Physiological Synchrony, Stress and Communication of Paramedic Trainees During Emergency Response Training

Vasundhara Misal[1], Surely Akiri[1], Sanaz Taherzadeh[2], Hannah McGowan[3], Gary Williams[2], J. Lee Jenkins[2], Helena Mentis[1], Andrea Kleinsmith[1]
[1]Department of Information Systems, University of Maryland Baltimore County, Baltimore, MD USA
{vasu1, sakiri, mentis, andreak}@umbc.edu
[2]Department of Emergency Health Services, University of Maryland Baltimore County, Baltimore, MD USA
{sanazt1, garywil1, jjenki3}@umbc.edu
[3]Neuro-Cognitive Psychology Department, Ludwig Maximilian University, Munich, Germany
hannahmcgow24@gmail.com

ABSTRACT

Paramedics play a critical role in society and face many high stress situations in their day-to-day work. Long-term unmanaged stress can result in mental health issues such as depression, anxiety, and post-traumatic stress disorder. Physiological synchrony – the unconscious, dynamic linking of physiological responses such as electrodermal activity (EDA) – have been linked to stress and team coordination. In this preliminary analysis, we examined the relationship between EDA synchrony, perceived stress and communication between paramedic trainee pairs during in-situ simulation training. Our initial results indicated a correlation between high physiological synchrony and social coordination and group processes. Moreover, communication between paramedic dyads was inversely related to physiological synchrony, i.e., communication increased during low synchrony segments of the interaction and decreased during high synchrony segments.

CCS CONCEPTS

• Human-centered computing ~ Collaborative and social computing ~ Empirical studies in collaborative and social computing

KEYWORDS: Physiological synchrony, electrodermal activity, stress, communication.

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1 Introduction

Paramedics play a critical role in society. As frontline workers, they are typically first on the scene to give acute emergency care before transporting patients to the hospital. While the role of paramedics is stressful by nature, over time, if left unmanaged, long-term effects include burnout, drug and alcohol abuse, and mental health issues such as depression [2], anxiety [1], and post-traumatic stress disorder [21]. In the short-term, increased stress can affect a paramedic's ability to focus on and perform medical procedures during an emergency response due to the negative effect on attention, decision-making and cognitive skills [1, 14]. Stress may also affect the interaction between paramedic team members. As paramedics often work with a partner, the stress experienced by one partner may influence the stress of the other [31]. Social interactions and teamwork are known to influence arousal levels of team members [2,33].

The level of arousal experienced can be measured from an individual's physiological responses, such as electrodermal activity (EDA). EDA is the measure of autonomic arousal in the electrical conductance of the skin [3] and is considered a reliable indicator of stress [18] and a reasonably robust measure of stress in real-world situations [45].

Research on physiological synchrony (i.e., the unconscious, dynamic linking of physiological responses such as heart rate and EDA) has given us insight about human-human interactions, such as level of social engagement [11], coordinated behavior [34], and team performance [10]. We propose to extend this line of work by exploring the relationship between physiological synchrony from EDA data, perceived stress and communication within paramedic trainee dyads in the high-stake situation of in-situ emergency response training, as opposed to social situations or highly controlled lab settings.

We adopted the algorithm presented in Marci et al. [4] to compute the moment-to-moment level of physiological synchrony of the dyad and an average measure of synchrony for the entire simulation. We examined two high- and two low synchrony simulations to explore the relationship between communication and synchrony. Initial results indicated a correlation between high physiological synchrony and social coordination and group processes. Communication within dyads was inversely related to physiological synchrony, i.e., communication increased during low synchrony segments and decreased during high synchrony segments.

2 Related Work

2.1 Effect of stress on Paramedics

Paramedics face many high stress situations in their day-to-day work. While moderate stress can improve cognitive performance, severe stress can impair attention [35], decision-making abilities [1, 14], and cognitive function [36] due to biological and neural mechanisms, with the potential to diminish medical care quality. Thus, stress in paramedics can negatively affect clinical performance and patient management and research indicates that amount of training and experience do not help reduce medical errors in high-stress situations [14]. Moreover, the ability to monitor and manage stress in medical personnel has the potential to reduce long term effects of stress on paramedics. In a literature review on occupational stress and informal stress coping strategies used by paramedics, Mildenhall [2] found work absence among ambulance staff in the UK was primarily related to stress, anxiety and depression [26].

Research has highlighted the need for interventions and systems in training aimed at stress awareness and management [37, 1]. Developing a comprehensive understanding of stress and how it is reflected in the team's interaction by exploring the level of synchrony between the paramedics can lay the groundwork for such interventions.

2.2 Physiological Synchrony

Research suggests that physiological synchrony correlates with psychological constructs across different types of relationships. Much of the research investigating physiological synchrony within dyads has focused on parent-child, couples, therapist-client, and social interactions (refer to [6] for a review). Results of studies examining therapist-client relationships showed that higher levels of synchrony were related to higher perceived empathy of therapists [4, 38].

Physiological-based synchrony is considered an important aspect of understanding coordinated work teams [32]. EDA and heart rate are shown to be correlated with how team members work together to complete tasks [10] and as an indicator of the quality of a team's interaction and learning [39]. Much of the research investigating physiological synchrony within teams has focused on team performance. For example, results of Elkins et al.'s [13] study in which four-person teams participated in military training tasks using both computer simulation and real-world trials showed that physiological synchrony could be used to differentiate between high and low team performance. Several studies by Henning and colleagues examined whether physiological synchrony could be used to predict team performance in a controlled virtual task [40] and video games [10].

3 Methodology

3.1 Participants and Procedure

Fourth-year paramedic students at the University of Maryland, Baltimore County were recruited as participants. A total of 11 paramedic trainees participated, 3 females and 8 males. Data was collected during the emergency response simulations carried out in the Field and Clinical Experience course as part of the curriculum. Each simulation day comprised six to eight simulations carried out by four trainees. Trainees alternated between the roles of team lead and team member for each simulation. Each trainee assumed the role of team lead twice per day with a different team member each time. The team lead was responsible for leading the medical response, providing instructions to the team member and determining the best course of action for medical treatment. The team member's role was to support the team lead in the medical response. A total of 45 emergency response simulations were recorded. The study was approved by the university's institutional review board (IRB). Informed consent was obtained one day prior to participation. Trainees were compensated $10.

At the start of each simulation day, participating students were fitted with the Empatica E4 wristband (described in Section 3.2). The wristband was worn on the trainees' non-dominant hand as is standard protocol [18]. The start and end time of each simulation was tagged through the physical button on each wristband to facilitate data processing. All simulations were audio-video recorded. Each simulation lasted approximately 10-20 minutes after which instructors rated the perceived level of stress experienced by each trainee.

3.2 Data Collection

Team lead and team member EDA was recorded for the duration of each simulation using the E4 wristband from Empatica Inc. [20]. While the E4 records multiple physiological signals (i.e., blood volume pulse, skin temperature and EDA), we focus on EDA in this analysis as it has been shown to correspond to arousal which has been shown to be indicative of stress and anxiety [22].The data was recorded directly onto the E4's flash memory, i.e., wirelessly. After each presentation session, the E4 was connected via USB to a PC and Empatica Manager was used to transfer the data to Empatica's secure cloud platform – Empatica Connect. Each student's already anonymized data was then downloaded and renamed with her/his anonymized participant ID.

The simulations were conducted in the clinical practice laboratory shown in Figure 1 which comprises a simulated patient home with living room space and a simulated ambulance interior and exterior with operational equipment. There is an observation room with a one-way mirror to monitor trainees in the simulation space without interfering with the simulation. The simulations, developed by the course instructors based on their field experience, were carried out on high-fidelity manikins [46] with moulage (i.e., makeup applied to replicate injuries) to increase the realism.

Figure 1: The clinical practice laboratory

The perceived level of stress the trainees experienced while performing the simulations was provided by the instructor on a 7-point Likert scale (1-lowest to 7-highest) after each simulation. We chose to use the instructor's rating over other possible sources such as the trainees themselves or outside observers given the instructors have the requisite training and expertise and are attuned to looking for signs of stress in paramedic trainees.

4 Computing Physiological Synchrony

Data pre-processing and analysis was conducted using Python 3.7 and python libraries NumPy, SciPy, and Pandas, and Ledalab.

The raw EDA data was smoothed using a Hann smoothing function with a 1.5-second window to reduce artifacts that are common in natural, uncontrolled settings. Artifact correction was performed using Ledalab [41].

We adopted Marci et al's [4] methodology to compute moment-to-moment synchrony and a single session index (SSI). The SSI is used as a measure of overall synchrony in the simulation and provides a point of comparison between team lead-team member dyads. The dynamic nature of the moment-to-moment synchrony allows us to explore specific moments within it.

First, the average slope value of the EDA was computed within a 5-second sliding window, incrementing every 1 second, resulting in a single value per second of EDA for each trainee individually. Next, Pearson's correlation coefficient (PCC) was calculated using the slope values between team lead and team member within a 15-second sliding window, again incrementing every 1 second. This means the first window computes PCC on EDA slope values from 1s to 15s. The window then increments by 1 second and computes PCC on slope values from 2s to 16s, etc. This provides us with a moment-to-moment correlation score indicating the level of synchrony within dyads for the previous 15 seconds.

Next, the SSI is calculated by taking the natural logarithm of the ratio of the sum of the positive correlations divided by the sum of the absolute value of negative correlations. The natural logarithm is calculated to account for the skew inherent in ratios. SSIs greater than zero indicate higher positive levels of physiological synchrony, while SSIs less than zero indicate lower levels of synchrony (i.e., more negative synchrony). SSIs around zero reflect neutral synchrony (i.e., equal positive and negative correlations).

We then adopted Slovak et al.'s [3] extension of [4]'s algorithm to compute a rolling SSI on a 60-second sliding window, incrementing every 1 second. This provides a metric for assessing the consistency of the signal over a longer period of time and takes into account duration and level of synchronization over time [3].

Armed with an objective measure of synchrony within the 45 simulations, we assessed the relationship between the instructor's ratings of trainees' stress level and the SSI, i.e., the level of synchrony. The instructor rated the team lead and the team member separately, therefore, to obtain a single rating we summed the instructor's ratings for each trainee pair. The results of Pearson's correlation coefficient demonstrated a statistically significant moderate relationship ($r(43)=.287$, $p=.05$). This means that higher levels of synchrony were correlated with lower perceived stress ratings, demonstrating that there is indeed a relationship between perceived stress and level of synchrony within our corpus.

5 Exploring Synchrony from Multimodal Data

While further quantitative analysis is underway to describe the relationship between perceived stress and synchrony, our analysis in this paper focuses on assessing links between synchrony and the team's communication content. We applied Linguistic Inquiry and Word Count (LIWC) [42] to analyze communication between team lead and team member during the simulation.

LIWC performs an automated analysis of the word use within transcribed spoken and written text and can give insight into the psychological meaning of word use. LIWC compares each word from a given text file with the LIWC dictionary and calculates the usage of words within different categories. The program outputs percentages (i.e., ratios) reflecting the number of words in each category divided by the total word count.

Table 1 LIWC results for first-person plural (we) and second person (you). The level of synchrony is listed in the second column. Last two columns represent words per second for low synchrony segment and high synchrony segment.

Session	Synchrony SSI	we	you	words per second	
				Low Seg.	High Seg.
03-06 S1	-0.47	1.73	3.14	0.76	0.3
02-04 S7	-0.11	1.43	3.05	0.46	0
11-05 S3	0.38	3.95	1.16	0.93	0.3
02-18 S2	0.28	4.59	1.86	1.2	0.7

Analysis of the conversation between paramedic dyads during simulation training can lead to a greater understanding of the influence of communication on their working relationship and impact on the level of physiological synchrony experienced. Our initial analysis was performed on the transcripts from four simulations; two high (SSI=0.38, 0.28) and two low (SSI=-0.47, -0.11) synchrony. To carry out the analysis, we transcribed the conversation between team lead and team member for the four simulations. Three members of the research team performed this step iteratively to ensure the transcription was as complete as possible after which the transcripts were analyzed with LIWC.

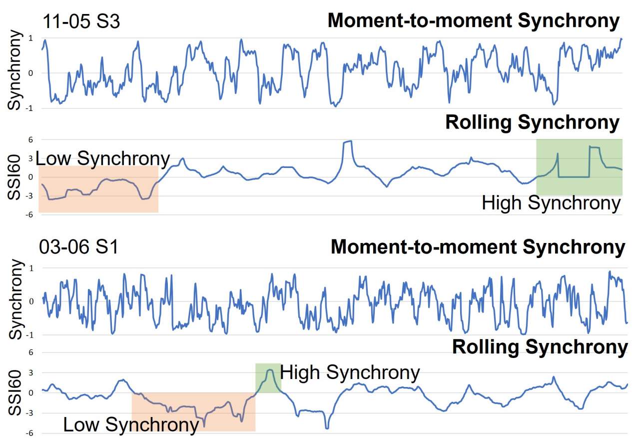

Figure 2: The first and second graphs represent moment-to-moment synchrony and rolling SSI for 11-05 S3. The third and fourth graphs represent moment-to-moment synchrony and rolling SSI for 03-06 S1.

Results of the LIWC analysis listed in Table 1 suggest a greater social relationship and coordination in the high synchrony dyad evidenced by pronoun use. We found a higher percentage of use of the first-person plural pronoun "we" in the high synchrony sessions (3.95% and 4.59%) compared to the low synchrony sessions (1.73% and 1.43%). Research suggests use of first-person plural pronouns may reflect group cohesion [43]. However, contradictory research showed that small groups working on a joint task reported greater group cohesion even though "we" was rarely used [44]. Additionally, the higher percentage of use of the second person pronoun "you" in the low synchrony sessions (3.14% and 3.05%), compared to 1.16% and 1.86% in the high synchrony sessions may be indicative of a lower quality of relationship [42]. In conclusion, the level of relation between paramedics drives the level of physiological synchrony between them.

To explore the relationship between physiological synchrony and communication at a more granular level, we selected segments of extreme synchrony within each session. Following Slovak et al.'s [3] rationale, *"if changes in synchrony do correspond to differences in interaction, comparing parts that are extreme in the underlying signal should reveal large effects, which can be then explored in a more focused way"* (p.515). The identified sections of extreme high and low synchrony for two of the simulations are illustrated in Figure 2. Overall, we found more communication between the trainees during the lowest synchrony segments. The average of the ratio of number of words per segment duration in seconds for the highest synchrony segments of the four simulations is near 0.32 per-second while it is considerably higher at 0.83 in the lowest synchrony segments of the four sessions.

In lowest synchrony segment of 11-05 S3, the team member is leading and dominating the discussion; word count is higher (84) for the team member compared to that of the team lead (60). A qualitative analysis of the conversation shows that team member is directing the team lead on what steps to follow next by giving direct orders, e.g., *"I really think we should work on the airway though"* and making statements followed by asking a rhetorical confirmatory question, *"Because 4 months, we can't give atropine. We can't give atrovax. We can't give albuterol. Right?"*

For the highest synchrony section of 03-06 S1, the team member leads the task which may be reflected by word count, i.e., 14, whereas the team lead's count is 2. The team member asks the team lead, "*How are you doing with that?*" which may demonstrate an attempt on the part of the team member to build social connection with team lead. Again, the analysis of high synchrony section appears to confirm that when there is social connection between paramedic trainees there is high physiological synchrony between them. Word count and qualitative analysis of communication during the highest synchrony segment of 11-05 S3 shows that even though the team member is not performing during the task, involvement in the conversation drives high physiological synchrony. Research by Sexton and Helmrich [43] found that individuals with higher word counts were rated as more involved and focused on the task. Also, the conversation between paramedic dyads shows the level of agreement, even though team member makes suggestions to team lead, *"You are right. I should have done that first."* However, a comprehensive qualitative analysis on all 45 simulations must be performed to verify the relation between involvement and physiological synchrony.

6 Conclusion and Future Work

We examined the relationship between EDA synchrony and communication within paramedic trainee pairs in the high-stake situation of in-situ emergency response training. Results suggest a greater social relationship and coordination in high synchrony dyads as evidenced by a higher percentage of first-person plural pronoun use. The exploration of extreme synchrony within the sessions shows increased communication within paramedic trainee dyads during the lowest synchrony segments as the ratio of number of words per segment duration in seconds is higher than the highest synchrony segments. Further, word count analysis and qualitative analysis of communication during the highest synchrony segments shows the involvement of the team member in the conversation drives high physiological synchrony, even though the team member is not performing during the task. In future we will verify these results and explore the relationship between EDA synchrony, perceived stress and communication within paramedic trainee pairs through a more in-depth qualitative analysis of all 45 simulations.

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REFERENCES

[1] LeBlanc, V., Regehr, C., Tavares, W., Scott, A., MacDonald, R., & King, K. (2012). The Impact of Stress on Paramedic Performance During Simulated Critical

Events. *Prehospital and Disaster Medicine*, 27(4), 369-374. doi:10.1017/S1049023X12001021

[2] Mildenhall, J. (2012). Occupational stress, paramedic informal coping strategies: a review of the literature. *Journal of Paramedic Practice*, 4(6), 318-328.

[3] Slovák, P., Tennent, P., Reeves, S., & Fitzpatrick, G. (2014, October). Exploring skin conductance synchronisation in everyday interactions. In Proceedings of the 8th nordic conference on *human-computer interaction*: Fun, fast, foundational (pp. 511-520). ACM.

[4] Marci, C. D., Ham, J., Moran, E., & Orr, S. P. (2007). Physiologic correlates of perceived therapist empathy and social-emotional process during psychotherapy. *The Journal of nervous and mental disease*, 195(2), 103-111.

[5] Levenson, R. W., & Ruef, A. M. (1997). Physiological aspects of emotional knowledge and rapport.

[6] Palumbo, R. V., Marraccini, M. E., Weyandt, L. L., Wilder-Smith, O., McGee, H. A., Liu, S., & Goodwin, M. S. (2017). Interpersonal autonomic physiology: A systematic review of the literature. *Personality and Social Psychology Review*, 21(2), 99-141.

[7] Coleman, R., Greenblatt, M., & Solomon, H. C. (1956). Physiological evidence of rapport during psychotherapeutic interviews. Diseases of the nervous system, 17(3), 71.

[8] DiMascio, A., Boyd, R. W., & Greenblatt, M. (1957). Physiological Correlates of Tension and Antagonism During Psychotherapy: A Study of" Interpersonal Physiology". *Psychosomatic medicine*, 19(2), 99-104.

[9] DI, A. M., Boyd, R. W., Greenblatt, M., & Solomon, H. C. (1955). The psychiatric interview: a sociophysiologic study. *Diseases of the Nervous System*, 16(1), 4-9.

[10] Henning, R. A., Boucsein, W., & Gil, M. C. (2001). Social–physiological compliance as a determinant of team performance. International Journal of *Psychophysiology*, 40(3), 221-232.

[11] Chanel, G., Kivikangas, J. M., & Ravaja, N. (2012). Physiological compliance for social gaming analysis: Cooperative versus competitive play☆. *Interacting with Computers*, 24(4), 306-316.

[12] Järvelä, S., Kivikangas, J. M., Kätsyri, J., & Ravaja, N. (2014). Physiological linkage of dyadic gaming experience. *Simulation & Gaming*, 45(1), 24-40.

[13] Elkins, A. N., Muth, E. R., Hoover, A. W., Walker, A. D., Carpenter, T. L., & Switzer, F. S. (2009). Physiological compliance and team performance. *Applied ergonomics*, 40(6), 997-1003.

[14] LeBlanc, V. R., MacDonald, R. D., McArthur, B., King, K., & Lepine, T. (2005). Paramedic performance in calculating drug dosages following stressful scenarios in a human patient simulator. *Prehospital Emergency Care*, 9(4), 439-444.

[15] Wastell, C. A. (2002). Exposure to trauma: The long-term effects of suppressing emotional reactions. The Journal of *Nervous and Mental Disease*, 190(12), 839-845.

[16] Warnecke, E., Quinn, S., Ogden, K., Towle, N., & Nelson, M. R. (2011). A randomised controlled trial of the effects of mindfulness practice on medical student stress levels. *Medical education*, 45(4), 381-388.

[17] Reed, D. A., Shanafelt, T. D., Satele, D. W., Power, D. V., Eacker, A., Harper, W., ... & Sloan, J. A. (2011). Relationship of pass/fail grading and curriculum structure with well-being among preclinical medical students: a multi-institutional study. *Academic Medicine*, 86(11), 1367-1373.

[18] Boucsein, W. (2012). Electrodermal activity. *Springer Science & Business Media*.

[19] Regehr, C., & Millar, D. (2007). Situation Critical: High Demand, Low Control, and Low Support in Paramedic Organizations. Traumatology, 13(1), 49–58. https://doi.org/10.1177/1534765607299912

[20] *E4 Wristband User's Manual 20150608. Empatica Milano Italy*, pp. 5-16, 2015

[21] Regehr, C., Goldberg, G., Glancy, G. D., & Knott, T. (2002). Posttraumatic symptoms and disability in paramedics. *The Canadian Journal of Psychiatry*, *47*(10), 953-958.

[22] Everly, G. S., & Lating, J. M. (2002). A clinical guide to the treatment of the human stress response (p. 131). New York: Kluwer Academic/Plenum.

[23] Waters, S. F., West, T. V., & Mendes, W. B. (2014). Stress contagion: Physiological covariation between mothers and infants. *Psychological science*, 25(4), 934-942.

[24] Ebisch, Sjoerd & Aureli, Tiziana & Bafunno, Daniela & Cardone, Daniela & Romani, Gian-Luca & Merla, Arcangelo. (2012). Mother and child in synchrony: Thermal facial imprints of autonomic contagion. *Biological psychology*. 89. 123-9. 10.1016/j.biopsycho.2011.09.018.

[25] Gray, R. (2005). Paramedic stress puts strain on emergencies. *The Scotsman*.

[26] National Health Service Information Center (2020) NHS Sickness Absence Rates February 2020, Provisional Statistics. Retrieved June 30, 2020, from https://digital.nhs.uk/data-and-information/publications/statistical/nhs-sickness-absence-rates/february-2020-provisional-statistics

[27] Burleson, B. R., & MacGeorge, E. L. (2002). Supportive communication. *Handbook of interpersonal communication*, 3, 374-424.

[28] Dellve, L., & Wikström, E. W. A. (2009). Managing complex workplace stress in health care organizations: leaders' perceived legitimacy conflicts. *Journal of Nursing Management*, 17(8), 931-941.

[29] MacGeorge, E. L., Samter, W., & Gillihan, S. J. (2005). Academic stress, supportive communication, and health. *Communication Education*, *54*(4), 365-372.

[30] Ledermann, T., Bodenmann, G., Rudaz, M., & Bradbury, T. N. (2010). Stress, communication, and marital quality in couples. *Family Relations*, *59*(2), 195-206.

[31] Sharma, P., Davey, A., Davey, S., Shukla, A., Shrivastava, K., & Bansal, R. (2014). Occupational stress among staff nurses: Controlling the risk to health. *Indian journal of occupational and environmental medicine*, 18(2), 52.

[32] Guastello, S. J., Marra, D. E., Perna, C., Castro, J., Gomez, M., & Peressini, A. F. (2016). Physiological synchronization in emergency response teams: subjective workload, drivers and empaths. *Nonlinear Dynamics, Psychology, and Life Sciences*, 20(2), 223-270.

[33] Stephen J. Guastello, Katherine Reiter, and Matthew Malon. 2014. Estimating Appropriate Lag Length for Synchronized Physiological Time Series: The Electrodermal Response. *PsycEXTRA Dataset*. https://doi.org/10.1037/e573792014-012

[34] Lindenberger, U., Li, S. C., Gruber, W., & Müller, V. (2009). Brains swinging in concert: cortical phase synchronization while playing guitar. *BMC neuroscience*, 10(1), 22.

[35] McHugh, R. K., Behar, E., Gutner, C. A., Geem, D., & Otto, M. W. (2010). Cortisol, stress, and attentional bias toward threat. *Anxiety, Stress, & Coping*, 23(5), 529-545.

[36] van Wingen, G.A., et al., Persistent and reversible consequences of combat stress on the mesofrontal circuit and cognition. *Proc Natl Acad Sci U S A*, 2012. 109(38): p. 15508-13.

[37] Harvey, A., Nathens, A. B., Bandiera, G., & LeBlanc, V. R. (2010). Threat and challenge: cognitive appraisal and stress responses in simulated trauma resuscitations. *Medical education*, 44(6), 587-594.

[38] Robinson, J. W., Herman, A., & Kaplan, B. J. (1982). Autonomic responses correlate with counselor–client empathy. *Journal of Counseling Psychology*, 29(2), 195.

[39] Dich, Y., Reilly, J., & Schneider, B. (2018, June). Using physiological synchrony as an indicator of collaboration quality, task performance and learning. In *International Conference on Artificial Intelligence in Education* (pp. 98-110). Springer, Cham.

[40] Henning, R. A., & Korbelak, K. T. (2005). Social-psychophysiological compliance as a predictor of future team performance. *Psychologia*, 48(2), 84-92.

[41] Benedek M, Kaernbach C. A continuous measure of phasic electrodermal activity. J Neurosci Methods. 2010 Jun 30;190(1):80–91.

[42] Pennebaker, J.W., Booth, R.J., Boyd, R.L., & Francis, M.E. (2015). Linguistic Inquiry and Word Count: LIWC2015. Austin, TX: *Pennebaker Conglomerates* (www.LIWC.net).

[43] Sexton, J. B., & Helmreich, R. L. (2000). Analyzing cockpit communications: The links between language, performance, and workload. *Human Performance in Extreme Environments*, 5, 63-68.

[44] Gonzales, A. L., Hancock, J. T., & Pennebaker, J. W. Language indicators of social dynamics in small groups. Communication Research.

[45] Adams, P., Rabbi, M., Rahman, T., Matthews, M., Voida, A., Gay, G., ... & Voida, S. (2014). Towards personal stress informatics: Comparing minimally invasive techniques for measuring daily stress in the wild. In Proceedings of the Conference on *Pervasive Computing Technologies for Healthcare* (pp. 72-79).

[46] Emergency Care & Trauma Simulation & Training. (n.d.). Laerdal Medical. Retrieved August 20, 2020, from https://www.laerdal.com/us/products/simulation-training/emergency-care-trauma/