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PERSUASIVE E-COACHING FRAMEWORK: TEST WITH A REDUCED NUMBER OF SENSOR

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ABSTRACT

Increasingly, persuasive technologies are used to convince, stimulate and motivate users to engage in healthy behaviours. Currently persuasive technologies are based either on social psychology theories (the user compares him/herself with other people), self-determination (human behaviour is a result of a decision that was either taken autonomously or that was rather imposed to a person), goal-setting (process by which people attempt to constrain unwanted urges by gaining control over the impulsive response), or health belief model (individual's perception of the *severity*, *benefit*, *barrier* of a situation or action to perform). However few approaches have tried to integrate user's emotion. In this paper we present a persuasive e-coaching framework which explicitly consider and integrate the emotion in the decision making process. Toward the objective to deploy such solution, the first critical step is to identify a sensor configuration that is accurate enough and minimally invasive. We present the results obtained with only one physiological sensor.

KEYWORDS

Emotion, e-coach, persuasive technology, physiological parameters, heart rate monitoring

1. INTRODUCTION

Increasingly, persuasive technologies are used to convince, stimulate and motivate users to engage in healthy behaviours. (Fogg2003) defines persuasive technology as "the class of technologies or interactive computing systems that are intentionally designed to change a person's attitude or behaviour." An important element of this definition is that a person being persuaded always has a clear and free choice to change attitude, behaviour or both. In this way, persuasion opposes coercion and deception, in which users are forced or manipulated to change their attitude or behaviour.

The European Artemis "With-Me" project intents to identify and provide complementary elements that will support/persuade the user to follow a diet, engage, maintain or increase physical activity. For that purpose With-Me project has identified and extracted a set of

behaviour change techniques, has investigated the effect of conscious and unconscious motivators as well as the role of social interactions. Even though these elements are very important, in this paper we focus on one important additional "ingredient" that is central to our decision-making process: our emotions.

Emotion processing and decision-making are integral aspects of daily life. Indeed any kind of recommendations, suggestions, reminders for a healthier lifestyle (physical activity, nutrition,…) will put the user in a position where he or she will have to decide whether or not to follow the suggested action. At that moment and among other parameters the emotional component will play a role. However, the understanding of the interaction between these constructs is limited. Scientific debate over whether subjective experiences of emotion are functional or maladaptive has been ongoing (Seo2007). Some argue that feelings are a source of unwanted bias (Shiv2005) and thus need to be properly regulated (Gross2003). Others maintain that feelings play an adaptive role in decision making and benefit personal well-being (Loewenstein2003). In both cases, and when aiming at developing e-coaching tools, the ability to detect emotional changes is valuable information that can be either reinforced or mitigated according to the context of the action, the user's profile and goals to be achieved. It is therefore necessary to measure, in real-time, such emotional responses in order to support their management.

In a recent publication described a "recommender system". When using applications with recommender systems the user is constantly receiving stimuli (e.g. visual, auditory etc.) that induce emotional reactions and states. These emotions influence, at least partially (according to the bounded rationality model (Kahneman2003) the user's decisions on which content to choose. Thus it is important for the recommender system application to detect and make good use of any emotion-related information.

The emotions play a different role depending on the stage of the interaction process. The authors proposed three interaction stages: the entry stage, the consumption stage and the exit stage. This approach is aligned with our coaching approach, however there are situations of functions that are not encountered in Tkalcic approach (e.g. the system is not able to react to an emotional change of the user).

In this paper we are presenting the selected theoretical framework (section 2) from which we have brought some modifications in order to better fit with the context of the With-Me project where users' emotions are integrated into the coaching strategies (section 3). An e-coach should be able to:

- First measure/detect, in real-time, whenever a strong emotion change happens and second react appropriately to this situation by either trying to mitigate or re-enforce this emotional change. The reaction (coach/e-coach) to an emotional stimulus depends obviously on the (emotional) profile of the user and also on the behavioural change technique (BCT) initially selected for this user. Following a strategy of responding to an emotional change, a dimensional model (valance, arousal) of emotions is preferred to a discrete model (e.g. happiness, fear, sadness, hostility, guilt, surprise, and interest). Indeed a dimensional model would be perceived, by the user, less intrusive than a discrete mode (Leon2009). This would then facilitate user acceptance. Moreover sensing and detecting discrete emotions are not currently possible with a minimalistic sensor configuration excluding discrete emotional models.
- Deliver to the user some information (reminder, recommendation, warning, information) that can elicitate certain types of emotion with the secondary aim to mitigate or reinforce a recently experienced emotion or simply induce a particular emotion at a particular time.

2. THEORETICAL FRAMEWORK

In 1896 Wundt first proposed a dimensional model of affect as part of his theory concerning mental chemistry, arguing that affect resulted from variations in basic dimensions of pleasure and arousal. Later, based on factor analyses of evaluative language, Osgood developed a dimensional theory of semantic meaning after finding that the most variance in semantic judgments was accounted for by a single factor, hedonic valence, which ranged from unpleasant to pleasant (Osgood1957). The fundamental role of hedonic valence in emotions received further support from studies of language categorization (Ortony1990), which proposed that human knowledge about emotions is hierarchically organized with a superordinate division between positivity and negativity. A second dimension also accounted for substantial variance in evaluative judgments; this was a dimension Osgood et al. labelled arousal. This dimension reflects the activation parameter in affective experience and ranges from an unaroused state (calm, relaxed, sleepy, etc.) to a state of high arousal (excited, stimulated, wide awake, etc.).

A third dimension was termed potency or dominance by Osgood et al. When rating static picture stimuli, dominance ratings are highly correlated with ratings of hedonic valence, with pleasant pictures rated as higher in dominance than unpleasant pictures. The dominance dimension is relatively weak in accounting for variance in evaluative judgments of symbolic stimuli. It is perhaps more potent in social interaction. For instance, dominance usually characterizes differences in unpleasant arousing events, with anger characterized by somewhat higher dominance than fear. Nonetheless, both are rated lower in dominance than highly pleasurable events. For symbolic sensory stimuli (pictures, sounds, words, etc.), there is no actual personal interaction in which social potency can play a role. In this case, dominance covaries highly with hedonic valence. Nonetheless, for more event-like stimuli, dominance will clearly account for some portion of variance in evaluative reports. In (Russell1977), dominance represents the degree of control over the emotion. In the literature there are terms that are commonly used and need a shared understanding. Therefore we present some definitions that are generally accepted about affect, emotion and mood. Then we will describe how emotions are part of the decision-making process.

2.1 Definitions

The constructs of mood and emotion are similar in that both refer to feeling states that can be broadly characterized as pleasant or unpleasant (i.e. positive or negative) and that reflect what is happening with the organism (Parkinson1996, Coan2007). Although the constructs of mood and emotion are closely related, they also reflect a number of fundamental differences including duration, frequency, intensity, and pattern of activation.

Mood is a much broader concept than emotion. First moods are experienced with greater duration than emotion (Gray2001). An emotion episode may last seconds, or minutes at the most. Emotions are intense yet brief. A mood, on the other hand, can last hours or even days. Therefore moods are experienced more consistently and frequently than emotions. True emotion reactions occur rarely. Second, moods and emotions differ in the experiences and events that trigger them (Gray2001).

Emotions are typically linked to a specific, defining moment that causes the response. Because emotions prompt the organism into action or decision, they must be triggered by a particular object. Moods, on the contrary, are not so much a reaction that is triggered by a specific event.

Affect is a broader, more inclusive psychological construct that refers to mental states involving evaluative feelings, that is, states in which a person feels good or bad or likes or dislikes what is happening (Parkinson1996). The second important issue in defining affect concerns the distinction between trait versus state affect. It can be studied either as a temporary, transient state or as a long-term, stable trait. State affects are defined as the experience of moods or emotions that are comparatively short-lived and follow a fluctuating course. They are transient episodes of feeling that are particularly influenced by the current situation (Tellegen1985, Watson2000).Trait affects, on the other hand, are durable dispositions or long-term, stable individual differences that reflect a person's general tendency to experience a particular affective state (Tellegen1985, Watson2000).

2.2 Emotions as Part of the Decision Making Process

During coach-coachee interactions, there is an exchange of information (recommendation, assessment, rewards, …) which involve jointly cognitive functions and emotional reactions/states. In the context of the With-Me project, we have decided to used physiological data to measure the emotional state of the user (see section 3.3 for the reasons of this choice), therefore we are describing now how the physiological and cognitive components could be interconnected. In (Parker2007) the authors reviewed several theories describing some hypotheses about the origin and nature of emotions.

- The "Commonsense" view of emotion. We perceive and interpret a particular stimulus, movements. "I see a bear, feel fear, experience a flood of physiological reactions, and run because I am afraid";
- The James-Lange Theory. Environmental stimuli triggers physiological responses and bodily movements, and emotion occurs when the individual interprets his or her visceral and these cognitive processes give rise to an emotion that triggers certain physiological reactions and body muscular responses. "I must be afraid because my heart is pounding and I am running like crazy";
- The Cannon-Bard Theory. Emotion is a cognitive event that is enhanced by bodily reactions. Bodily reactions do not cause emotion but rather occur simultaneously with the experience of emotion. "I am afraid because I know bears are dangerous";
- The Schachter-Singer Theory. Emotions depend upon a kind of double cognitive interpretation: We appraise the emotion-causing event while also evaluating what is happening with our bodies. "I am afraid because I know bears are dangerous and because my heart is pounding".

How can emotions and cognitive processes be combined? It has already been identified that emotions could be a behaviour change technique when using narrative persuasion (Moyer-Guse2008). Narrative persuasion refers to the use of narrative messages (narratives) as a persuasion tool. Narratives are messages that present information in a story format as opposed to an abstract format. They are designed to engage the audience, and typically involve a protagonist, and contain emotionally appealing information. For example: (McQueen2011) exposed women to either an informational video about breast cancer, or a narrative video. The

videos provided the same information but in a different format. The informational video provided the information in a didactic, expository form, whereas the narrative video provided the information in the form of personal stories of breast cancer survivors. Women who watched the narrative video experienced more positive and negative emotions, reported stronger identification with the message source, and were more engaged with the video than women who watched an informational video. The narrative video was also better liked, enhanced recall, reduced counter arguing, and increased breast cancer discussions with family members. Note that in narrative persuasion emotions are involved together with other determinants such as affective attitude, behavioural intention and beliefs, perceived risk, perceived severity, perceived vulnerability. Based on these observations we are proposing how emotions could be used as a coaching ingredient.

3. EMOTION AS A COACHING INGREDIENT

3.1 Emotions as Part of the Decision Making Process

Inspired from the theories presented in section 2.2, we represent how emotions (and emotional profile) are contributing to short and long term actions (Figure 1).

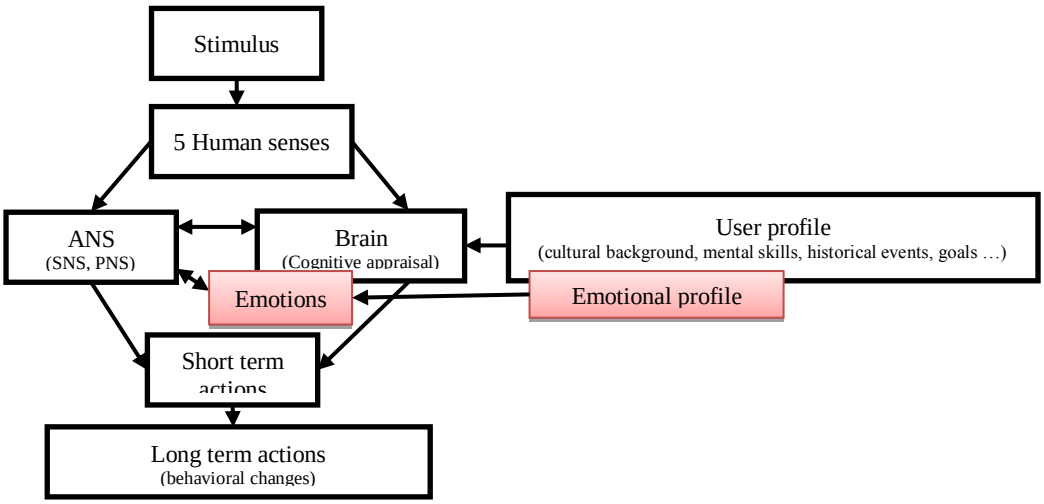

Figure 1. The place of emotion: from stimulus to actions

• Stimulus or (eliciting stimulus). It corresponds to any daily life stimuli: vision or smell of non-healthy food, call from a personal coach to suggest jogging, an internal thought of sitting on a sofa to watch TV, bad news from the doctor about the latest medical tests related to heart conditions, reminder to perform the daily rehabilitation exercise, or perform a stress assessment test.

• Human senses. This step is just to make explicit the fact that stimuli can be in any "dimensions" or different kinds (sight, taste, touch, hearing, smell, proprioception, thought).

• ANS. Autonomic nervous system (ANS) activity is viewed as a major component of the emotion response. See (Kreibig2010) for complete review of the empirical basis for the postulate of emotion-specific ANS activity. Monitoring physiological parameters (e.g. Heart Rate Variability, galavanic skin response, …) is a way (used in the With-Me project) to quantify the emotion response/state of a person.

• Brain. It refers to theories of emotion which implicate people's personal interpretations of an event in determining their emotional reaction. The most important part of this theory (Cannon1931) is the way we interpret the event (was the event a positive or a negative occurrence) as well as what we think caused the situation.

• User profile. In the field of Human Computer Interaction (HCI), users' individual differences and their tasks are always indicated as the two most important issues addressing usability (Nielsen1993). Users are not homogeneous; they differ in many respects, such as gender, age, physical abilities, educational level, organizational culture, operator skills etc. Beside these standard profile attributes that are relevant for With-Me, it is important to consider the user's "emotional profile". Salovey and Mayer originally coined the term "emotional Intelligence" in 1990. However, Daniel Goleman popularized it in 1995 in the title of his bestselling book, Emotional Intelligence: Why it can Matter More than IQ? (Goleman1995). Goleman defined emotional intelligence as: "understanding one's own feelings, empathy for the feelings of others and the regulation of emotion in a way that enhances living". What made this book so popular were two claims: Firstly, emotional intelligence may be more important for personal success than Intellectual Quotient (IQ). Secondly, unlike IQ emotional intelligence can be improved.

• Short term actions. As shown in Figure 1 and explained in (Loewenstein2003), conventional theories of decision making include only "expected emotions" where the decision makers anticipate the upcoming emotions (consequences of his/her choice) and thus take them into account when making decisions. However Loewenstein also puts emphasis on how "immediate emotions" (emotions experienced at the time of the decision making) can influence the decision by altering the decision maker's perceptions of probabilities or outcomes or by altering the quality and quantity of processing of decision-relevant cues. Note that this emotional influence may either serve or not the decision marker. In With-Me one approach is to use emotional changes to trigger a feedback (e.g. via a virtual coach, reminder, real coach reaction) that will help the user to take the right decision toward healthier actions: perform now (short-term action) a recommended physical activity, or eat healthy food for the coming lunch (short-term action). Another approach is to deliver a stimulus (e.g. a message) that specifically designed to elicitate a particular emotion to the user. This might be a positive emotional content to reinforce a particular achievement.

• Long term actions. One of the With-Me objectives is to support behaviour changes that are sustained over a long period of time (months, years). This is why we have added this final block in Figure 2 that corresponds to long-term actions and habits. The user supported by adapted persuasive mechanisms has adopted new behaviours which have become routines. Hypothesis: repetitive feedbacks with positive emotional content sustain better long-term changes.

From the scheme presented we see the importance of two key aspects: being able to (1) elicitate a certain type of emotions and (2) detect and classify human emotional responses when they arise. We are presenting now the different blocks of the figure, focusing on the key element: the coaching module.

3.2 Emotional Coaching Module

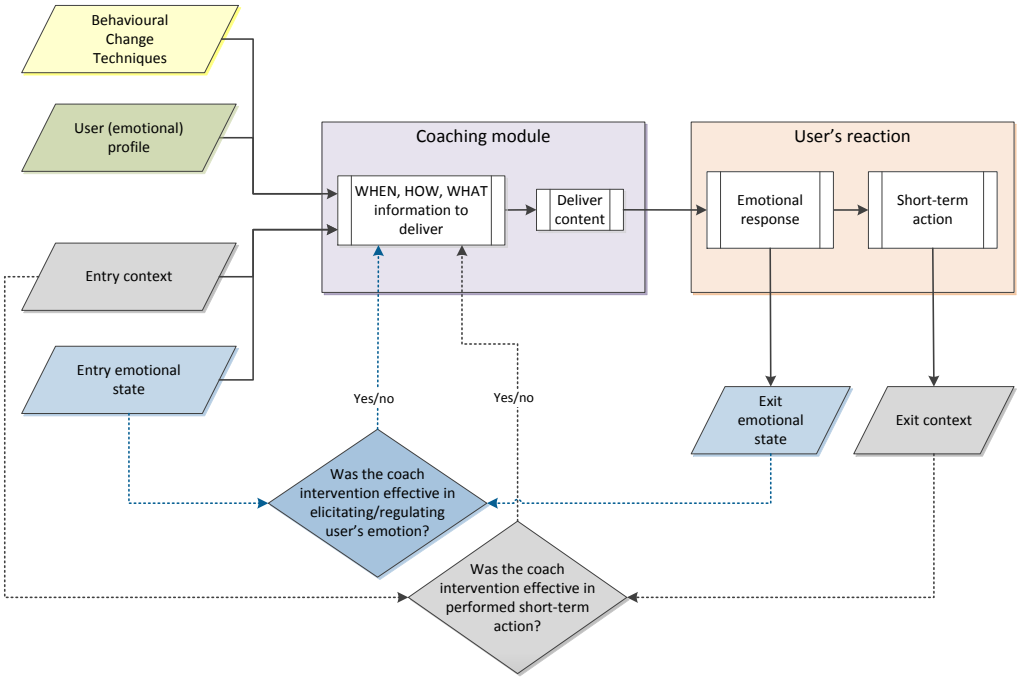

Figure 2. Emotional coaching framework

We are presenting our emotional coaching framework (Figure 2). The coaching framework is composed of a central module (coaching module) which take as inputs (a) the behavioural change technique selected for a particular user, (b) the user emotional profile, (c) the entry context, and (d) the entry emotional state. The coaching module is responsible of deciding WHEN, HOW and WHAT information to deliver/transmit to the coachee.

3.2.1 WHEN

When should the coach intervene? What is the optimal moment? It depends on the combination of all input parameters and their values at a particular moment. As explained in (Loewenstein2003), conventional theories of decision making usually include only the "expected emotions" where the decision makers anticipate the upcoming emotions (consequences of his/her choice) and thus take them into account when making decisions. However Lowenstein (Loewenstein2003) also puts emphasis on how "immediate emotions" (emotions experienced at the time of the decision making) can influence the decision by altering the decision maker's perceptions of probabilities or outcomes or by altering the quality and quantity of processing of decision-relevant cues. Therefore and considering only emotional-related triggering conditions we have identified two relevant intervention moments:

• After an acute emotional change

This could be the situations when a user (with eating disorder) is seeing or smelling of non-healthy food or when a person (recovering from an heart attack) gets bad news from the

doctor about his/her last medical tests related to heart conditions, or when a worker is experiencing very high negative emotional change at work after a conversation with a colleague. In these situations the coach would immediately react in order to mitigate the effect of the elicited emotion (e.g. trying to avoid the user to eat the food that has been seen).

• After a specific "emotional response pattern"

In this scenario, the coach is not responding to a specific event in time, but is rather responding to the time history (for example the last hour) of emotional responses/states. An intervention of the coach will be triggered when some conditions are met. For example a recommendation might be sent when the user hasn't experienced strong emotional stimuli for the last hour. This strategy can be selected when it is known that a particular user is strongly receptive to suggestions when being "calm".

3.2.2 HOW

"How" refers to the modality (format) of the intervention done by the coach or e-coach (text, audio, speech, image or video), but also to the way messages/instructions are transmitted to the user (with or without emotional content):

• Message without emotional content

In this case no particular action is taken to embed any emotional content into the stimulus. This means that the stimulus is only proving neutral (emotional) information. For example, the user is experiencing a strong negative emotion and the message delivered to the person only aims at diverting his/her attention or advice a relaxation technique.

• Message with "on purpose" emotional content

In this situation the message to be delivered is explicitly designed to (1) elicitate a particular and pre-defined emotional response or to (2) mitigate the current user's emotional response. For that purpose one can refer to section 4 for selecting features that have been demonstrated to elicit human emotion. For example, the user is experiencing a strong negative emotion and the message delivered to the person aims at diverting his/her attention and also ties to elicit an "opposite" emotion (e.g. positive).

We can note that a succession of the e-coach intervention with "on purpose" emotional content will contribute or define a "personality of the coach" that should be adapted to the personality of the user, as shown in (Delaborde2013). This relates to the characteristics of an efficient coaching platform able to keep a coachee using the platform because it is pleasant.

3.2.3 WHAT

What should the coaching system suggests or says? WHAT refers to the content of the message that the coaching system delivers to the user. This content will depend on:

• The domain in which the coaching system wants to intervene to coach the user to a healthier lifestyle: nutrition, physical activity or social interaction.

• The type of message to be delivered: positive reinforcement, warning, advices, others.

• The user's personality and what content is more efficient for this kind of user/personality.

• The personality of the coach, for consistency and to reinforce this personality.

3.2.3 Illustrative Use Cases

• A user, with eating disorder, is seeing or smelling of non-healthy food. In this situation the coach immediately reacts to a strong emotional (compulsive) reaction in order to mitigate the effect of the elicited emotion and tries to avoid the user to eat this food.

• A person recovering from a heart attack gets bad news from the doctor about his/her last medical tests related to heart conditions. The professional who gets real-time information about the user's strong negative reaction to this announcement will adapt/extend his/her explanations.

• A worker is experiencing very high negative emotional change at work after a conversation with a colleague. This person is warned about it and recommendation is proposed to regulate his/her emotional response/state (relaxation exercises).

3.3 Technical Requirement: sensing the Emotional State of the User

Since our application aims at using the emotional state/responses as part of an e-coach, it is therefore mandatory to be able to measure/collect quantitative information related to this state. For that purpose a large palette of modalities and sensors has been considered and studied in the last decades: vision-based system, audio/speech system, textual information, touch sensors, physiological and bio signals (HR/HRV, GSR, and EEG). In the context of the With-Me project, we have decided to use physiological signals to detect and quantify the emotional response/state. Some relevant approaches to physiological emotion detection include the work of Nasoz (Nasoz2004), Kim (Kim2004) or Leon (Leon2007) and the recent review of Kreibig (Kreibig2010). However, in With-Me, an emotion detection algorithm had to be developed to support real applications with users, evolving in a non-controlled environment. In such context the requirements listed below applied:

1. Real-time detection of emotional state (negative, neutral, positive). Having a real-time detection system allows the With-Me coach to immediately respond either to sudden emotional changes or to propose recommendations at a preferred emotional moment in time.
2. Suitable for being used in natural environments and during daily life activities.
3. As a consequence of requirement number 2, the physiological emotional monitoring device needs to be fully wearable.
4. The device must use the least obtrusive sensor configuration possible (preferably only one sensor).
5. (optional) Low cost solution. This final requirement is not mandatory. However, if our aim is to develop a With-Me coach that can be used by a large part of the population, the required devices should be economically affordable.

4. MEASUREMENTS AND METHOD

In previous works (Leon2007) (Leon2010), the emotion detection and classification algorithm (Figure 3) was explained and validated using several physiological signals (heart rate variability, skin resistance, blood volume pressure). In the lab trial presented in this publication, the objective was to validate the use of a unique physiological signal (requirement 4), the heart rate variability (HRV), to correctly detect in real-time, positive, neutral and negative emotions (requirement 1).We carried out this trial with laboratory equipment, the PowerLab of ADInstruments.

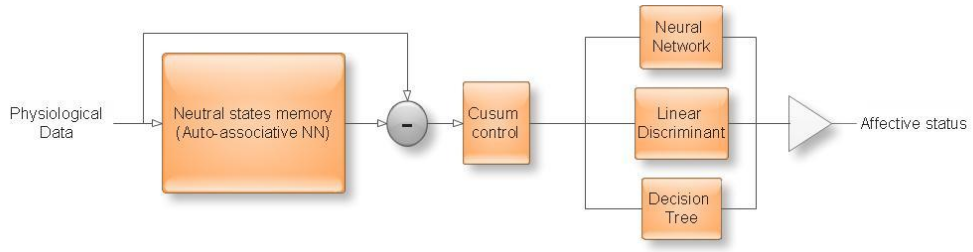

Figure 3. SENTIENT emotion detection and classification algorithm

From a previous internal trials, we used three films that elicitated better positive emotions ("Drop dead Fred", "El Milagro de P.Tinto" and "Austin Powers"), negative emotions ("El Bola", "El Espinazo del Diablo" and "Mar Adentro"), and neutral responses (the bars, the countdown and the spiral).

From the initial set of 23 participants, nine participants completed this phase of the user tests (4 males / 5 females; 28-45 years old; native Spanish speakers: employees of Tecnalia). They were given a written description the test and two copies of the consent form to sign before beginning the test. Subjects were instructed that they could drop out at any moment if needed.

Subjects were seating on the sofa in the living room area of the Tecnalia HomeLab (https://www.flickr.com/photos/tecnalia/sets/72157626908269164/detail/) and were wearing the wireless PowerLab device. Two investigators controlled the movie clips, monitored the signal acquisition as well as the real-time emotion detection and classification outputs from a control room. After each movie clip showed, the lights were turned on for the participant to fill out a questionnaire. In these questionnaires, we assessed the subjective emotional experience of the user (valence: positive, negative, neutral; arousal: intensity). When mapped these answers, all users' answers coincided with expected emotional group (neutral, positive or negative).

5. RESULTS

Due to an error in the data acquisition, results for participants 1 to 4 were considered invalid, and they were therefore not included in this section. The error was corrected, and we conducted the tests with participants 5 to 9. Table 1 shows the classification results, per user, per movie and overall.

Table 1. Emotion detection and classification accuracy results

Movie clips	Users					
	5	6	7	8	9	Mean per clip
1. Spiral (neutral)	Neutral	Neutral	Neutral	Negative	Neutral	80%
2. El Bola (negative)	Neutral	Negative	Positive	Negative	Negative	60%
3. Drop dead Fred (positive)	Positive	Positive	Neutral	Negative	Negative	40%
4. Countdown (neutral)	Neutral	Neutral	Neutral	Neutral	Neutral	100%
5. Espinazo del Diablo (negative)	Neutral	Neutral	Positive	Negative	Negative	40%
6. Milagro de P. Tinto (positive)	Negative	Positive	Neutral	Positive	Neutral	40%
7. Bars (neutral)	Neutral	Positive	Neutral	Neutral	Negative	60%
8. Austin Powers (positive)	Positive	Positive	Positive	Neutral	Positive	80%
9. Mar Adentro (negative)	Negative	Negative	Positive	Neutral	Negative	60%
Mean per user	66.7%	77.8%	44.4%	55.6%	66.7%	**62.2%**

- Based on the questionnaires filled by the users, all movies elicitated the expected emotional group (neutral, positive or negative) in all users.
- The overall accuracy of the classification method (neutral, positive and negative emotions) was of 62.2%. This is almost twice better than random (33%).
- Neutral events detection sensitivity is 80%. In contrast, positive and negative events detection sensitivity is 53.3% in both cases. This shows that the algorithm tends to keep in neutral state.
- The accuracy detecting non-neutral state (positive or negative elicitation detected as positive or negative in the user), is 73.3%, which is better than random (50%).

6. CONCLUSION

An e-coach system aims to support people in preventing diseases but also managing health conditions such as overweight, stress, or heart conditions. However changing its own lifestyle is never easy, it is an every-minute challenge and requires long-term efforts which are usually difficult to handle alone. We therefore proposed to enhance standard e-coach by adding the user's emotional component into coaching strategies (section 3.2) in which we give recommendations about WHEN, HOW, WHAT to transmit to the user by explicitly using emotion-related information. Similar to Tkalcic et al. (Tkalcic2011) the "coaching module" (Figure 2) takes as input the emotion entry state, but also context information, the user emotional profile, and a personalized behavior change technique (BCT). The outputs of the "coaching module" are the exit emotional state and the short term action taken by the user.

We have pointed out that technology is now mature enough to automatically measure and estimate the real-time emotional response/state of a person. Taken into consideration the requirements imposed by the context of use (section 3.3), we have tested and evaluated a wearable minimal sensor configuration (only one physiological sensor) combined with a

real-time emotion classification algorithm derived from (Leon2007) from which we concluded that:

- User profile is an important component when elicitating emotions. When the user profile is taken into account, the elicitation is stronger, and so it should be contemplated in an e-coach.
- Longer videos are better for elicitating emotions. The reason may be the storytelling and its ability to involve the user into a certain emotional "path" with cumulative stimuli, and therefore a stronger emotion elicitation.
- Using only HRV as input for the proposed emotion detection algorithm provided a sensitivity of 73.3% to detect non-neutral states and an overall sensitivity of 62.2% to classify neutral, positive or negative events. The sensitivity of positive and negative events is of 53.3%. This means that the algorithm has a better sensitivity detecting neutral events, which shows that the algorithm tends to keep in neutral state. The algorithm is 60% better than random detecting positive and negative events. We consider that it is a good results comparing with research SoA and taking into account we are only using one physiological signal (HRV).

The next step will be to switch from a laboratory conditions (laboratory equipment, controlled conditions, ...) to a real life environmental conditions (wearable sensors, real life conditions, ...), and to evaluate the probable loss of accuracy. We will need to select the most suitable (in term of comfort, price, quality of measurements) wearable heart rate monitor able to provide RR intervals (in order to compute HRV). Choice will be between a watch type (Empatica E4 wristband) or chest mounted device (Alive Heart and Activity Monitor, Zephyr HxM, Polar H7 heart rate, Nuubo nECG).

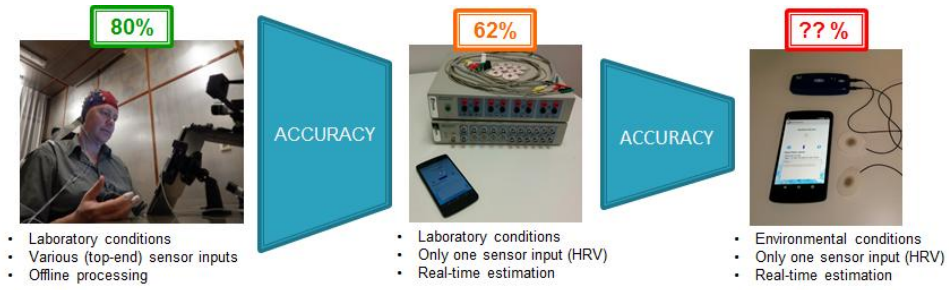

Figure 4. Emotion classification performance as a function of the equipment and condition of use

The next challenge will be to implement an artificial intelligence coach able to (a) define the WHEN, HOW, WHAT of the "coaching module" based on the current inputs (see Figure 2) and also (b) adapt, over time, these assignation based on feedback information: "was the coach intervention effective in elicitating/regulating user's emotion" and/or "was the coach intervention effective in generating the appropriate short term user action?".

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