Psychophysiological Measures of Learning Comfort: Study Groups' Learning Styles and Pulse Changes

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Abstract

This study provided empirical support for tutor-led study groups using a physiological measurement and study survey data. The scope of this preliminary study included determining differences in biology and chemistry study group members' (N = 25) regarding learning styles and pulse rate changes. As hypothesized, there was significant evidence that pulse rate decreased during the sessions, suggesting less stress. Significant differences in final and initial pulse rate were found for biology students when their learning style was matched to the style of instruction. The results suggest that gearing instruction styles to students' learning styles may reduce learning stress in some cases.

Creating measurable and relevant learning outcomes is a crucial portion of education and has become an important strategic objective for higher education in addition to grade school. The trend towards outcomes assessment has implications for developing ways to more effectively facilitate instruction and learning (Johnson, 2006). Learning style refers to the compilation of preferences and abilities an individual has relating to information gathering and processing (Johnson & Orwig, 1998). Learning styles include both biological and psychological aspects of the individual (Davis & Franklin, 2004). Based on these characteristics, some learning and teaching methods are more effective for some individuals and less effective for other individuals. Therefore, learning style is an important factor in how an individual learns and in creating and assessing learning outcomes. R. Dunn (1984) posited that teaching in a format that was consistent with a student's preferred learning style was one of the most efficient ways to customize individual instruction. There are different learning styles

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mentioned in the literature including sensory preferences, such as the Dunn and Dunn learning model (Dunn, 1990), or those associated with personality characteristics such as those identified with the Myers Briggs Type Indicator (Jie & Xiaoqing, 2006; Myers, 1962).

One of the challenges with assessing learning assistance outcomes is gathering data that is both objective and relevant. This is due in part to the presence of many possible confounding variables. Additionally, the modes of learning assistance, such as one on one tutoring, do not naturally fit the constraints of experimental research such as the inclusion of a control group or random selection. Finding ways to measure physiological and psychophysiological data may help to strengthen educational research by the addition of some rigors associated with scientific inquiry. Pulse rate is one measure of psychophysiological arousal, such as stress (Youngmee, 2006). D. Rowland, A. Kaarianinen, & E. Houtsmuller (2000) demonstrated a connection between psychological response to a stimulus and physiological arousal in a learning activity. However, no research revealed in a literature search extended psychophysiological measures to learning styles. Therefore, this research helps fill a gap in the literature by demonstrating a preliminary connection between psychophysiological data as a measure of a student's learning comfort and information presented in accordance with different sensory learning preferences.

Background

The sensory model of learning styles is the model that can be most closely matched with stimulus processing in the brain. Because this empirical study sought to gather psychophysiological data, this model was the most appropriate to use for assessing students' learning styles. This model posits that there are four major forms of modality of learning styles: visual, auditory, kinesthetic, and tactile (DiCarlo & Lujan, 2006).

Students with a visual preference learn best through a pictorial form or via other visual information. Students with an auditory style favor auditory stimuli, such as through lectures or discussions. Students with a tactile style prefer to learn through interaction with textual materials where they can hold the pencil or touch the paper handout, for example. Students with a kinesthetic preference learn better through performing or doing activities that promote physical involvement and manipulation of objects (DiCarlo & Lujan, 2006). Thus, the model of learning style that focuses on sensory preference suggests that signals between sense organs and information processing in the brain are modulated by individual preferences for one type of information over another.

Findings in cognitive psychology have suggested that pulse rate increases when the student reads a sentence that he or she does not recognize or understand, and pulse rate decreases when the student reads a sentence that he or she comprehends (Beyda & Spence, 1980). Consistent with the literature on stress and heart rate, a decrease in heart rate could suggest less stress or anxiety and, therefore, higher levels of comfort with learning such as obtaining information via the preferred sensory pathway. Thus, measuring pulse rate change provides a measure of student comfort with material.

Method

Participants

The participants (N = 25) consisted of adult coed students taking BI 101 and CH 101, introductory level biology and chemistry courses. Students in all sections of these classes were invited to participate in the study group. After attending an information session about the research, students who agreed to participate in the research signed documents indicating their informed consent.

Measures

This study utilized three measures, the Barsch (1980) Learning Style Inventory (LSI), students' pulse rate, and a self-disclosing Likert-type survey. The Barsch LSI was developed to indicate students' preferences towards visual, sensory, tactile, or kinesthetic learning styles. The students received training in manually measuring their pulse rates and applied this training two times during each session to obtain an initial and final pulse rate. A self-disclosing Likert-type survey was completed at the last study session to assess students' perceptions of study group outcomes. The surveys were approved for use by faculty and an administrator.

Procedure

The Barsch (1980) Learning Style Inventory was administered to all students in the study groups, and the dominant learning style was then analyzed for each student according to the inventory key. Students were informed of their learning style preference, but they were not told what learning style was the primary mode of delivery for each study session. The students attended a one-hour study session for their course once a week for four weeks. The BI 101 and CH 101 study groups met separately because the content for each session was specific to each course.

Each session included three elements: it was conducted by an experienced peer tutor with College Reading and Learning Association Certification, it contained a specific learning activity delivered primarily through one sensory mode, and it included two pulse rate measurements. Each student took his or her initial resting pulse rate five minutes into the study session to allow for the student's pulse rate to recover from normal activity involved in getting to the session. Each student also took his or her final pulse rate, according to directions from the peer tutor, at the halfway point of the one-hour session, after the student engaged in the learning activity. Study sessions were held once a week for each course. The content for each session was based upon what the students were learning in their classes during a given week. The sensory mode featured at a given session was randomly alternated for each course. The same peer tutor led every session.

Week 1. The BI 101 study group featured visual delivery while the CH 101 study group relied on tactile information. In the BI 101 study group, the tutor used pictures, chalk diagrams, and computer animation to visually explain and clarify the structure of the cell and its organelles. In the CH 101 study group, students used paper, pencils, and textual materials in the form of worksheets, crossword puzzles, and practice problems of the topics being covered in class. These topics were solving stoichiometry problems,

balancing chemical equations, and calculating molarity.

Week 2. The BI 101 study group focused on the kinesthetic mode of learning. The tutor instructed one student to hold a basketball at different heights while the other students jumped to reach it to demonstrate the role of activation energy in chemical reactions. To demonstrate differences between anabolic and catabolic reactions, the tutor instructed the students to link arms to represent building up a larger unit from smaller parts and then releasing one another to indicate being split into smaller parts. Thus, the students got to act out their understandings of the biological processes being studied.

The CH 101 study group used the auditory mode of learning. The tutor provided a mini-lecture and asked the students to talk with each other about what they understood from the lecture. The students also verbally explained to one another how they would approach each question the tutor asked them in order to achieve the correct answer.

Week 3. The BI 101 study group emphasized tactile information in the form of worksheets, crossword puzzles, and practice problems about photosynthesis and cellular respiration. The CH 101 study group learned about Hess's Law and the fundamental concepts of calorimetry through visual information, pictures, and equations written on the board. The students demonstrated learning by identifying the pictures that were conceptually correct and which problems were correctly solved.

Week 4. The BI 101 study group engaged in auditory learning by receiving a mini-lecture from the tutor on the cell cycle. The tutor explained the stages of cell division and, after the students discussed the topic with one another, aurally quizzed the students to test their knowledge of the material covered in the session. The CH 101 study group featured kinesthetic information. The tutor used inflated balloons to represent atomic orbitals. The students manipulated the balloons to learn about the shape and layout of atomic orbitals. The tutor provided a kinesthetic learning activity for Hund's Rule by placing paper on the floor to represent atomic orbitals. Each student, representing one electron, took his or her place on a piece of paper until each piece of paper had one student standing on it. The remaining students were then paired with the students already standing on the paper. The action involved in this activity represented electrons spreading out in orbitals until all orbitals had one electron before electrons formed pairs in orbitals.

At the last session, students completed the self-disclosing, Likert-type survey to assess their perceptions of the study sessions. Students responded to the following items using one (strongly disagree) to five (strongly agree) rating: a) material was presented in an understandable way, b) tutor explained concepts clearly, c) in session activities and materials were helpful, d) would recommend study group to others, and e) study group increased performance in class assignments and tests.

Results

The data was examined from the following perspectives: composition of study groups according to learning style preference and pulse rates, pulse rate changes when students' preferred learning style matched or did not

match a session's delivery style, and pulse rate changes and self-disclosure data to identify whether student comfort was increased through participating in the study sessions as a whole.

The results of the Barsch (1980) inventory showed that 34% of the students in the biology study group had a dominant visual learning style, 22% of the students in that group preferred kinesthetic learning, 22% of the class preferred a bimodal learning style (two styles close together in preference) of visual and kinesthetic, 11% of the students preferred the auditory style, and 11% of the students favored tactile learning. Visual learning was also the dominant mode in the chemistry study group with 44% of the class scoring highest on this style of learning. Auditory was the second most preferred style, 25%, followed by kinesthetic, 19%, tactile, 6%, and bimodal visual and kinesthetic.

In addition to describing the groups in terms of sensory learning styles, the mean final pulse rates for two of the study sessions were calculated and compared to normal pulse rate ranges for healthy adults, determined to be between 60 and 100 beats per minute (Klabunde, 2007). The distribution of final pulse rate for all students was roughly symmetrical and was consistent with the normal adult range (see Figure 1).

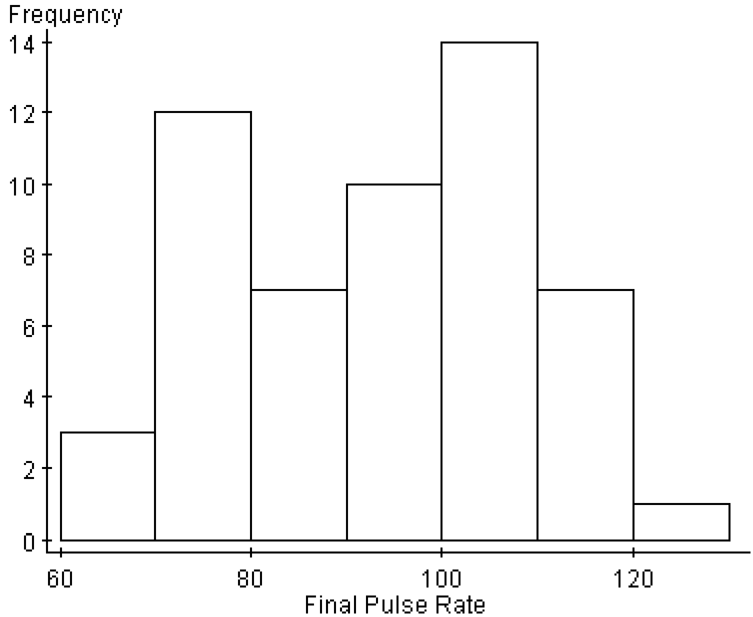

Figure 1. Combined distribution of participants' mean pulse measured at two study sessions.

Establishing that the students' pulse rates were close to the normal range was important for controlling for some pulse rate abnormalities that might impact how well the results could be generalized to a larger population.

To determine whether there was a statistically significant decrease in pulse rate when instructional style matched dominant learning style, a paired-sample t-test was conducted. The results showed that the students in the BI 101 group whose learning style matched the style presented in the study session had a significantly lower pulse rate than the students whose learning style was not matched in a given session. The same analysis of the CH 101 did not detect a significant difference in pulse rate when the students' learning styles matched the instructional styles of focus (See Table 1).

Table 1

Comparison of Mean Pulse Rate Changes

Learning Style and Instructional Delivery	Biology	Chemistry
Matched vs. Not matched	$H_A : \mu_1 - \mu_2 > 0$	$H_A : \mu_1 - \mu_2 > 0$
Mean Pulse Rate Difference	12.64	5.00
Standard Error	5.14	6.96
t statistic	2.46	0.71
p-value	0.0108	0.2412

Note. Based on information retrieved using StatCrunch 4.0. H_A refers to alternative hypothesis; μ_1 refers to mean of unmatched; μ_2 refers to mean of matched. The null hypothesis: $H_0 : \mu_1 - \mu_2 = 0$.

The mean pulse rate of the biology study group members whose learning style matched instructional style of focus was lower than the mean pulse rate of students whose learning style was not matched during the session. In contrast, results from the chemistry study group did not show a statistically significant difference between matched and unmatched pairings of learning style and instructional style of focus. However, data from both study groups showed that without considering learning style and delivery style final pulse rates were lower than initial pulse rates. The mean difference was 9.41 beats per minute with a standard error of 2.41. The t-statistic was 3.91 and the p value was less than 0.0001. This supported the notion that participating in peer-led study groups led to decreased physiological arousal, consistent with higher levels of learning comfort.

The statistical analysis suggested that for the biology students the visual and kinesthetic delivery styles were most effective because the average final pulse rate was significantly lower than the average initial pulse rate ($p<0.02$). For the chemistry students, the most effective learning styles were the tactile and auditory modes because their average final pulse rate was significantly less than their initial pulse rate ($p<0.05$).

In addition to the physiological data, the students' responses to the evaluation showed that students perceived the study sessions to be helpful (See Table 2). Possible responses were 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree). All response means for each question in the evaluation instrument were 4.66 or higher. For the items material presented in an understandable way, session activities and materials were helpful, and recommend study groups to other students, all students' responses were strongly agree.

Table 2

Study Group Evaluation Summary.

Item	BI 101 Mean	SD	CH 101 Mean	SD
1) Material presented in understandable way.	5	None	5	None
2) Tutor explained concepts clearly.	4. 83	.44	5	None
3) Session activities and materials were helpful.	5	None	5	None
4) Recommend study to others.	5	None	5	None
5) Study group increased performance in class assignments and tests	4.66	.44	4.66	.44

Note. Microsoft Excel 2003 used to analyze data.

Discussion

The most promising implications of the results from this empirical study are two-fold. First, physiological data, along with self-disclosure surveys, supports the efficacy of peer-led study groups as a way to increase student comfort and enhance learning. Second, psychophysiological data may allow researchers and practitioners to better customize learning assistance strategies, such as delivering material in a way that takes into account the students' learning styles in some cases. The data from the study groups affirmed the theories applied and matched with survey responses that study groups were helpful and material was presented in an understandable way. Results from the self-disclosure survey clearly indicate that students found the study sessions beneficial, believed the study groups had boosted their academic performance, and would recommend the sessions to others. Lower heart rates were consistent with higher comfort through each session.

Results of the study provide initial support for the effectiveness of peer-led study sessions in decreasing stress and, therefore, increasing comfort associated with learning. Final pulse rates were significantly lower than initial pulse rates for both biology and chemistry study groups. Additionally, the biology study group members' results indicated an increased comfort when material was presented in a format consistent with their dominant learning style as opposed to their non-dominant learning style. The chemistry study group did not show statistical evidence of increased comfort when learning style and instructional style were matched. This difference in the biology and

chemistry study groups upholds the value of providing learning assistance techniques that match the students' major learning style in some settings. The findings simultaneously raise questions for future research to consider regarding when (and why) matching delivery and learning style matters.

Implications

In addition to the aforementioned research avenue, there are several other crucial praxis implications of the findings:

- Learning comfort may play an important role in student retention. B. Linn & R. Zeppa (1984) and C. Struthers, R. Perry, & B. Menec (2000) noted a relationship between academic performance and stress students' experienced during studying. Therefore, learning assistance techniques such as the study groups used in this research and incorporating delivery methods that reached different learning styles in some settings could help mitigate student stress and increase student retention.
- Empirical support of the use of tutor-led study groups strengthens the field of learning assistance and is useful for learning center personnel who need to provide their administrators with outcomes-based evidence.
- Because students' vary according to the type of sensory information they prefer, it is important for tutors to be adept at practical and creative ways to meet students' learning needs.
- There appears to be certain classes or course areas where presenting information in multiple sensory modes is more efficient. This is indicated by the differences in the biology and chemistry study groups with regard to matching learning and delivery style. This study highlights the need for additional understanding of the differences between the role of learning styles and learning comfort in the two science courses featured in the study sessions. With this knowledge, learning center administrators could better use their resources and train tutors on the appropriateness of incorporating and applying learning style knowledge.

Further Study

Running the study groups again along with a physics study group and an organic chemistry study might provide some insight as to whether a difference in the results could be explained by whether the course is more heavily math-based (e. g., physics or chemistry) or conceptually based (e. g., biology and organic chemistry). Future research might also benefit from overcoming the limitations of this study by utilizing a larger sample size, multi-institution sample, and proportionate random sample. Additional research regarding possible confounding variables such as age, gender, ethnicity, familiarity with the subject (e. g., having had college level courses previously), or degree of science anxiety might help clarify the results more fully. A pre-test and post-test design might allow researchers to track the impact of the study sessions while accounting for baseline levels of scientific knowledge. Future research might also benefit from more regulated experimental conditions or more sophisticated physiological measures, such as measuring blood pressure, or monitoring pulse rate continuously.

However, the challenge with implementing these suggestions is that doing so may take away from the efficiency of the students' experiences or take the focus from providing learning assistance services.

Other suggestions for future study might be using a different learning style instrument and comparing the results using the Barsch (1980) questionnaire with other learning style models. The research could also benefit from a stronger qualitative component or more extensive survey questions to determine what helps foster the comfort and to learn more fully how students perceive the learning assistance they receive. An obvious example might be including an anxiety scale to assess students' perceptions of anxiety before, during, and after the study group sessions. Longitudinal research could examine whether the findings are part of a larger trend.

Conclusion

This study provided support for the role of psychophysiological data in determining the efficacy of learning assistance methods and the application of learning style theories. The results indicated that students who participated in the study groups had significantly decreased pulse rates, pointing to enhanced learning comfort. Increased comfort has been associated with better academic performance and retention. Thus, the research upheld the value of learning assistance techniques in academic achievement and retention. The results also suggested that matching information delivery and learning style aided student comfort in some cases, such as those in the biology study group, although explaining and predicting these differences will need to be shown through additional research and practice. Understanding both students' preferred learning styles and matching instruction to learning preferences can help educators make decisions about customizing the lesson to the students' individual preferences (DiCarlo & Lujan, 2006).

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