The Stress of Online Learning: An Experiment

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A feasibility study compared stress levels of 39 nursing students learning how to author a database with ACCESS either in isolation or in a group setting with an instructor. The ability of continuous cardiopulmonary data and three salivary cortisol samples to compare the online learning stress indicates new technologies can inform science. All students experienced stress overtime and statistically significant differences between the two groups were found. An allostatic learning model developed that permits study of biophysical, environmental, and instructional variables simultaneously.

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The need to understand the stress of learning grows as people live longer. Computerized vests and salivary cortisol levels were tested with beginning nursing students in the first three weeks of school to see if the new technologies could detect stress differences in two online settings. The feasibility of combining physical, psychosocial and instructional design variables in one study was tested.

Stress impacts both the quality and length of life (Sapolsky, 1998), but the stress of learning is yet to be understood. Sapolsky discusses the importance of how emotions interplay with brain function and body development. Overly stressed children can stop growing, become ill and even die. There are many studies about how extreme stress affects children but few studies report biophysical reactions to normal learning stress. Lack of non invasive technologies contributed to this deficiency. Most studies regarding biophysical variables are set in laboratory settings using artificial interventions. The invasive technologies made it difficult to study people in vivo. Recent developments changed this situation. Holistic theories permit the inclusion of biological measurements; brain research findings enable research of learning physiology; and advanced measuring technologies facilitate field data collection.

As no educational stress theoretical framework was found, the allostatic load theory (McEwen, 1998) was adopted for this study. Scientists posit that continued activation of stress hormones to maintain homeostasis eventually creates harmful reactions resulting in illness and death. Multisystem research seeks to understand how the central nervous system responds over time in order to develop prescriptions for improving health and optimize education.

Understanding the body's normal reaction to everyday activities like school advances educational research while at the same time, illuminates the health issues involved as people live longer. Learning stress creates a number of long term physiological and performance complications. Stress reduces immune function making people vulnerable to disease (Glaser, Robles, Malarkey, Sheridan, & Kiecolt-Glaser, 2004). Yearly health epidemics in K-12 are expected with the accompanied absenteeism and lost productivity. Gathering people together so they can transmit disease has been given as the main contributing factor, but little understanding of the stress/immune function connection is reported in the literature.

The allostatic load theory is organized so as to represent the cascade of events that lead from initial stress response to allostatic load which produces illness. The initial stress response to academic tests, speaking before people, or turning in assignments needs to be related to allostatic load as well as educational achievement. This report questions whether research into educational physiological responses can inform science and instructional design. Can gathering stress data provide an organizational structure to explain the cascade of events leading to drop-out or achievement?

Stress blocks learning by limiting perception, thinking, and memory capabilities. The initial stress limiting the ability to perform or retain knowledge in class is compounded later when performance is required. Stress hormones spike, reducing the capacity to remember initial concepts, impairing problem solving and reducing performance quality (Sapolsky, 1998). This problem can be dangerous in health professions, law enforcement, air controllers and other public service professions where decision making impacts public safety.

The amygdala and hippocampus portions of the brain interpret what is stressful then regulate appropriate responses by controlling the release of glucocorticoids and activate the sympathetic nervous system in order to aid adaptation (Gesing et al, 2001). Increased glucocorticoids impair memory function, disrupt problem solving, and weaken spatial recognition memory (Rozzendaal, 2001; McEwen & Seeman, 2003; McEwen, 2007). Cortisol, one of glucocorticoids, plays a major role in learning, and memory processes (Bremner, Vythilingam, Vermetten, Anderson, Newcomer, & Charney, 2004; Charney 2004). Overtime cortisol release can become detrimental to health (McEwen, 1998).

The sympathetic nervous system controls heart and respiratory functions. Cardiac and respiratory systems instantaneously respond to perceptions (Sapolsky, 1998). Until recently heart and respiratory variables could only be measured periodically providing a snapshot of physiological fluctuations which can miss peak and valley responses. Means summarizing the total body function were also impossible.

Until recently biophysical measurement was limited to laboratory settings. Blood draws, urine samples, and connection to machines prevented measurement of the daily living experience. Cortisol measures the function of the glucocorticoid system (Stewart, 2000). Cortisol activates the fight or flight bodily reactions. The invention of salivary sampling enabled field study collection. Salivary samples are reliable, inexpensive, and possible during in vivo study.

Since the heart and lungs are instantaneously responsive to aversive stimuli, continuous measurement of these variables can provide a “moving” picture of student experience. In past educational research, heart and respiratory rates were measured

periodically so that events between measurement periods were missed. Periodic measurement makes it impossible to find the peaks and valleys of stress or to detect abnormal events. The invention of ambulatory measurement devices permits noninvasive continuous cardiopulmonary measurement during everyday experiences.

Methodology

Students were screened for health, lifestyle, medication and illness factors that might impair cortisol secretion. Thirty-nine nursing students were selected for a subset of a larger study and signed an institutional review board approved consent form in a northwest region university. Students were randomly assigned to either a classroom or isolated setting. The classroom was a computer laboratory with 3-5 students, and an instructor who answered questions. The isolated setting was a room with an internet connected computer and no one else.

Participants completed surveys, kept a "feelings" journal and submitted to several biophysical measures: salivary cortisol, blood pressure, pulse, and respiration. Preceding the data gathering, students experienced a half-hour instructional period followed by a five-minute relaxation period. A half-hour rest period occurred again after the quiz. Biophysical measures were collected after each relaxation period and one hour into the data gathering period. The LifeShirt® by Vivometrics Inc. collected the continuous cardiopulmonary data throughout the period and 5 minute means were selected to coincide with each of the periods mentioned.

Students wore the computerized Life Shirt® under clothing. The vest collected continuous data through various sensors including bands for pulmonary function (tidal

volume, respiratory rate, sighs, etc) and electrical activity of the myocardium via a 3-lead electrocardiogram, and activity/posture via a tri-axial accelerometer.

Data Variables

All physiological and self-report measures were taken while students sat at their computers. The statistical software, VivoLogic, provided means, medians, upper and lower quartiles. Means for five minute periods pre/post/intervention were used for analysis. Correlations and t-tests, ANOVAS and repeated measures were performed as needed.

Self-report measures include: An author developed personal information form, the Learning Orientation Questionnaire (LOQ) (Martinez, 1998; Martinez & Bunderson, 1999; Jones & Martinez, 2001), the Stress Arousal Checklist (SACL) (Corcoran & Fischer, 1987; Duckro, Korytnyk & Vandenberg, 1989), the Computer Anxiety Rating Scale (CARS) (Heinssen, Glass, & Knight, 1987), and Holmes and Rahe's Social Readjustment Rating Scale (SRRS) (Miller & Rahe, 1997). Students noted 1-5 feeling words in a "feelings journal" throughout the experience.

Results

The larger study contained 92 predominately Caucasian (90%), female (91%), and in the 19-29 year old age group (90%) students. Participants in the subset provided data during the hours of 1-4 pm during the first three weeks of school. Participants reported an average of 8.5 hours sleep the night before. Most students' last meal was not nutritiously balanced, consisted of sugar and fat sources.

Self reports informed which lifestyle issues were associated with biophysical stress. Participants with the highest cardiopulmonary rates were analyzed separately. This

group demonstrated poor nutrition, the least sleep, the highest computer anxiety rates, high stress and arousal rates, and lowest quiz grades of the sample.

Self-reports

Social Readjustment Rating Scale: Life event stress was measured by the Holmes and Rahe's revised Social Readjustment Rating Scale (Miller & Rahe, 1997). The hierarchical checklist of 43 positive and negative stressful life events were checked if occurring within the last year. Most students in the high stress range, but no correlations were found with any other surveys**.**

Learning Orientation Questionnaire: The learning orientation questionnaire (LOQ) is a 45 question 7 point scale anchored in very characteristic and very uncharacteristic of me. that identifies the psychological influences that govern different behaviors towards learning. It addresses learner emotions, intentions and social factors that influence the cognitive component of learning (Jones & Martinez, 2001; Martinez & Bunderson, 1999; Spaid, 2002). The LOQ describes four learning orientations: Transforming, Performing, Conforming or Resistant. In this study 11% of the students were transformers. These students prefer to manage their own learning experience and are internally motivated to achieve complex goals. They use sophisticated learning strategies to achieve. Most students were performers 71% reporting a desire to use social learning with teacher direction for goal achievement. There were 18% conformer learners and no resistant learners. Conformers prefer step by step procedures with clearly defined goals and processes. They desire to complete assignments but are not internally motivated to study anything extra. The LOQ produced a Cronbach alpha of .80.

Correlation statistics were analyzed on three subscales effort, conative, and autonomy with other self-report scales and quiz grades.

Grades from the 10-question quiz significantly correlated with student learning orientation. Four significant positive correlations were found: LOQ with stress arousal checklist (p=.02)LOQ/effort with the SACL/arousal scale, LOQ/autonomy with SACL/stress, and LOQ/conative with SACL/arousal. The latter was the most significant correlation (p= .01).

Stress Arousal Checklist: Reactions to proximal stress were measured by the Stress and Arousal Checklist (SACL). The SACL contains 30 items which are one-word positive and negative adjectives commonly used to describe psychological stress. Two distinct measures were obtained. "Stress" was defined as the perception of situations as unpleasant and "arousal" was defined as increased physiological activity that can be positive or negative (Corcoran & Fischer, 1987; Duckro, Korytnyk & Vandenberg, 1989). The Cronbach alpha for this study was .89.

Computer Anxiety Rating Scale: by Heinssen, Glass, and Knight resulted in a Cronbach's alpha of .81 for this study. The scale consists of 19, self-rating questions that assess an individual's level of computer anxiety (Hopson, 2001). For each statement the participant decided whether to disagree or agree using a 5-point Likert-type scale ranging from strongly disagree to strongly agree. Scores could range from 19-95. Higher scores indicated higher levels of computer anxiety (Heinssen et al., 1987). Computer anxiety was found in only 10 percent of the larger sample and did not correlate with either age or gender. A negative correlation between computer experience and computer anxiety levels

(r= -.379, p < .00) supports prior literature findings that more experience results in lower anxiety levels.

Journals with 1 to 5 feeling words provided qualitative data. Most students reported confusion, frustration at least once during the study module. The times negative feelings were related could be found in the LifeShirt data.

Biophysical Measures

All students experienced a salivary cortisol rise at some time during the study. Since the diurnal expectation posits a steady decrease in cortisol levels as the day progresses, any rise is an indication of stress. Significant differences for the amount of change from times "pre" to "peak" and for "peak" to "post" were t = 2.66 with a p value of <.01 indicating a rise and then a fall in cortisol levels for the whole class. No significant between group differences were observed. The periodic measurement of pulse, respiratory and blood pressure using traditional methods did not detect differences between groups or over time.

Continuous Cardiopulmonary Measures: A comparison of group means using the t-test noted no difference between the isolation and classroom groups for the pre study relaxation period heart rate mean. A slight difference between group heart rate mean during the "peak stress" period was p = .07 (t = 1.842).

Repeated measures for heart rate means for the whole study period (pre, peak, post) indicated a significant difference (f =12.71, p <.00) across time with a trend (f = 2.72, p = .07) toward difference between groups. A mean of the highest heart rates for the 5 minute periods showed a difference between the means of isolated and classroom groups during the "peak stress" period (t = 8.96, p <.00). A minimum heart rate mean for

each 5 minute period was also compared. The minimum heart rate means over time was p = .05 and t = 1.99. The findings indicate learning stress differences were greatest during the intervention (study) period for the two groups. The post period means were compared for the two settings and no significant differences were found for the overall, maximum, or minimum means. A comparison between groups for maximum heart rate means found ($f = 10.65$, $p < .00$) over time and ($f = 9.01$, $p < .01$) for groups indicating that although everyone experienced a jump in heart rate, isolated students experienced higher peak rates than their peers.

Respiratory rates differed over time. The sigh volume means significantly differed between groups ($t = 2.82$, $p = 0.01$). The whole sample differed in the sigh volume maximums from pre study and peak stress periods ($t = 2.46$, $p = 0.02$) and then again between peak stress and post study ($t = 2.38$, $p = 0.02$) indicating study periods had more sighs than pre and post periods. The sigh is considered one measurement of stress. Tidal volumes demonstrated similar findings to sigh volumes over time with significant maximum ($t = 9.67$, $p < .00$) and minimum rates ($t = 5.68$, $p < .00$)**.** The only difference between groups was during the beginning relaxation period ($t = 2.99$, $p = 0.01$) indicating students in isolation may not feel as relaxed as those in classroom situations.

The number of breaths/minute indicated people breathe differently during learning ($t = 4.68$, $p < .00$). There was also a difference in breaths/minute between the isolation and classroom groups. The variation may indicate students in isolation were not as relaxed as those in the group situation ($t = 2.06$, $p = 0.05$). Respiratory rates demonstrated similar changes over time ($t = 9.05$, $p < .00$). Differences between the two

groups before the learning period were $p < 0.00$ ($t = 2.99$). Again data suggests isolated students were not as relaxed as the classroom group.

Discussion

The answer to whether or not the computerized vest could detect difference during an online learning situation was answered in the affirmative. Differences over time and between groups were found. The usefulness question of the physical data was found when self report and physical variables reinforced and verified each other, such as the those with high cardiopulmonary rates reporting high stress and arousal feelings and earning low quiz scores. Lifestyle practices were also associated with this group.

Since periodic measurement using traditional tools did not provide significant differences overtime or between groups, the use of continuous data analysis suggests the need for more study. Linking qualitative data to the continuous physical data provided insight into reasons for heart and lung function. Since the qualitative data also provided place in the online learning module, one can study instructional design elements that stress students.

The development of a model that includes behavioral, experiential, biophysical, and instructional design elements was formulated. The allostatic learning model (Appendix A) provides a method for organizing the literature about factors contributing to learning success and a way to design future studies. The model requires testing which is planned for a number of future studies.

Participants judged the LifeShirt ® as comfortable and not interfering with the learning experience. A disadvantage was the need to dress in the vest before coming to class. The device demands calibration to provide a baseline for the computer. A

relaxation level was needed pre and post intervention to provide a break from other types of stress, like travel and meeting deadlines.

Stress: All students reported experiencing learning stress. Biophysical and self-report methods indicate that proximal and not life event stress was associated with the learning process and grades. Differences between isolated and classroom settings were found. The isolated students seemed to experience an anticipatory stress that dissipated over time. Anticipatory stress is not mentioned in the literature and needs study.

Cortisol was not as effective a measurement tool. No between group differences for salivary cortisol may indicate a lack of test sensitivity or too small a data collection period. A larger sample or a longer study period may produce other findings. Other glucocorticoids may prove more sensitive to subtle changes.

All measurements were taken while students remained seated. Variable differences occurred even though body movement was controlled. In the past this has been the most difficult type of difference to detect.

Learning orientation research indicates the ability to predict grades in web based courses so stress levels should correlate with orientation. Findings suggest learning orientation may relate to how the student felt emotionally and physically, but not to experiences that occurred more distantly like divorce and death. This may suggest that after adaptation occurs it is not impact proximal stress.

Study of the student process as it occurs gave insight into distance education which proved “invisible” until now. Differences found between online isolation and classroom groups suggest that the learning environment influences student experience.

If larger studies produce similar findings between isolated and classroom settings then supports for distance students may be justified. Future researchers may establish "normal levels" of biophysical fluctuations that can "diagnose" individual and product problems.

Since the feasibility of gathering biophysical variables during lived experience is now possible, environments that impact learning such as distance education, simulations, and virtual learning can be compared. The continuous measurement of biophysical reactions can aid in understanding student process in order to understand the filtering of psychological reactions. Future discussion of the costs and benefits of different delivery models could include biophysical costs. Since research indicates stress impacts health, the stress of learning should be considered a cost.

More understanding of individual responses to learning stress is needed. A holistic approach to learning and instructional design appears possible. Researchers can now explore the impacts of stress during life-long learning, patient education, and health promotion situations.

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Appendix A

Allostatic Learning Model