028765
FUGA
The fun of gaming: Measuring the human experience of media enjoyment

STREP / NEST-PATH

PUBLISHABLE FINAL ACTIVITY REPORT

Title of Contract	**FUGA - The fun of gaming: Measuring the human experience of media enjoyment**
Acronym	**FUGA**
Contract Number	**NEST-PATH-028765**
Start date of the project	**1.5.2006**
Duration	**36 months, until 30.4.2009**
Reporting period	**May 2006 – April 2009**
Date of preparation	**15.5.2009**
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Partners:

Partner 1 (CKIR)	FI
Partner 2 (TKK)	FI
Partner 3 (HGO)	SE
Partner 4 (HMTH)	DE
Partner 5 (UKA)	DE
Partner 6 (TUE)	NL

Project funded by the European Community under the FP6
New and Emerging Science and Technology (NEST) programme.

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Digital (e.g., computer and console) games have emerged as one of the most popular forms of mass mediated entertainment in many countries among a range of people. In addition to entertainment, digital games are more and more used for therapeutic, educational, and work-related purposes. However, there are no established methods to measure dynamically changing gaming experience. Being able to measure Game Experience during game play with high temporal resolution will be very important from the perspective of game designers, media psychologists, and those who are concerned with the potential adverse effects of games.

Project Objectives

The main objective of FUGA was to create novel methods and improve existing measures in order to examine how the different dimensions of Game Experience can be assessed comprehensively with high temporal resolution. FUGA employed a broad variety of innovative techniques based on (a) laboratory and mobile psychophysiological recordings (e.g., facial electromyography [EMG], electroencephalography [EEG], electrocardiography [ECG], and electrodermal activity [EDA]), (b) functional magnetic resonance imaging (fMRI), (c) eye movement recordings, (d) the so-called (online) implicit association test (IAT), and (e) tracking of behavioral indicators of emotion and motivation. An important objective of FUGA was to establish the construct validity, reliability, and predictive validity of the different Game Experience measures. A further objective was to develop a prototype of an emotionally adaptive game that dynamically changes its behavior based on the player's emotional state as indexed by psychophysiological measures.

Figure 1. A mobile physiological data acquisition system (Varioport-B) used to study psychophysiological responses during mobile gaming.

Contractors Involved

Chaired by Center for Knowledge and Innovation Research, Helsinki School of Economics (FIN), six top-class European research partners, including Helsinki Institute for Information Technology (FIN), Gotland University (SWE), Hannover University of Music and Drama (GER), University of Aachen (GER), and Eindhoven University of Technology (NL), cooperate to achieve the objective of FUGA.

Main Activities and Results

In Workpackage 2 (Theoretical Foundations), as the first step of the project, the project partners elaborated a multidimensional model of Game Experience. Overall, the complex combination of cognitive, affective, and (virtual) behavioral responses to digital games that manifest in different modes of enjoyment (which consist of interplays between subprocesses of action/performance, narrative/drama, and media-form/world-representation) is assumed to be affected by interindividual and intra-individual differences in players' motivation, players' processing of game events, and players' actual performance. Personological/stable and situational/variable factors thus interact with the actual game features (e.g., task settings, narrative and drama settings, sensory immersion etc.) and represent important elements of the generalized equation of video game enjoyment (see Figure 2). The project partners also elaborated the theoretical linkages between the identified dimensions of Game Experience and the different measures that have been used in FUGA. This work provided the foundation for the empirical studies.

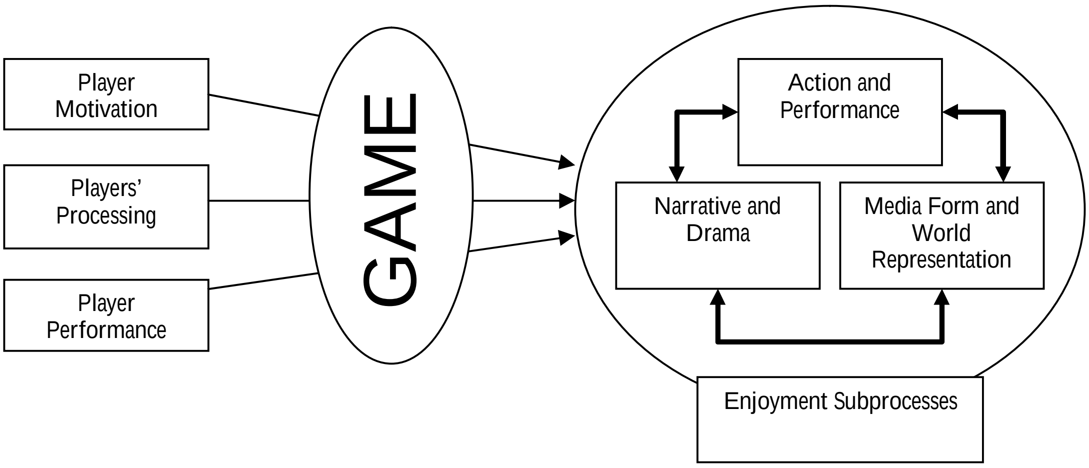

Figure 2. A proposal for a general model of video game enjoyment.

In Workpackage 3 (Planning and Preparation of Empirical Studies), the project partners planned the details of the empirical studies and completed extensive methodological preparations. They also developed novel measurements (e.g., IAT-based procedure) and modified existing methods (e.g., Think Aloud) to suit the project's goals and requirements. Planning of stimulus games resulted in several different game levels based on Half-Life 2 (see Figure 3). The game levels were implemented in Workpackage 4 (Stimulus/Game Development). Among other things, the game levels were designed to examine (a) the influence of the facial expression (smile or frown) of the non-player character (NPC) in connection with a task requiring the player either to kill or rescue the NPC (depending on whether the NPC was presented as a spy or an ally), (b) phasic psychophysiological responses to specific in-game events, (c) tonic responses to different types of play, and (d) the flow experience. In Workpackage 4, in addition to stimulus games, prototypes of emotionally adaptive games were developed. As a first step, a platform for emotional adaptation (Emoengine) that is based on the Varioport-B physiological data collection system was created. The implemented game prototypes were EMOTetris, an emotionally adaptive Tetris variation, and EMOShooter, a FPS game with several different adaptations based on psychophysiological signals.

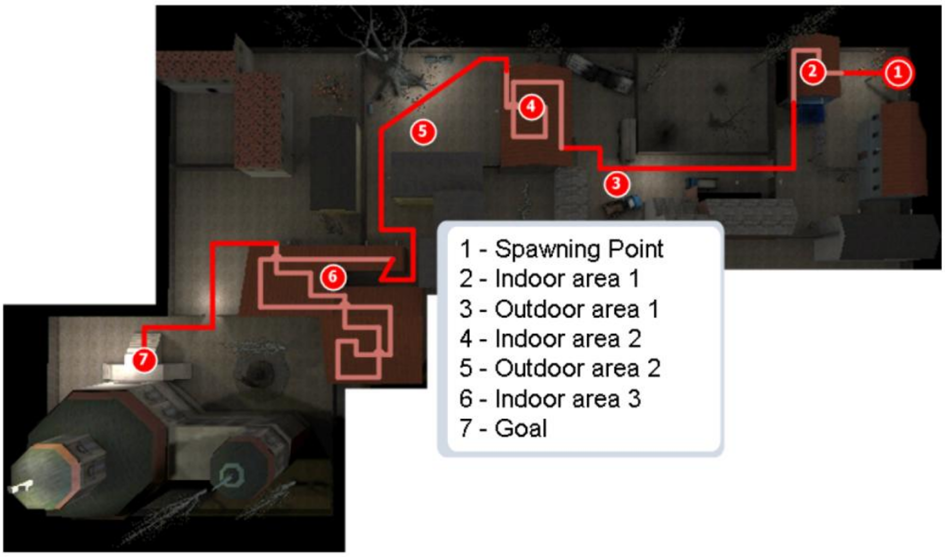

Figure 3. In the project, a modification of a commercial game was created. Presented here, *Secret corridors* was the level developed for an immersive experience of roughly 10 min duration.

The Game Experience Questionnaire (GEQ) was also developed. The core GEQ includes seven factors: (a) Imaginative and sensory immersion, (b) Competence, (c) Flow, (d) Tension, (e) Positive affect - fun & enjoyment, (f) Negative affect, and (g) Challenge/Suspense. The short version of the core GEQ was developed for measuring game experience in connection with in-game events. For social (multi-player) games, the GEQ includes also three social presence components: (a) Psychological involvement – empathy, (b) Psychological involvement - negative feelings, and (c) Behavioral involvement. In addition, the instrument includes four post-game experience components: (a) Positive experience, (b) Tiredness, (c) Negative experiences, and (d) Returning to reality. The GEQ was originally developed in two languages, English and Dutch, followed by Swedish, Finnish, and German versions of the instrument. The GEQ was found to be sensitive to pick up differences in difficulty level, for example. The three most relevant GEQ dimensions – challenge, negative affect, and tension – showed differences in the expected direction.

In Workpackage 5 (Construct Validity Studies), the project partners carried out a large number of experiments to validate different measures of game experience based on psychophysiological recordings, fMRI, behavioural measurements, and implicit measures of game-related cognitions. These experiments established the validity of many (but not all) of the measures used. Psychophysiological measures turned out to be, first and foremost, measures of emotional processes during game play. In general, they were not related to the other dimensions of Game Experience. The association of psychophysiological measures with emotions is in agreement with the results of psychological basic research on emotions. However, as opposed to those previous studies mostly using static emotional stimuli, the FUGA studies showed that psychophysiological measures were measures of emotional processes during a dynamic flow of events and action (i.e., game playing). Of the psychophysiological measures, particularly facial electromyographic (EMG) activity over zygomaticus major, corrugator supercilii, and orbicularis oculi were associated with positive and negative emotions during game playing. The relationship of EDA with emotional arousal was not conclusively established.

The association of frontal EEG asymmetry with self-reported emotional valence during game playing was in the opposite direction to that predicted. This appears to suggest that games eliciting strong withdrawal motivation are retrospectively assessed as pleasant. Frontal EEG asymmetry was also associated with other dimensions of Game Experience. No significant differences were found between psychophysiological responses elicited in the laboratory and home playing contexts, which supports the validity of laboratory studies. The FUGA studies did not only establish the validity of the different measures, but also addressed some interesting theoretical issues. For example, gender differences were found in the emotional responses to collaborative and competitive game playing. Men exhibited more positive facial EMG responses to competition compared to collaboration, whereas among women, there were no differences.

Figure 4. EEG measurement while a participant is playing a video game.

The fMRI experiments showed that it is possible to identify specific brain activity patterns that correlate not only with game play events but also with derived constructs, such as the flow dimensions. The findings were validated by, for example, neuroanatomical evidence and correlation with findings from the questionnaires (e.g., GEQ) and game selection. The results indicate that game and flow experience are neurobiologically not unitary but significant dimensions can be assigned to neural networks. We have to consider the reward system for success and failure events, limbic structures for pleasant and unpleasant experience, orbitofrontal for affect, and higher order cortical structures, such as the temporal pole, for modulation of the game experience. In particular, fMRI provides an opportunity to move from a pure descriptive to a more understanding description of human gaming behavior.

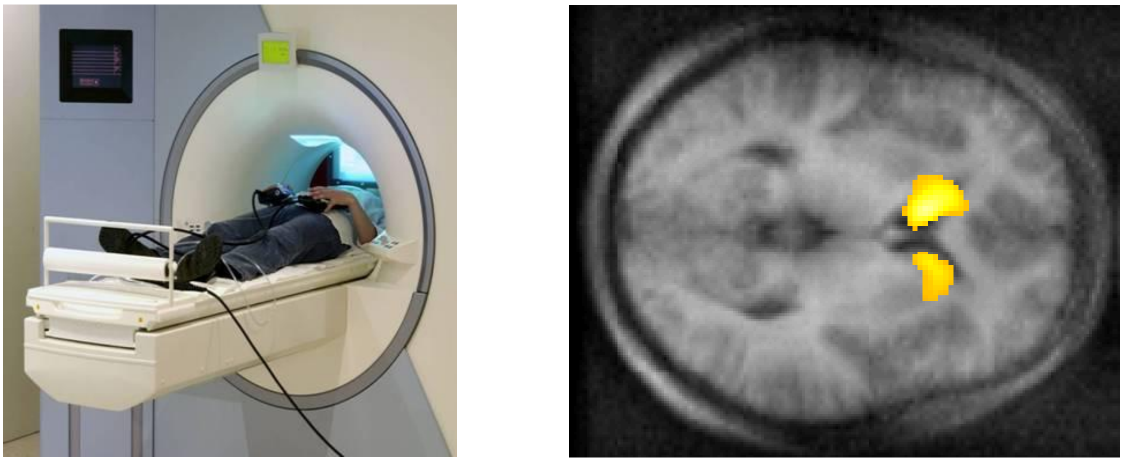

Figure 5. Subject during functional measurements in an MR tomography (left panel). MR compatible stimulus equipment delivers visual and auditory game stimuli; MR compatible input devices are used for game control. Neural correlates of game failure (right panel). Failure events lead to a deactivation of the caudate nucleus, indicating that a tonic activation of the brain reward system is interrupted when the subject fails in the game.

In a series of studies, several implicit measures of video game identification and self-esteem were also examined. The studies showed that several candidate measures of video game identification (EAST, AMP, LDT, SDT) failed to show adequate psychometric properties. However, the standard implicit association test (IAT) was found to be a valid and robust measure of identification. Although being successful in a game is clearly connected to the enjoyment of playing, domain-specific dimensions of self-worth may operate in the psychological system underlying player performance and game enjoyment. That being the case, the implicit measures of self-esteem may be too broad and not specific enough to uncover those mechanisms. Although the methodological objective of defining a solid implicit measurement approach to player state self-esteem could not be achieved, the line of experiments increased our understanding of the complex mechanisms behind player performance and self-esteem. In general, the FUGA studies demonstrated that intuitive, spontaneous, automatic responses are involved in players' information processing during game play, automatic cognitions being part of the game enjoyment phenomenon. The behavioral measures used in FUGA (e.g., observational coding of player behavior, automatically captured behavioral measures) showed that behavior was most pronounced in the in the most difficult game level.

In Workpackage 6, the reliability studies showed that test-retest reliabilities for the psychophysiological measures were mostly high. Test-retest reliability coefficients were excellent for corrugator supercilii EMG measurements and EDA both when using absolute values and delta scores. Test-retest reliability was lower, but still quite high, for orbicularis oculi EMG responses when using delta scores. Test-retest reliabilities for the self-report measures were, in general, moderate to high; temporal stability was particularly high for valence ratings, the GEQ dimensions, and FlowGrid. Intrasession reliabilities varied strongly for the different measures, but were highest for EDA. Many condition effects on psychophysiological, self-report, and automatic behavioral measures found in the first (construct validity) experiments were also replicated in the reliability experiments.

The FUGA partners also examined the predictive validity of the different Game Experience measures. Psychophysiological measurements, particularly EDA and orbicularis oculi EMG activity, obtained when playing digital games in the laboratory were found to be predictive of actual playing behavior (e.g., total playing time, frequency of playing sessions, game choice) during a 3-week follow-up period. Likewise, they predicted free 1-hour game playing immediately after the laboratory session. Psychophysiological measures were stronger predictors of subsequent game playing behavior compared to self-report measures. This is important information for game developers and supports the idea of using psychophysiological measures when pretesting different versions of digital games.

Overall, the scientific output of the FUGA project is remarkable. Video game enjoyment, a concept that has become increasingly important to various disciplines and is connected to many domains of academic and applied research, is now, after three years of multidisciplinary inquiry, understood much better than before. FUGA has advanced the science of media experiences significantly. Aside of conceptual progress, the project's main goal, exploring and defining measurement tools that enable research and business communities to deal with the empirical assessment of game enjoyment more effectively, has also been achieved. FUGA has generated substantial methodological knowledge that can be used in various scenarios and contexts. The innovative measurement approach provided by FUGA can be applied when designing new digital games for different purposes (e.g., entertainment, education, therapy). Superior tools to measure game products' entertainment value will support European game companies to design games that suit customer requirements most precisely, which will be a unique advantage in the extremely competitive digital game markets of the world.

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FUGA - Fun of Gaming

2. Dissemination and use

In the FUGA project, the project partners have developed measures and methodologies for testing digital games. They have also created research designs and paradigms that can be used in game research in the future. Research on the measurement of game experience has significantly been advanced by the knowledge created in the FUGA project. In general, this knowledge is procedural in nature, thereby being incompatible with conventional IPR measures. Potential commercial exploitation of the knowledge could take place in the form of consulting to the gaming industry and/or licensing of the technology and know-how. In the future, the methodological approach developed in FUGA can be expected to be adopted by European game companies. However, although the established methodology is basically exploitable as is, further practical improvements and scientific validation work with some of the measures are needed before such exploitation would be expected to be commercially successful.

The FUGA partner TKK/HIIT has also successfully developed two emotionally adaptive game prototypes in the project. The tests of the prototypes with end-users have produced a lot of insight on the use of biosignals in adaptive applications and new types of game interaction mechanisms. The prototype development work done in FUGA is continued in a new domestic (Finnish) research project entitled Emokeitai. There are four industrial partners in Emokeitai. Emokeitai is targeted to mobile gaming and social media domains. A new version of the game prototype will be introduced during 2010. TKK/HIIT is also developing new projects related to desktop and console gaming, which will utilize the FUGA prototypes.