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Original Article

Why Is Facebook So Successful? Psychophysiological Measures Describe a Core Flow State While Using Facebook

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Abstract

People are more and more using social networking sites (SNSs) like Facebook and MySpace to engage with others. The use of SNSs can have both positive and negative effect on the individual; however, the increasing use of SNSs might reveal that people look for SNSs because they have a positive experience when they use them. Few studies have tried to identify which particular aspects of the social networking experience make SNSs so successful. In this study we focus on the affective experience evoked by SNSs. In particular, we explore whether the use of SNSs elicits a specific psychophysiological pattern. Specifically, we recorded skin conductance, blood volume pulse, electroencephalogram, electromyography, respiratory activity, and pupil dilation in 30 healthy subjects during a 3-minute exposure to (a) a slide show of natural panoramas (relaxation condition), (b) the subject's personal Facebook account, and (c) a Stroop and mathematical task (stress condition). Statistical analysis of the psychophysiological data and pupil dilation indicates that the Facebook experience was significantly different from stress and relaxation on many linear and spectral indices of somatic activity. Moreover, the biological signals revealed that Facebook use can evoke a psychophysiological state characterized by high positive valence and high arousal (Core Flow State). These findings support the hypothesis that the successful spread of SNSs might be associated with a specific positive affective state experienced by users when they use their SNSs account.

Introduction

Facebook.com is a social-networking Web site. Its creators described it as "a social utility that helps people communicate more efficiently with their friends, family and coworkers."[1] This description reflects a functional definition based on three factors: communication (what), efficiency (how), and friend/family/coworkers (who). However, it does not address one important issue: why people like to communicate efficiently with their friends/family/coworkers. The popularity of the Facebook formula is worldwide. With over 350 million active users, Facebook.com is the second most trafficked social-networking site in the world.[2] In the United States, most Facebook users (40.8 percent) are between the ages of 18 and 24, whereas users between 35 and 54 have been reported as the fastest growing segment over the past few years.[3] There are some studies that try to explain the use of Facebook: Ramirez et al.[4] conceptualize the information-seeking strategies; Lampe et al.[5] describe Facebook in terms of use functions; Joinson[6] also identified different uses and motivations of Facebook. These studies all focus on the functional use of Facebook, describing it in terms of what users do while using their Facebook accounts, identifying and studying specific activities such as social browsing, social searching, impression management, and communication. In this study we try to focus on why people enjoy the activities that have been described and classified in the scientific literature. Our hypothesis is that all those activities lead to a positive emotional experience that people appreciate and seek again. Identifying the evidence-based pattern associated with such a positive emotional experience in terms of somatic activity might be important to understand this phenomenon. To identify the psychophysiological pattern of the Facebook experience, we will refer to the scientific framework of the Theory of Flow[7] and to the Valence-Arousal Model of affective states.[8] In this work, we analyze the psychophysiological indexes during Facebook use to answer the following research question:

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RQ1: Is the experience of Facebook associated with a specific psychophysiological state?

Specifically is it possible, using psychophysiological measures, to identify the specific pattern of users' affective state while experiencing Facebook in the Valence-Arousal plane? In particular, we aim to explore the following research question relying on the Lang model of emotions[8] (see Table 1).

RQ2: Is the psychophysiological state of people using social networking characterized by high positive valence and high arousal (core flow state)?

We now briefly enlighten the theory of flow and the psychophysiological studies related to the Valence-Arousal space.

The theory of flow

The concept of being in flow was first introduced by Csikszentmihalyi,[9] while attempting to find out what drove people in free-time activities that did not seem to follow the utility-centered motivational theories of the time. From countless interviews he derived what appeared to be a form of intense engagement and enjoyment, which he named "flow." According to this model, flow can occur when the challenge provided by the activity is high enough but the skills of the person can still cope with the situation (i.e., challenge and skills are balanced and on a high enough level), but concerns about how the concept should be operationalized have emerged.[10] Qualitative research has been carried out and the experience of flow has been studied primarily with questionnaires and interviews.[7] The answers to these questionnaires are transformed into dimensions that provide a composite flow score.[11] Flow is not usually considered as an all-or-nothing peak performance; there are instead different levels of flow since it is a continuous variable that can be used to characterize the experiential quality of any everyday activity.[12] Findings from a wide range of domains, including chess playing, writing, sports, and visual arts, show a positive correlation between flow state measures and objective measurements of quality of performance.[12] In addition, flow has been suggested to function as a reward signal to promote repetition and practice about the activity inducing flow.[13] Yet, other studies have found positive correlations between flow and quality of life,[7] giving reason for investigations of relations between flow and health. These observations motivate a scientific investigation of the biological basis of flow.

Specifically, in this work we carry out research on flow state as a subjective experience characterized by positive valence and high arousal (see Fig. 1), during the use of Facebook, considered as an optimal experience that students appreciate and seek out; thus, it should likely function as a prototypical elicitor of engagement in terms of a flow state. See also Table 2 for specifications about the link between flow and other cognitive processes.

Table 1. The Lang Model of Emotions

Lang model of emotions[8] is empirically derived from 100 subjects watching pictures from the International Affective Picture System, whereas some of their physiological indexes are monitored, as Skin Conductance (SC) and electromyography activity (EMG) from corrugator supercilii (CS) muscle. The model is described by a Cartesian plane where on the X axis are plotted the arousal values and on Y axis are plotted valence values. Valence and arousal values are the coordinates to locate subjects' reactions to pictures. For each picture, both valence and arousal values are expressed by subjects along a pictographic scale SAM (Self-Assessment Manikin is a 9-point scale in its paper-and-pencil version) from "I don't like it at all" to "I like it very much" for valence, and the same ratio is used for arousal (from "I don't feel aroused at all" to "I feel very aroused"). Lang found on one side positive correlations (0.90) between valence values and EMG measures and, on the other side, a positive correlation (0.81) between the arousal values and SC measures. In our experiments, we rely as well on EMG values of corrugator muscle as representative of valence axe, according also to other research studies.[20] We rely also on SC measures as representative of arousal measures. However, to completely rely on Lang model, we have to derive its Cartesian plane with its four quadrants. Thus, we choose the experimental protocol composed by three different experimental situations, which allows the identification, in terms of psychophysiological patterns, of the three correspondent quadrants of Lang model, namely, Relaxation, Engagement, and Stress. The ability of relaxation and stress situations used in our study to induce the target affective states has been showed in two other research works.[18,19] We did not add a fourth experimental situation to derive the fourth quadrant since we are here mainly interested on Engagement and Flow rather than depression/boredom, represented by the fourth quadrant in Lang model. In this way, on one hand, it is possible to evaluate the reliability of Lang model by means of physiological measures. On the other hand, relaxation and stress situations are like points of reference in Lang Cartesian space to compare Facebook use patterns with relaxation and stress patterns, because the psychophysiological patterns about stress and relaxation are better known and understood according to the empirical findings already available in the scientific literature, whereas in the literature there is a lack of knowledge about psychophysiology and Facebook usage. The comparison should help also the interpretation of all psychophysiological data emerged in our study, since a second aim is to identify the psychophysiological pattern of engagement in terms of Flow. We can add here that, in a broad way, the concepts of affective valence and arousal are explicated in terms of specific motivational systems in the brain. In Lang theory, the affects are driven by two primary motive systems: the appetitive system (consummatory, sexual, nurturing, etc.) prototypically expressed by behavioral approach, and the aversive system (protective, defensive, withdrawing, etc.), prototypically expressed by behavioral escape and avoidance. The dimension of valence is reflecting the activation/inhibition of these two motivational systems, whereas arousal is reflecting the intensity of activation (metabolic and neural) of either or both motivational systems. The four quadrants in Lang model are described by low arousal, positive valence (relaxation); high arousal, positive valence (excitement/engagement); high arousal, negative valence (stress); low arousal, negative valence (depression/boredom). These four quadrants are quite general in comparison to all the panorama of affective states that humans can feel. Nevertheless, the model might represent the starting point for further research aimed to refine affective states detection.

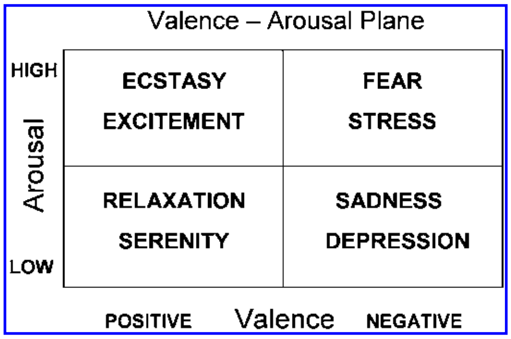

FIG. 1. The valence-arousal plane (re-adapted from Lang[8]).

As suggested by Cowley et al.[14] it is possible to adapt the challenge/skills model introduced by Csikszentmihalyi to the domain of digital media, including video games and other online activities. More, Martin, and Jacskon[15] identified a more focused dimensions of flow: "core flow," a targeted perspective capturing the experiential essence of flow. In particular, the analysis of core flow is aimed at capturing the phenomenology of the flow experience and so is a targeted measure aimed at assessing the more real-time experience of flow. As Martin and Jackson underline, "the core flow…is likely to be relevant to studies where the more wide-ranging aggregate and multidimensional flow is not as central as the more targeted subjective optimal experience itself" (p. 153).

This article, in which we study the link between core flow and psychophysiology during Facebook use, is intended as an additional exploration of this research direction, as there is little previous literature on the subject, some of which includes the psychophysiology of flow during music performance or listening,[16] and an unpublished master's thesis,[17] in which subjective flow reports were compared to psychophysiological measures. On one side, it should be associated with (a) decreased cardiac Inter Beat Interval (IBI), (b) increased respiratory depth and period, and (c) increased Skin Conductance (SC) values. The set of these first physiological indexes highlights a higher arousal. On the other side are (d) decreased activity in Corrugator Supercilii (CS), (e) decreased pupil dilation, and (f) lower beta wave activity coupled with higher alpha waves should underline the positive affective state coupled with an effortful attentional load (usually characterizing a flow state) rather than with a typical pattern generally correlating with cognitive and physical load. See Table 3 for detailed specifications and meanings of these psychophysiological signals.

Experimental Protocol

Participants were 30 healthy students from IULM University of Milan and Catholic University of Milan, ranging in age from 19 to 25 (mean: 22 ± 2.1). They had to send their

Table 2. The Link Between Flow and Other Cognitive Processes

Flow and emotions: According to its definition, flow is associated with feelings of enjoyment and positive affect, because a strong autotelic experience might reduce the role of external rewards till the point they are perceived as redundant.[13] In addition, the state occurs when profoundly and actively engaged in a task or in a situation, performing under concentration that often leads to a state of increased arousal activity. The association between flow on one side and affect and arousal on the other shows that the flow experience brings certain emotional content. A number of characteristics of flow experience are, respectively, found to be dependent on affective states. For instance, the engagement during a task, or the appraisal process while coping with a challenge are both related to the level of affect.[25] Positive affective states in general reduce self-conscious awareness.[26] According to all these observations, it is reasonable to study and frame flow experiences referring to a model of human emotions. Since the flow experience is not an on-off state, but rather can vary along a continuum, the discussion of emotional and psychophysiological measures correlating with flow experience will be framed within a dimensional range, rather than discrete emotional states for which flow may occur. The affective states should then be considered as prototypes of emotions corresponding to different levels of valence and arousal as coordinates for each dimension. The valence dimension represents the involvement of neural structures and pathways in either the appetitive or aversive motivation systems, whereas the arousal dimension represents modification in terms of somatic activity, reflecting different levels of metabolic and neural activation. A flow state falls in the upper left quadrant of the affective space, being associated with an affective state defined by moderate to high degrees of both dimensions (henceforth referred to as joy, excitement or ecstasy). It is possible to highlight that the Cartesian plane of valence and arousal can organize not only subjective but also somatophysiological responses, as described later on. Providing the coordinates of flow experience in the valence-arousal space allows the formulation of the hypothesis about how psychophysiological measurements of affective states can be used to define the flow experience.
Flow and attention: Attention, not just emotion, also plays a key role in determining whether a person is in a flow state or engaged in a task. Attention is also a prerequisite for being able to pursue goals and carry on a goal oriented strategy.[27] Even if speaking of a focused and at the same time effortless attention appears a contradiction in terms, the flow state is considered a subjective experience of heightened, unforced concentration. Due to this state of high attention, the positive valence can distract an individual from negative or even painful stimuli.[28] This suggests that a task requiring an important attentional load may be experienced as less effortful when in a state of positive affect. Similar theoretical models have been considered for research studies in the field of psychophysiological stress.[29] This temporary aversion might be explained by the fact that the brain systems respond in a different way to a stimulus or a situation depending on whether attention is focused on sensory-related or affect-related characteristics.[30]
Flow and expertise: Expertise, defined as implemented and stored long-term representations in the brain by virtue of previous experience, is another important factor that drives planning and expectations[31] and that can affect sensory processing to attend to task-relevant cues.[32] Expertise is then having a significant role in facilitating sustained attention, in reducing distractibility and in promoting many characteristics that define flow states. This also implies that the link between expertise and flow depends on the level of task difficulty, related also to the novelty versus familiarity of the stimulus/situation.

Table 3. Experimental Procedures

Procedures: Suitable subjects were contacted via e-mail and/or via telephone to plan and schedule their participation to the lab experiments at the Institute of Human, Language and Environmental Sciences at IULM University. A researcher was welcoming them to the Lab, and assisted them for the duration of the whole laboratory sessions. The researcher was trained in maintaining a neutral tone and behavior during the experimental acquisitions. After arriving to the psychophysiological lab, they were asked to sit down in front of a computer and were informed about the goals of the study, procedures, and cautions for study participations. To collect the data about psychophysiological indexes, probes were attached by the experimenter while explaining briefly the general rationale of the test. Sensors were applied as follows: the respiration belt was first placed on the chest; the EMG sensors were attached to the CS, after the researcher cleaned the skin with abrasive paste. Two Electroencephalogram (EEG) sensors were positioned on the frontal lobes, one on the left and the other on the right, with the respective reference electrodes on the ear lobes, cleaned again with abrasive paste. All EEG electrodes were applied, adding conductive paste to make better the detection of EEG signals. The two SC adhesive patches were situated on the nondominant palm. Lastly, the Blood Volume Pulse (BVP) sensor was placed on the top of the index finger, also on the nondominant hand. Once the subject felt comfortable, the experimental test started while instructing subjects to try to remain without moving during the presentation of the stimuli. They were allowed to move the dominant hand to use the mouse.

Sequence of experimental sessions: The stimuli were presented in the following order. Relaxation was always the first session. Some distraction sessions were inserted to cover the real goal of the research, then a 3-minute session of free navigation on Facebook, and, finally, a 4-minute stress epoch. The order of experimental stimuli was not randomized. This was for two different reasons: (a) To make sure that all subjects started from the same 4-minute relaxation session that represented also a baseline epoch; (b) the stress epoch was always last, because a research study[19] showed that a randomized experimental design might affect the psychophysiological patterns of interest, which in this study is represented by Facebook use. Since the recovery of physiological signals after stress might affect the navigation on Facebook, we did not use a randomized design. In this study, we focus the attention on relaxation, Facebook navigation, and stress.

Stimuli: The relaxation epoch was a sequence of panorama pictures lasting 9 seconds each, since research [18,19] has shown the ability of such scenes to evoke relaxation. Every 30 seconds, a white cross on a black slide was presented for 6 seconds. This slide was inserted in the stress epoch as well, as a marker stimulus, to compare the pupil dilation from relax versus stress in front of the same slide. As long as the same slide has the same color and luminance settings, any significant difference in pupil dilation might be addressed to the inner state of subjects. The Internet navigation while subjects were visiting their account on Facebook lasted 3 minutes. Basically, once the Internet browser presented the login Web page, subjects entered their account after logging in, with the instruction to do whatever they wanted but staying for the whole 3 minutes on their Facebook account. The stress session was divided into two different situations: the first was a 2-minute stroop task; the second was a 2-minute arithmetical task.[18,19] Once the stress sessions ended, the experimenter assisted the subject in removing all patches and sensors, debriefing about the experimental goals.

Measurement of the physiological signals: In order to analyze the central nervous system responses, EEG was measured by means of a two- channel system. According to the 10–20 electrode system, the electrodes for the EEG were all placed on the frontal lobes, in FP1 and FP2. The reference electrode was attached to the left earlobe and to the right earlobe, respectively. For monitoring the responses of the autonomic nervous systems, physiological signals from BVP, SC, Respiration, and EMG from CS muscle were monitored. Procomp (Thought Technology) was used for the measuring and Biograph Infinity 3.2 and Matlab 7.2 were used to compute the analysis. The sampling frequency for measuring the physiological signals was set at 256 Hz. Pupil dilation was recorded by and computed by Tobii Studio software at 50 Hz.

Meaning of the psychophysiological signals: the EEG is the recording of electrical activity along the scalp produced by the firing of neurons. It is typically described in terms of rhythmic activity, divided into bands by frequency as reported by the nomenclature: that is, any rhythmic activity between 8 and 12 Hz can be described as alpha, whereas between 13 and 16 Hz as beta. These designations arose because rhythmic activity within a certain frequency range was noted to have a certain distribution over the scalp or a certain biological significance; in previous research EEG was successfully used to discern between different affective states.[33–35] Regarding the indexes of heart rate rhythms, amongst others, the Inter Beat Interval, also known as RR Interval from BVP is the average distance in milliseconds between heart beats: that is, in a very general way, a distance of 1,000 milliseconds (1 second), means that there is a beat every second (60 beats per minute, generally during rest). On the opposite, a distance of 500 milliseconds (half second) means that there are two heart beats every second (120 beats per minute, which means an important increase of cardiac rhythm in comparison to rest). Several studies showed how cardiac activity is correlating with affective states.[36–38] About Respiration, the rationale is very similar to heart rate rhythms: here, we used the average respiration period in milliseconds as time duration of a single breath cycle that can vary also according to emotional states.[38–40] The SC is the measure of electrical conductance of the skin, which varies in presence or absence of sweat: SC values increases when the sweating glands, controlled by the autonomous nervous system, release more sweat because of motor or mental increased activity (once the environmental temperature is controlled and always the same); this measure correlates too with affective phenomena.[41,42] The EMG is the measure of the electrical activity produced by skeletal muscles: here the target muscle is the CS, due to its strong correlation with affective states.[8,20,43] Pupil dilates because of the increasing of the light in the environment or because of mental or emotional reasons (once the light of the environment is controlled and always the same).[44,45]

Baseline conditions and comparison with Relaxation and Stress: In this study, the baseline condition is relaxation. Baseline procedures are often used in psychophysiological research. However, this is not the only reason that explains why we use in our study a relaxation session. As we said above, relaxation and stress situations provide prototypical experiences able to elicit psychophysiological patterns that identify the correspondent quadrants of relaxation and stress in Lang model of emotions, where we can plot Facebook usage too. Facebook usage represents a prototypical situation able to elicit the psychophysiological patterns that identify the correspondent quadrant of engagement in Lang model. During the few

(*continued*)

Table 3. (Continued)

minutes of Facebook usage while sitting in the Lab, subjects might have experience of different affective states. However, based on the SC and EMG psychophysiological patterns identified in the study and averaged for each experimental situation, the quadrant of excitement in Lang model is where Facebook usage on average is located. A statistical analysis of physiological patterns from the three different experimental situations shows significant differences for many signals monitored. These findings support the reliability of Lang model and its three quadrants here considered. Lang model might represent the basis for further research work aimed to pursuit the goal to identify in what extend or when affective states like anger, stress, or joy are experienced while using Facebook. This goal will imply different statistical analyses of psychophysiological patterns. Instead of considering the average for the whole experimental session as we did in this study, a punctual analysis of physiological patterns might allow in the future the possibility to track within the four quadrant of Lang model the shifts (if any) of affective states.

Hardware description and recording settings: Data acquisition was performed at IULM University of Milan using Flexcomp Infinity, a 10 channel USB PC peripheral by Thought Technology. Every channel was acquired at 2,048 Hz and exported at a 256 Hz sampling rate. The Lab was equipped with two portable PCs, one for delivering the stimuli and the other for data acquisition. Respiration, SC, BVP, EMG, and EEG were continuously recorded through sensors opportunely placed on the student's body. The pupil dilation was recorded by Tobii 1750 hardware, synchronized with the psychophysiological equipment by means of a TT-AVsync from Thought Technology.[46] In addition, student facial expressions and student interactions were also recorded by webcam for eventual future analysis.

Facebook account name in order to participate. Following the system-usage approach[7] for information systems research, we decided to focus on the relation between user and system rather than on the relation between user and task or between system and task (the consequences of this choice are discussed in the Conclusions section). For this reason, the only inclusion criterion was a general knowledge and competence about Facebook: the sample includes only subjects who have been using regularly (at least once a week) a Facebook account in the last 6 months. This implies that the selected sample is skilled enough both to interact with a normal personal computer and to use their Facebook account. They were requested not to smoke, drink caffeine, or drink alcohol, which could affect the central autonomic nervous system, for a week before the experiment. They were all volunteers recruited at the IULM University campus and at the Catholic University campus. The full experimental protocol is detailed in Table 3.

Results

We analyzed student psychophysiological reactions correlated with their affective states as dependent variables to our experimental sessions by means of somatic activity in terms of SC, Respiration, IBI, Electroencephalogram (EEG; Alpha and Beta waves patterns and ratio of Theta/Alpha waves), Electromyography (EMG) from CS muscle, and Pupil Dilation signal processing and statistical analysis. A detailed description of the meaning of these physiological indexes is reported in Table 3. Looking at the graph in Figure 2, for SC, on average stress epoch is the highest value, whereas SC during relaxation is the lowest. SC value for Facebook is between stress and relaxation. In Figure 3 are presented Respiration results: the stress epoch shows highest values, whereas lowest rates are during relaxation; Facebook values are ranging between relaxation and stress values. About heart rate variability, the IBI index shows in Figure 4 that the lowest values are for stress and the highest during relaxation. However, even if the engagement values are between stress and relaxation, they elicit similar trends to relaxation ones in terms of mean values, but with a different standard error value. The beta waves in Figure 5 are showing how relaxation values are the lowest, whereas stress values are the highest; Facebook values are between relaxation and stress. For pupil dilation in Figure 6, Facebook use corresponds to the lowest values, whereas the highest are for stress; relaxation values are falling between stress and Facebook use; however, they are closer to Facebook rather than to stress values. The EMG values in Figure 7 show similar trends as seen for pupil dilation.

Statistical and correlation analysis

Means and standard errors for all physiological indexes considered were computed in SPSS for each subject, and then averaged for each epoch (Relaxation, Facebook use, and Stress). Statistical analysis was performed to compare the

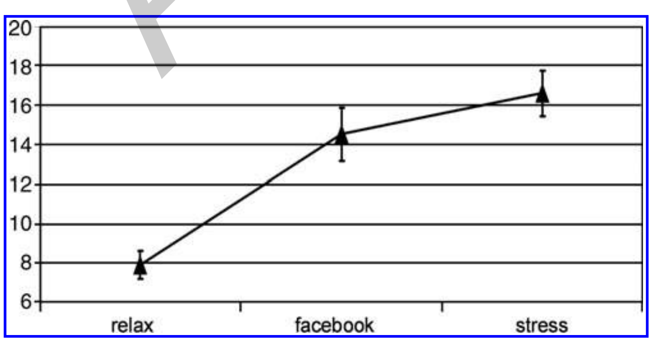

FIG. 2. Mean and standard errors values of Skin Conductance.

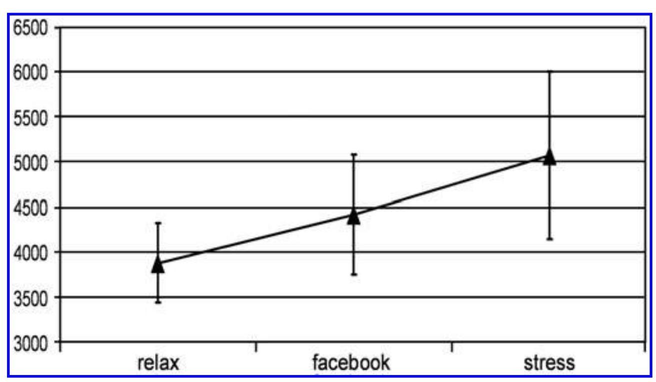

FIG. 3. Mean and standard errors values of Respiration Period.

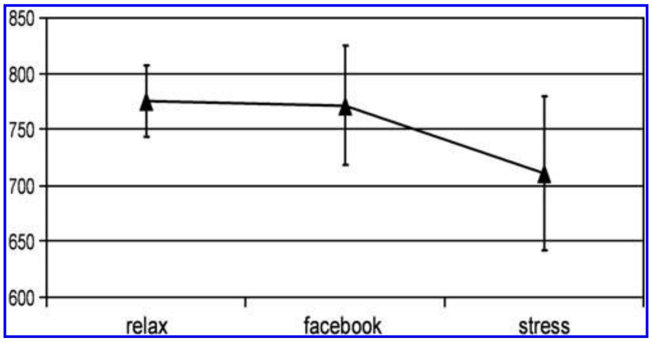

FIG. 4. Mean and standard errors values of Inter Beat Interval.

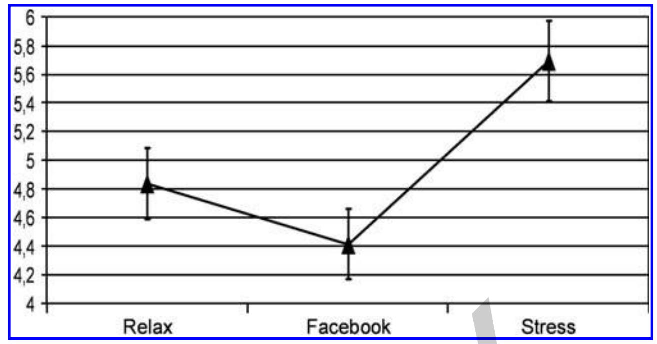

FIG. 6. Mean and standard errors values of Pupil Dilation.

mean values of the three emotional states (Relax, Stress, and Facebook) using a Student's *t* test with Bonferroni multiple comparison correction. Figure 8 exemplifies T-Student statistical analysis showing the degree of confidence for each physiological index considered in differentiating the three main affective states examined: Relax versus Stress, Relax versus Facebook, and Stress versus Facebook. Figure 8 shows also how three indexes over nine physiological measures considered (IBI, Beta waves, and EMG from CS) are not significant in distinguishing between Relaxation and Facebook use. About the confrontation between Facebook Use and Stress, two over nine indexes (SC and Beta waves) are not significant. The physiological measures that are always providing significant results for all conditions are Respiration Period, the Alpha waves (both for Low and High bands) together with the Theta/Alpha ratio, and the Pupil Dilation. All indexes show a significant distinction between stress and relaxation; this result will be discussed in a separate article. Here we focus our attention on Facebook use.

Discussion

SC, Respiration, cardiac IBI, EMG of CS, frontal EEG, and Pupil Dilation measurements were significantly associated with the three different experimental conditions. Taking into account the results from psychophysiological data, it is possible to answer to the RQ1, supporting the hypothesis that Facebook use elicits a specific psychophysiological pattern in comparison to relaxation and stress patterns. Comparing the data from relaxation and stress, it is evident how for the latter data suggest that during a cognitively demanding test there is an increased activation of the sympathetic branch of the autonomic nervous system, combined with the highest SC values, deep breathing reflected by the longest respiration period, the shortest IBI, the highest Beta waves activity, the greatest activation of EMG of CS, and the largest pupil dilation. On the contrary, during relaxation there is an increased activation of the parasymphatetic system, expressed by opposite trends. In general, sympathetic outflow responds to the emergency situations (fight and flight reactions) and facilitates the expenditure of energy (emotion, cold, exercise, and pain), whereas parasympathetic division is more active during rest and sleep and promotes restoration and conservation of energy. For example, life-threatening situations modulate deeply the sympathetic outflow that includes vasoconstriction in the skin and splanchnic vessels, vasodilatation in skeletal muscles, sweating, and release of adrenaline from adrenal medulla.[18]

During Facebook use, except for respiration and beta waves where Facebook values are falling almost exactly in between relaxation and stress values, all other Facebook values are showing different trends: for SC, Facebook and *stress* values are similar; on the contrary, for IBI, Facebook and *relaxation* are similar. For EMG CS and Pupil Dilation, Facebook values were the lowest ones, whereas relaxation values were between Facebook and stress ones. About SC values during stress and relaxation, they are showing trends seen in previous studies,[19,20] but for the Facebook use, SC values are quite high. These results reflect an higher emotional activation, since it is known that sympathetic nerve activity in the skin is mainly regulated by environmental temperature (that has been always the same during experimental tests) and central activations related to affective and

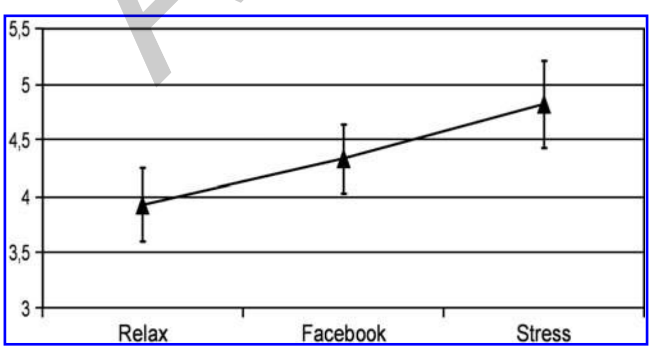

FIG. 5. Mean and standard errors values of Beta Power.

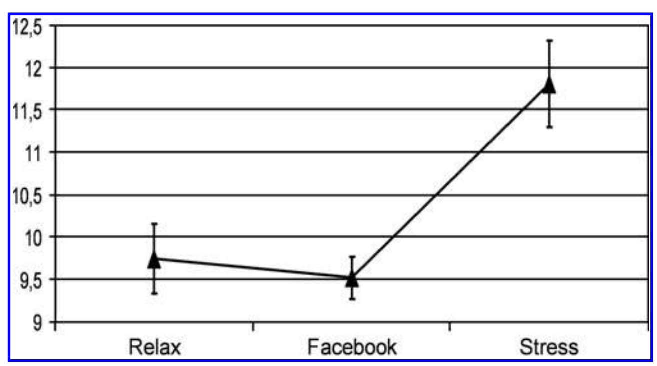

FIG. 7. Mean and standard errors values of EMG CS. EMG, Electromyography; CS, Corrugator Supercilii.

Variable	N	T-Student statistics		
		Facebook VS Relax	Facebook VS Stress	Relax VS Stress
Respiration Period	30	0,000101558**	1,73895E-05**	1,57433E-11**
Skin Conductance	30	2,90826E-09**	0,117130569	9,05125E-06**
Inter Beat Interval	30	0,383113702	0,000127167**	0,000338415**
Low Alpha Power	30	1,09611E-06**	0,015213988*	0,000102467**
High Alpha Power	30	7,84758E-06**	0,011425678*	0,000185375**
Beta Power	30	0,094361642	0,127833393	0,041442291*
Theta/Alpha Power	30	0,009558667*	0,015527985*	0,000415472**
EMG of Corrugator	30	0,439717431	0,021684279*	0,028216156*
Pupil Dilation	30	0,035537832*	1,53811E-10**	5,22115E-10**

FIG. 8. T-Student statistical analysis showing the degree of confidence for each physiological index considered in differentiating the three main affective states examined: Relax versus Stress, Relax versus Facebook, and Stress versus Facebook. ** and white background when $p < 0.005$; * and gray background when $p > 0.005$ and when $p < 0.05$; black background when $p > 0.05$.

cognitive states.[18] The cognitive states mostly correlating with SC changes are novelty and attentional issues, which can be excluded here since all the participants did already know Facebook and an important attentional load should be reflected by the cardiovascular system, whereas the Facebook IBI values are similar to relaxation and very different from stress, in addition to the fact that even the beta waves and pupil dilation values are not showing values coherent with the possibility that attentional factors might be here affecting the SC values. Thus, the SC values during Facebook represent an important emotional physiological correlate. The high heart IBI observed with Respiration Period increase (reflecting thus, aside SC, a raise in the sympathetic activity) shows how a longer respiration period increases the efficiency of oxygenation. During inhalation, the oxygen in the lungs has maximum access to deoxygenated blood; during exhalation, which has a longer duration than during shallow breathing, the heart rate decreases and the heart is allowed to relax. Consequently, it may be that while respiratory period was entrained to the Facebook use because of the sympathetic activity augmentation, respiratory period was increased to meet metabolic demands, without necessarily producing an increase in cardiac output. This indicates that Facebook use elicits a state that might in fact be associated with an increased parasympathetic modulation of sympathetic activity. This combination of cardiorespiratory patterns on one side reflects similar finding from other studies[16]; on the other, it might provide a specific signature of the state of engagement while in a core flow state evoked, in this research work, by Facebook use.

Considering now the brain wave patterns, the results are showing significant differences about the Alpha waves for all conditions, but not for the Beta waves as seen in student reading a detective tale,[20] where the Beta waves values were the highest even in comparison to stress, whereas for Facebook use and e-Learning situation[19] the values are between stress and relaxation. These findings, according to the scientific literature that associates alpha activity with situations of lower brain activity and beta waves with higher brain activity, might reveal how students are more activated in terms of a more important arousal (in terms of SC and Respiratory activity) rather than in terms of brain activity. This interpretation can take into account also the significant differences found for the Theta/Alpha ratio, known in the scientific literature as an index correlating with recreational and creativity situations. All these consideration might support the idea that during Facebook use students were concentrated by means of an effortful attention about their activity, according the hypothesis that, whereas in a core flow state, the level of concentration are characterized by effortful attentional load.

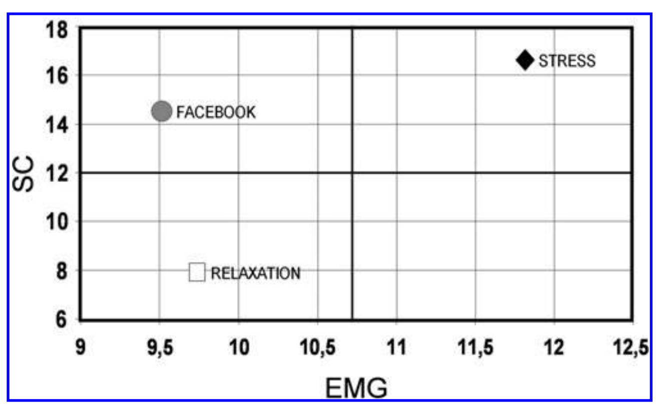

FIG. 9. The averaged data from all subjects for each epoch (relaxation, Facebook use, and stress) are plotted distributing the SC values along the Arousal axe (Y axe), and the EMG of CS along the Valence axe (X axe).

The EMG of CS data confirm that during Facebook use the students showed the lowest level of muscle tensions, supporting the general interpretation of psychophysiological pattern correlating with an engaging recreational activity associated with positive valence, relying on previous research that showed the strong correlation between EMG of CS and positive affective states.[21] Last but not least, the pupil dilation index, used in this study as an additional psychophysiological measure, shows a similar graph trend seen for EMG of CS. The stress situation reveals how pupils dilate the most. The relaxation epoch elicits a significant restriction of both pupils. It is worthy to note that the lowest dilation values are during Facebook use, as seen for EMG of CS data. Further research might focus the attention to the possibility that pupil dilation, aside attentional issues, might reflect positive/negative issues related to the valence of emotional states.

To answer the RQ2 and to better interpret the results, we take into account the Valence-Arousal model described, considering the SC values along the axis of arousal and the EMG of CS along the axis of valence. In Figure 9 we present the bidimensional plane of Valence-Arousal model with all the data averaged for each epoch (Relaxation, Facebook use, and Stress). SC values are distributed along the Y axis, representing the dimension of Arousal, from Low arousal (Low SC) to High Arousal (High SC). The EMG of CS values are distributed along the X axis, representing the dimension of Valence, from positive to negative valence. According to the Arousal-Valence model, the experience of Facebook falls in the upper left quadrant of the affective space, being associated with an affective state defined by moderate to high degrees of both dimensions (henceforth referred to as joyous and excitement). Taking into account this result and the other psychophysiological signals discussed above, it is possible to answer to the second research question: the psychophysiological state of people using social networking is characterized by high positive valence and high arousal, corresponding to a core flow state.

Conclusion

This research project shows how a multidimensional psychophysiological approach allows exploring evidence-based study of human experience; moreover, it provides a confirmation of SC and EMG of CS as efficient dimensions for the Arousal-Valence model to represent affective states. Last but not least, this research illustrates also that pupil dilation might represent an interesting contactless psychophysiological index combined with all other measures. This study shows results that support the hypothesis that Facebook use is able to generate an experience marked by a specific psychophysiological pattern in comparison to relaxation and stress situations, correlating in particular with an affective state characterized by high positive valence and high arousal, leading to a core flow state that might represent a key factor able to explain why social networks are spreading out so successfully.

A possible shortcoming of this study is the focus only the relation between user and system rather than on the relation between user and task or between system and task: for instance, users' knowledge about computer and SNSs, their ability or competence at performing certain computer tasks, their self-efficacy, and their previous experience can all influence SNSs' use and performance,[17] but are not investigated in this study. User traits too are considered as exogenous variables and excluded from the study. Further research will be helpful in exploring how all these different factors influence human experience during information systems usage.

In conclusion, within the boundaries of the study, the success of SNSs might be addressed also to the ability they have in inducing positive emotional experiences: quoting the broaden-and-build theory of positive emotions[22]: "positive emotions promote discovery of novel and creative actions, ideas and social bonds, which in turn build that individual's personal resources; ranging from physical and intellectual resources, to social and psychological resources. Importantly, these resources function as reserves that can be drawn on later to improve the odds of successful coping and survival." Affective computing[23] is a promising research field, even if further investigation will be important in defining more specific patterns not only for the affective state of core Flow, but also for more specific emotional states, in order to integrate the role of emotions with other important constructs developed to study human–computer interaction and SNSs use.[24] For future research, it would be very interesting to have the possibility to simply track on Lang model (enriched with multidimensional psychophysiological measures like EEG, heart rate, respiration, and pupil dilation, aside SC and EMG) the affective states of Facebook users while they are using their account. This is one of the final goals of affective computing, and this study is aimed to open the way to the achievement of this goal.

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