National Journal of Physiology, Pharmacy and Pharmacology

RESEARCH ARTICLE

Effect of learning modalities on visuomotor performance and mental flexibility in professional students

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Received: August 02, 2020; **Accepted:** August 20, 2020

ABSTRACT

Background: The style of learning in an individual is the preferable choice of processing and transforming knowledge. The modalities of learning styles are unimodal, bimodal, and multimodal learning style. Trial making test (TMT) is a neurocognitive test which measures the domain of cognition, its speed of processing, its sequencing order, mental flexibility, and visuomotor skills. **Aim and Objective:** To compare visual-motor skills and mental flexibility in different learning modalities in professional students. **Materials and Methods:** Institutional ethical clearance and written informed consent was obtained. Cross-sectional observational data were collected. VARK questionnaire was administered to professional students between the age group of 18 and 25 years. 55 unimodal, 56 bimodal, and 36 multimodal students who volunteered for the study performed the TMT consisting of Trial A an index of mental skills and Trial B an index of mental flexibility was measured in time (seconds). TMT composite score (B-A) was used to remove the speed content from the test evaluated, resulting in a more refined index of mental flexibility. **Results:** Significant differences in visual-motor skills (TRIAL A) and flexibility (TRIAL B) were seen between groups by one-way ANOVA (F [2.144] = 53.8 l, $P < 0.001$) and (F [2.144] = 69.26 $P < 0.001$), respectively. Tukey's post hoc test showed that the visual motor skills was significantly prolonged ($P = 0.001$) in multimodal students compared to bimodal and unimodal groups and between uni and bimodal groups, while mental flexibility was decreased significantly in multimodals when compared to unimodals. The composite score was statistically significantly different between groups by one-way ANOVA (F [2.144)] = 27.28 $P < 0.001$) and Tukey's post hoc test showed that multimodal participants composite score were prolonged compared to unimodal participants ($P = 0.001$). **Conclusion:** Visual-motor skills and mental flexibility was significantly prolonged in multimodal compared to unimodal and bimodal learning style.

KEY WORDS: Learning Style; Neurocognitive Mental Flexibility; Trial Making Test

INTRODUCTION

Learning is a process of relating the ideas and connecting the knowledge in sequential order after understanding. It is independent and critical thinking and ability to transfer knowledge to new and different contexts. According to Kolb, the psychological aspect which results from individual differences determines the particular strategy of a person choosing while learning.[1] Another study emphasized learning style as cognitive affective, psychological, and affective traits that provide a relatively stable indicator of how learners perceive, interact with, and respond to the environment.[2] Each one's concentration, mental processing internalization, and retention of new and difficult information emerges from his specific style of learning.[3]

Access this article online	
Website: www.njppp.com	Quick Response code
DOI: 10.5455/njppp.2021.10.08228202020082020	

Every individual has a certain degree of preference of one or more style of learning based on the Fleming VARK questionnaire. The finding suggested each one preferred strongly either the visual, auditory, read-write, and Kinesthetic Component of the style of learning. Depending by the modalities of the style of learning, if it is single or double and more than two preferred styles, it is called as unimodal, bimodal, and multimodal style of learning, respectively.[4]

Most of them prefer to learn in a particular style, with each type of learning contributing to the success in retaining what they have learned. It is observed from few studies that students retain 10% of what they read, 26% what they hear, 30% what they see 50% of what they see and hear, 70% of what they say, and 90% of what they say and do something else.[5]

This fact shows that each learning style has its own strength and weakness. Some like to learn in many ways, while others might only favor one or two types. Those learning to study in multiple ways score high compare to who prefer only one mode of style of learning. Few students' favor kinesthetic type of instruction such as the experimental active and hands-on while others are more auditory and visual.[3] Young and adult develop executive functions such as attention control[6] and working memory due to neurobiological changes.[7]

Trail making test (TMT) is a neurocognitive test to measure the cognitive domains of processing speed, sequencing mental flexibility, and visual-motor skills which comprises trial A and B.

This was developed by Partington and Leiter in 1938 and it was originally part of the Army Individual Test Battery (Partington and Leiter, 1949) used by the U.S. Army. Trial A is primarily a task of visual-motor performance and trial B measures working memory and mental flexibility of cognition.[8] The learning problems are always dependent on the cognitive processing of the individual to learn the material not the subject as such.[2] This study aims to know the effect of learning modalities on visuomotor skills and to assess mental flexibility by TMT in professional students.

Objectives

The objectives of the study were as follows:

1. To determine the learning modalities by the VARK questionnaire
2. To determine the visuomotor skills and mental flexibility by performing the TMT in professional students
3. To compare the visuomotor skills and mental flexibility in different modalities in professional students.

MATERIALS AND METHODS

It is a cross-sectional observational study which was performed in the professional students between the age group of 18 and 20 years from Sri Devaraj Urs Medical College in the Department of Physiology after getting permission from the institutional ethical committee. The consent was taken from the professional students after explaining the procedure to them.

Sample size was calculated by Epi Info based on the previous study of 56 students in each group of unimodal bimodal and multi modal each.

$$n = (Zm\ 2 + Zb)\ 2^{*}\ (p1\ (I-p1) + p2\ (1-p2)\ 2/(p1-p2)\ 2$$

where $Z\alpha/2$ is the critical value of the normal distribution at affective $\alpha/2$ (e.g., for a confidence level of 95%, α is 0.05 and the critical value is 1.96), $Z\beta$ is the critical value of the normal distribution at β (e.g., for the power of its 80%), and the p1 is its 64% and p2 is its 36% are the expected sample proportion of the two groups.

In this study, the participants were students from MBBS, Allied Health, and Nursing. The learning styles among the students were determined using the VARK questionnaire which was administered individually to the students consisting of 16 questions developed by Fleming (version 7.8).[9]

These questions belonged to the visual, auditory read-write, and the kinesthetic type. The students were allowed to opt one or more than one option as they preferred. They were divided as visual, auditory, read-write, or kinesthetic, depending on the predominant choice they made. If they choose one preference, they were called unimodal if they choose two preferences, they were considered as bimodal and if it was more than two choices, they were called tri/multimodal.

To determine the visuomotor skills and mental flexibility, TMT A and B were used, respectively. Trial A requires the individual to draw to connect 25 encircled numbers distributed on a page. Trial A tests the cognitive processing speed which is the visuomotor performance. Trial B is similar, except the person must alternate between numbers and letters, which is used to measure working memory and mental flexibility examine exclusive functioning. Both the TMT A and B were performed on the unimodal bimodal and trimodal students of the study group. TMT composite score, which is Trial B completion score minus Trial A completion score time, was used to remove the speed element from the test evaluation, resulting in a more refined index of mental flexibility. A higher score on Trial A and B and the composite score (B-A) reflects more time.[10] The total time for the test is 5–10 min.[11]

RESULTS

The Statistical Package for the Social Sciences (SPSS) version 20.0 (IBM, Armonk New York, USA) was used for the analysis. Data is represented as a mean standard. One-way ANOVA was used to test the difference between the different learning style groups. Tukey post hoc Test was used the find the significant difference in between the group. A total of 147 students participated in the study in which 51 (34%) were MBBS students, 42 (28.6%) were from nursing and the rest 54 (36.7%) were from allied health science. The VARK questionnaire of (7.8 version) was completed by all the participants and it was found to be as shown in Figure 1.

Tukey's post hoc test showed that the visuomotor skills were significantly prolonged ($P < 0.001$) in multimodal students compared to bimodal and unimodal groups, while mental flexibility was decreased significantly in multimodal when compared to unimodal [Figures 2 and 3].

The composite score was statistically significantly different between groups by one-way ANOVA (F [2.144] = 27.28 $P < 0.001$) and Tukey's post hoc test showed that multimodal participants composite score was prolonged compared to unimodal participants ($P < 0.001$) [Figure 4].

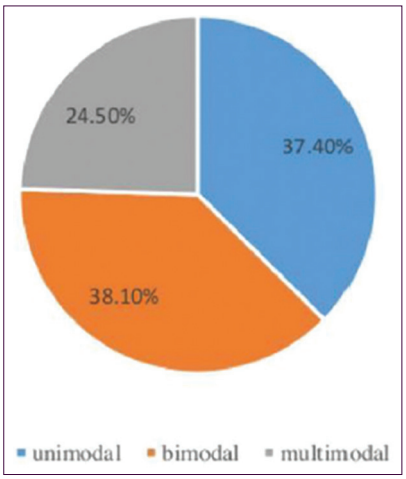

Figure 1: Percentage preference of learning style among the professional student. Significant differences in visuomotor skills Trial A and flexibility Trial B were seen between groups by One way ANOVA [F (2, 144) = 53.81, $P < 0.001$] and [F (2, 144) = 69.26, $P < 0.001$], respectively.

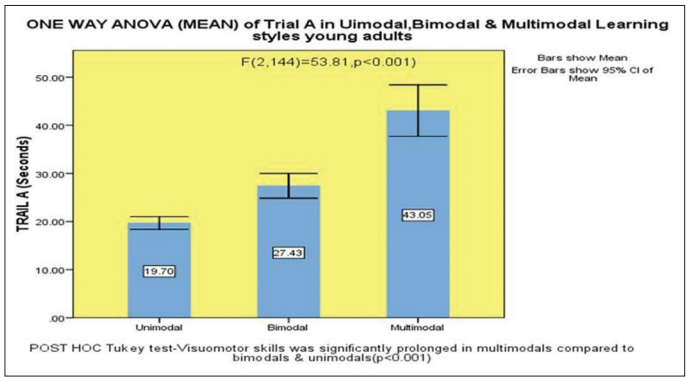

Figure 2: Bar chart representation of one way ANOVA mean of the Trial A in the unimodal bimodal and multi-modal learners

DISCUSSION

Learning involves understanding, relating ideas, and making connections between prior and new knowledge. TMT was chosen as it is a simple test of cognition which access the visual attention and the speeding process of the executive function. We compared performance on the TMT among the students with different learning style and grouped them as unimodal bimodal and multimodal learners using VARK questionnaire by Fleming; unimodal learning style was the most important predictor of performance on both tasks of the TMT, taken separately as well as on executive functioning (Task B-A) having one single type of learning style might also

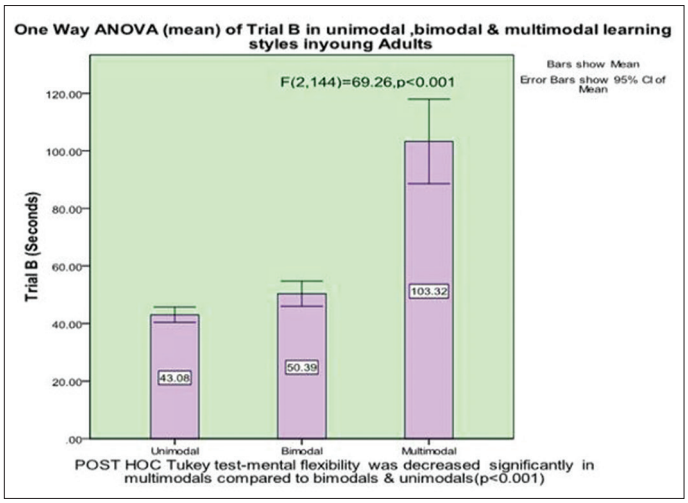

Figure 3: It is Bar chart representation of one way ANOVA mean of the Trial B score in the unimodal, bimodal and multi-modal learners

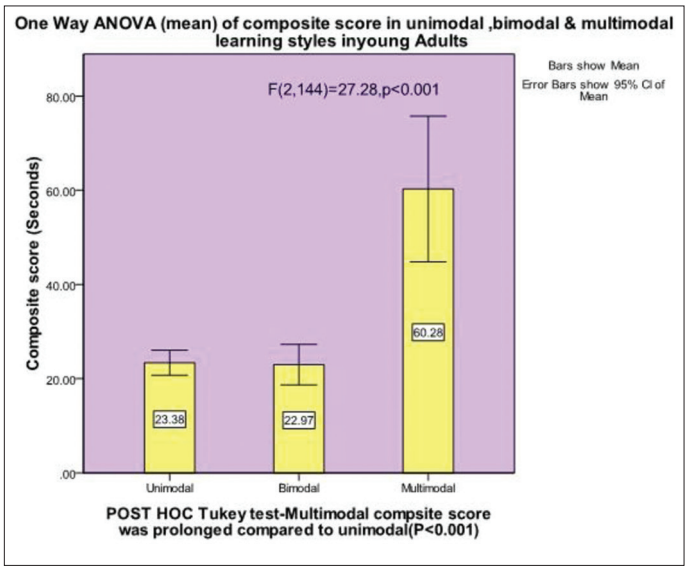

Figure 4: Bar chart representation for one way ANOVA mean in the composite score (B-A) in the unimodal bimodal and multi-modal learners

have facilitated easy performance on a novel test, what so ever may be the profession of the student either MBBS or allied health or nursing. What so ever may be the profession of the student either MBBS or allied health or nursing,regardless of the field of any profession only learning style was considered.

Not much study has been conducted between the learning style and TMT. In another study, the comparison was made between the age education and gender and found that a higher level of education had a shorter time for the TMT and they also showed that women performed better than men and showed that as age advances the TMT time also prolonged.[12]

From our study, we have observed that the unimodal learners took the least time of 19.70 ± 4.97sec and 43.08 ± 9.98 sec to complete Trial A and Trial B. Similarly, the multimodal learners took the longer duration of 43.05 ± 16.35 sec and 103.32 ± 45.04 sec for the completion of both the task A and B, respectively, as seen in Figures 3 and 4. Being a student of health professionals would not matter. The cutoff values for TMT for A and B are 40 sec and 91 sec, respectively.[13,14]

Unimodal learning may be more focused in their activities in the various aspects of learning such as the problem-solving skills and active learning strategies that could be used which help in the promotion of enthusiasm and motivational skills.

In contrast to our expectation, we found multimodal learners proved to show more time consumption in the TMT which involves thinking through reasoning skill, which improves problem, solving and decision-making skills among them. Their ability to multitasking at a point may waver their focus and decrease concentration in one aspect.

Many studies with larger samples are required to replicate the cutoff for the test in the Indian population students so that these cutoffs can be generalized.[15]

CONCLUSION

The unimodal learning style individuals are found to be faster in their cognitive domains of processing speed, in the sequencing process, mental flexibility, and visual-motor skills than the multimodal learning style individuals.

ACKNOWLEDGMENTS

We would like to acknowledge the students who have co-operated for this study.

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How to cite this article: Shenoy UG, Ashwathappa J, Shivram R, Priya S. Effect of learning modalities on visuomotor performance and mental flexibility in professional students. Natl J Physiol Pharm Pharmacol 2021;11(01):5-8.

Source of Support: Nil, **Conflicts of Interest:** None declared.