Game Experience and Brain based Assessment of Motivational Goal Orientations in Video Games

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Abstract. The current study aims to measure the goal orientations motivation in different scenes of a video-game. The evaluation of player experience was done with both subjective measures through questionnaire and objective measures through brain wave activity (electroencephalography - EEG). We used GameFlow questionnaire to characterize the player's mastery goal in playing video game (Master or Performant). In terms of brain activity, we used the Frontal alpha asymmetry (FAA) to assess the player approach/withdrawal behavior within a game scene. Using game scene's design goal (defined by OCC variables) and player personality traits (using Big Five questionnaire), the resulting machine learning model predicts players' motivational goal orientations in order to adapt the game. In this study, we address player's motivation in game scenes by analyzing player's profile, his situation in scene and affective physiological data.

Keywords: Motivation, Video Games, Goal orientations, Player Model, EEG

1 Introduction

The ultimate question that a game designer is always trying to answer is: "how to make the game more attractive for the player and hold his attention more and more?" This question is all about the **Motivation of the player** in playing the game. Motivation has been extensively studied in psychology and social science. Motivation is defined as: "*The willingness to put effort into achieving goals*" [1]. Several researches suggest that goal-directed approach and withdrawal behaviors are regulated by two basic motivational systems: avoidance system and approach system [2]. As a result of nature selection, Approach-avoidance motivation is deeply embedded in our mind because it is crucial for survival to discriminate between pleasurable and rewarding stimuli that we can approach, and dangerous stimuli that we should avoid [3]. Many studies from neuroscience [4, 5] have proven the existence of approach-related motivation in neural circuity. In fact, behavioral approach is localized in the left anterior cortical regions, and behavioral withdrawal is in the right anterior cortical regions using Functional magnetic resonance imaging (fMRI). Moreover, many studies [6-8] associate the Frontal alpha asymmetry (FAA) EEG measure with approach and withdrawal motivational tendencies and individual differences in personality and also

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other studies [9, 10] underscore the role of prefrontal cortex in emotion and motivation process.

During a game, players' motivation is also influenced by achievement need which is a social factor where the player is driven by the motivation to excel and make success in challenging situations. To maintain the player's flow [11] during the game, the challenges should be in the same level of player's competences. When the challenge surpasses the player's skills, he will feel very frustrated, but the lack of challenge induces boredom [12, 13], which leads to make the player unmotivated in both cases and may stop playing the game.

The goal orientations motivational theory takes consideration of both approach withdrawal behavior and mastery goal in assessing the motivation. Coming from educational psychology, this theory investigates the learner's motivation in four achievement goal orientations in educational settings [14-16]. Up to our knowledge, this is the first approach addressing the study of players' motivational goal orientations in video game settings. In addition, it is important that such environments can detect the player's motivation in game scene and provide help in the right time to keep him playing and evolve his experience during the gameplay.

Modeling of the player's motivation during a game is a difficult process due to the complexity that exists to identify the player achievement goals and behavior. In a different situation, the same cause or stimulus provoke different behaviors depending of important factors like goal, personality and preferences. In this context a cognitive approach proposed by Ortony, Clore and Collins (1988)[17] was used to represent the game scene goal defined by the designer. The OCC model evaluates a situation with descriptive variables (global, central and local variables), that the designer gives for each scene to represent his scene's goals.

The present paper aims to predicting motivational goal orientations in a game scene by using the scene OCC description and player's personality traits. We ask in this paper the two following research questions: how to assess the player mastery goal in playing a video game and characterize his approach related behavior within a game scene? If so, can we predict players' motivational goal orientations toward a new scene using machine learning model?

The organization of this paper is as follows: in the next section, we present an overview of the motivation theories and video games. In the third section, we explain our empirical approach in assessing players' motivational goal orientations. In the fourth section, we detail our experimental methodology. In the fifth section, we present the obtained results and discuss them. In the last section, we conclude with a discussion of the present research as well as future work.

2 Background in motivation and video games

2.1 Motivation and motives

Psychologists [18] define motivation as "*hypothetical construct used to describe the internal and / or external forces producing the initiation, direction, intensity and persistence of behavior*"; which gives an idea about the wide broad that covers the concept of motivation. Therefore researchers in their studies approach motivation by working on the narrower more precise concept of motive.

A motive is a need or desire that stimulates and directs behavior towards a goal that is expected to be satisfied. For example, going to the gym can have different motives: interest in workout, want to be in shape and to have healthy body, willingness to impress someone, desire to escape the anxiety associated to overweight, etc. It pushes you to take action to achieve your goal. Two people could produce exactly the same behavior with very different motives. Several theories have been proposed to explain the range of motives that push humans and animals to act. Some focus on physiological needs (Water, food, sleep ...), others on superior needs and social motives such as the need for success. The theory of the hierarchy of needs of Maslow (1943) [19] covers all these needs. This theory gives an overview of human motives, from the most elementary to the noblest.

Among contemporary motivation theories, the theory of self-determination [20], which is based on the existence of two types of motivation (intrinsic vs extrinsic), each leading to different behaviors.

Intrinsic motivation. Intrinsic motivation characterizes individuals who practice an activity for self-interest, pleasure and satisfaction [20]. Intrinsic motivation is characterized by an internal locus of control to meet individual needs for competence and self-determination. The motives for these behaviors have an internal origin. For example, you study because the subject interests you or you eat because you're hungry.

Extrinsic motivation. Extrinsic motivations are linked to the interests of an individual to an activity with external tending causal locus, largely directed by external factors (rewards, obligations, pressure, etc.) [20]. The feeling of self-determination then decreases according to whether the individual loses control over the regulation of his behavior. The motives here have an external origin. For example, you study to have good grade or to avoid having bad one.

2.2 Motivation theories

It's generally accepted in contemporary psychology that no instinct really motivates human behavior. In fact, most recognize that biological forces imply human motivation. Moreover, others identify social motives as additional drives that guide and direct human behavior. Unlike the primary drive, social motives are learned: they are acquired through experience and interaction with others, for example: achievement, affiliation, curiosity …etc.

Biological approaches.

Drive reduction theory. Theory of motivation that proposes: a need generates a drive that the organism is motivated to reduce [21]. A *drive* is an internal state of activation or tension generated by an underlying need that the organism is motivated to satisfy. This theory is based on the concept of homeostasis, according to which the organism tends to maintain a state of internal equilibrium essential to its survival (body temperature, glucose level, oxygen level, blood pressure ...). For example, a need to drink or eat disturbs the internal equilibrium, which gives rise to a drive that forces the organism to act to reduce tension by satisfying this need and restoring the state of internal equilibrium.

Arousal theory. This theory claims that an organism is motivated to maintain an *optimal level of arousal*. If the arousal level goes down under an optimal level, we look for increasing it and if it goes over that level, we try to decrease the arousal. If the arousal level is very low, *stimulation motives* push us to increase the arousal level. Stimulation motives refer to processes like: curiosity, exploration desire, playing, and object manipulation. Term arousal level refers to the degree of activity of the organism in a continuum that ranges from sleep to stress through various degrees of awakening, alertness and alertness. Stimulus with high intensity (like high noise, flashing lights…), stimulants (like caffeine, nicotine, cocaine …), emotions (like anger, joy, surprise ...) or biological needs increase the arousal level. According to law Yerkes Dodson [22-24], there is a relationship between the arousal level and performance by attention and concentration, but only up to a point. A task is accomplished more efficiently when the arousal level suites the degree of difficulty: simple and routine tasks requiring a relatively high arousal level (to increase motivation); the moderately difficult tasks ask an average level of arousal and difficult and complex task, ask a lower arousal level (to facilitate concentration).

Personality and social motives approaches.

Achievement Motivation theory. The achievement need is an important dimension of human motivation; it is a desire to accomplish something difficult, and to excel in it. This need is influenced by internal drive for action (intrinsic motivation), and the pressure exerted by the expectations of others (extrinsic motivation). According to Henry Murray (1938) [25], this need is particular since the more success is made, the more the person is motivated to make more achievements. According to researchers [26-28], achievement-motivated people set ambitious but nevertheless realistic and achievable goals.

For these people, easy-to-reach goals are irrelevant because the easily attained success is not a genuine achievement. On the other hand, they avoid setting unrealistic goals and taking risks too high, which would be a waste of time. According to other research [29], low achiever people take no risk since they are motivated by the fear of failure rather than by the success possibilities. Their goals are either very easy to make or very difficult so they are not embarrassed by the failure.

Goal orientation theory. According to the goal orientation theory, the motivation to succeed varies depending on whether the goal is one of mastery (goal defined according to self) or performance (goal defined by comparison with others), and according to whether it aims at Approach (get something nice) or avoidance (avoid something unpleasant). This theory distinguishes **four goal orientations**: (i) *mastery-approach* where individuals seek to achieve mastery or self-improvement, (ii) *master-avoidance* where individuals seek to avoid failing achievement of a task mastery, (iii) *performance-approach* where the main focus is for individuals to accomplish and outperform others, and (iv) *performance-avoidance* where one seeks to avoid doing worse than others in given tasks [2, 16, 30].

2.3 Motivation and video games

Looking at how users are engaged in playing with intrinsically motivating games, Malone (1981) [31] has been interested in studying the theory behind intrinsically motivating learning, or learning to which the individual engages without Motivation (rewards or punishments). He describes the characteristics of environments that make them intrinsically motivating, with individual motivations such as challenge, fantasy, curiosity and control [32]. These characteristics can be considered as theories on how to make learning fun [33]. In more recent research [34, 35] Przybylski, Rigby and Ryan identified two other motivational factors associated with games, autonomy and competence, originating from self-determination theory [20]. Games with motivating experience can be explained by the concept of flow [36], a term invented by Csikszentmihalyi to describe a condition in which a person experiences a challenge that extends its competences without being too difficult nor too easy (engaging in an appropriate level of challenge depending on the player's skill) and have clear objectives and immediate feedback on progress [11]. In his book “A Theory of Fun for Game Design” [37], the game developer Ralph Koster stressed out the importance of integrating psychological theories in game design. Additional study [38] on MMORPG games, finds that factors addressed by extrinsic motivation theories (rewards) and intrinsic motivation (exploration, social needs, competence and mastery) contribute to players game enjoy. These findings actually provide some evidence supporting that intrinsic and extrinsic motivations are a false dichotomy.

3 Experimental settings

3.1 Participants

This study involves 21 participants (12 males; 9 female), aged between 18 and 35 years from a North American university. We have discarded 2 participants due to technical problem while collecting data. The players were categorized according to hours of play per week (5 extreme players, 6 intermediates and 8 novices).

3.2 The game - Outlast

In this study, participants were asked to play the first level of a horror commercial game named *Outlast* (developed by Red Barrels Games). This first-person game takes the player in a horrifying hospital full of dead bodies and monsters. The player takes the role of an investigative reporter that gathers evidences against the *Murkoff Corporation* who made horrible experiments on mental patients in the hospital. The only means of survival are to flee the enemies or to hide from them, the player cannot attack them. This genre of games stimulates the player's emotional reactions and his approach/avoidance motivation.

3.3 Experiment and equipment

The Experiment begins by receiving the participant in our laboratory; we introduce him to the testing room. To avoid interferences with the equipment, the participant was invited to turn off his phone. The participant signs a consent form to register his experiment agreement. After installing the EEG and EDA (Electro-dermal activity) sensors on the participant, the researcher checks the webcam recording the user's face and the eye-tracker calibration. The experiment Design was conducted in the platform iMotions that allows the multimodal synchronization of different sensors. By clicking the start button, iMotions platform launches the data recording and the game where the participant plays the first level.

3.4 Measures

Because of the complexity of the motivation concept and its components, it is difficult to measure motivation. Different studies have used several methods, subjective or objective, in order to evaluate the motivation.

Subjective measures. We have used questionnaires before and after the play session to get the users information and their game evaluations. We first gave pre-test questionnaires to collect socio-demographic data and the player's profile (school level, their preferred games and hours of play per week) and also the "Big Five" questionnaire [39] for the assessment of the participant's personality traits (openness, neuroticism, extraversion, agreeableness and conscientiousness). In the post-test, we used the immersion and flow questionnaire. The questionnaire was adapted from the GameFlow questionnaire [40, 41]. These questionnaires are composed of Likert-type items where the answer is expressed on a scale between 1-"disagree at all" and 7-"completely agree". In addition, participants were asked to answer a final questionnaire about their emotions felt during stages of the game. In fact, post-test questionnaires can serve as an indicator of player's motivation. Since, improved motivation may bring improved performance of the player.

Objective measures. We believe that monitoring and analyzing objective measures like ocular and physiological signals is the most appropriate methodology for emotional and cognitive states recognition in the gaming context. We have collected multimodal data from the player's body and face to analyze his affective and mental state. In this study, we are using among these measures: EEG data to compute the *Frontal Alpha Asymmetry* (FAA) and eye-tracking data to detect the scenes visualization time and duration.

Frontal Alpha Asymmetry. The frontal asymmetry (FAA) is an unfiltered and unbiased phenomenon associated with emotion and motivation. Brain scientists have consistently found that higher engagement of the left compared to the right frontal brain is related to positive feelings and higher engagement [42]. Due to the inverse relationship between alpha power (8-12 Hz) and cortical activity, decreased alpha power reflects increased engagement. The special effect of the asymmetry in frontal alpha power was initially detected in studies investigating biomarkers of personality [43].

While this "emotional" effect was found to be indicative of a personality trait (supposed to be very stable across the life span), recent evidence suggests that it also varies depending on emotional stimulation, reflecting whether or not someone is drawn towards or away from something or someone. In short, this "approach/avoidance effect" reflects someone's motivation [44].

Eye-tracking analysis. For each participant, we annotated his play-session by defining Areas of Interest (AOI). The AOIs refer to the game stages/scenes. Through the game, a participant may take different duration for the different game scene. We used the software iMotions to replay and annotate chronologically the participants' game session. The annotation allows the software to compute the gaze statistics by AOI. Using hit time and the time spent metrics, we identified the time and duration that the player spent for each scene.

4 Method

Thus, we performed a multimodal analysis using several sources of information to determine the level of affective reactions of the players. We used several sources of information such as: questionnaires, eye tracking and EEG physiological data. This require the use of statistical analyzes and AI techniques for the selection and extraction of characteristics and the construction of the player's motivational model.

The EEG headset consists of 14 data-collecting electrodes and 2 reference electrodes, located and labeled according to the international 10-20 system. The participant's EEG data was calibrated using his neutral state of mind when looking at gray screen for 6 seconds which is considered as our baseline period.

4.1 The FAA computation

The frontal asymmetry index was computed from raw frontal EEG data using electrodes F3/F7 and F4/F8 (see Fig.1). We calculated FAA by following the steps below:

- Preprocess the data to attenuate artifacts (eye blink and muscle artifacts) by applying an order 5 Butterworth filter between 0.5 and 50Hz.
- Epoch the baseline-corrected data. In this step, the continuous data was broken into smaller parts of 2 seconds epoch [45] (with 75% overlap). For each epoch, we compute the Alpha Power using the library PyEEG[1](a python module to extract

[1] http://pyeeg.sourceforge.net/

EEG features). Using Fourier frequency analysis, the original signal is split up in frequencies in order to remove specific frequencies, before transforming back the signal with only the frequencies of interest.

- Average the Alpha power across all of the artifact-free epochs of the baseline and game scenes signal.
- Compute the normalized FAA as the log of the difference between alpha power density of the right hemisphere and the left hemisphere divided by their sum.

$$FAA = \log(\frac{Alpha\ Power_{Right} - Alpha\ Power_{Left}}{Alpha\ Power_{Right} + Alpha\ Power_{Left}})$$

Higher scores on this asymmetry index indicate greater relative left hemisphere activation which means that the scenes' motivation is APPROACH oriented otherwise it is AVOIDANCE oriented.

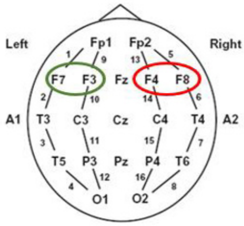

Fig. 1. Used EEG sensors in the FAA calculation

4.2 Player mastery goal assessment

To characterize the player category (Master or Performant), we identified the performance question in the 'Immersion-Game experience' survey (see Table 1). We categorized the player's achievement goal as Master if:

*Average(Mastery) >= 1.5*Average(Performance).*

We fixed the "1.5" threshold by checking information related to the preferred games, the play time per week and the GPA in the demographic self-report which is matching with the participants' report of 'immersion-Game experience' survey.

Table 1. Achievement goal related questions from the 'Immersion-Game experience' survey

Achievement goal	Questions
Mastery	I would have liked to succeed in the game.
Mastery	I wanted to replay the game despite the failures.
Mastery	I feel satisfied when I see that the game is progressing.
Performance	Winning or losing the game did not interest me. I was not interested in the outcome of the game (win or lose).
Mastery	At the end of the session, I regretted not being able to continue the game.

Performance	The level of the challenge of the game corresponded to my skills as a player.
Mastery	I try to play as best as I can to win the game.
Performance	Sometimes I wanted to give up because the level of difficulty was too high.
Performance	The actions to be performed were becoming more and more difficult as I progressed through the game.
Mastery	The game was easy to win.
Performance	I think I made some progress at the end of the session compared to the beginning.
Mastery	The more I progressed in the game, the more I got interesting rewards (number of fans, bonuses, new weapons, new abilities, medals ...).
Performance	Sometimes I would have wanted to change the keys used to better control the game.
Mastery	I would like to replay this game.

4.3 OCC game scene representation

To predict the player motivation for new game scenes, we need first to characterize the game scenes according to the designer perception and goals using variables from OCC model [17]. The OCC model evaluates a situation with descriptive variables (global, central and local variables). These cognitive variables characterize a person's interpretation of a situation as desirable or undesirable, expected or unexpected, etc. Global variables are included in all situations, whereas the central and local variables are specific to certain situations characterizing their informational content.

Table 2. Global, central and local variables and their associated values

	Global variables		Central variables			Local variables										
Evaluation Variable	Surprise	Sense of reality	Desirability	Approval	Attraction	Desirability by other	Esteem for other	Merit for other	Likelihood	Realization	Effort	Agent	Power of the link	Deviation	Disposition	Familiarity
Values	0 (False) or 1 (True)	0 (False) or 1 (True)	-1, -0.5, 0, 0.5, 1	-1, -0.5, 0, 0.5, 1	-1, -0.5, 0, 0.5, 1	-1, -0.5, 0, 0.5, 1	-1, -0.5, 0, 0.5, 1	-1, -0.5, 0, 0.5, 1	-1, -0.5, 0, 0.5, 1	-1, -0.5, 0, 0.5, 1	-1, -0.5, 0, 0.5, 1	0 (other) or 1 (self)	0, 0.5, 1	-1, -0.5, 0, 0.5, 1	0, 0.5, 1	-1, -0.5, 0, 0.5, 1

In the table above (see Table 2), we summarized the OCC variables and their possible values. Thus, we can formally represent a game scene with vector of 16 numerical values. Thanks to its generality, The OCC model representation of the scene remains applicable to game scenes for learning or entertainment purposes.

4.4 The Motivation Prediction

In this section we describe our approach to training and evaluating classifiers for the task of detecting the motivational state of mind of a person given the person's cognitive situation in game, personal and demographical data. We approach this problem as a 4-class classification problem.

Features extraction. We perform a feature selection over the feature vector by extracting features using Principal Component Analysis (PCA) and Univariate feature selection (Univariate feature selection examines each feature individually to determine the strength of the relationship of the feature with the response variable). Then we combine the results through a pipeline into a single transformer. The 10-fold Cross validation method allowed to train and validate our model with better generalization.

Training set construction. In order to train a scene's motivation predictive model, we used a training set containing scene descriptions, participant's sociodemographic information and personality traits and also the participant's mastery goal and his approach related behavior in the game scene (Performant/Master-Approach/Avoidance). That we determined through the combination of the FAA computation section above and the categorization of the players we present above. The model use 23-dimensions vector: 16 variables from the OCC model, 2 socio-demographic variables (gender, age), 5 personality trait values as **input** variables and the motivational goal orientations as the **output result**. The method has been developed with Python language and scikit-learn[2] library. We have trained and validated our model using the 10-fold Cross validation method. We are interested in inducing a classifier of the following form:

– MotivationClassifier(*Playerdata*)→[Performant-Approach, Performant-Avoidance, Master-Approach, Master-Avoidance]

Where "*Playerdata*" is the 23-dimension vector presented above [*Performant-Approach, Performant-Avoidance, Master-Approach, Master-Avoidance*] is the sets of motivational states to be discriminated. The dataset contains 245 examples distributed over the 4 classes as follow Performant-Avoidance: 66/245 – 26%, Performant-Approach: 52/245 – 21%, Master-Avoidance: 71/245 – 28%, Master-Approach: 55/245 – 22%. Thus if a classifier always predict the most present class which is Master-Avoidance it will get 28% of precision that will be considered as our baseline.

[2] http://scikit-learn.org/stable/

5 Results

In this approach, we evaluated classifier by performing the standard 10-fold cross validation in which 10% of the training set is held out in turn as test data while the remaining 90% is used as training data. The optimum parameters for the classifier were found with a grid search.

Table 3. the classifiers F-score and parameters

CLASSIFIER	F1-Score (parameters)
RFC	**81%** (PCA = 3, Univ=10, n_estim = 10)
SVM	**75%** (PCA=15, Univ=10, Kernel ='linear', C=1.0, gamma= 0.04)
KNN	**73%** (PCA=3, Univ=2, k=70)

Compared to KNN and SVM methods, Random Forest achieves the best performance with the average accuracy of 81% for all goal orientations classes, as illustrated in Table 3.

The confusion matrix of Random Forest is shown in Figure 2, which gives details of the strength and weakness of the generated model. Each row of the confusion matrix represents the target class and each column represents the predicted class. The element (i, j) is the percentage of samples in class i that is classified as class j. We can see that the goal orientations are generally recognized with very high accuracy of near ninety percent. The model differentiates between Mastery and Performance classes. But it makes some errors in recognizing whether it is Performance-Avoidance or Performance-Approach and also fewer errors between Mastery-Avoidance and Mastery-Approach.

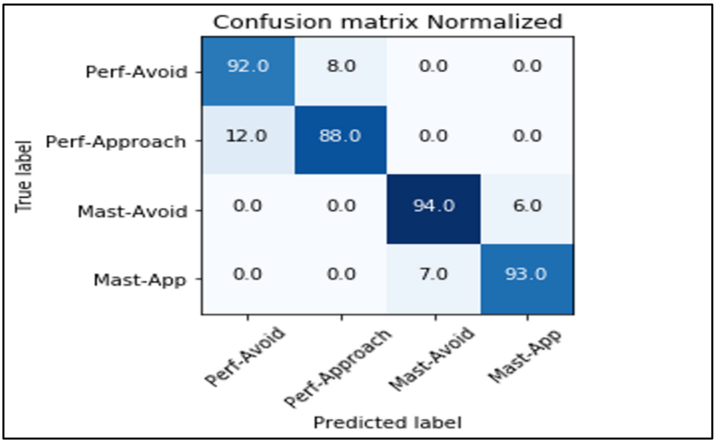

Fig. 2. Confusion matrix of the motivational goal orientations prediction with RFC

With these results, our motivation prediction approach provides a simple and reliable way to predict the motivational goal orientations of the learner/player that can be

implemented in a distant game environment. The resulting model predicts the learner /player's goal orientations from only the game scene's OCC representation and the Big Five result without using invasive technique (physiological sensors, EEG, etc.).
Additionally, based on this assessment, we can make adaptations in the environment according to learner's motivation. In fact, Kaplan and Maehr [46] made comparison between aspects of educational environments (Task, Authority, Recognition, Grouping, Evaluation and Time) in mastery goals Vs performance goals emphasizing environments. For example, these environment aspects can be modified based on this assessment to foster learner's motivation. Moreover, based on the model of motivated action theory [47], Goal orientations describe a profile of structured hierarchies of goals that lead to the learner/player's specific action plan goals (Seek feedback, Manage impression, Allocate resources and Explore problem). Using this predicted player's actions, the adaptation strategies can modify the environment by providing hints, messages, feedbacks, rewards or changing the problem difficulty.

6 Conclusion

In this paper, we assessed players' motivational goal orientations in their interaction with the commercial game "Outlast" using game scene's design goals, player characteristics, EEG and eye-tracking data. We presented our method in categorizing the player as "Master" or "Performant" using the GameFlow questionnaire. We also assessed the Approach withdrawal behavior toward a visualized game scene using the Frontal Alpha Asymmetry (FAA) during time window calculated from eye tracking data. We have also built a machine learning model for predicting player's motivational goal orientation using game scene's design goal (defined by OCC variables) and the player's personality traits (using the Big Five questionnaire).

The obtained results are very promising for their future integration in a motivationally intelligent serious game. This integration would clearly contribute to learning since it combines the game scene's design objectives to the learner/player's motivation. Furthermore, a practical real-time non-invasive assessment of learners' motivation is now feasible, since we can rely on this assessment as a substitute for self-reports that can disturb a learning/gaming session. Moreover, the system can become more adaptive in terms of its response to learner's motivation within the game scenes. In further work, we will target the learner's reported emotions in the prediction which would contribute to more comprehensive models of learner/player affect.

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