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Does Reaction Time and Memory Vary in Students with Different Learning Styles?

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Abstract

Introduction: Learning styles are characteristic to individuals since they prefer a modality for perception and processing of the information in different learning situations. VARK, model proposed by Fleming, is an acronym that stands for Visual (V), Aural (A), Read/Write (R), and Kinesthetic (K) preference modalities. VARK has been used in various educational filed to study students preferred learning style. However, there is lack of objective evidence in support of the VARK learning style. The present study was designed to investigate whether reaction time and memory varied in students with different learning styles.

Methods: 29 participants were included in the study. 20 participants with Visual (VLS) and 9 participants with Aural Learning Styles (ALS) classified on the basis of VARK questionnaire and VARK Research algorithm were included. We then subjected them to Auditory Reaction Test (ART), Visual Reaction Test (VRT), auditory and visual memory tests to compare their reaction time and memory with respect to their learning styles.

Results: It was observed that the mean ART was faster than the mean VRT in both the learners. The mean VRT was found to be faster than the mean ART in VLS and the mean ART was found to be faster than their mean VRT in ALS. But the above findings were also found to be statistically insignificant. VLS outperformed ALS in Word Memory tests and ALS scores were better in Digit Memory, however ANOVA did not reveal any significant differences in both the two learning style groups.

Conclusion: Further objective studies are needed to be done in participants with A or V learning style classified according to the VARK Research algorithm, to give more evidence in support of the VARK learning styles.

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Introduction

Learning and Memory are closely associated with each other. Learning is the acquirement of information and memory is concerned with the storage and retention of that information (1). Out of the various sensory inputs, students acquire information most commonly from auditory and visual inputs. Various factors are said to influence the learning process like learning style and teaching style. Learning style is the characteristic cognitive, affective, social, and physiological behaviour which acts as a stable indicator of perception, interaction and response of learners in a learning environment (2). Individuals have their characteristic learning style and prefer a particular modality for perception and processing of the information in different learning situations (3).

In the current student-centred learning approach, several models have been proposed to assess the learning styles. The VARK model was proposed by Fleming and is one of the widely studied due to its ease of use. VARK stands for Visual (V), Aural (A), Read/Write (R) and Kinesthetic (K) preference modalities. VARK deals with perceptual modes and thus is in the category of instructional preference. Students are classified into four different modes of learning on the basis of the standardized questionnaire. Each option correlates to a preferred sense of modality. According to Fleming, visual learners prefer learning through maps, charts, graphs, diagrams, highlighters, different colours, pictures, word pictures, and different spatial arrangements. Aural learners prefer information that is heard or spoken to and these learners learn best by explaining new ideas to others, discussing topics with other students and their teachers, using a tape recorder, and attending lectures. Read/Write learners have a preference to lists, essays, reports, definitions, printed handouts, readings and taking notes. Kinesthetic learners prefer to learn from examples, situations, demonstrations, case studies, practice, field visits, doing trial and error methods to understand things, laboratories, hands-on approaches (4, 5). Knowledge of the learning style of students may be useful for understanding the differences in students, and may also help the teachers to design appropriate learning tools. VARK was statistically validated by Walter et al. in 2010 (6). VARK has been used to assess the learning style of students in several educational streams (7–14).

Apart from its ease of use, VARK has various strengths like its inclusiveness of learning potential of all the students. VARK promotes the idea that students can learn in different ways and encourages the teachers to respect these differences. VARK encourages flexibility in designing resources and in changing the learning conditions (14).

Subjective studies have shown that the VARK learning style is associated with academic performance (7, 11). The results concluded that the dominant Read/ write surgical residents performed better than the dominant aural learners (7). While other subjective studies suggest that learning styles do not contribute significantly towards the learning outcomes (8, 9, 15–17).

There is a lack of objective evidence to support VARK, apart from a recent study which used visual evoked potentials to support the validity of VARK (18). The results of visual evoked response potentials elicited by a picture task revealed that V learners had larger P200 amplitudes than the R learners. Thus, further Objective evidence is required to ensure the validity of the VARK learning style (18).

Reaction time is the time interval between the application of a stimulus and the appearance of appropriate voluntary response by a subject. It involves stimulus processing, decision making, and response programming of the subject. Reaction time is dependent on several factors viz arrival of the stimulus at the sensory organ, transduction to a neural signal, synaptic transmissions and processing, activation and contraction of the muscle, and the measured external parameter. All of these factors have a processing time, which contributes to the overall reaction time (19). Reaction time is an indicator of attention and speed of information processing (20). Researchers recognised that different learners had different cognitive styles and information-processing strategies that determine a learner's standard mode of perceiving, remembering, thinking and problem-solving (21). Few studies have inquired

into the association of learning styles and reaction time. The purpose of this study was to find the association of auditory reaction time (ART), visual reaction time (VRT) with visual and aural learning styles classified using VARK. The hypothesis of the study was to ascertain whether the students with visual learning style (VLS) had a better visual reaction time as compared to the students with aural learning style (ALS) and whether ALS had a faster auditory reaction time than VLS.

Short term memory which was initially thought to be an auditory process is now also considered to involve a visual process. Information received through the visual or auditory stimuli is processed in the brain and converted into short-term memory for its later retrieval. Hence visual and auditory senses are the most common mode through which visual and auditory short-term memory is formed (22). No studies have inquired into the correlation of memory with learning style. This study aims to know whether VLS have a better visual memory than ALS and vice versa.

According to Meshing hypothesis, learning is better, if the format of the instruction matches with that of the preferred learning styles of the learner. For example, for an aural learner, providing him with aural instruction is much better than providing him with visual instruction. However, there has been no credible evidence as of yet, to support this hypothesis (23, 24). The present study was designed to investigate whether reaction time and memory varied between students with Aural and Visual learning styles.

Materials and Methods

The present cross-sectional study was carried out at Department of Physiology, Kasturba Medical College, Manipal. Ethical clearance was obtained from the Institutional Ethical Committee. Participants were recruited into the study after obtaining their written informed consent. Participants were required to be in good health, without smoking habits, with normal vision and hearing and be free from any disorders of learning or any other disorder affecting psychomotor abilities. Sample size was determined using power of study at 80%, probability of α error at 0.05, using anticipated standard deviation in population to be 1.5 from previous studies (22). Further the number of participants in each group was determined by the availability of unimodal learners. 126 students from various streams of Master of Science from Manipal Academy of Higher Education, Manipal, were screened for the study using VARK questionnaire and 38 unimodal learners with either A or V learning style were included in the study. The students were classified using the VARK questionnaire (Version 7.1). The participant's group consisted of 25 females and 13 males. This group had a mean age of 22.84±2.02 years with a range of 21 to 30 years. Participants were asked to refrain from any caffeinated food items for at least 4 hours prior to testing and to get a regular night's sleep of at least six hours.

Study procedure:

(a) Analyzing VARK

To assess the modality preference of students, each participant was provided with a VARK questionnaire which consisted of 16 questions with four options each. The questions described the day to day life situations related to their learning experience. Each option correlated to a sensory modality preference. They could circle more than one option if a single answer did not match their perception. Completed questionnaires were collected and analysed using the VARK questionnaire scoring chart. 38 participants with V and A learning style were selected and further analysed using VARK Research algorithm (copyright release obtained from VARK Learn Co.Ltd). 9 participants with VARK type One style were excluded. Thus 20 V (2 - very strong, 3 - strong, 15 - mild) and 9 A (1 - strong, 8 - mild) participants were selected for the study. Read/write (R), Kinesthetic (K), bimodal and polymodal learners were excluded from the study. Bimodal learners prefer two modes of learning style, while multimodal have preference for two or more modes of learning style.

(b) Measurement of Auditory & Visual Reaction Time and Memory:

These tests were conducted in an isolated and quiet room in the Neurophysiology Lab of Department of

Physiology. The participants were asked to sit comfortably on a chair. The participants were thoroughly explained about the test procedure & sufficient trials were provided to make them accustomed to the procedure. ART and VRT were measured using SuperLab v5. Memory tests were performed using Microsoft PowerPoint software.

Auditory Reaction Time (ART):

Auditory reaction time was measured by presenting an auditory stimulus sound (beep sound of 1000 Hz) at variable time intervals. Participants were instructed to close their eyes, place their index finger on the space bar and press the space bar on the keyboard as soon as they heard the sound.

Visual Reaction Time (VRT):

Visual Reaction Time was measured by presenting a visual stimulus in the form of a coloured circle (red, green & blue with radius 1.5 cm) in the centre of a white screen background. Participants were asked to concentrate on the fixation cross and press the space bar as soon as they saw the coloured circle. ART and VRT were measured in milliseconds.

(c) Memory tests:

The methodology for the memory tests was adopted from the study done by Mittal et al. (22). Memory tests comprised of a set of 2 visual memory tests and two auditory memory tests. Participants were given proper instructions before the test. Memory tests were conducted one at a time and a gap of 5 minutes was given after each test.

Visual memory tests comprised of the following two tests

In visual digit memory (VDM) and visual word memory (VWM), a ten slide PowerPoint presentation of 10 familiar, unrelated words and ten digits were prepared respectively. Each digit/word was displayed on the screen for 3 seconds, one after another. Participants were asked to wait for 30 seconds, memorise them following which they were instructed to recall and write the words/digits on a sheet of paper within 30 seconds. The participants could recall in any order.

Auditory memory tests comprised of two tests

In auditory word memory (AWM) and auditory digit memory (ADM), participants were made to listen to the clear voice recording of 10 different words/digits in 30 seconds. After that, participants were asked to memorise them, wait for 30 seconds, and were then instructed to recall and write the words/digits on a sheet of paper within 30 seconds.

Each memory test was rated on a score of 10.

Statistical Analysis:

SPSS 16 version was used to do the analysis. The analysis of descriptive statistics is described as means& SD. An independent-sample t-test was conducted to compare reaction time and One-way ANOVA to compare memory scores between the two learning style groups. Statistical significance was set at a p-value of <0.05.

Results

29 participants were included in the study, 20 in the VLS group and 9 in the ALS group. The mean age of the participants in the VLS group was 23.05 years, and in ALS it was 22 years. There were twelve females and eight male participants in the VLS group, and six females and three male participants in the ALS group.

ART and VRT

Overall the mean ART (272.17 ms) was faster than mean VRT (286.61 ms) in both VLS and ALS.

The mean ART was faster in ALS as compared to VLS (Table I). An independent-sample t-test was conducted to compare ART in VLS and ALS. There was no significant difference in the ART of VLS ($M=279.33$, $SD=28.52$) and ALS ($M=256.27$, $SD=38.39$); $t(27) = 1.80$, $p = 0.08$.

The mean VRT was faster in VLS as compared to ALS. An independent-sample t-test was conducted to compare VRT in VLS and ALS. There was no significant difference in the VRT of VLS ($M=284.32$,

TABLE I: Participants performance in ART VRT and Memory tasks.

VARK modality preference		*ART*[a]	*VRT*[b]	*Visual Digit Memory*	*Visual Word Memory*	*Auditory Word Memory*	*Auditory Digit Memory*
		Milliseconds		*From a Maximum Score 10*			
VLS[c]	Mean	279.33	284.79	4.95	7.25	6.90	5.55
N=20	S.D.	28.52	30.02	1.67	1.65	1.74	2.37
ALS[d]	Mean	256.27	290.65	5.11	6.67	6.00	6.56
N=9	S.D.	38.39	39.35	2.09	1.32	1.12	2.40
Total	Mean	272.17	286.61	5.00	7.07	6.62	5.86
N=29	S.D.	330.27	32.58	1.77	1.56	1.61	2.39

Abbreviations: a) ART: Auditory Reaction Time; b) VRT: Visual Reaction Time; c) VLS: Visual Learning Style; d) ALS: Auditory Learning Style

SD=30.02) and ALS (M=290.65, SD=39.35); t (27) = -0.44, p = 0.662.

Memory Tests:

Total mean score of all subtypes of memory tests for VLS was 24.79 and for ALS was 24.34. In both the groups of learning, performance was highest in VWM and the least in VDM. On comparing the performance of visual and auditory memory in both the groups, the VLS outperformed ALS in Word Memory tests (AWM (VLS=6.90; Aural=6.00), VWM (VLS=7.25; ALS=6.67) but ALS performed better in Digit Memory tests (ADM (VLS=5.55; ALS=6.56), VDM (VLS=4.95; ALS=5.11). However ANOVA did not reveal any significance difference between the two learning style groups for VWM ($F(1,27)=0.867$, $p=0.360$), VDM($F(1,27)=0.050$, $p=0.826$), AWM ($F(1,27)=2.002$, $p=0.169$) or ADM($F(1,27)=1.106$, $p=0.302$).

In the VLS group, ANOVA revealed a significant difference between the scores of various memory tests ($F(3,76)=6.716$, $p<0.001$). Between the memory tests.

Post hoc Bonferroni test revealed that the score for VWM was significantly higher than that of VDM ($p<0.01$) and ADM ($p=0.033$), but not significantly higher than AWM. AWM was significantly higher than VDM ($p=0.010$). There was no statistically significant difference in between scores of memory tests in ALS group.

Discussion

Learning style is an approach through which a learner saves, recalls and processes the concepts effectually (23). The present study investigated whether reaction time and memory varied in students with different learning styles. Although statistically insignificant, the mean VRT in VLS was faster than the VRT of ALS. While ART was faster in ALS, there was no statistical difference in reaction time between the two learning style groups.

In ALS, although statistically insignificant, the mean ART was found to be faster than the ART of VLS (Table I). Earlier studies have suggested that as soon as the brain receives the stimulus, sooner is the information processing and thus faster is the motor response elicited due to commands from the motor cortex (25). Thus the VLS had a faster response to the visual stimulus and hence had a faster afferent pathway to the brain. A faster conduction and thus quick processing of the visual information produced a quick motor response by pressing the specified button on the keyboard and thus possessed a quicker VRT than the VRT of an aural learner. Similarly, it can be implied that in students who preferred an aural mode of learning had a faster response to an auditory stimulus and thus a quicker ART than that of the VLS.

In the study, mean ART was found to be faster than the mean VRT in both VLS and ALS (Table I), but this finding was found to be statistically insignificant.

This finding that ART is faster than VRT correlates to the studies done in the past by Pain & Hibbs and Thompson et al. which shows that simple ART is fastest for any given stimulus (19, 26). An investigation by Kemp validated this finding by explaining the duration of the auditory stimulus to reach the brain to be 8-10 ms in comparison to a visual stimulus that took 20-40 ms to reach the brain. This infers that the visual stimulus reaches the cortex much slower than the auditory stimulus (27). Hence, the results also denote that irrespective of the learning style of visual or auditory, the mean ART is faster than mean VRT.

On comparison of mean scores on memory tests in VLS and ALS, the VLS outperformed ALS in Word Memory tests and ALS performed better in Digit Memory tests (Table I). However, there was no statistically significant difference in the score of each test among the two learning style groups. In VLS, the mean score for VWM was higher compared to that of ALS and thus words visually seen were better recalled than words heard but this finding was statistically insignificant. This could be correlated to the findings which suggest a better recall of visual stimuli in comparison to auditory stimuli (22), however, VDM scores were higher in ALS. Both the group of learning styles performed well in VWM than in AWM. Although there was no statistically significant difference observed in the score for each memory test among the VLS and ALS, there was a statistically significant difference observed in the scores of visual & auditory memory tests in the VLS group. This is consistent with the previous studies that have shown that visual memory is superior to auditory memory (28, 29). Literature suggests that visual stimuli are better recalled than the auditory stimuli even after external auditory training. Auditory memory was found to be superior only after a three-day period of external auditory training and a simultaneous three-day period of visual memory decay (30). The possible explanation provided is that the auditory stimuli are characteristically different than the visual stimuli as they are psychophysically less memorable (29). The reason for the poor recall of words heard than the words seen is that the visual stimuli (words) are static, more defined, distinct with unique characteristics of their own, while the auditory stimuli are dynamic, with less definable features. Hence the differential processing of visual or auditory stimuli at the respective cortices contributed to the visual superiority (31, 32), as the auditory memory had a poor representation (30). The brain creates a mental image in response to visual stimuli while in response to an auditory stimulus it needs to hear the word first and then create an image for its retrieval which can delay its recall (33). Thus, it can be implied that a learner having an aural learning style, his visual memory was better than auditory memory which correlates to the study performed by musicians and non-musicians, wherein the musicians who have similar characteristics of an aural learner, were better in remembering pictures or scenes than sound clips (29). Additionally, for word memory task, phonological and graphemic processing are involved. While in digit memory task these processes are not essential(ref). So, probably VLS have better phonological and graphemic processing and thus they performed better in Word Memory tests (34).

The validity of VARK questionnaire has been questioned due to the lack of evidence (23, 24). A study by Thepsatitporn and Pichitpornchai was the first one to give some objective evidence in support of the VARK learning style. The study focused on V and R learners and showed that visual evoked potentials, i.e. P200 amplitude could be used to objectively differentiate between V and R learners for a picture task. However, there was no significant difference for the word task (18). While our study focused on the V and A learning styles, and there was no significant difference between reaction time and memory scores of the two groups. Further investigations are needed to give an objective evidence for the support of VARK learning style questionnaire. The strength of our study included: classification of learning styles using the VARK Research algorithm and use of reaction time tests and memory tests which are inexpensive easy to administer and can be repeated for studies easily. The major limitation of our study was the small sample size since the percentage of students with only V, or A style of learning is less. Also, most of the participants were mild V, or A. Further objective studies can be done in participants with very strong or strong A or V learning style classified according to the VARK

Research algorithm.

Conclusion

Learning style that is characteristic for each learner is essential to be known to employ respective learning strategies to enhance learning. The VARK learning styles encourages the learners to reflect on how they learn and explore various other learning strategies of their liking. This study investigated whether reaction time and memory varied in students with different learning styles and thus provide some objective evidence in support of VARK. However, this study denotes that irrespective of the learning styles, the learners did not have a significant variation in their reaction time and memory. Hence, learning styles did not have any influence on the reaction time and memory of the learner.

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