

Visual attention in gameplay

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The State of Game Research

The emergence of computer game research and the shaping of a multidisciplinary academic field addressing games has encountered many doubts from politicians and staff members at traditional departments at education institutions and universities in Sweden. From its emergence at the end of the 1990's game research had a very strong Culture Studies emphasis, but slowly a trend is emerging towards more empirical studies. This movement has several apparent causes, including a lack of concrete outcomes as to how players are effected by different designs, the mental and emotional affect of gameplay, transference between a physical and digital world or vice versa, and low number of innovative game prototypes being created by the game research community. *Game studies* belongs within the broader field of Cultural Studies, describing what games are and how they are experienced from player and group perspectives, and how games and play fit within broader cultural reflections. However, this is primarily reflection without any systematic empirical validation. In a search for more empirically grounded methods, it has become increasingly common to look at players and gameplay from *behavioural* and *social science* perspectives.

More recently, so called serious games have been gaining increasing attention. Serious games are not at all new, they have existed in fields outside the entertainment industry focus of most game research, while nevertheless having the same basis in digital simulation and interactive visualisation. For serious games, learning and the interaction patterns are a central question, since these represent the interesting skill outcomes of gameplay. Key questions in serious games are what skill-based knowledge is created by gameplay and how to make this explicit. Entertainment games are also learning environments; playing creates knowledge and it is important socially and politically for non-gamers and gamers alike to understand what this knowledge is in order to be able to validly debate its value.

The field of game research today has therefore expanded with no single approach; the need for a single approach can be said to be weak or may be an impossibility since the subject is multidisciplinary and therefore impossible to approach from one perspective. Game studies have to be supported by different scientific fields to feed into the core content of what is asked in relation to games. We have Literature Science, Rhetoric, Science of Communication, Mathematics, Artificial Intelligence, Art, Animation, Modeling, Physics, Psychology, Cognition, Language, Linguistics, Image Processing... all these different takes on games, their interpretation and/or their investigation have different relevance depending on what about games is being studied. The methodology developed within my PhD project aims to satisfy criteria derived from the needs of game development education programs and the commercial game industry, in addition to the need to establish strong foundations and credibility for the subject as an academic field as discussed above.

Education programs

To create game development education programs focused on the content of how to build games has been a challenging international task due to the lack of established methods, models, theories and content. To shape game programs is to consolidate the knowledge per se but it also demands that people, teaching staff, want to build up the subject as such and to fight for its legitimacy. It is not just the staff but that head of departments, managements, principles, and faculty boards that have to understand the complexity of a game development program and have an understanding what resources it takes. The lack of comprehension by leaders of different kinds together with the complexity of the subject can create devastating situations for staff and students. The devastation can show in the lack of awareness of how a field with rapid technological development has to have people with high expertise in both software and hardware, and how these are used and can support innovation in the specific context of game development. Innovation is not just the use of 'off the shelf' products; innovations are made where ideas go further than established practice and specialist knowledge is developed and nurtured.

From the needs of educational programs, the following criteria for a research paradigm may be identified:

- Strong theory and methods that facilitate education in game development practice. Education program content should benefit from research in being able to provide more than just training in well-established development methods.
- Methodologies that have rigour and outcomes comparable with those of highly respected and established academic fields

Industry

The existing game industries have an interest in research with practical outcomes and therefore fields having practical outcomes should be prioritized in research if we want to have impact and influence in industrial development. If we look at the military, medicine, and aviation fields, all have had a great exchange between industry and academia in research and development leading to operational innovations. A similar relationship should be possible in a mature relationship between academic game research and the commercial game industry, if the academic game research community is conducting relevant research and if the industry is mature enough to recognize and relate to the research process. In addition, the Serious Games field is important in diversifying opportunities for existing and new game development companies and reducing the dependency on any single sector such as the entertainment computer game sector.

From the needs of the game development, the following criteria for a research paradigm may therefore be identified:

- Research outcomes should contribute directly to improving industry development methods and opportunities.

- Research outcomes should contribute to the diversification of game development to provide applications meeting the needs of diverse industry sectors (i.e. serious game in addition to entertainment games)

Summary of the PhD Project

My PhD project “Psychophysiology, Semiotics and Game Design” began with the aim of shaping a method by which gameplay could be investigated from both a qualitative and quantitative aspect in high resolution with a particular view to interrelate different data sets to see how they differ or share similarities. Hence the main emphasis has been to approach games and game research from a different angle from the dominant focus on cultural studies and sociological approaches.

The goal has been to investigate whether the affordances of more empirical game research add concrete outcomes answering questions such as: how game design can depend on patterns of player perception and awareness during play, what effect on players do design features have in terms of emotional experience and cognitive learning, how can gameplay be changed to take advantage of biometric data as input to the game mechanics, how can new gameplay concepts be based upon similarities, differences and transfer between virtual and physical game worlds, and how can this knowledge lead to innovative prototypes that can be tested and discussed in concrete critical discussions. The innovations are not just for entertainment and training but can also be tools for handicapped people as well as for people performing more physically via a so called *performative interactor* or a *provoking opponent interactor*.

In response to the educational and industry criteria suggested above, the project has become focused upon the following elements:

- The adoption of theories and methodological tools from cognitive science
- A prioritization of empirical methods of investigation
- A focus upon the impact of game design features on the behavior and cognitive processes involved in gameplay
- A particular focus on eyetracking studies of the visual cognition processes involved in gameplay and how these are influenced by the design of game features such as spatial layout and the nature and distribution of game challenges in relation to player goals

The main theories of concern are visual attention theory (task relevant looking), learning theory and cognitive psychology, all different subfields of cognitive science. Cognitive science is not a stand-alone-answer but a foundational perspective for being able to interpret structures of meaning (semiotics), design issues (game design or interaction design), reactions and responses to phenomena (subjectively and physiologically) in gameplay.

Method

The method adopted, at a generic level, is to seek theories in association with validating empirical criteria, as follows. *Construct validity*: how can we claim that a measurement is valid? Construct validity refers to the degree to which experimental variables can match a certain theory and the distinctions within the theory in order to form a coherent whole. *Reliability*: the quality and repeatability of measurements. Reliability must take account of learning effects when a person is doing an experiment test twice. Repeatability is assessed among different groups independently of each other. *Predictability*: the ability to forecast of a system state and how it operates quantitatively or qualitatively

Empirical techniques and their apparatus

The empirical goal is to be able to measure gameplay activity in order to validate theories of how gameplay is generated in relation to specific tasks and settings and how design choices make a difference to the player and what these differences mean. In pinning down how a game task is performed we seek to understand the formal, informal and skill-based knowledge involved and then correlate this with responses to questions and interviews to identify if any patterns occur or if there are any detectable tendencies of particular kinds.

The method I/we have developed is the interconnection of an eyetracker and a game engine to facilitate the analysis of visual cognition in gameplay. The Tobii 1750 eyetracker includes a computer screen with build in camera and diodes, and this is integrated with the HiFi simulation engine developed by the Swedish Defence Research Agency (FOI). The purpose of the interconnection is to enable real-time logging of gazed objects in a 3D game world. A gazed object in the 3D virtual game world is logged every 20ms with log data indicating the object's identity and its position. A verification study has been carried out, showing that the integrated system has 80% accuracy in spatial and temporal resolution and object discrimination (Sennersten et al, 2007)). With some minor and simple changes to the cursor graphic this could be increased to 90% for spatial accuracy.

The purpose of developing an empirical data acquisition system for player gaze distribution is to readily obtain quantitative data that can be cross-correlated with qualitative data obtained by questionnaires and interviews to see if there are any interesting relations (i.e. differences and/or similarities) between observed visual attention behavior and subjectively reported experience during gameplay. Testing specific hypothesis regarding visual attention and behavior require the definition of relevant variables that provide the basis for the implementation of a purpose-specific game level to function as an experimental stimulus. Real time logging is then run during game sessions while participants are playing.

Summary of results so far

It is not necessarily the case that quantitative and qualitative data reveal the same behaviors, as discovered by Sennersten (2004). In that study, players said in the questionnaire that their visual attention was directed towards the representation of the face region of NPCs (non-player characters) when entering a room to rescue a hostage, but the measured data revealed that 90% of the participants

actually directed their gaze towards the hands. A plausible hypothesis for why they looked more at the hands is that most threats are executed from that region.

An experiment carried out in summer 2007 is still under analysis. In this study real time gaze data in a 3D setting was collected and both pre and post questionnaires were completed before and after each game session. The hypotheses in this study are of two kinds. H1: the position of a gun graphic cues attention within the 2D screen surface, and H2: gaze is firstly directed upon an opponent prior to shooting the opponent. The chosen binary variables referring to the position of each enemy when encountered in the stimulus level are side (left or right), distance (near or far) and gun position (left, right). The data reveal that hypotheses H2 is correct 90 % of the time: players do look first on their opponent and then shoot, while only 10% shoot first and look afterwards. The latter case occurs in particular when the workload on the player is higher (due to higher perceptual loading), suggesting a greater cognitive demand upon maintaining situation awareness in relation to the relatively clear cognitive task of shooting an enemy. Further experiments will be required to determine in more detail how (and if) this apparent use of peripheral vision changes systematically in relation to changing perceptual loading.

Conclusion

Cognitive studies of gameplay can provide models of how players play and the cognitive skills acquired during play based upon empirical data. Data collected can be very extensive and the models obtained can be much more detailed than those obtained via qualitative methods. Hence the ongoing program of cognitive studies of gameplay represents significant work for a community dedicated to this approach.

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