which means that learning difficulties can be overcome with appropriate intervention, getting a percentage gain of 52% for the strongly agree option.

No.	Question	Strongly Agree	Agree	Somewhat Agree	Disagree
1	fMRI studies have shown how the learning environment can influence brain activity, demonstrating the importance of creating a safe and supportive environment for learning.	33%	47%	10%	10%
2	fMRI has revealed the role of motivation in the learning process, showing how interest and engagement can increase brain activity and enhance learning	50%	40%	8%	2%
3	fMRI can help understand how students think about their own learning processes, which can help them develop more effective learning strategies.	66%	30%	4%	0%

4	fMRI studies encourage collaboration between neuroscience, educational psychology, and pedagogy to develop a more comprehensive understanding of learning difficulties.	45%	35%	12%	8%
5	It is important to consider the ethical implications of fMRI research, such as potential stigmatization and data privacy.	52%	38%	8%	2%
6	It is important to ensure that fMRI research is accessible to all, including marginalized populations and those with financial limitations.	36%	54%	5%	5%
7	It is important to communicate fMRI research results in a way that is easy to understand by key stakeholders, such as teachers, parents, and policy makers	62%	20%	18%	0%
8	It is important to translate fMRI research findings into educational practice, developing interventions and tools that can be used in classrooms.	40%	40%	10%	10%
9	Further research is needed to understand the complexity of the human brain and how it processes information and learn, which will help in developing more effective solutions to learning difficulties.	55%	25%	15%	5%
10	fMRI studies offer the potential to revolutionize our understanding of learning difficulties and pave the way for more effective and personalized interventions to help all students reach their full potential.	55%	35%	10%	0%

In the statement in table 3 above, the researcher has also created ten questions. Which can be seen from the first question regarding fMRI studies that have shown how the learning environment can influence brain activity, showing the importance of creating a safe and supportive environment for learning, getting a percentage result of 47% of agree options. Next question number two on fMRI has revealed the role of motivation in the learning process, showing how interest and involvement can increase brain activity and improve learning, getting a strongly agree option percentage score of 50%. The third question that fMRI can help understand how students think about their own learning process, which can help them develop more effective learning strategies, received a percentage score of 66% strongly agree.

The fourth question about fMRI studies encourages collaboration between neuroscience, educational psychology, and pedagogy to develop a more comprehensive understanding of learning difficulties, resulting in a 35% percentage score for the agree option. The fifth question about It is important to consider the ethical implications of fMRI research, such as the potential for stigmatization and data privacy, received 52% of strongly agree options. Question six: It is important to ensure that fMRI research is accessible to all, including marginalized populations and those with financial limitations, also achieving a percentage gain of 54% for the agree option.

Furthermore, the seventh regarding the importance of communicating fMRI research results in a way that is easily understood by key stakeholders, such as teachers, parents and policy makers, received a percentage score of 62% strongly agree. The eighth question about It is important to translate fMRI research findings into educational practice, develop interventions and tools that can be used in classrooms, obtained a percentage of 40% strongly agree. In question number nine, further research is needed to understand the complexity of the human brain and how it processes information and learn, which will help in developing more effective solutions to learning difficulties. Also found in the most options were strongly agree as much as 55%. The latter question on fMRI studies offers the potential to revolutionize our understanding of learning difficulties and pave the way for more effective and personalized interventions to help all students reach their full potential, with as many as 55% strongly agree.

Diagram 1

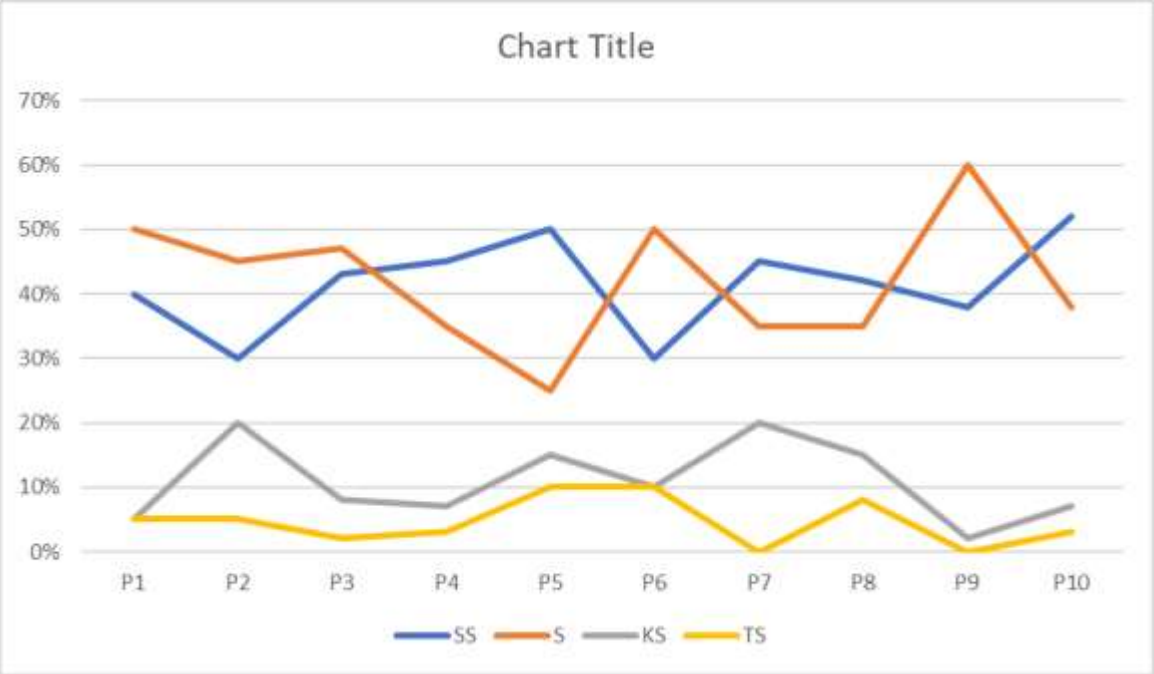

Diagram 2

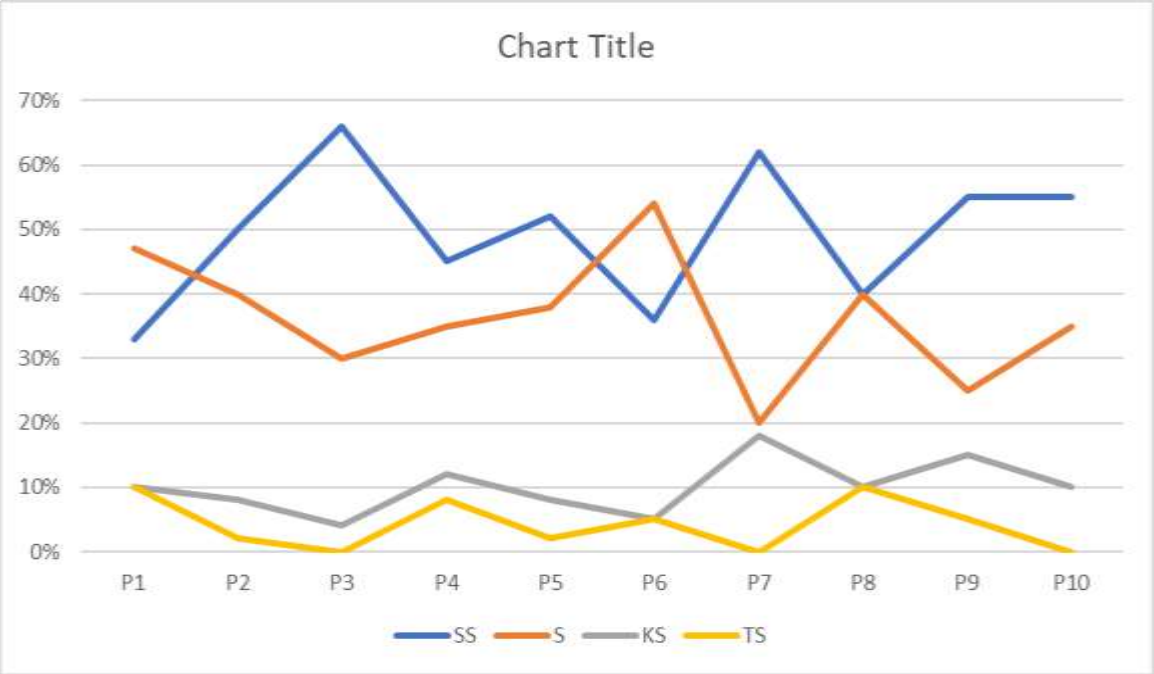

Table 3

T-test Regarding Progress in Understanding the Neurological Basis of Learning Difficulties Through fMRI Studies.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PRE TEST	45.4500	20	9.89670	2.21297
	POST TEST	38.2000	20	11.09101	2.48003

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PRE TEST & POST TEST	20	-.734	.000

Paired Samples Test

	Paired Differences				
				95% Confidence Interval Difference	
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper

Pair 1	PRE TEST - POST TEST	7.25000	19.54718	4.37088	-1.89836	16.3983

Based on the results of table 3 above, it is a T-test using the SPSS application. From the research results, the researcher can conclude that the T-test in the first output section explains the mean as the average. In the Pre Test the average number produced was 45.4500, while in the Post Test the result was 38.2000. Based on these results, it can be formulated that there are differences in the results of the respondents' answers. Next, in the Paired Samples Correlations section, you get a correlation of -734, and the sign size is 000. Next, in the Paired Samples Test section, we obtained a result of 19.54718 in the Std section. Deviation, while in the Std. Error Mean obtained a result of 4.37088. Based on these results, regarding progress in understanding the neurological basis of learning difficulties through fMRI studies.

Table 4
T-Test Regarding Progress in Understanding the Neurological Basis of Learning Difficulties Through fMRI Studies.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PRE TEST	10.4500	20	5.22620	1.16861
	POST TEST	4.4000	20	3.77527	.84418

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PRE TEST & POST TEST	20	.164	.490

Paired Samples Test

		Paired Differences				
					95% Confidence Interval Difference	
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper
Pair 1	PRE TEST - POST TEST	6.05000	5.92475	1.32481	3.27713	8.82287

Furthermore, in table 4, there are also the results of research using the T-test. It can be seen in the first output section that the Pre Test results were 10.4500, and the Post Test results were 4.4000. In the Paired Samples Correlations section, you get a correlation of 164, with a sign result of 490. Meanwhile, in the Paired Samples Test

section, the results were 5.92475 in the Std section. Diviation, and Std. The mean error is 1.32481. Based on the results of this research, it can be seen between each question asked by researchers regarding progress in understanding the neurological basis of learning difficulties through fMRI studies.

DISCUSSION

Understanding the neurological basis has advanced significantly (Feng et al., 2021). Research and development in the field of neurology in recent years has increased the ability of neurologists to detect and treat various nervous system diseases (Heneka et al., 2020). They have understood the process of neuronal development and brain function, which is the basis for understanding the sources of neuropsychological disorders (Kargbo, 2023). Neurologists use a variety of techniques to examine their patients, including physical examinations, neurological examinations, laboratory tests, and imaging (Cavayas et al., 2020). Additionally, they have an understanding of the various behavioral assessments associated with neurodevelopmental disorders, also known as neuropsychological assessments.

This assessment also includes various combination methods for treating neurodevelopmental disorders in children and adults (Dewey et al., 2019). Neurologists use various methods to cure their patients, such as medication, physical therapy, and surgery (Kopatz et al., 2021). They also understand brain plasticity, which allows optimal treatment of behavioral disorders included in neuropsychological studies (Gorka et al., 2020). Advances in basic understanding of neurology in recent years have improved the ability of neurologists to diagnose and treat various diseases of the nervous system (Chen et al., 2020).

Understanding the process of neuronal development and brain function is the basis for understanding the causes and neurological disorders (Paudel et al., 2020). Therefore, they can provide more efficient and effective care to patients with nervous system disorders (Brogi et al., 2019). The branch of medical science known as neurology studies the human nervous system, which consists of the brain, spinal cord, nerves, and nervous tissue (Pervin et al., 2021). Neurology doctors perform examinations and diagnoses to identify nervous system diseases such as stroke, epilepsy, multiple sclerosis, and Parkinson's (Endres et al., 2022). They also carry out treatment and care to treat the symptoms of the disease.

Neurologists use a variety of methods to perform their examinations, including physical examinations, neurological examinations, laboratory tests, and imaging (Shroff, 2020). Physical examination assesses muscle weakness, walking problems, and impaired coordination; neurological examination assesses sensation, vision, and hearing disorders; and laboratory tests assess the concentration of enzymes and electrolytes in the blood (Talib et al., 2021). Imaging includes the use of an MRI or CT scan to determine whether there is damage to the nervous system. Neurology doctors also carry out treatment to treat the symptoms of the disease (Mishra et al., 2021). This may include the use of medications, physical therapy, or surgery.

Neurology doctors not only treat diseases in adults or the elderly, but also in children; Pediatric neurologists, or pediatric neurologists, examine and treat neurological disorders in newborns through teenagers (Nguanchoo et al., 2023). In some cases, neurologists can also perform nerve transplants to treat disorders of the nervous system (Glat et al., 2020). Additionally, they can be found in hospitals and clinics. Understanding the neurological basis of learning problems has been greatly improved through fMRI studies (Bansal et al., 2022). This brain imaging technique allows researchers to see a person's brain activity directly as they perform learning tasks (Josephs et al., 2019). This has opened up new insights into how the brain stores memories, processes information and controls behavior (Lemarié et al., 2019). All of these functions are important for learning.

FMRI has increased understanding of neurological fundamentals and how the brain functions in the learning process (Juliao Caamaño & Alonso Beato, 2020). By looking at brain activity directly and studying how the brain processes information, researchers can understand how the brain functions in the learning process and how to improve brain abilities through early stimulation and nutrition (Naim-Feil et al., 2022). Neurology doctors also carry out treatment to treat the symptoms of the disease (Bhimraj et al., 2020). This may include the use of medications, physical therapy, or surgery operasi (Japanese Gastric Cancer Association, 2021). In some cases, they can also perform nerve transplants to treat disorders of the nervous system (Crabb et al., 2020).

CONCLUSION

Knowledge of how the brain functions during the learning process has increased as a result of advances in understanding the neurological basis of learning problems. Neurology doctors can understand how the brain functions when learning by using physical examinations, neurological examinations, laboratory tests, and imaging. They can also understand how proper nutrition and brain stimulation can improve brain abilities. According to research on learning difficulties, the main cause of learning difficulties is brain dysfunction, also known as cerebral dysfunction.

Understanding how the brain functions during the learning process has been improved through the use of data collection techniques such as electroencephalogram (EEG) and computed tomography (CT) scans. Therefore, neurologists can provide more efficient and effective care to patients who experience learning difficulties. Advances in understanding the neurological basis of learning problems in recent years have helped neurologists diagnose and treat a variety of nervous system diseases. They now understand the process of neuronal development in the brain and their functions, which lays the foundation for understanding the causes and neurological disorders. As a result, they have the ability to provide more effective and efficient care to individuals with learning difficulties.

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