

Relationship Between Sensory Processing Patterns and Critical Thinking in Students

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Abstract

Background: Sensory processing pattern is a unique characteristic in each human. Critical thinking is a well-known skill of successful individuals.

Objectives: This study aimed to investigate the correlation between the critical thinking skills and sensory processing patterns of students of Medical Sciences.

Methods: This cross-sectional study was conducted on 213 students (147 males and 66 females). Brown's Adolescent and Adult Sensory Profile Questionnaire and Ricketts' Critical Thinking Questionnaire were used for data collection. Data analysis was performed using SPSS software (version 24) and appropriate statistical tests (i.e., the Pearson correlation test and independent samples t-test).

Results: Critical thinking had a significant positive relationship with sensory sensitivity ($r=0.229$) and a significant inverse relationship with sensory seeking ($r=-0.249$) and low registration ($r=-0.223$). Critical thinking had a significant positive relationship with students' grade point average ($r=0.875$). Additionally, there was no significant relationship between critical thinking with sensory avoidance ($r=0.099$) and age ($r=0.847$). In the sensory processing patterns, only low registration had a significant relationship with gender ($P<0.05$).

Conclusion: Students whose dominant patterns of sensory processing were sensory sensitivity and sensory seeking had better and worse critical thinking skills than others, respectively. It seems necessary to pay attention to sensory processing patterns in students to develop their mental skills, especially critical thinking.

Keywords: Thinking, Perception, Student, Critical Thinking, Sensory Processing Pattern

Background

Sensory processing patterns are among the most fundamental psychological features that explain how individuals perceive and react to environmental stimuli. The findings in the field of sensory processing confirmed that individuals process sensory information in different ways, which means that some individuals are more or less sensitive to sensory information than others (1-3). In 1997, Aron et al. developed the term "sensory processing sensitivity". According to this definition, individuals with the characteristic of sensory processing sensitivity tend to deep and powerful processing of a large amount of information, including paying close attention to other individuals' moods or artworks, such as analyzing a painting (1).

Despite the findings of Aron et al., Winnie Dunn proved that there are four patterns of sensory processing. Dunn's four-factor sensory processing model is a very popular model among occupational therapists (2). In this model, sensory processing style is in the form of four characteristics, namely low registration, sensory sensitivity, sensory avoidance, and sensory seeking. Dunn stated that sensory processing depends on two main factors, including threshold (high or low) and response strategy (active or inactive). As a result of this theory, the four following concepts are defined:

- 1) High threshold and passive response are classified as low registration.
- 2) High threshold and active response are classified as sensory seeking.

3) Low threshold and passive response are classified as sensory sensitivity.

4) Low threshold and active response are classified as sensory avoidance (2).

Sensory processing is an essential factor that is effective in numerous aspects of individuals' lives, especially students (4, 5). Mahmoudi et al. demonstrated that there is a sensory processing disorder in students with poor sleep quality (6). Yano et al. showed that there is a relationship between sensory processing sensitivity and depression (7). Amemiya et al. indicated that emotional control in students with sensory sensitivity was improved through yoga (8). What can be concluded from the aforementioned studies is the effect of sensory processing patterns on individuals' behaviors and reactions (1). Studies also acknowledge that creativity, maturity, and commitment play a special role in the quality of students' education (9). The aforementioned concepts are described as "critical thinking" (10). Critical thinking is defined as the ability to search for an issue, challenge, or situation to synchronize all available information related to the subject under study and arrive at a solution or hypothesis to justify the individual's orientation (11).

Critical thinking is defined in different terms. One of the reasons is that critical thinking is a subjective concept that requires high-level cognitive functions that make it more difficult to define and accurately measure a unit (12). Another reason is that each investigator has defined it according to their perceptions and research findings (13). Numerous studies have been carried out on the relationship between critical thinking with academic achievement and other aspects of students' lives (14). Akpur et al. showed that critical thinking has a positive and significant relationship with academic achievement (15). In a study, Soleimanpouromran et al. emphasized the effect of critical thinking on increasing positive social skills, reducing impulsive and rebellious behaviors, and increasing communication with peers (16).

Although studies have not confirmed the direct effect of critical thinking on physical health, considering that critical thinking is one of the main skills for medical students in clinical decision-making (17). Both categories (i.e., sensory processing and critical thinking) affect different aspects of human life, and critical thinking is one of the main factors in students' academic achievement (18). In addition, no study has examined the relationship between critical thinking and sensory processing pattern. Therefore, the present study was designed to investigate the correlation between critical

thinking and sensory processing in students of Medical Sciences.

Objectives

This study aimed to investigate the correlation between the critical thinking skills and sensory processing patterns of students of Medical Sciences.

Methods

The present cross-sectional study was conducted on 213 students of Hamadan University of Medical Sciences in the academic year 1399-1400 using convenience sampling. The sample size was determined using the PWR software package in R.3.6.1 software. The significance level was considered 0.05, and the test power was 90%. The value of r , which shows the correlation based on previous information, was 0.22. The inclusion criteria were the age of at least 19 years and healthy condition (i.e., no report of an acute or chronic physical or mental disorder that disrupted an individual's life). Before completing the questionnaire, the first author gave the necessary explanations about the project process, and the questions were answered through the internet. The questionnaires were sent to the subjects via email or social media. Internet informed consent was obtained from the participants at the end of the e-questionnaire for their anonymized information to be published in this article. All analyses were carried out using SPSS software (version 24).

Research Tools

1) Demographic questionnaire included information on age, gender, school of study (i.e., medicine, dentistry, pharmacy, paramedical science, nursing, and rehabilitation), academic year (first to the sixth year), grade point average (GPA), and place of residence (dormitory or native city)

2) Brown's Adolescent and Adult Sensory Profile Questionnaire (19) is an adaptation of the Sensory Processing Questionnaire for Children and Colleagues, which was developed in 2001. This questionnaire is a self-report scale with 60 items and sensory processing patterns in four areas of low registration, sensory seeking, sensory avoidance, and sensory sensitivity. Each pattern has 15 items with a score range of 15-75. This questionnaire does not have any cutoff points. The respondent should rate the items using a 5-point Likert scale (never, rarely, sometimes, often, and always) (19). Brown et al. offered the internal consistency of the subscales of this questionnaire within the range of 0.60-0.78 (19). In a study by Gamarisa et al. the Cronbach's alpha coefficient of this test was equal to 0.87 for the whole scale. The Cronbach's alpha coefficients of this

test for the subscales of low registration, sensory sensitivity, sensory seeking, and sensory avoidance were 0.71, 0.72, 0.65, and 0.75, respectively (20). In the present study, internal consistency was obtained through Cronbach's alpha coefficient for the whole test ($\alpha=0.847$).

3) 33-item Ricketts' Critical Thinking Questionnaire (10) was administered to assess critical thinking skills in students. The scale was designed by Facione et al. and received significant differences in relation to the California Critical Thinking Disposition Inventory (CCTDI) (21). Ricketts tried to provide a shorter, more effective, and more reliable scale. The Critical Thinking Tendency Questionnaire was based on Facione's Critical Thinking Scale (22). On this scale, the subject should indicate on a 5-point Likert scale (from strongly disagree equal to 1 and strongly agree equal to 5) the extent to which he/she disagrees or agrees with each of the statements. In items 2, 12, 15, 19, 23, 30, 32, and 33, the scoring is obtained in reverse. This scale has three subscales, namely creativity (the first 11 items), maturity (the next 9 items), and commitment (the last 13 items). The total score on the Critical Thinking Questionnaire for each individual is within a range of 33-165. This questionnaire does not have any cutoff points. Ricketts administered the Critical Thinking Questionnaire to 60 agricultural students to standardize it. The reliability coefficients of the subscales of this test were reported as 75%, 57%, and 86% for creativity, maturity (cognitive maturity), and commitment (mental engagement) (23). In a study by Pakmehr et al. the psychometrics of this questionnaire in the Persian language was obtained, and the reliability coefficient of this questionnaire in Persian was reported to be 91% (24). In the present study, the internal consistency of Ricketts's Critical Thinking Questionnaire was confirmed and calculated by Cronbach's alpha coefficient ($\alpha=0.844$).

Before participating in the study, the students were provided with the necessary explanations about the research process and the two concepts of sensory processing and critical thinking. Students' participation in the research was informed and voluntary. Moreover, in the draft research form, it was possible to communicate with students to answer their questions and possible concerns during the study. Then, the data were analyzed using appropriate statistical tests. The Pearson correlation test was used for three purposes, including exploring the relationship between sensory processing patterns and subscales of critical thinking, investigating the relationship between subscales of critical thinking and GPA, and studying the relationship between age with critical thinking and sensory

processing patterns. The independent t-test was used to investigate the relationship between gender with sensory processing and critical thinking. A p-value less than 0.05 was considered statistically significant.

Results

A total of 213 students of Hamadan University of Medical Sciences, including 147 females (69%) and 66 males (31%), from different fields of medical sciences in 2 months participated in this investigation. The highest and the lowest numbers of participants were related to medical students ($n=40$, 18.77%) and health students ($n=20$, 9.38%), respectively. Table 1 shows further details of demographic variables.

The students obtained the highest score among the four sensory processing patterns in the sensory sensitivity pattern, with a mean score of 48 ± 5 . Moreover, the lowest score was obtained in the low registration pattern with an average score of 34 ± 6 . The average total score of critical thinking for students was 124 ± 5 . The Pearson correlation test was used to investigate the normality of data distribution in the dimensions of sensory processing and critical thinking (using a Q-Q plot test) (Table 2).

Table 1. Demographic Characteristics of Subjects

Variables	n	%
Gender		
Male	66	31
Female	147	69
School		
Medicine	40	18.77
Dentistry	38	17.84
Paramedicine	30	14.08
Nursing	12	5.63
Radiology	18	8.45
Midwifery	28	13.14
Pharmacy	32	15.02
Rehabilitation	25	11.73
Physiotherapy	10	4.69
Occupational therapy	15	7.04
Health	20	9.38
Academic year		
First	38	17.84
Second	96	45.21
Third	29	13.61
Forth	12	5.67
Fifth	18	8.45
Sixth	20	9.22
Residence		
Native city	128	60.09
Dormitory	85	39.9

There was a significant and positive correlation between GPA and critical thinking score ($P < 0.05$, $r = 0.875$).

Table 2. Mean and Standard Deviation Related to Scores of Sensory Processing Patterns and Subscales of Critical Thinking and Total Score of Critical Thinking

Subscales		Mean	Standard deviation	Minimum	Maximum
Sensory processing patterns	Low registration	34	6	18	58
	Sensory avoidance	38	6	20	64
	Sensory seeking	40	7	22	65
	Sensory sensitivity	48	5	32	63
Subscales of critical thinking	Maturity	33	3	23	43
	Creativity	43	5	30	54
	Commitment	47	4	33	61
Total score of critical thinking		124	5	90	155

Table 3. Correlation Coefficient Values between the Subscales of Critical Thinking and Sensory Processing Patterns

Items	Commitment	Maturity	Creativity	Sensory avoidance	Sensory seeking	Sensory sensitivity
Maturity	0.597**	-	-	-	-	-
Creativity	0.606**	0.632**	-	-	-	-
Sensory avoidance	-0.093	-0.132	-0.046	-	-	-
Sensory seeking	-0.193*	-0.237**	-0.219**	0.690**	-	-
Sensory sensitivity	0.117	0.221**	0.256**	-0.187	-0.028	-
Low registration	-0.197*	-0.186	-0.192*	0.632**	0.702**	0.043

**P<0.01, *P<0.05

The examination and comparison of the relationship between sensory processing patterns and critical thinking subscales showed that the commitment subscale had a significant inverse relationship with seeking ($r=-0.193$) and low registration ($r=-0.197$). The maturity subscale had a significant inverse relationship with sensory seeking ($r=-0.237$), low registration ($r=-0.186$), and sensory avoidance ($r=-0.132$). The maturity subscale had a significant positive relationship with sensory sensitivity ($r=0.221$). The creativity subscale had a significant reverse relationship with sensory seeking ($r=0.219$), sensory avoidance ($r=0.046$), and low registration ($r=0.192$). In addition, creativity had a significant and positive relationship with sensory sensitivity ($r=0.256$) (Table 3).

Among the four dimensions of sensory processing, critical thinking had a significant and positive relationship with sensory sensitivity ($r=0.229$, $P<0.05$). Critical thinking also had a significant reverse relationship with sensory seeking ($r=-0.249$, $P<0.01$) and low registration ($r=-0.223$, $P<0.01$) (Table 4). The results showed that among the sensory processing patterns, gender was associated only with low registration ($P<0.05$). Female students scored higher in this pattern than male students. Furthermore, the results confirmed that there was no significant correlation between age with sensory processing ($P>0.05$) and critical thinking ($P>0.05$) (Table 5).

Discussion

The present investigation confirmed that for students who participated in the study, sensory sensitivity had the most significant relationship among

the four patterns of sensory processing with critical thinking and its subscales (i.e., creativity and maturity). Sensory seeking and low registration also showed a significant inverse relationship with critical thinking. All patterns of sensory processing had a significant relationship with at least one of the subscales of critical thinking. Extensive investigations have been accomplished on the consequences of sensory processing patterns on behaviors in healthy and disabled individuals (25, 26). For example, Meredith et al. showed that coping approaches could reduce distress in individuals with sensory sensitivity (27).

Another finding of this study is that the patterns of low registration and sensory seeking had a significant inverse relationship with critical thinking. In 2012, Rizzo et al. demonstrated a positive relationship between creativity and sensory sensitivity, which is confirmed by the results of the present study (28). What is important about the aforementioned finding is paying attention to the definitions of each of the sensory processing patterns. In the pattern of sensory sensitivity, the threshold is low and the model of response is inactive (2); therefore, it is expected that individuals who have this pattern are likely to be people with higher critical thinking skills and can more effectively understand the tensions and feedback from the environment, manage them using critical thinking skills, and provide logical and accessible solutions (29).

Regarding the two patterns of sensory seeking and low registration, which showed both a significant inverse relationship with critical thinking, it is noteworthy that in both of these patterns, the response method is active. Regarding the four patterns of sensory

processing, Winnie Dunn said that “individuals whose sensory processing patterns of sensory sensitivity and avoidance are predominant have a more accurate and comprehensive awareness of environmental stimuli, such as sound, smell, and touch”. The difference between sensory sensitivity and sensory avoidance is in the method of response, in which the former is active

response and the latter is passive response (2). Despite the scientific evidence that critical thinking and its subscales are related to the four sensory processing patterns, it cannot be precisely confirmed or rejected that people with a low threshold and passive response (sensory sensitivity) think more critically than others.

Table 4. Relationship between Critical Thinking and Sensory Processing Patterns Using Pearson Correlation Test (n=213)

Variable	Sensitivity	Seeking	Low registration	Avoidance
Critical thinking	0.229**	-0.249**	-0.223**	-0.099

**P<0.01, *P<0.05

Table 5. Relationship between Demographic Variables with Critical Thinking and Sensory Processing Patterns

Variables		Critical thinking				Sensory processing patterns			
		Commitment	Creativity	Maturity	Total	Low registration	Sensory avoidance	Sensory seeking	Sensory sensitivity
Gender	t	-0.9	0.59	0.21	0.07	-1.97	-0.98	0.16	0.36
	%95 confidence interval of difference	-1.60 to 0.59	-1.08 to 2.02	-1.28 to 1.60	-3.40 to 3.65	-3.89 to 0.00	-2.97 to 0.98	-2.02 to 2.38	-1.40 to 2.03
	P-value	0.03	0.03	0.00	0.00	0.59	0.81	0.89	0.21
Age	r	-0.03	-0.03	0.09	0.01	-0.06	-0.08	0.03	0.09
	P-value	0.66	0.63	0.18	0.84	0.32	0.23	0.62	0.14

The findings of the present study also indicated that critical thinking had a positive and significant relationship with GPA, which is the main sign of academic achievement. Some studies confirm the aforementioned finding and some studies violate this finding (30-32). Sireerat et al. examined the relationship between critical thinking and GPA in Thai dental students (using the CCTDI) and showed a positive and significant relationship between GPA and two areas of critical thinking (except for systematicity and confidence in reasoning) (33). Contrary to the results of the present study, Aghaei. et al. who examined the relationship between critical thinking and academic achievement in undergraduate physical education students, concluded that there is no significant relationship between academic achievement and critical thinking skills (31). For the determination of the exact relationship between GPA and critical thinking, it is necessary to perform studies with a larger statistical population among students and other populations.

Conclusion

The results of the present study indicated that the students with high sensory sensitivity patterns have better critical thinking skills than others, and this pattern has the most significant relationship in the four patterns of sensory processing with critical thinking and its subscales (i.e., creativity and maturity). Individuals

with sensory seeking and sensory processing patterns of low registration have less critical thinking skills than others. The results showed that students with a high GPA also have higher critical thinking skills. All patterns of sensory processing had a significant relationship with at least one of the subscales of critical thinking. The results confirmed that the sensory processing factor is important and influential in critical thinking skills. Therefore, it seems necessary to pay attention to the patterns of sensory processing in students and other populations because it can be effective in the development of their mental skills, especially critical thinking.

Limitations: The present study was a cross-sectional study and the results were obtained in a certain period. It is suggested to conduct a more detailed investigation of the relationship between critical thinking skills and sensory processing patterns using longitudinal studies to provide more reliable results. Another limitation of this study was the use of tools (self-report type) that increased the probability of incorrect completion of items by the subjects. The closure of universities made it impossible for Face-to-face communication with students. Furthermore, due to the sampling method, the study sample might not be representative of all the students at Hamadan University of Medical Sciences; therefore, the results should be generalized with caution.

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