OUR EMOTIONS ARE CHANGING DURING THE COVID-19 PANDEMIC

By Sentio Solutions

ABSTRACT

The scope of this report is to explore and present the way the Autonomic Nervous System and the emotions people are experiencing have changed during the COVID-19 pandemic.

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1. Introduction

The impact of global pandemics extends far beyond the actual pandemic duration and even though the effects on physical health are systematically captured and quantified, the mental health burden has been inadequately monitored. However, the scientific community has long recognized the need and importance of assessing the medium-to-long term effects of such events on people's mental health and well-being[1,2]. The first research works addressing the impact of the COVID-19 pandemic on people's mental health have already appeared, just a couple of months after the disease outbreak[3],[4],[5]. In addition to the literature, Sentio has conducted a survey to identify if and how COVID-19 has impacted people's mental health. The results showed that over 60% of those surveyed state that their current mental health state is worse or much worse now than before the pandemic.

Even though extensive research efforts have focused on the post-assessment of mental health aspects related to massive disease outbreaks, the lack of reliable and objective data has significantly limited the respective analysis. Having recognized the value and potential of physiological data to convey information related to people's emotional state and mental health condition, Sentio Solutions was founded in the USA in 2015 with a mission to change the way we prevent, diagnose, and care for mental health by using objective data for the first time to provide proactive care and support to those in need. Four years later, the *Feel Program*[6], a holistic mental health program that combines technology and science to improve a person's emotional state, delivering real-time mental health support when they need it most, had been created and launched.

The Feel program consists of 4 components: the *Feel Emotion Sensor* an emotion tracking wearable device that detects and quantifies a person's emotional changes, *ML algorithms* generating emotion alerts based on the collected physiological signals, the *Feel mobile app* which responds to those changes and deploys real-time interventions, and a *licensed therapist* for weekly 15min check-in sessions. The collected biosignals are strongly correlated with the functioning of the Autonomic Nervous System (ANS); specifically, electrodermal activity (EDA), heart rate variability (HRV), and skin temperature (ST) have been widely known to constitute reliable

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[1] Ayers, K., Yellowlees, P. (2012). Mental Health Considerations During a Pandemic Influenza Outbreak. The Internet Journal of Rescue and Disaster Medicine, Vol. 9(1), pp. 9-12.

[2] Lee, A. M., Wong, J. G., McAlonan, G. M., Cheung, V., Cheung, C., Sham, P. C., Chua, S. E. (2007). Stress and Psychological Distress among SARS Survivors 1 Year after the Outbreak. The Canadian Journal of Psychiatry, Vol. 52(4), pp. 233-240.

[3] Xiang, Y. T., Yang, Y., Li, W., Zhang, L., Zhang, Q., Cheung, T., & Ng, C. H. (2020). Timely mental health care for the 2019 novel coronavirus outbreak is urgently needed. The Lancet Psychiatry, Vol. 7(3), pp. 228-229.

[4] Ho, C. S., Chee, C. Y., Ho, R. C. (2020). Mental Health Strategies to Combat the Psychological Impact of COVID-19 Beyond Paranoia and Panic. Annals of Medicine, Vol. 49(3), pp.155-160.

[5] Galea, S., Merchant, R. M., Lurie N. (2020). The Mental Health Consequences of COVID-19 and Physical Distancing: The Need for Prevention and Early Intervention. JAMA Internal Medicine.

[6] http://feelprogram.com/

indicators of the ANS activity[7],[8],[9], and people's emotional status[10],[11],[12]. In the context of this work, physiological data collected by the Feel Emotion Sensor has been employed to assess the emotional and mental health status of individuals, who have joined the Feel Program in early 2020, and to explore and assess the impact of the COVID-19 pandemic and global lockdown on people's emotional and mental health status.

The current analysis is based on data that has been acquired from 36 users, who joined the Feel Program in the USA (11 individuals) and Europe (25 individuals) during the period 20/02-13/04 (51st to 104th day of the current year). Even though lockdown dates and measures vary for different countries, they are mainly spread in the period 14/03-18/03. Therefore, for the purpose of this analysis, March 17th has been assumed to be the global lockdown date. The gender distribution of the population is 30% male and 70% female. The dataset employed for the following analysis includes 128mil EDA samples, 400mil HRV samples, and 64mil ST samples. The processing and analysis of this dataset have resulted in the identification of approximately 900 significant emotional moments belonging to 4 different emotion categories (i.e. Joy, Contentment, Distress, Sadness), which have been sent as emotion alerts to our users via the Feel mobile app. When receiving an emotion alert, users may provide their feedback regarding its validity, as well as journal it and add details such as perceived intensity level of the emotional moment, as well as associate specific emotional tags with it.

[7] Critchley, H. D. (2002). Review: Electrodermal Responses: What Happens in the Brain. The Neuroscientist, Vol. 8(2), pp. 132-142

[8] Evans, S., Seidman, L. C., Tsao, J. C., Lung, K. C., Zeltzer, L. K., & Naliboff, B. D. (2013). Heart rate variability as a biomarker for autonomic nervous system response differences between children with chronic pain and healthy control children. Journal of pain research, Vol. 6, pp. 449-457

[9] C. L. Tan, Z. A. Knight (2018). Regulation of Body Temperature by the Nervous System, Neuron, Vol. 98(1), pp. 31-48.

[10] Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. Biological Psychology, 84(3), 394–421.

[11] Shu, L., Xie, J., Yang, M., Li, Z., Li, Z., Liao, D., Xu, X., & Yang, X. (2018). A Review of Emotion Recognition Using Physiological Signals. *Sensors*, *18*(7), 2074

[12] Kim, K.H., Bang, S.W. & Kim, S.R. (2004). Emotion recognition system using short-term monitoring of physiological signals. *Med. Biol. Eng. Comput.* Vol 42, pp. 419–427.

2. The emotional space has been nettled as expressed by the ANS activation

As expected, the emotional space, represented by the emotions experienced by our users, has been significantly affected by recent events related to the COVID-19 pandemic and the lockdown measures imposed by governments worldwide. This impact is vividly captured by the different patterns and values of the physiological signals and is expressed at the respective distributions, where the majority of the extracted features and signal characteristics exhibit significant changes[13].

This is clearly depicted in *Figure 1* which illustrates the distribution of the most important extracted features when they are projected in a 2-D representation, before (blue dashed line) and after (salmon-pink to red contour areas) the lockdown dates. The respective contour lines capture areas with equal data probability density, while as we move from the salmon-pink to red colored areas, the respective probability density increases.

Figure 1 clearly demonstrates that a considerable drift of the feature distributions has occurred as a result of the imposed lockdown. In other words, almost half of the area is common between the two emotional spaces, while the blue dashed area representing the initial emotional space has moved towards the upper left corner after the lockdown. Most probably, this can be attributed to novel emotions experienced by our users, as will be demonstrated in Section 4.

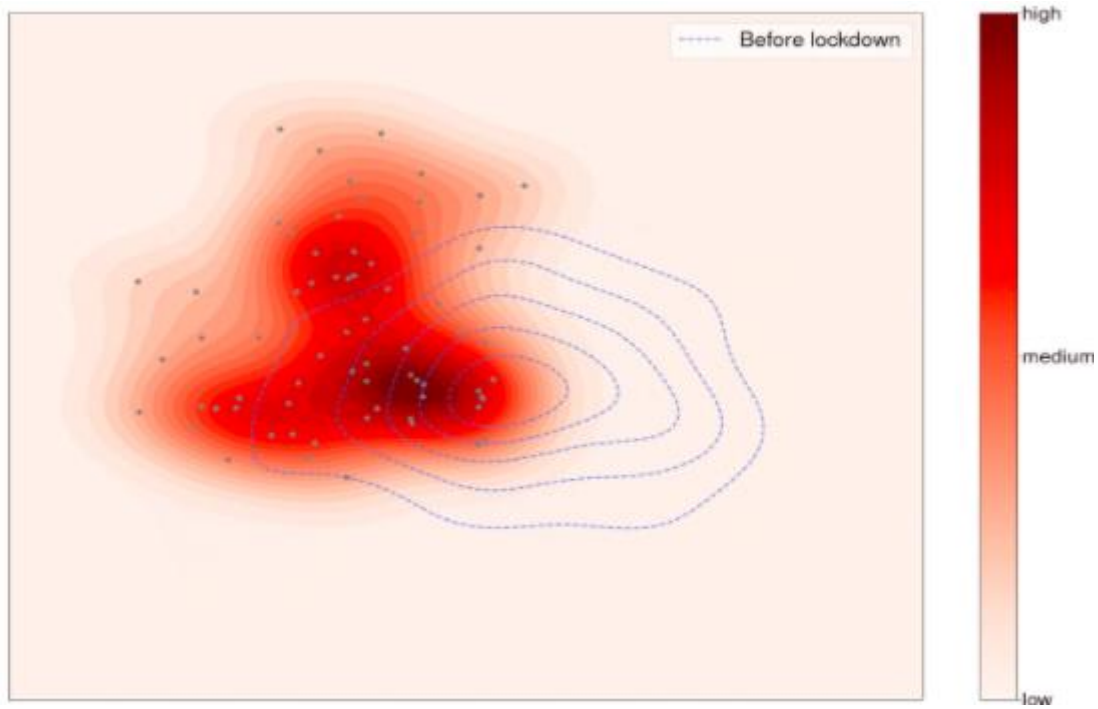

Figure 1: *Contour plots of the distribution of the most important EDA and HRV features related to the emotional space before and after the lockdown.*

[13] *K-S test, p<0.01*)

The overall shift of the emotion space is also reflected at the level of individual features, as this is depicted in the significantly different distributions before and after the lockdown. A sudden decrease in the mean width values of the EDA responses[14] can be easily observed at the lockdown date (*Figure 2*), while values tend to stabilize at lower levels during the post-lockdown period, implying that EDA responses follow a more abrupt increasing and decreasing pattern. It is evident that a sudden change of people's physiological data at the lockdown, is followed by different physiological, and therefore emotional, patterns after the lockdown.

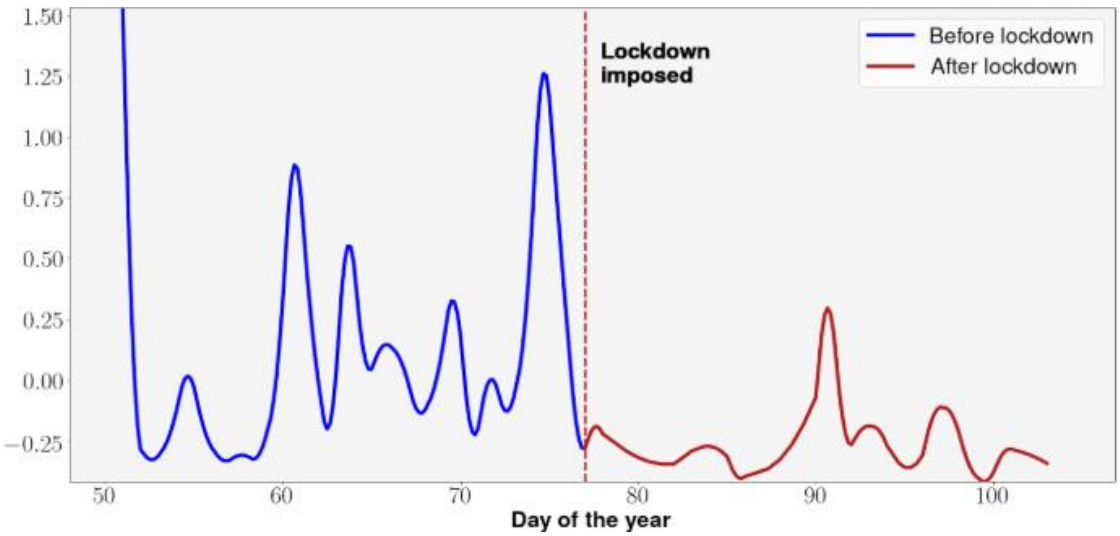

Figure 2: *Temporal evolution of the mean width of the EDA responses for days 51 to 104 of the year.*

3. Novel negative valence emotions

The previous section has clearly demonstrated that the emotion space, as it is captured by the collected physiological data that is related to emotional events, has exhibited a considerable shift following the COVID-19 pandemic and imposed lockdown measures. Moreover, our analysis of the users' feedback showed that negative valence emotions experienced have almost doubled after the lockdown compared to positive ones. As mentioned earlier, part of the user interaction with the emotional alerts received is to report the intensity of each emotional moment on a scale of 1-10 with 10 corresponding to the most intense emotion.

Thus, focusing on the negative emotional moments that are prevalent after the lockdown, the normalized histogram of the user reported intensity pertaining to the negative emotions before and after the lockdown is presented in *Figure 3*. A substantial shift towards increased intensity levels can be observed, as after the

[14] EDA responses are changes in the EDA level related to the level of arousal elicited by a stimuli with either positive or negative emotional valence.

lockdown more than 60% of the emotional moments are characterized by intensity levels equal or higher than 7, while the respective number was less than 30% before the lockdown. Additionally, mean intensity has increased by approximately 25% after the lockdown has been imposed.

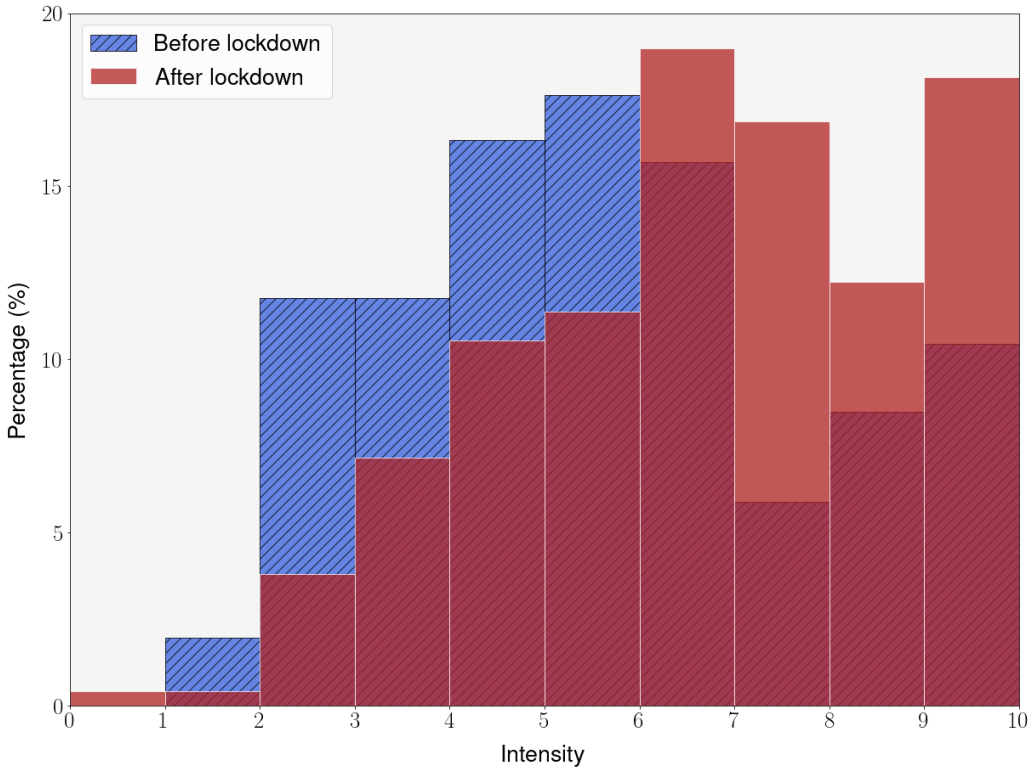

Figure 3: *Normalized histogram of arousal levels of the emotions experienced by the users before and after the lockdown.*

An interesting note here is that the significantly increased intensity levels observed in the previous figure are not necessarily associated with experiencing more intense emotions, but could also be attributed to the introduction of new emotions, which were previously rare or not familiar during the 2-month period. To this end, *Figures 4-5* represent the emotion tags that the users have attributed, as a response to the emotion alerts received, to the Sad and Distress emotional moments. It is clear that prevailing emotion tags before the lockdown tend to appear less frequently (i.e. Anxious, Bored, Upset, Stressed, Annoyed, Angry) after the lockdown, while others have become far more frequent (i.e. Vulnerable, Miserable, Empty, Terrified, Fearful). Novel emotional tags constitute more than 30% of the post-lockdown negative emotional moments. This is aligned with the observation that the COVID-19 pandemic and the lockdown have triggered the occurrence of new, previously unusual, emotion categories that people have not been accustomed to.

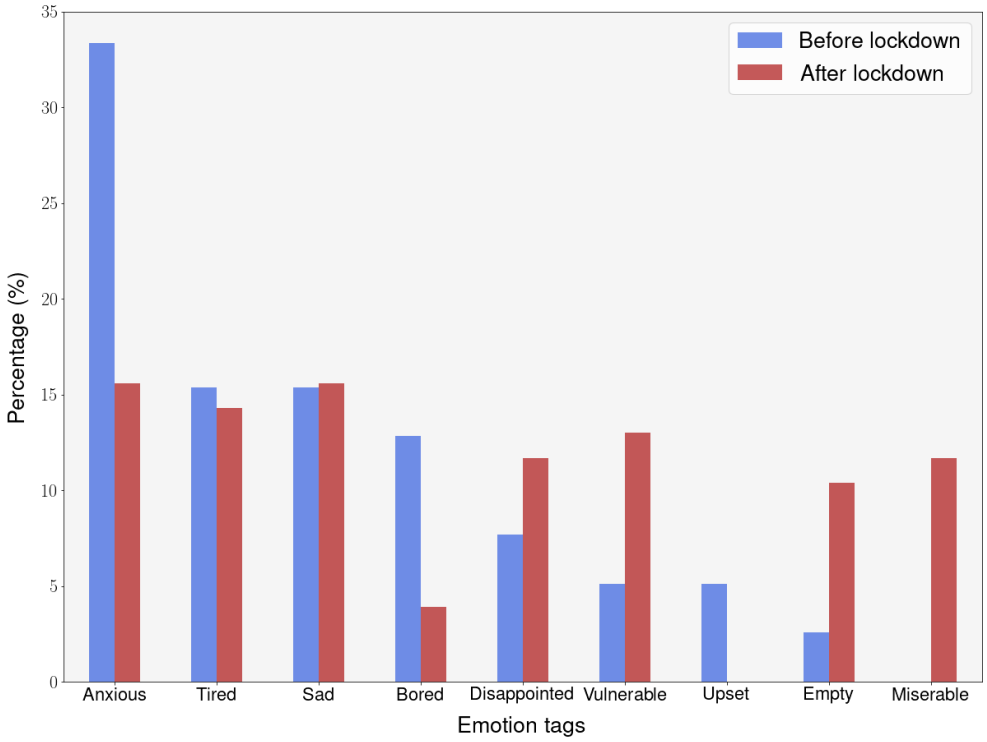

Figure 4: *Normalized histogram of the emotion tags of the "Sad" emotion moments before and after the lockdown.*

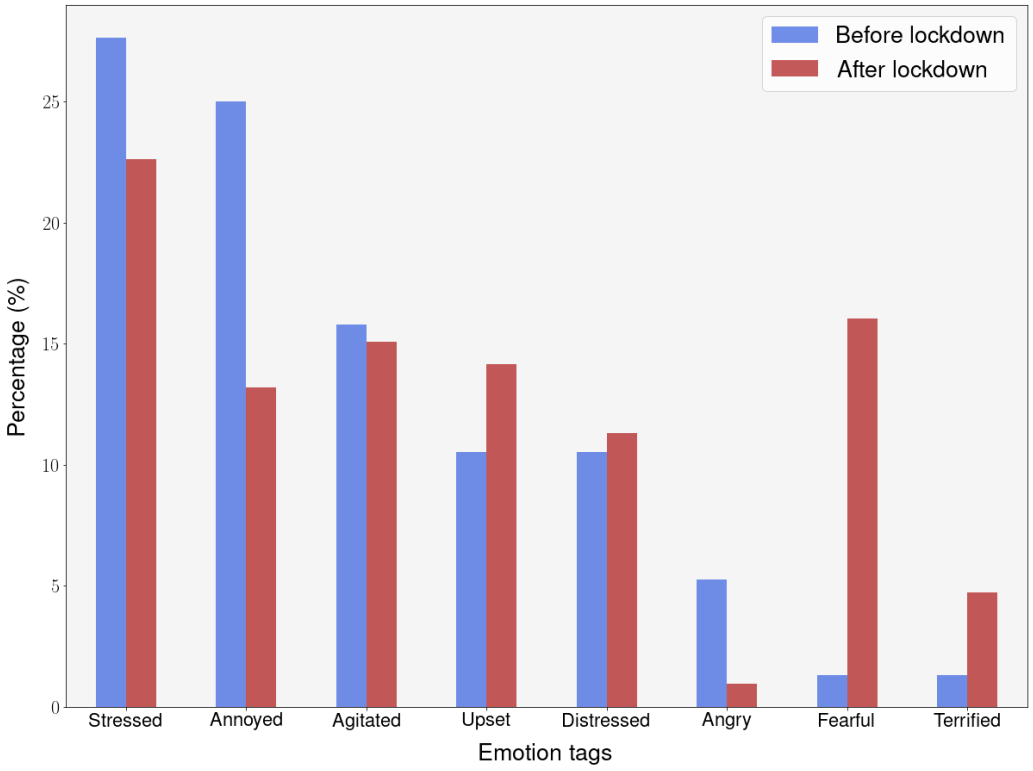

Figure 5: *Normalized histogram of the emotion tags of the "Distress" emotion moments before and after the lockdown.*

These novel emotions under the grand area of Sad and Distress emotion space are reflected in the physiological data corresponding to them, as well. *Figure 6* showcases that maximum EDA values have significantly changed after the lockdown, since a shift towards lower EDA values is observed for negative emotions, possibly indicating the emergence of novel emotional areas.

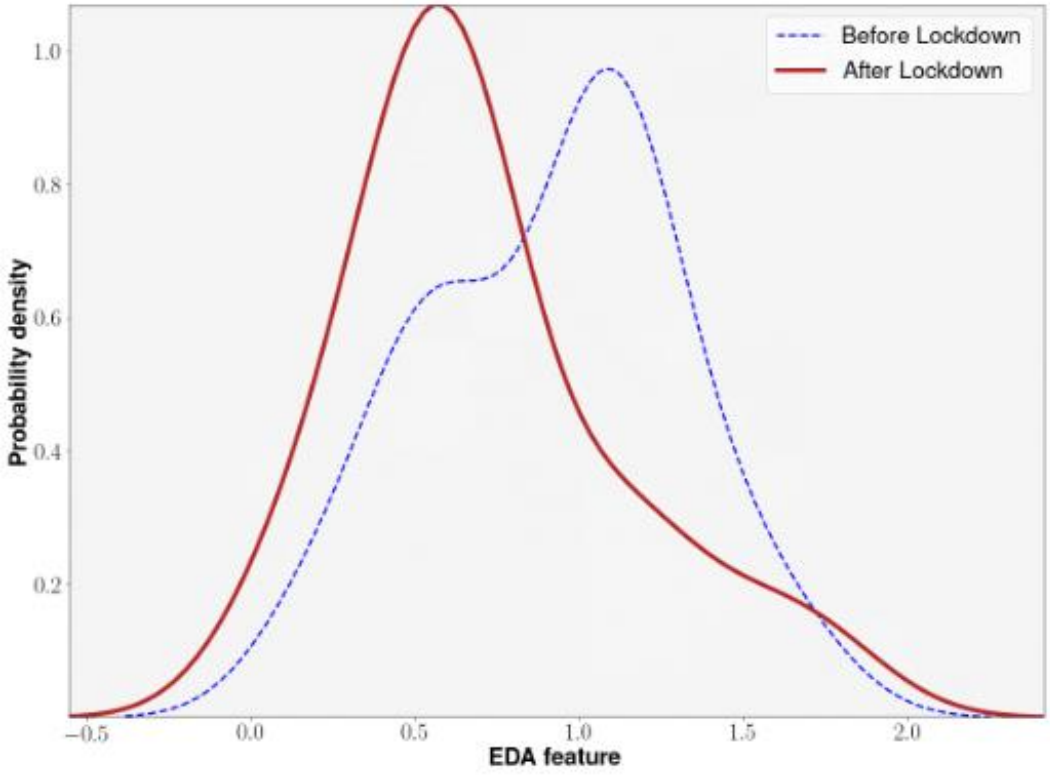

Figure 6: *Distributions of the maximum EDA values for negative emotional moments before and after the lockdown.*

4. Conclusion

The previous sections have explored and analyzed the impact of the COVID-19 pandemic on people's ANS activity and emotions experienced. For the very first time, physiological data has been deployed to quantify and visualize the impact of an extraordinary global change in living standards and circumstances on people's emotional state wellbeing. Key outcomes, among others, that should be emphasized are:

- The activity of the Autonomic Nervous System has significantly been modified
- The emotional space, as expressed by the acquired physiological data, has been altered
- Negative valence emotions experienced by people are far more prevailing
- Perceived intensity of the experienced emotions has been enhanced

- Novel negative emotions tags have been reported

In this turbulent situation, where negative emotions are more frequent and their effect is perceived as more intense by users, the need for mental health care and support is of paramount importance[15]. Additionally, feedback from our clinical lead indicates that during the first week of the lockdown people had a fight or flight response to the program that could be attributed to (a) an increase in anxiety and an inability to tolerate maintaining a new activity and/or (b) a survival instinct to prioritize what is essential for survival. However, the engagement of the therapist served to ground participants' thinking and allow them to exit the flight or fight response. This is depicted by the significantly enhanced user engagement levels in the Feel Program, where after the lockdown we have noticed:

- more than 50% increase in weekly time spent in the Feel App
- the Feel App accessed 60% more frequently
- double mental health interventions completed
- 97% participation in the weekly sessions with the Feel therapist

Get more info on how to support your mental health with the Feel Relief program.

LEARN MORE

[15] https://uploads-ssl.webflow.com/5ea3342eb75c164e5a5b4424/5ea8365442d319318ea9b9f7_Feel_USA_Infographic2.pdf