

HEC MONTRÉAL

**Évaluation multiméthode de l'engagement des spectateurs en contexte
de jeu numérique et social**

par

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**Sciences de la gestion
(Option Expérience utilisateur dans un contexte d'affaires)**

*Sous la codirection de
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Résumé

Avec le nombre grandissant de spectateurs de sports électroniques, il est important de tenir compte de ce segment du marché lors du design des jeux numériques. Dans ce mémoire, nous explorons les facteurs qui influencent l'engagement émotionnel des spectateurs en contexte de jeu numérique et social.

Pour évaluer l'engagement, nous avons adapté une méthodologie qui permet de trianguler les données physiologiques et perçues, tel que suggéré par la littérature sur l'expérience du joueur. Le jeu numérique et social utilisé dans cette étude est le GRiD Crowd. Il est inspiré d'un des premiers jeux d'arcades inventés; le Pong. Contrairement au Pong original, GRiD Crowd est projeté sur le sol à grandeur humaine. La détection de mouvement est utilisée pour permettre aux joueurs de contrôler leur palette avec leur corps. Les spectateurs utilisent une application web sur leur téléphone intelligent pour envoyer des effets favorables et nuisibles aux joueurs. Nous avons manipulé l'accès des spectateurs à cette application web et nous avons contrôlé la composition des groupes afin d'étudier les facteurs qui influencent l'engagement. Nous avons observé que l'utilisation de l'application web augmente l'activation émotionnelle ce qui mène à un plus grand engagement des spectateurs.

Notre étude contribue à la littérature en offrant une méthodologie qui permet de trianguler données physiologiques et perçues dans une expérience en mouvement et avec plusieurs participants. De plus, elle offre aux concepteurs de jeux vidéo une proposition de design qui permet d'engager les spectateurs, un segment de leur marché qui prend de plus en plus d'importance.

Mots clés : Expérience du joueur, engagement du spectateur, jeu social, jeu numérique, jeu interactif

Abstract

As esport spectatorship has become a worldwide phenomenon, keeping the spectator in mind while designing games is becoming more important. Here, we explore the factors that influence spectators' emotional engagement in the context of a social digital game.

To evaluate engagement, we adapted a methodology that allows triangulation of physiological and perceived data, as suggested by player experience literature. The game used in this study is GRiD Crowd, which was inspired by Pong; one of the first arcade games invented. The difference from the original version is that GRiD Crowd has enlarged Pong to be human size. The game is projected on the ground and movement detection technology allows the players to use their body to control the paddle. Spectators use a web app on their smartphone to send power-ups and obstacles to the players. We manipulated when the spectators could use that influence and controlled the composition of the groups to understand what increased engagement. We observed that when the spectators use the web app, their arousal is higher which increases their engagement.

Our study contributes to the literature in offering a methodology that allows triangulation of physiological and perceived data in an experience that requires movement and a group of people. This study is also offering a design proposition that allows the engagement of spectators, a market segment that becoming more important.

Keywords : player experience, spectator's engagement, social game, digital game, interactive game

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Tableau 1 – Descriptive statistics per group

Liste des abréviations

CER = Comité d'éthique de la recherche

EDA = Activité électrodermale

IPM = Interaction personne-machine

ECG = Electrocardiogramme

SAM = Self-Assessment Manikin

Avant-propos

Les recherches effectuées pour le présent mémoire ont été approuvées par le comité d'éthique de la recherche de HEC Montréal. Le format de mémoire par article a été approuvé par les deux codirecteurs de recherche et par la direction du programme. Les coauteurs ont approuvé la présence des deux articles dans ce mémoire.

Les deux articles seront soumis pour les publications scientifiques. Le premier pour le journal évalué par les pairs JoVE qui impose une vidéo accompagnant l'article écrit. Ce journal porte sur des méthodologies de recherche qui sont plus facilement reproductibles avec une vidéo.

Le deuxième article sera soumis dans le cadre de la conférence CHI Play 2020 qui se tiendra à Ottawa. Cette conférence se spécialise dans les recherches dans le monde du jeu.

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Introduction

In our experience, the greatest challenge lies not in developing the technology for audience interaction, but in designing engaging activities.

Dan Maynes-Aminzade, Randy Pausch, & Steve Seitz

Mise en contexte de l'étude

En 2015, l'audience du sport électronique était estimée à 115 millions de personnes, ceci englobant ceux qui regardent occasionnellement une partie de jeu vidéo en ligne, mais aussi ceux qui se rendent dans une arène. L'audience de 2020 est estimée à 303 millions de personnes, soit une hausse de 163% en 5 ans (Warman, 2017). L'industrie du jeu vidéo vit donc un changement de paradigme où les spectateurs aussi doivent être pris en compte lors du design. Les plateformes d'échange de messages lors des parties sont grandement utilisées et permettent un plus grand engagement des spectateurs dans un jeu où ils ne participent pas activement (Hamari & Sjöblom, 2017). Que se passerait-il si ces spectateurs pouvaient, à l'aide d'une interface, avoir un impact sur l'issue du jeu? C'est dans ce contexte qu'a émergé la présente recherche qui porte sur l'engagement des spectateurs dans un contexte de jeu numérique et social.

Depuis les deux dernières décennies, on observe une importante quête vers la compréhension de l'engagement des utilisateurs dans un contexte d'interaction personne-machine (IPM)(O'Brien, Cairns, & Hall, 2018). Pour être en mesure de comprendre l'engagement des utilisateurs, il faut le définir, savoir comment le mesurer et aussi déterminer quels designs permettent de l'atteindre (O'Brien et al., 2018). C'est ce qui sera abordé dans les prochains paragraphes.

Commençons par sa définition, un des domaines qui a influencé sa détermination est l'éducation. Pour Reeve et al. (2004) l'engagement est la "behavioral intensity and emotional quality of a person's active involvement during a task" (p. 147). Pour Fredricks, (Fredricks, Blumenfeld, & Paris, 2004) une autrice influente dans ce domaine, l'engagement des étudiants comporte trois dimensions: comportementale, émotionnelle et

cognitive. Cette conceptualisation a mené à un consensus; l'engagement est un construit multidimensionnel (O'Brien & Cairns, 2016). Le terme est donc souvent décortiqué par les auteurs pour comprendre ce qui le compose. O'Brien et al. (2018) ont utilisé plusieurs attributs pour le définir, la *focused attention*, la *perceived usability*, l'*aesthetic appeal*, l'*endurabilité*, la *novelty* et la *felt involvement*. D'autres auteurs du domaine du jeu numérique ont utilisé les concepts de l'attention, de l'immersion, de l'*involvement*, de la présence et du flow (Bouvier, Lavoué, & Sehaba, 2014). Certains ont aussi mentionné l'activation (ou l'excitation) comme étant un aspect important de l'expérience de jouer (Boyle, Connolly, Hainey, & Boyle, 2012), 20. En effet, se laisser emporter par l'excitation d'une activité fait partie de l'engagement dans le jeu (Bouvier et al., 2014). Nous allons donc définir l'engagement comme étant l'intensité émotionnelle vécue et perçue par une personne durant un jeu.

Pour approfondir la compréhension du terme engagement, il faut aussi savoir comment le mesurer. Comme Martey et al. (2014) l'ont conclu dans leur recherche intitulée “Measuring Game Engagement”, l'utilisation d'une seule méthode de mesure omet plusieurs aspects importants de l'engagement du joueur. C'est donc avec un mélange de questionnaires d'auto-évaluation, d'entrevues et de mesures physiologiques qu'on arrive à réduire les omissions (Martey et al., 2014). Lorsqu'il s'agit de mesures explicites, questionnaires ou entrevues, il est difficile de demander à l'utilisateur s'il a été « engagé ». Ce terme suscite souvent de la confusion et plusieurs participants ont du mal à comprendre la signification de l'engagement où l'associent au plaisir (Latulipe, Carroll, & Lottridge, 2011). Il faut alors trouver une façon de le demander qui réduit la confusion. Ceci a donné lieu à beaucoup de recherches sur les mesures de l'engagement (Josef Wiemeyer, Lennart Nacke, 2016). Plusieurs auteurs ont créé des questionnaires d'auto-évaluation pour mesurer l'engagement des joueurs tels que: le *Game Engagement Questionnaire* (GEQ) par Brockmyer et al. (2009) qui mesure l'engagement dans les jeux vidéo violents pour en comprendre leur impact; l'*Engagement Questionnaire* (EQ) de Mayes & Cotton (2001) qui mesure le niveau d'engagement et ce qui différencie les joueurs et plus récemment, le *User Engagement Scale* de O'Brien et al. (2018) qui utilise l'approche multidimensionnelle de l'engagement.

D'un point de vue physiologique, aucune mesure directe de l'engagement n'existe. Cependant, l'activité électrodermale (EDA) est liée à l'engagement dans le contexte de performances artistiques (Latulipe et al., 2011). L'EDA est mesurée grâce à des électrodes placées dans la paume de la main. Les électrodes enregistrent les variations dans la conductivité de la peau causées par la sudation (Nacke, 2015a). Ces variations sont un indicateur de l'activation émotionnelle (Lang, 1995). Ainsi, il est possible de mesurer les changements émotionnels vécus en temps réel. Cette mesure a aussi été très utilisée pour mesurer l'activation physiologique dans le contexte de jeux (Martey et al., 2014). Les variations peuvent signifier l'engagement, mais aussi la frustration et la désorientation (Heather L. O'Brien and Elaine G. Toms, 2013). Pour permettre une interprétation adéquate des résultats, il est donc primordial de les croiser avec des questionnaires et des entrevues (Nacke, 2015a). Cependant, ce mélange de méthodes pour obtenir des données plus véridiques est moins utilisé dans le contexte du *spectateur* d'un jeu tel que démontré par toutes ces recherches influentes dans le domaine de l'expérience spectateur : Reeves, Benford, Malley, & Fraser, (2005), Cheung & Huang, (2011), Downs, Smith, Vetere, Loughnan, & Howard, (2014), Downs, Vetere, & Smith, (2015), Tekin & Reeves, (2017).

Finalement, il est d'intérêt de se pencher sur les designs qui optimisent l'engagement de l'utilisateur. Des recommandations de design interactif s'adressant aux spectateurs ont été faites dans l'article de Reeves et al. (2005). Ils mentionnent que la façon dont sont révélées les actions des *performers* (ou joueurs dans notre cas) influence l'appréciation des spectateurs. Leur taxonomie décrit quatre types de design: "secretive", où les spectateurs ne savent pas ce que les joueurs font, ni les effets de leurs actions, "expressive", où les spectateurs sont au courant des actions des joueurs et leurs effets, "magical", où seulement les effets sont révélés et finalement "suspenseful", où les actions des joueurs sont montrées, mais pas les effets. Cheung a ensuite utilisé ces concepts pour développer l'*information asymmetry*, qu'il décrit comme étant la situation dans laquelle les joueurs et les spectateurs n'ont pas accès à la même information lors d'un jeu (2011). Il conclut que les spectateurs apprécient l'*information asymmetry* au début d'une partie puisque ça permet un suspense dans la révélation de l'information.

Bref, l'engagement est un construit multidimensionnel qui a souvent été redéfini par les auteurs s'y intéressant. Plusieurs méthodes existent pour le mesurer chez les joueurs de jeux numériques, mais elles ne sont que rarement appliquées aux spectateurs.

Questions de recherche

L'objectif de ce mémoire est donc de pousser la réflexion sur les types de mesures de l'engagement et sur les designs qui permettent de l'atteindre dans le domaine du jeu numérique. C'est à l'aide de deux articles que nous répondrons aux questions suivantes.

1. Comment mesurer l'engagement des spectateurs dans un contexte de jeu numérique et social?
2. Quels sont les facteurs qui influencent l'engagement des spectateurs dans un contexte de jeu numérique et social?

En se basant sur la conceptualisation multidimensionnelle de O'Brien et al. (2018) ainsi que les recherches de Martey (2014) qui préconisent l'utilisation de la triangulation de mesures implicites et explicites, nous proposons une méthode expérimentale qui permet de déterminer un facteur important de l'engagement des spectateurs. En effet, nous avons observé qu'ajouter une composante interactive qui permet d'influencer le jeu aux spectateurs crée une plus grande activation, ce qui augmente l'engagement dans un contexte de jeu numérique et social.

Méthode et expérimentation

Contrairement aux championnats de sport électronique observés en ligne, le stimulus utilisé ici est un jeu qui se joue physiquement sur un terrain et où joueurs et spectateurs sont dans la même pièce. En développant cette expérience, Moment Factory (2016) avait comme objectif d'offrir un jeu numérique et social qui peut être déployé dans un lieu public. La mécanique est celle du Pong, un jeu d'arcade mis en marché en 1972 par Atari. Ce qui est différent de la version originale est la taille puisqu'elle a été agrandie à échelle humaine. En effet, les joueurs utilisent les mouvements de leur corps pour déplacer la palette qui leur permettra de renvoyer la balle de l'autre côté du terrain (voir figure 1). Pour permettre à un

grand nombre de spectateurs de participer, ils peuvent faire usage d'une interface accessible sur téléphone intelligent via un hyperlien. Ceci leur donne accès à des votes qui surgissent tout au long de la partie où ils peuvent décider d'aider ou de nuire aux joueurs sur le terrain (voir figure 2). Une fois qu'un vote a été effectué, une page leur annonce combien de personnes ont voté pour la même chose qu'eux (voir figure 3).



Figure 1. Le jeu GRiD Crowd par Moment Factory (2019)



Figure 2. Page de vote de l'interface du public avec barre de chronomètre



Figure 3. Page où on voit le nombre de votes par choix

Voici les votes qui ont surgi durant les parties; voulez-vous rendre la balle plus rapide ou plus lente ? Voulez-vous grossir la palette du joueur rouge ou du joueur bleu ? Voulez-vous accélérer la balle pour le joueur rouge ou le joueur bleu ? Voulez-vous modifier la taille de la balle en plus grosse ou en plus petite ? Lequel préférez-vous entre Godzilla et King-Kong ?

Les votes surgissent à intervalles réguliers et les spectateurs ont 10 secondes pour y répondre. Les joueurs sur le terrain ne sont pas au courant de ce qui s'en vient et savent seulement que les spectateurs peuvent influencer le jeu mais ne savent pas comment. Le but est d'obtenir 3 points en tentant d'empêcher l'adversaire de réceptionner la balle avec sa palette.

Pour étudier l'engagement des spectateurs, nous avons mené 8 séances de test avec un total de 78 participants. Dans chaque séance, 10 personnes étaient dans le public, 2 étaient sur le terrain et jouaient 3 parties. Nous avons récolté des données perçues à l'aide de questionnaires auto-rapportés des 78 participants et avons mesuré l'activité électrodermale (EDA) de 12 personnes.

Objectifs de l'étude et contributions potentielles

L'objectif de cette étude est d'offrir aux chercheurs une méthode qui permette de mesurer des données physiologiques et auto-rapportées par des spectateurs dans un contexte de jeu où les participants ont la liberté de leurs mouvements. Ensuite, cette étude propose une solution de design qui permet une hausse dans l'activation émotionnelle et donc dans l'engagement des spectateurs. Ainsi, on apporte une réponse aux chercheurs du domaine de l'expérience spectateur en leur suggérant que l'interactivité permet l'engagement. L'industrie pourra aussi utiliser l'interactivité pour engager un grand groupe de personnes, un segment du marché des jeux vidéo qui est grandissant.

Structure du mémoire

L'article trouvé au chapitre 1 permettra de répondre à la première question de recherche (comment mesurer l'engagement des spectateurs dans un contexte de jeu numérique et social?). L'article qui compose le chapitre 2 répondra à la deuxième question de recherche

(quels sont les facteurs qui influencent l'engagement des spectateurs dans un contexte de jeu numérique et social?). Les deux articles seront soumis dans des publications scientifiques. Une vidéo méthodologique est aussi présente en annexe 1 pour montrer de façon visuelle la méthode utilisée dans le deuxième article.

Informations sur le premier article

L'autrice de ce mémoire a eu le soutien de MITACS pour réaliser les phases de collectes de données, d'analyse et de rédaction au cours des mois de mai à septembre 2019. La collecte de données a été réalisée chez Moment Factory qui a prêté ses locaux et son jeu pour répondre aux questions de recherche. C'est un article méthodologique accompagné d'une vidéo qui sera soumis à la revue scientifique Journal of Visualized Experiments (JoVE). Étant donné la nature visuelle et l'aspect novateur de la méthodologie utilisée, il était pertinent de choisir ce médium. L'article présent au chapitre 1 suit la structure demandée par JoVE qui requiert un manuscrit où les étapes du protocole sont détaillées. Le manuscrit est accompagné d'une vidéo qui montre certaines étapes clé de réalisation du protocole. La vidéo est annexée à ce présent mémoire.

Résumé du premier article

Cet article vise à répondre à la question: Comment mesurer l'engagement des spectateurs dans un contexte de jeu numérique et social? Dans l'article, nous proposons une façon de croiser données auto-rapportées et données physiologiques pour étudier l'engagement des spectateurs. L'enjeu représenté dans cet article est la synchronisation des données électrodermiques (EDA) qui est réalisée grâce à des caméras qui permettent de poser des marqueurs sur certains moments importants du jeu. Avec cette méthode, il est possible de mesurer l'activation physiologique de plusieurs participants dans un jeu digital physique où les mouvements des participants sont illimités contrairement aux études similaires où les participant sont assis devant un écran. On applique donc une méthode utilisée dans l'évaluation de l'expérience du joueur au spectateur.

Informations sur le deuxième article

Le deuxième article sera soumis à la conférence *CHI Play 2020*. C'est la méthode présentée dans le premier article qui est utilisée pour répondre à la question de recherche.

Résumé du deuxième article

Pour investiguer quel design d'expérience interactive permet l'engagement des spectateurs, nous utilisons le GRiD Crowd (Moment Factory 2016), un jeu inspiré de Pong (Atari, 1972). Les changements dans l'engagement des spectateurs suite à l'ajout d'une plateforme interactive chez le spectateur ont été évalués. Les impacts de ces différences ont été mesurés à l'aide de l'activation physiologique et de questionnaires. L'influence des spectateurs était réalisée à l'aide d'un téléphone intelligent, où 78 participants regroupés dans deux groupes, avec des amis ou avec des inconnus, étaient testés. Nous avons découvert que lorsque les participants avaient un impact sur le jeu, leur activation était plus élevée, ce qui permettait un plus grand engagement.

Tableau. 1 - Contribution dans la rédaction des articles

Étapes du processus de l'étude	Contribution
Soumission d'une demande à la bourse MITACS	Compléter la soumission en ayant l'accord du partenaire – 90% <ul style="list-style-type: none">● Les coauteurs ont supervisé la demande pour y suggérer des modifications
Exploration des possibilités avec le partenaire	Identifier les possibles stimuli à étudier - 60% <ul style="list-style-type: none">● Le partenaire a fourni une liste de stimuli possibles

Définition de la question de recherche	<p>Définir comment le stimulus peut être utilisé pour une question de recherche - 80%</p> <ul style="list-style-type: none"> ● Le partenaire a conseillé les avenues possibles avec le stimulus choisi ● Les coauteurs ont commenté cette suggestion
Revue de la littérature	<p>Identifier ce qui a été étudié dans le domaine du jeu pour trouver comment combler le manque à la littérature - 100%</p> <ul style="list-style-type: none"> ● Identifier les bons outils de mesure pour répondre à la question de recherche - 50% ● Le Tech3lab a conseillé les outils de mesure physiologiques à utiliser
Approbation éthique	<p>Compléter la demande au CER et les modifications à y apporter – 90%</p> <ul style="list-style-type: none"> ● L'équipe du Tech3Lab a fait la relecture de la demande avant la remise

Conception du design expérimental	<ul style="list-style-type: none"> ● Concevoir le protocole d'expérimentation – 80% ● Les co-auteurs ont participé en suggérant des modifications ● L'équipe du Tech3Lab a recommandé un protocole d'utilisation de l'outil physiologique ● Organiser la salle de collectes chez le partenaire – 100% ● Installer le matériel lors des collectes de données
Recrutement des participants	<p>Concevoir le questionnaire de recrutement, recruter et gérer les participants – 90%</p> <ul style="list-style-type: none"> ● Une coordonnatrice du partenaire a participé au recrutement en leur envoyant des invitations sur leur calendrier ● L'assistante de recherche a aidé à recruter des participants ● Faire la pige et remettre les compensations – 100%
Prétests et collecte de données	Organisation du pré-test au HEC Montréal - 100%

Extraction et transformation des données	<p>Extraction des données physiologiques - 80%</p> <ul style="list-style-type: none"> ● Faites sur le logiciel Photobooth de Cube développé au laboratoire (Courtemanche et al., 2018) ● Extraction des données explicites – 100% ● Transcrire les données des questionnaires papier sur des documents excel ● Transcrire les verbatim des entrevues
Analyse des données	<p>Analyses statistiques des données physiologiques et des questionnaires - 80%</p> <ul style="list-style-type: none"> ● Analyses statistiques avec l'aide du statisticien du Tech3Lab selon les besoins des coauteurs ● Interprétation des résultats faite en collaboration avec les co-auteurs
Rédaction des articles et du mémoire	<p>Rédaction des articles et du mémoire - 100%</p> <ul style="list-style-type: none"> ● Les co-auteurs ont été présents à toutes les étapes d'écriture pour commenter les articles et le mémoire.

Chapitre 1 - Premier article¹

TITLE:

Measuring Engagement in a Social Digital Game

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KEYWORDS:

Behavior, electrodermal activity, emotion, social gaming, physical videogames, interactive games.

SUMMARY:

We propose a methodology that enables to measure engagement of spectators of a social digital game. This method combines physiological and self-reported data. As this digital game involves a group of people that are free of their movements, the experience is filmed using a novel synchronizing technique that links physiological data with events in the game.

ABSTRACT:

The goal of this methodology is to assess explicit and implicit measures of engagement in a social digital game that involves a group of participants and motion tracking. In the context of games that are not confined within a screen, measuring the different

¹ Manuscrit en préparation pour soumission à JoVE

dimensions of engagement such as physiological arousal can be challenging. The focus of the study is made on the spectators of the game and the differences in their engagement according to interactivity. Engagement is measured with physiological and self-reported arousal, as well as an engagement questionnaire at the end of the experiment. Physiological arousal is measured with electrodermal activity (EDA) sensors that record the data on a portable device (EDA box). Portability was essential because of the nature of the game which is akin a life-size pong and includes many participants that move. To have an overview of the events of the game, 3 cameras are used to film 3 angles of the playing field. To synchronise the EDA data with events happening in the game, boxes with digital numbers are used and put in the frames of cameras. Signals are sent from a sync box simultaneously to the EDA boxes and to light boxes. The light boxes show the synchronisation numbers to the cameras, and the same numbers are also logged on the EDA data file. That way, it is possible to record EDA of many people that move freely in a large space and synchronise this data with events in the game. In our particular study, we were able with this method to assess the differences in arousal for the different conditions of interactivity. One of the limitations of this method is that the signals cannot be sent farther than 20 meters away. This method is therefore appropriate for recording physiological data in games with an unlimited number of players but is restricted to a limited space.

INTRODUCTION:

Innovations in the gaming industry allow new types of experiences that move forward from traditional console-based gaming¹. With digital games that use motion tracking systems and that are not confined within a screen, it was necessary to find new ways to measure spectators' experience in a context where space is not clearly defined. Testing the experience of the spectators can help to understand better the positive and negative aspects and therefore improve the design².

The purpose of this methodology is to enable the measurement of engagement of spectators of a social digital game. More precisely, the difference in arousal that leads to engagement when the spectator has access to a web application that influences the gameplay. This method combines physiological and self-reported data. As this game is social, and therefore, involves a group of people that move, the experiment is filmed. With the use of cameras and portable physiological devices, we were able to synchronize physiological data with events in the game.

The use of physiological measures is a common and validated approach for measuring game engagement³. It has also been used in other research domains such as education⁴. Because emotional engagement is not observable and self-report can be biased, Charland et al. used physiological arousal to assess emotional engagement in learners that were solving problems⁴. They used electrodermal activity (EDA) to measure physiological arousal, which is a widely used method⁵. EDA is measured through conductivity of the skin that varies according to the differences in sweat gland activity³. This gives access to

real-time emotional variations. EDA is associated with many constructs such as stress, excitement, frustration, and engagement⁶. The combination of physiological and self-report responses are therefore recommended to complement EDA³. The Self-Assessment Manikin (SAM) is a pictographic scale that assess three dimensions of emotion which are valence, arousal and dominance⁷. We only used the arousal dimension which was asked using a visual 9-point Likert scale ranging from calm to excited. Perceived arousal has been used in combination with physiological arousal⁶.

The studies in the field of games that use physiological evaluation are mostly done in laboratory settings³. In traditional video games contexts, participants are seated in a chair and stay in the same position for the duration of the experiment. They are expected to look at a screen where all the action takes place. In this case, it is simple to start the recording of the game at the same time as the recording of the physiological data⁸.

In the context of new digital games that take place outside of the screen and where participants stand and are free to move, traditional EDA recording might not be appropriated. We are using this context to illustrate our proposed methodology. GRiD Crowd⁹, the game used in this study, is akin a life-size Pong¹⁰. In the version used for this research, the game is projected on the ground and the players use their bodies as controllers. Movement detection technology allows the paddle to follow the two players, situated at opposite sides of the playground. An example of how the players prevent the ball from hitting the virtual wall behind them is presented in Figure 1. This version of the game involves spectators standing on the sides of the playground, who can use their smartphone to influence the gameplay. Using a mobile web application, spectators can vote for certain power-ups or obstacles that can either help or harm the players (e.g., less walls versus more balls, or modulating the speed of the ball). The option with the most votes wins.

In this illustrative study, we investigate the influence of interactivity on spectators. We studied which condition (with or without smartphone) allowed more engagement of the spectators. A within-subject design was used for the smartphone condition, in order to assess the difference in arousal and therefore in engagement. Each member of the public was randomly assigned to 2 games with access to their smartphone to influence the gameplay and 1 game without access to their smartphone. Game engagement literature suggests that giving many interactive options can lead to higher engagement¹¹. Research in education found that physiological arousal is a correlate of emotional engagement⁴. Building on game engagement literature and research in education, we hypothesized that giving access to interactivity to the spectators would increase their arousal which would increase their engagement.



Figure 1. GRiD Crowd by Moment Factory (2019)

Contrary to studies about *player* experience, studies about *spectators* of a digital game rarely use psychophysiological measures. They are mostly done with questionnaires¹², observation¹³, and interviews¹⁴. One difficulty of using psychophysiological measures on spectators is that they are often a group and their movements are less predictable than the ones of the players. That is why we used multiple cameras to capture their movements as well as portable EDA devices. Participants also were wearing jerseys with their participant number to be able to link each data to the right participant.

As we used a within-subject design for the smartphone condition, each subject participated to 2 games with smartphone and 1 game without smartphone. Synchronization of EDA data with the starts and ends of each game was therefore crucial to assess the differences in each condition of interactivity. It would be impossible to start the recording of the three cameras at the same time as the recording of the EDA on two spectators due to the dimensions of the room. To overcome that, we have used a new synchronization technique called “wireless synchronisation protocol for the acquisition of multimodal user data”¹⁵. Bluetooth Low Energy (BLE) signals are sent from a sync box simultaneously to the EDA boxes and to light boxes (see Figure 2). The signals are incrementing numbers that start at one. The light boxes show the synchronisation numbers to the cameras, and the same numbers are also logged on the EDA data file (see Figure 3). This allows to synchronise events happening in the game to variations in the EDA recordings. In our case, we identified the starts and ends of the 3 games. Then we could link the game to the condition and to the participant number. That way we could identify which dataset corresponded to which condition.



Figure 2. Sync box (left) and light box (right) showing a number¹⁵

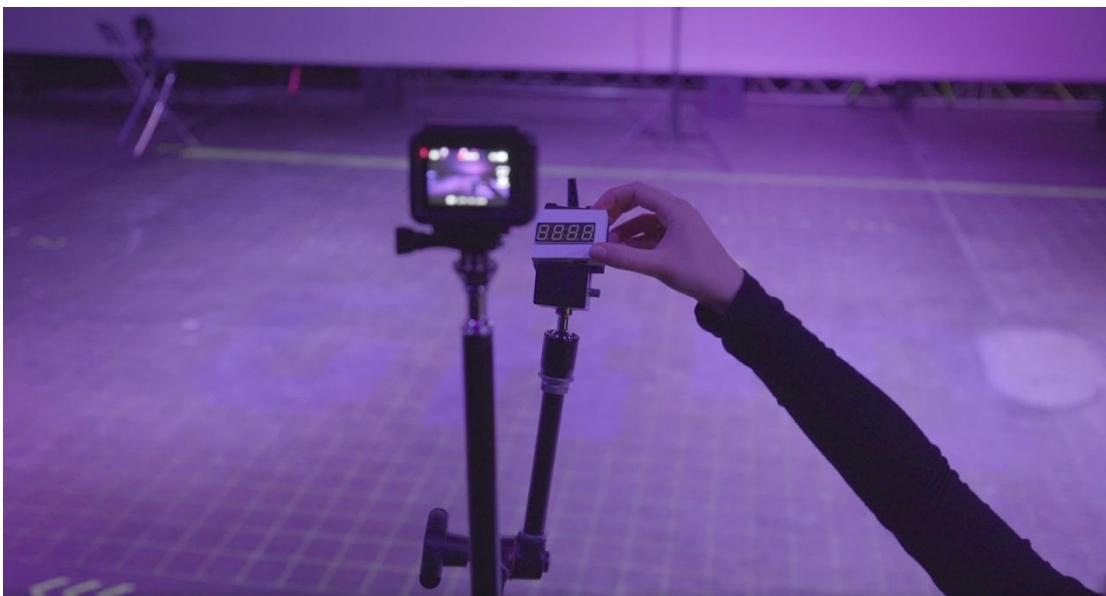


Figure 3. Light box positioned in front of a camera¹⁵

The following sections will be presenting the protocol, followed by the representative results, the figures and tables and the discussion. This order of information required by JoVE. The representative results aim at presenting the success of the protocol taking into account the research objectives so that researchers can have a sense of the outcomes of using this method. The table of materials is required for JoVE articles so that researchers

are able to replicate adequately the methodology. The discussion is focused on the protocol and not on the results, it includes the critical steps, troubleshooting, limitations, significance and future applications of the method.

PROTOCOL:

The following section describes the protocol that allows the use of the technique developed by Courtemanche et al¹⁵. We adapted the technique to answer our research question. This protocol received an ethical certificate from our institution's ethics committee.

Please note that the steps were performed in the studio of the creators of the game, i.e., Moment Factory, but could be replicated in a laboratory setting or other environment that has enough space to fit the game.

In this protocol, we use physiological devices from BITalino (r)evolution Freestyle Kit (PLUX Wireless biosignals S.A.)¹⁶. The devices were mounted inside a 3D printed casing. We will refer to those devices as EDA boxes (boxes used to record the EDA of the participant), light box (the box with a digital light), and the sync box (box that sends signals to the EDA boxes and the light boxes to synchronise data). The synchronization software enabling the “wireless synchronisation protocol for the acquisition of multimodal user data”¹⁵ was embedded onto the boxes.

The next section details specifically:

1. Participant Screening and Preparation for the Experiment
2. Conditions and Experimental Design
3. Collection Preparation
4. Welcoming Participants
5. Physiological Devices Presentation
6. Installation of the Physiological Device
7. Record Baseline
8. Start the Experiment
9. Ending the Experiment
10. Cleaning up Materials
11. End of Experiment
12. After the Experiment
13. Prepare the Data for Analysis
14. Upload to Photobooth
15. Analyse data

To help researchers to better understand this detailed protocol and replicate it adequately, a video of the key steps is presented in the link below:

<https://youtu.be/hzc1ZtACBVU>

The video is also available on a USB flash drive in Annex 1.

1. Participant Screening and Preparation for the Experiment

- 1.1. Recruit participants that understand the experiment's language , that are 18 years old or over, that are able to stand for 20 minutes, that possess a smartphone dating from a maximum of 5 years (for the purpose of the game), that do not have skin allergies or sensitivities, that do not have a pacemaker, that do not suffer from epilepsy or another diagnosed health problem.
- 1.2. Recruit groups of people that are friends, and other groups of people that do not know each other to control for familiarity. Group sizes should be determined based on the purpose of the study and the available room. In the current study, groups of 12 people were ideal.
- 1.3. Schedule participants. Give few options of dates and times so that you can manage scheduling easily. For groups that know each other, impose a date and time. You can group the people that do not know each other on their most convenient dates.
- 1.4. Make sure that people charge their phones beforehand and bring their phone charger in case of low battery.

2. Conditions and Experimental Design

- 2.1. Prepare the randomization sheet for the interactivity condition by associating each participant number to the two conditions of interactivity for each game. The first condition is having access to a smartphone that influences the game and the second condition is not having access to the smartphone. Also assign numbers to players and to spectators who will wear an EDA box.

3. Collection Preparation

- 3.1. Plug the EDA boxes, the three light boxes and the sync box into the charging station.
- 3.2. Open the game in the studio (projector and 3D scanner for movement detection technology).
- 3.3. Test the game by running it through a full game.
- 3.4. Place the consent forms, the pre-experiment questionnaire and jerseys on a table in the greeting area.
- 3.5. Write the name of the researcher and the date on each consent form.
- 3.6. Put the participant's numbered jerseys on the table with each consent form.
- 3.7. Test the Bluetooth connection of the light boxes.
 - 3.7.1. Set the sync box to "manual".
 - 3.7.2. Turn on the three light boxes.
 - 3.7.3. Turn on the two EDA boxes.
 - 3.7.4. Turn on the Bluetooth on the EDA boxes.
 - 3.7.5. Turn on the sync box.
 - 3.7.6. Push the pulse button on the sync box.
 - 3.7.6.1. The light boxes should flash the number 01.
 - 3.7.7. Turn off the sync box, the light boxes and the EDA boxes.
- 3.8. Set the sync box and light boxes in place for the collection.
 - 3.8.1. Place the light boxes in view of each camera.

- 3.8.2. Put the sync box on the tripod, at a height of 6 feet.
- 3.8.3. Set the sync box to “auto”.
- 3.9. Unplug the batteries and put them into the cameras.
- 3.10. Check that battery power can record for over an hour.
- 3.11. Place the camera in order for the framing to include all four extremities of the game’s playing field, and the light box.

4. Welcoming participants

- 4.1. Greet the participants at the front door. Verbatim: “Hi, welcome to the experimentation, the test will take place in the room next to us, behind the black curtains. First, please sit at the table.”
- 4.2. Seat participants at the table where the consent forms and jersey were previously placed.
- 4.3. Once all the participants have arrived and are seated, describe the tools which will be used to collect data for the present study. Verbatim: “We are using two tools to collect data. First, cameras will film your experience. Second, we will choose two participants randomly to measure sweat on the palm of their hand with electrodes. These tools were presented in the consent form.”
- 4.4. Ask the participants to read and sign the consent forms. Verbatim: “I will ask you to read the consent form. The two copies are identical. One is for you, one is for me. Please answer all the questions and sign both copies. Tell me if you have any questions and let me know when you are finished.”
- 4.5. Wait until they sign and go around the table to sign the consent form yourself, in front of them. Before signing, verify that all questions have been answered.
- 4.6. Put one copy of the consent form into a folder designated for this purpose and give the participant the second copy.

5. Physiological devices presentation

- 5.1. Ask the participants to put on the jersey with their participant number
- 5.2. While the participants start to fill the consent forms and pre-experiment questionnaire, ask the two randomly selected participants to get up and walk to a secluded area for the EDA installation.
- 5.3. Ask all other participants to begin filling in the pre-experimental questionnaire during this time.

6. Installation of the physiological device

- 6.1. On the non-dominant hand, ask the participants to remove any jewelry.
- 6.2. Use an antiseptic wipe to clean the area where the electrodes will be placed.
- 6.3. Remove the plastic of the electrode and place them on the hands of the participant.
- 6.4. Snap the two sensors on the two electrodes.
 - 6.4.1. The red wire must be placed on the thumb’s side.
 - 6.4.2. The black wire must be placed on the other side, under the pinky finger.
- 6.5. Plug the sensor wire to the A3 port of the EDA box.
- 6.6. Ask the participant if they tend to have sweaty palms.
 - 6.6.1. If they say that they do, wrap medical tape around the electrodes the metal part.

- 6.7. Add an armband over the palm of the hand, to secure the sensors and electrodes in place.
- 6.8. Turn on the EDA device.
- 6.9. Check that the Bluetooth switch is still on.
- 6.10. Check that the four lights flash.
- 6.11. Note the number of the participant and the number of the EDA box.
- 6.12. Place the EDA box on the belt or in the pocket of the participant.
- 6.12.1. If the participant's clothes do not allow this placement, offer them a belt and hook the EDA to the belt.
- 6.13. Ask the participant's wearing the EDA boxes to return to the table with the others and complete the pre-experimental questionnaire.
- 6.14. Go around the table, starting with the participant who do not have the EDA, and check that all questions have been answered.
- 6.15. If the questionnaire is completed, put it in the folder with the participant's consent form.
- 6.16. Once all participants have completed the pre-experimental questionnaire, walk participants to the game studio.

7. Record Baseline

- 7.1. Verbatim: "Before starting, I need to calibrate my tools. I will ask you to breathe calmly and to fix something in front of you for two minutes. We are starting now."
- 7.2. Simultaneously, turn the EDA devices off and then on.
- 7.3. Start a timer for 2 minutes.
- 7.4. After the minute ends, turn the EDA device off and turn them on again.

8. Start the experiment

- 8.1. Start the recording of the three cameras and turn on the three light boxes.
- 8.2. Verify that the light boxes and the full playing field are still within the camera frame.
- 8.3. Verify that the sync box is on "auto".
- 8.4. Turn on the sync box.
- 8.5. After 10 seconds, the numbers on the light boxes should flash
Note: this indicates that the sync box is automatically sending a pulse every 10 seconds to both the lights and the EDA boxes.
- 8.6. Explain the game. Verbatim: "The game is similar to Ping-Pong. You will understand while playing. To win, one player needs to make 3 points. Some members of the public will use their smartphones to influence the game by visiting the website URL that is projected on the playground."
- 8.7. Using the randomization sheet with the number of participants for each condition, tell the participants who will play the game, and who will be on the sidelines as spectators.

Note: For the purpose of this study, participant's wearing the EDA boxes cannot be selected as playing participants.

- 8.8. Tell the participants who will use their smartphone. Verbatim: "p01, p02, p03, p04, p05 you will use your smartphone for this game. The others, leave your

smartphone in your pocket. These people will need to visit the URL of the game to influence it.”

8.9. Start the game

8.9.1. Tell the game technician to start the game by opening the projectors and the movement detection technology.

8.9.2. Tell the players the scenario. Verbatim: “Here is the context: you are walking in a public space and you see this game. You decide to participate.”

8.9.3. While the participants are playing, visually check that the lights are flashing every 10 seconds.

8.9.4. In between each game, ask participants to fill in the Self-Assessment Manikin (SAM) Scale⁷ questionnaire on their smartphone on an URL.

Verbatim: “the first game is over. I will ask you to fill out a questionnaire on your smartphone about the experience you just lived. You need to answer 3 questions using 3 scales. Don’t evaluate the game itself but rather how you felt during the participation. The link is the following: ...”

8.9.5. Once done ask all participants to return to their place and repeat steps 8.8 to 8.10.4 for 3 games.

9. Ending the experiment

9.1. Post experiment questionnaire

9.1.1. Verbatim: “Thank you very much for participating in the game. The last game is over. You will now fill two paper questionnaires. Then, you can leave. Please follow me to the greeting room.”

9.1.2. Ask all participants, except the two with the EDA, to go back to the table where they completed their consent form and pre-experimental questionnaire. They will answer the UES-SF two times, one time thinking about when they had the smartphone and one time when they didn't have the smartphone, this is written in the instructions of the questionnaire.

Verbatim: “The participants with the physiological tool, you can wait for me at the table where we installed the tool. The others, here is an end of experiment questionnaire, please answer extensively by explaining clearly what you mean. Tell me if you have questions.”

9.2. Removal of the physiological device

9.2.1. Ask the participant to give you the box.

9.2.2. Turn off the device.

9.2.3. Turn off the Bluetooth of the device.

9.2.4. Unplug the sensor from the A3 port.

9.2.5. Remove the armband.

9.2.6. Unsnap the sensor from the electrodes.

9.2.7. Ask the participant to remove the medical tape and electrodes on their hand.

9.2.8. Give the participant a tissue to remove the cream in the hand.

9.2.9. Remove the micro SD card from the EDA box.

9.2.10. Repeat steps 9.2.1 to 9.2.9 with the second EDA participant.

9.3. Bring the participants to the table where the other participants are sitting.

- 9.4. During that time the other participants were filling the end of experience questionnaire. Verbatim: "Here is an end of experiment questionnaire, please answer extensively by explaining clearly what you mean. Tell me if you have questions."
- 9.5. When they are finished with the end of experiment questionnaire, ask the two EDA box participants to follow you to the interview area.
- 9.6. Conduct the interview.
- 9.7. Once participants finish filling in the questionnaire, verify that they are adequately completed and collect them.
- 9.8. Place filled out post-experiment questionnaires with pre-experiment questionnaire and consent form in the folder.
- 9.9. Debrief the participants
 - 9.9.1. Once participants finish, thank them for their participation, and walk them out. Verbatim: "Thank you everybody for your participation. During the experience, we tested the engagement of the public in a social context to see what are the factors that influence engagement. You are now part of a draw to win a pair of tickets for a multimedia show."

10. Cleaning up materials

- 10.1.1. Turn off the 3 light boxes and stop the recording of the 3 cameras.
- 10.1.2. Remove the batteries and SD cards of the three cameras and place the batteries in the charger.
- 10.1.3. Turn off the sync box.
- 10.1.4. Plug the EDA boxes, light boxes and sync box in the charging station.

11. End of experiment

- 11.1. Transfer the physiological data on the computer.
 - 11.1.1. Put the micro SD card from the EDA box in the adaptor.
 - 11.1.2. Transfer the data to the computer in a folder named by the number of the participant.
 - 11.1.3. Delete the files in the micro SD card.

12. After the experiment

- 12.1. Verify if the data is valid
 - 12.1.1. Select all the data and put it in an excel file.
 - 12.1.2. You can hide the columns that are not useful.
 - 12.1.3. Select approximately 1 to 3000 lines and make a scatter plot. If all the data is between 240 and 550, the data is valid.
 - 12.1.4. Verify if the markers generated by the sync box are present by selecting the event column, and by selecting the "sort" option in excel. That way you will see all the markers that were generated. Sometimes there are markers that did not appear. This is not a problem, only one marker will provide you a point of reference. From this point, you can calculate the beginnings and ends of the events using the time of the camera. There are 100 data points every second.
 - 12.1.5. Press control Z to revert the sorting of the markers.

13. Prepare the data for analysis

- 13.1.1. Add an event_start_end column.
- 13.1.2. Watch the footage, when there is the beginning of an event, calculate the difference between the time of the event, and the last marker.
- 13.1.3. When you find the seconds related to the event start, add a marker named event1_start in the excel file. Do the same for the end of the event.
- 13.1.4. Repeat steps 13.1.1 to 13.1.3 for the baseline.
- 13.1.5. When you are finished adding the markers, export the excel file in TXT (tab delimited text). You will have two per participant, one with the experiment data and one with the baseline data.
- 13.1.6. Export these files in Photobooth, a software by Cube (see next section). This will generate a file ready for analysis that contains the relative time, absolute time, events and EDA signal.

14. Upload to Photobooth

- 14.1. On the first page that you will see, click « add project ».
- 14.2. Add a title.
- 14.3. Add a description.
- 14.4. Enter the date of the project and how many participants.
- 14.5. Click on the name of the project.
- 14.6. Click on experimental design.
- 14.7. Enter the information necessary for the signal type which was physiological, EDA, Bluebox, Bluebox and version 3.0.
- 14.8. Enter the coded events as they were coded previously in the excel file. Choose Bluebox, version 3.0.
- 14.9. Add a transformation. Choose GSR which refers to galvanic skin response or EDA.
- 14.10. Click on unlock to lock your project
- 14.11. Import the files previously prepared
- 14.12. First you need to give information about the participant by putting their email
- 14.13. Then you can upload the data file, which needs to be zipped in order for the software to recognize it
- 14.14. Then click on the pie to upload
- 14.15. Go to analysis and choose data exportation, select your participant and their data.
- 14.16. Click on export data to have a file ready for analysis. This can take hours if you have many participants. The file will appear under “filename” at the end of exportation.
- 14.17. Use the file generated for physiological data analysis

15. Analyse Data

- 15.1. Standardize the EDA data.
- 15.1.1. Subtract the EDA mean to the EDA value, then divide by its standard deviation (where the mean and standard deviations are based on the entire dataset)¹⁷.

15.2. Baseline the EDA data

15.2.1. Subtract the mean of baseline EDA from each EDA standardized value, where the mean is based on the baseline data for each participant in question¹⁷.

15.3. Calculate the means for each condition of interactivity for the SAM Scale and the UES-SF

15.4. Assess the mediation role of arousal in the relationship between interactivity and spectators' engagement using Baron & Kenny's procedure¹⁸

15.4.1.1.1. Test two mediation models, one for each type of arousal; physiological and self-reported.

15.4.1.1.2. Test the relationship between the independent variable (interactivity) and the mediators (physiological and perceived arousal).

15.4.1.1.3. Test the relationship between the independent (interactivity) and dependent variables (engagement assessed in the UES-SF).

15.4.1.1.4. Assess the relationship between the combination of the independent variable and the mediators, and the dependent variable.

REPRESENTATIVE RESULTS:

This section provides the results from our illustrative study in order for the readers to understand the outcomes of using this methodology. In this study, we recruited the participants using Facebook and our institution's panel of participants. Of the 78 participants, 40 were women. The mean age is 22 years old. None of them had already played the game tested. Other exclusion criteria can be found at step 1 of the protocol.

In the table of descriptive statistics, we can see the means per condition for each measure. The mean of the arousal dimension of the Self-Assessment Manikin (SAM) is reported in the second column of the table. The SAM Scale was administered using a visual 9-point Likert scale ranging from calm to excited⁷. We can see that they were more excited with the smartphone. The third column shows the difference between the mean of the standardized EDA for each condition, again showing that it was higher with smartphone. The fourth column reports the means for each condition in the User Engagement Questionnaire. A 5-point Likert scale ranging from "Strongly agree" to "Strongly disagree" was used¹⁹. Again, we can see that perceived engagement was higher with smartphone. The p-values are reported for each measure, confirming their statistical significance. With the Baron & Kenny's procedure we were able to identify the mediation role of arousal in the relationship between interactivity and spectators' engagement¹⁸.

These results show that this method provides the necessary data to compare different measures of the two conditions of interactivity. Having lived and perceived arousal in the measures provide a more robust assessment as suggested by player experience literature³.

FIGURES AND TABLES:

Conditions	Perceived arousal (SAM Scale)	Standardized EDA	Engagement (UES-SF)
With smartphone	5.54	0.0295	3.49
Without smartphone	4.64	-0.1262	3.31
<i>p</i>	< .001*	< .001*	< .001*
<i>N</i>	78	12	78

* p-values were measured using a linear regression with random intercept with a two-tailed level of significance.

Table 1. Descriptive statistics per group

TABLE OF MATERIALS:

Name of Material/ Equipment	Company	Catalog Number
BITalino (r)evolution Freestyle Kit (PLUX Wireless biosignals S.A.)	BITalino	810121006
Devices -1 syncbox -3 light boxes -2 EDA boxes	Developed by Tech3Lab researchers ¹⁵	n/a
CubeHX ²⁰	n/a	n/a

Charging station	Prime 60W 12A 6-Port Desktop Charger	RP-PC028
6 USB3 wires for charging	Insignia 3m (10 ft.) Charge-and-Play USB A/ Micro USB Cable	NS-GPS4CC101-C2
3D scanner	Velodyne LiDAR	VLP-16
Projectors	Barco	F90-W13
Jerseys* -Fabric -Tape -string	Any	Any
2 low light cameras	Sony	A7S
2 tripods for the A7S	Manfrotto	MVK500190XV
2 light stands for the go pro and the syncbox	Impact	LS-8AI
1 plier for the light stand of the syncbox	Neewer	Super Clamp Plier Clip
1 magic arm for the light box of the go pro	Magic Arm	143A
1 Go Pro	Go Pro	5
1 Microphone	Rode	VideoMic Rycote
2 armbands	Amyzor	Moisture Wicking Sweatband

*Make them yourself by taping the number on the fabric and perforating two holes to enter the string

Table 2. Table of materials

DISCUSSION:

Existing laboratory methods use softwares to start recording the screen of a videogame at the same time as physiological data⁸. In the context of digital games that do not take place within a screen, this method is inadequate. With the synchronization of data that our protocol suggests, this issue is bypassed. No matter when the recordings will start,

the data can be linked. We are demonstrating that the technique proposed by Courtemanche et al. can be applied to games research, specifically games that take place outside of the traditional console-based gaming¹⁵. With the synchronized physiological data and the self-reported measures, we were able to compare two conditions of interactivity and observe a difference in engagement.

For researchers who wish to use this protocol, there are some recommendations that are not to be missed. In fact, there are some critical steps in the protocol. Since the method is relying on technology and will be “on” for a long time, all the material should be fully charged before the experiment to prevent data loss. The EDA equipment should always be tested to make sure that it is fully charged, that the Bluetooth reception is working and that the lights are flashing. Although the light boxes are very important for synchronisation, if the light only sends one signal during the whole game it is possible to use the data. The events will then be calculated according to their camera time difference from that only signal. If one light is not sending any signal, it is possible to use the two others to calculate the events. If none of the lights are working, it is also possible to turn on the two EDA boxes and the sync box all at the same time and make it visible in the camera frame and rely on that for the synchronisation of data.

It is also recommended to transfer the data after each collection session to avoid linking the data set to the wrong participant. It will also allow to verify that data was recorded since we do not have access to it in real time. If it is not done, the assumption is that there should be 3 TXT files in the micro SD card for each collection session per participant. The first file as a test (when the device is installed on the participant), the second file for the baseline and the third file for the recording during the actual games.

It is important to note that there is a maximal dimension of the room for the signal to be working. If the sync box is farther than 20 meters from the other boxes, the signal won’t be sent.

This method could be used by game designers who wish to understand the lived experience of their public. As opposed to self-reports or interviews, physiological measures are objective and recorded without stopping the game²¹. Coupled with self-reported measures, they offer a more accurate way of measuring the participants emotional reactions²¹. Understanding better the user allows for better designs².

Due to its portable equipment, this method could be used outside of the laboratory setting. It could be recreated in the real context of the game, which is a public space in our case. This would promote the ecological validity of the research. This method could also benefit other fields of research. As Charland et al. state, engagement in learning is crucial⁴. This method could allow the assessment the multiple dimensions of engagement in the real context of a class. Emotional responses has also been found to lead to important outcomes in the shopping environment²². This method could provide arousal assessment in the context of shopping malls. In sum, this methodology is applicable to a wide variety of other fields of research.

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The authors have nothing to disclose.

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Chapitre 2 - Deuxième article

“I Want to Play Too”: The Response to Impactful Interactivity on Spectators’ Engagement in a Digital Game

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ABSTRACT

As gaming spectatorship has become a worldwide phenomenon, keeping the spectator in mind while designing games is becoming more important. Here, we explore the factors that influence spectators’ engagement. Through the use of GRiD Crowd, a game akin a life-size pong, different levels of spectator influence on the game were tested and their impact on engagement via arousal measures were analyzed. Spectator influence on the game was accomplished via smartphone, where 78 participants put in different audience compositions (alongside friends or strangers) were tested. We found that when the spectators had an impact on the game, higher levels of emotional arousal were recorded, which generated an increase in engagement. These results provide a suggestion of design that could be used by game designers who wish to engage their spectatorship, a segment of their target market that is becoming impossible to ignore.

Author Keywords

Spectators engagement; audience experience; social gaming; physical videogames; interactive games.

CSS Concepts

- Software and its engineering~Interactive games; Human-centered computing~User studies

INTRODUCTION

With an estimate number of 303 millions of esport spectators worldwide in 2020 (growth of 163% from 2015), the importance of the spectator in digital games is becoming undeniable[37]. A shift in interest from the user to the spectator has been observed in the literature about human-computer interaction (HCI) in the last two decades. This shift has been seen in interactive installations in public spaces [39], in video games [13] and in games in public spaces [5]. Literature suggests that spectators can play a variety of roles within digital games that can influence in different ways the experience of the players [14]. Downs et al. recommend game designers to be more aware of the importance of the spectator when they create digital

games. Authors like Downs et al.[14], Reeves et al. [33] and Cheung & Huang [13] provide us with a better idea of how the spectators behave in the context of watching other people interacting with systems. Although these studies provide information about behavior, they do not recommend a specific type of design that would enhance the engagement of the spectators in the game. That is why it was of interest to investigate the factors of engagement of spectators of a social digital game.

To investigate the factors of engagement, we used GRiD Crowd [15], a game akin a life-size Pong [2]. The game is played with one player on each side of the playground and with spectators on the sidelines. In the version used in this research, the spectators have access to an interface with which they can modify the gameplay. Since interactivity has an effect on engagement [34], we manipulated the use of the interactive feature by spectator to investigate if influencing the game would increase their engagement. We hypothesize that adding interactivity through the use of a smartphone, should increase arousal, which in turn, should increase engagement.

There were 78 participants in our study. A within-subject design was used for the interactivity condition, where each member of the public played 3 games in total. They were randomly assigned to two games with access to their smartphone to influence the gameplay and one game without access to their smartphone. A subsample of spectators were randomly selected in order to assess their physiological arousal.

Controlling for audience compositions (alongside friends or strangers), we observed that when the spectators had access to interactivity, their physiological and perceived arousal were higher, which in turn increased their perceived engagement.

RELATED WORK

Spectator Experience

A very influential study on spectators' experience is from Reeves and al.[33]. They raise the importance of the *manipulations* and *effects* in relations to the interactions with a digital system. The *manipulations* pertain to the actions taken by the user that are perceived by the system. The *effects* are the responses of these manipulations by the system. The ways in which these two phenomena are perceived or not by the spectator influence their experience. Their taxonomy lists four types of designs that can influence the appreciation of the spectators. There is the “secretive” design, where the spectators are not aware of the manipulations nor their effects, “expressive” design where the spectators are aware of both the manipulations and the effects, “magical” design, where only the effects are revealed and finally “suspenseful”, where the manipulations are perceivable but not the effects [33]. Cheung & Huang built on that literature with a shift from interactions in a public space to games in the private space. They suggest that *information asymmetry* between the player and the spectator is key to create suspense in the experience of the spectator [13]. Tekin & Reeves also studied games played in the home [36]. In the light of their research, they invite game designers to offer information only available to spectators, but which contribute to the game[36]. This recommendation comes from their discovery of the ‘dual vision’ which

means that the spectator can analyze the player's moves but also the game itself. The spectator becoming an "assistant" to the player in giving playing advices. This role is similar to the ephemeral "coach" role described by Downs et al. after observing that spectators were giving verbal advice to the players in a research about social video-gaming [14]. Downs et al. then recommended game designs where the spectators that would be identified as "coaches" could have access to information that the players do not have.

Engagement

User engagement is a concept that has been omnipresent in the HCI literature for the last two decades [30]. Industry leaders as well are trying to find new ways to gain sustained interest from their users in a highly competitive market. Many authors have tried to define and measure engagement [30]. One area that has been important in engagement research is education. Student engagement is defined as having three components: behavior, emotion, and cognition [16]. This conceptualization has been used in other areas such as digital systems. For O'Brien et al., engagement is "a quality of user experience characterized by the depth of an actor's cognitive, temporal, affective, and behavioral investment when interacting with a digital system" [30].

Because engagement is a multidimensional construct, it is difficult to simply ask users if they felt "engaged". This term may be confusing and some people mistake it for appreciation or simply do not know how to rate their level of engagement [20]. To resolve this, many authors have used multiple dimensions to measure engagement. For instance, Webster & Ho used the following dimensions: challenge, feedback, control, variety, attention focus, curiosity, intrinsic interest, and overall engagement [38]. Mayes & Cotton suggested five factors: interest, authenticity, curiosity, involvement, and fidelity [23]. Brockmyer et al. also used multiple engagement dimensions (immersion, presence, flow, and psychological absorption) to study the impact of violent video games [8].

More recently, O'Brien et al. proposed the User Engagement Scale Short Form (UES-SF) [30]. It was based on the Long Form (UES-LF) that has been used in many fields of research including video games [31]. The robustness of the UES-LF has been reevaluated in 2016 in regard to its dimensionality, reliability, validity, and generalizability [29]. In this reevaluation, it was found that many authors did not use the scale in its entirety. This led to the creation of a shorter version. Since then, authors have used it to measure engagement in interactive media [9], brand recognition [1], chatbot interaction [35] and other digital systems.

This scale is especially validated for western adults in the context of evaluating digital technologies and its short length makes it suitable for within-subject studies [30]. It can be administered more than once according to the needs of the research [30].

Following O'Brien's definition of engagement, The UES-SF is multidimensional. It is comprised of *perceived usability, aesthetic appeal, focused attention, and reward* [30]. The perceived usability subscale is the "negative affect experienced as a result of the interaction and the degree of control and effort

expended” [11, p. 30]. The aesthetic appeal is the “attractiveness and visual appeal of the interface” [11, p. 30]. Focused attention means “feeling absorbed in the interaction and losing track of time” [11, p. 30]. Lastly, there is reward, which is “a single set of items made up of the endurability, novelty and felt involvement components in the original UES” [11, p. 33].

The use of a combination of self-report questionnaires and physiological measures is a common and validated approach for measuring game experience [17]. Engagement was found to correlate with physiological arousal [12], which means the activation of the body system as opposed to sleepiness [19]. A widely used method of measuring physiological arousal in games is electrodermal activity (EDA) [22]. EDA is measured through conductivity of the skin that varies according to the differences in sweat gland activity [26]. This gives access to real-time emotional variations. It also correlates with perceived measures of arousal which can be assessed with a self-report scale [18].

As opposed to measuring player experience, where it is common to use this combination of methods, it has been rarely used in the context of studying spectator’s experience. One study that used it this combination of methods is from Latulipe et al. where they found a strong correlation between self-reported arousal and physiological arousal [20]. Their findings also validated that spectators’ engagement is reflected by physiological measures of arousal.

HYPOTHESIS DEVELOPMENT

Building upon Loren and Rachel Carpenter’s experiment at SIGGRAPH 1991 [10] and Mayne-Aminzade’s study on different technologies that can trigger audience participation [24], we used the game mechanics of the well-known arcade game Pong [2]. One of the main conclusions of Mayne Aminzade’s study is that “the greatest challenge lies not in developing the technology for audience interaction, but in designing engaging activities” [24]. That is why we put our focus on finding the most “engaging” design for spectators. Literature suggests that promoting social interactions or giving many interactive options can lead to higher engagement [34]. As Sid Meier, a renowned video game designer, said, “a [good] game is a series of interesting choices” [27]. This shows that making choices, or influencing a game is a crucial component to a good gaming experience. Maynes-Aminzade stated, in the study using Pong, that if the users are not aware that the effects of their actions are linked to the gameplay, they will not continue playing [24]. A research about museums and learning also suggests that adding an overt interactive component to a digital experience enhances cognitive engagement [32]. Other studies in the field of learning and education found that an important correlate of engagement is arousal [12]. This was also stated by Latulipe et al. in a research about audience engagement [20]. As their study suggests, temporal physiological arousal reflects audience engagement. Thus, we posed the hypothesis that giving access to interactivity to the spectators would increase their arousal, which in turn, would increase their engagement.

METHODS

Experimental Design and Sample

The version of Pong [2] used for this research was developed by Moment Factory [15] and has been scaled to be human size. GRiD Crowd [15], which is the name of this version, is projected on the ground and the players use their bodies as controllers. Movement detection technology allows the paddle to follow the two players, situated at opposite sides of the playground. An image of the two players is presented in Figure 1. As opposed to Loren & Rachel Carpenter's and Mayne Aminzade's experiments, here the spectators are not actively playing the game. They are rather modifying the experience of the players by using an interface that either facilitates or hinders the gameplay. They are given access to a mobile web application on their smartphone on which they can vote for certain power-ups or obstacles (see votes list below). The option with the most votes wins. Using Reeves and al. terms; the spectators manipulate the digital system to send effects to the game [33]. The players being only aware of the effects, but not the manipulations used by the spectators, similarly to the "magical" design but pertaining to the players [33]. There were 8 sessions of a maximum of 12 people that took part in 3 games. Three games was the maximum amount that would allow the experiment to last for an hour. We did not want to go over that as to not lose the attention of our participants. Two people per group were randomly assigned as players. Two or three spectators per group (18 in total) were randomly selected to wear a device assessing their physiological arousal (i.e., EDA).

A within-subject design was used for the interactivity variable, in order to assess the difference between having an impact on the game and not. Each member of the public was randomly assigned to 2 games with access to their smartphone to influence the gameplay and 1 game without access to their smartphone. When they have access to their smartphone, the votes appear at regular intervals and the spectators have 10 seconds to vote an example of the votes might be seen in Figure 2. Other votes that appeared were:

- Fast ball or slow ball?
- Enlarge paddle of blue player or red player?
- Accelerate the ball for blue player or red player?
- Bigger or smaller ball?
- Which one do you prefer between Godzilla and King Kong?

When a vote pertains to the two players, they both have the effect. For enlarging the paddle or accelerating the ball, only one player (blue or red) had the effect, the colours of each player being indicated on the projected ground. When a spectator answers, she sees how many people voted for the same choice as her as shown in Figure 3. Each spectator voted approximately 5 times per game which lasted for 5 minutes on average.

There were a total of 78 spectators in our study. The majority of the participants were aged between 18-25 years old. None of them had previously played the game tested (GRiD crowd). They were recruited using Facebook and our institution panel of participants. All the participants signed a participation consent form. The research was approved by our institution's ethics review board. Participants were compensated

with a draw for two show tickets. To be part of the research, participants needed to be 18 years old or over, be able to stand for 20 minutes, possess a recent smartphone (less than 5 years old), not have skin allergies or sensitivities, not have a pacemaker, not suffer from epilepsy, and not have a diagnosed health problem.

Procedure

After signing the consent form, participants filled a paper questionnaire. The participants that had the number 1 or 2, were assigned to a physiological device that was installed on the palm of their hand. This assignment was random since their numbers referred to the numbers on their jerseys and they could choose any jersey. Then, all participants entered the studio where the game was played and were free to position themselves anywhere around the playground. They were asked to relax and fix something in front of them for 2 minutes, this was used as a baseline for the physiological devices. Then, they were asked to imagine that they were walking by this game in a public space and they had time to participate. They were told it was similar to ping-pong and that they would easily understand the gameplay. Two people were randomly assigned as players and were asked to stand at each side of the playground (Figure 1). The researcher then stated who would use their smartphone for that game using a short URL. Each game lasted for 3 points. A point is made when the ball misses the paddle. Then, two other games were played with the same players, but different participants were told they could use their smartphone. Between each game, all spectators filled a short questionnaire on their smartphone. At the end of the three games, participants filled two other paper questionnaires, the User Engagement Scale and a qualitative questionnaire and then were free to leave. The participants that had the physiological device stayed to answer interview questions. They were asked to talk about their appreciation of the experience with and without the smartphone which also was addressed in the qualitative questionnaire.



Figure 1. GRiD Crowd by Moment Factory (2019)



Figure 2. Voting page of the spectator's interface with the timer bar below



Figure 3. Page with the number of voters per choice

Measures and Apparatus

Since familiarity may have an effect on EDA [21], we controlled for the composition of the audience with four sessions that were comprised of people that were friends and four sessions comprised of strangers. The game was projected on the ground via Barco F90-W13 Projectors. One Velodyne LiDAR VLP-16 was used to detect the movements of the players which made the paddle move accordingly. The spectators used their own smartphone to vote on the power-ups and obstacles.

EDA was measured with a portable apparatus. This was necessary since the participants were standing and moving. The device consisted of a BITalino (r)evolution Freestyle Kit (PLUX Wireless biosignals S.A.) [4] installed in a 3D-printed box that hung on the belt of the subjects (see Figure 4). Three cameras in total filmed the right, the left, and the overview of the playground. Two of the cameras were Sony AS7 and the other one a GoPro 5. One of the three cameras was recording sound with a plugged-in Rode microphone. Every participant had their number on their chest.

To synchronize each game to variations in the EDA recordings, we used a synchronization technique developed by Courtemanche et al. Bluetooth Low Energy (BLE) signals were sent from a sync box simultaneously to the EDA recording 3D-printed boxes and to light boxes. The signals are incrementing numbers that start at one. The light boxes show the synchronization numbers to the cameras, and the same numbers are also logged on the EDA data file (see Figure 5).

A baseline of two minute was performed before starting the game recordings. Physiological measures were taken on a total of 18 participants (23% of all participants). However, 6 of our 18 had too many movement artefacts to be analyzed and thus were discarded.



Figure 4. The EDA device



Figure 5. A light box being placed in the frame of a camera

Arousal can also be confounded with frustration or disorientation when measured with EDA [11]. To avoid misinterpretation of arousal, the literature suggests crossing the data with questionnaires and interviews to understand why variance may occur [26]. Therefore, combining perceived arousal, measured with a self-report scale [26], and the lived arousal, measured with physiological data, contributes to more accurate results [20]. Only the spectators' experience was measured, the players were not asked to fill questionnaires and were not assigned a physiological device.

The arousal dimension of the Self-Assessment Manikin (SAM) Scale was used to assess perceived arousal [6]. Following the procedure used in a study of games in arcade halls [25], the SAM Scale was administered directly after each game, on a link provided that participants could access on their smartphone. They were asked to answer using a visual 9-point Likert scale ranging from calm to excited. After the three games ended, the User Engagement Scale Short Form [30] was administered two times. One time thinking about the experience with the smartphone and one time thinking about the experience without the smartphone. A 5-point Likert scale ranging from "Strongly agree" to "Strongly disagree" was used.

Analysis

The reliability of the UES-SF was assessed. Its Cronbach alpha was 0.71, which is acceptable [28]. Thus, the overall mean of all scale items was used in the analysis as the dependent variable.

EDA values were standardized, then baselined. To standardize, we subtracted the EDA mean to the EDA value, that we then divided by its standard deviation (where the mean and standard deviations are based on the entire dataset) [7]. To baseline, we subtracted the mean of baseline EDA from each EDA standardized value, where the mean is based on the baseline data for each participant in question.

Baron & Kenny's procedure [3] was used to assess the mediation role of arousal in the relationship between interactivity and spectators' engagement. We tested two mediation models, one for each type of arousal; physiological and self-reported. Three steps are required for this procedure. First, we tested the relationship between the independent variable and the mediators. Second, we tested the relationship between the independent and dependent variables. Third, we assessed the relationship between the combination of the independent variable and the mediators, and the dependent variable. A linear regression with random intercept with a two-tailed level of significance was used to detect the relationships between independent and dependent variables and the possible mediators.

RESULTS

Table 1 shows the arousal and engagement means per experimental conditions. The perceived arousal was on a 9-point Likert scale and the engagement dimensions on a 5-point Likert scale.

Conditions	Perceived arousal	Standardized EDA	Engagement
With interactivity	5.54	0.0295	3.49
Without interactivity	4.64	-0.1262	3.31
N	78	12	78

Table 1. Descriptive statistics per group

In the first step of the Baron and Kenny procedure, results suggest that there is a significant relationship between interactivity and the two arousal mediators (perceived arousal: $\beta = .927$, $t(150) = 4.42$, $p < .001$, 95% CI [.58, 1.274] and physiological arousal: $\beta = .172$, $t(3666) = 5.16$, $p < .001$, 95% CI [.117, .227]). In the second step, results suggest that there is also a significant relationship between interactivity and engagement ($\beta = .171$, $t(153) = 3.58$, $p < .001$, 95% CI [.092, .250]). Third, the relationship between interactivity and engagement remains significant ($\beta = .0746$, $t(147) = 5.08$, $p = .039$, 95% CI [.050, .099]) when perceived arousal is included in the model, suggesting a partial mediation of perceived arousal. In addition, the relationship between interactivity and engagement remains significant ($\beta = -.1591$, $t(3665) = -26.06$, $p < .001$, 95% CI [-.17, -.149]) when physiological arousal is included in the model, again suggesting a partial mediation of physiological arousal. These results support our hypothesis.

The control variable which was familiarity (with friends or strangers) was not significant.

DISCUSSION

We found that physiological and perceived arousal were higher with interactivity, which in turn increased engagement. This means that when the spectators could influence the game, their arousal was higher which increased their engagement in the game.

Our first contribution is responding to Downs et al. [14] and Tekin & Reeves' [36] suggestion to offer information only available to the spectator, but that also contributes to the game. To analyze the potential benefits of this suggestion, we used Mayne-Aminzade's focus on engagement and found that it resulted in an increase in engagement [24]. We are also building on Reeves et al. taxonomy that focused on the reveal and hiding of information to the spectator. According to them, the hiding or reveal of certain manipulations and effects of the *player* can influence the spectator's experience with the digital system. Adding to that, we are suggesting that hiding some elements of the manipulations of the *spectator* is a good way to enhance spectator's engagement[33]. It would be interesting to push that question in trying to see having spectators influence the game changed the players' experience too.

Second, we also are in line with the museum engagement literature [32] and the player engagement literature [34] that states that interactivity is a factor of engagement by showing that this can apply to spectators of a game too.

Third, building on performing arts audience literature that states that arousal is a reflection of engagement, we further show the underlying process of the impact of interactivity on engagement for spectators [20]. Being active rather than passive, or the activation generated by the interactivity was spontaneously mentioned by 24% of the participants when asked why they preferred the experience with smartphone interactivity. Again, suggesting that arousal was an important factor for the participants.

These findings could also be useful for game designers that wish to create games that are engaging for the players but also their spectators. As esport spectatorship is growing in popularity, industry leaders will need to take into account this segment of their target market. Adding interactivity could mean higher levels of engagement for a larger number of people.

It is important to note that the survey-based method is subjective and relies on the memory of the participants. Because the questions of the UES-SF were asked after the three games ended, some information may have been lost[17]. Asking to fill the questionnaire in between each game on the smartphone may have prevented potential memory effects.

This study could benefit from a recollection of data in an actual public space where people come and go without being imposed a role. This could take into account the importance of organic transition from; spectator without smartphone, to spectator with smartphone, to player as mentioned in other terms by Wouters et al.[39]. This would also give the study more ecological validity since its aim is to be deployed in the public space.

CONCLUSION

Spectators' engagement is highly relevant to the gaming industry that is facing a growing popularity of esport spectatorship. The subject of spectator's involvement in games has been increasingly studied for the past two decades in literature. As Downs et al. [14] and Tekin & Reeves [36] suggested, we gave some information only accessible to the spectator and found that, in our particular setting, spectators felt more arousal and therefore more engagement in a game that they were watching when they could influence the outcome of the game. This research does not answer the wide array of questions that this highly actual subject is facing but it is suggesting a way to design experiences that take into account the engagement of the spectator. It also opens up a world of opportunities in the types of impact the spectators could have on games.

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Conclusion

Sommaire

L'objectif de cette étude était de développer une méthodologie afin de déterminer les facteurs d'engagement des spectateurs d'un jeu numérique et social. Notre étude, menée auprès de 78 participants (40 femmes et 38 hommes en moyenne âgés de 22 ans), nous a permis de tester une méthodologie de synchronisation des données physiologiques. C'est avec cette méthodologie, qui combine données physiologiques et données auto-rapportées, que nous avons déterminé que l'interactivité engendre une augmentation de l'activation ce qui permet un plus grand engagement chez les spectateurs d'un jeu numérique et social.

Rappel des questions

1. Comment mesurer l'engagement des spectateurs dans un contexte de jeu numérique et social?
2. Quels sont les facteurs qui influencent l'engagement des spectateurs dans un contexte de jeu numérique et social?

Dans le premier article, nous avons présenté une méthodologie qui permet de mesurer l'activation physiologique et perçue ainsi que l'engagement perçu. Nous avons adapté la technique de synchronisation des données physiologiques proposée par Courtemanche et al. (2018) en l'appliquant aux outils boîte EDA, boîte de lumière et boîte de synchronisation (Patent No. VAL-1783, 2019). Nous ainsi ainsi découvert que cette technique s'applique au contexte d'un jeu numérique et social. Nous avons aussi été en mesure de trianguler les données récoltées pour faire l'analyse nécessaire à notre deuxième question de recherche.

Nous avons répondu à notre deuxième question de recherche à l'aide du jeu GRiD Crowd (Moment Factory, 2016). En ayant comme condition l'accès à l'interactivité, nous avons constaté que lorsque les spectateurs avaient un impact sur le jeu grâce à une interface mobile, leur activation était augmentée ce qui causait un plus grand engagement.

Le résultat principal de cette recherche est que les spectateurs d'un jeu numérique et social ont un plus grand niveau d'activation physiologique et perçu lorsqu'ils peuvent influencer le jeu, ce qui permet un plus grand engagement dans l'expérience.

Contributions théoriques

Le domaine de la ludologie comporte plusieurs méthodes d'analyse de l'expérience du joueur (Nacke, 2015). Avec ce mémoire, nous proposons une méthode qui s'inspire de ces connaissances, mais qui l'applique aux spectateurs de jeux, plus précisément, à leur engagement. Les recherches qui s'intéressent aux spectateurs d'expériences numériques utilisent plus souvent les questionnaires (Downs et al., 2014), observations (Tekin & Reeves, 2017), et entrevues (Downs et al., 2015). Dans cette recherche, nous combinons données auto-rapportées et physiologiques, ce qui se fait souvent dans le domaine de l'étude du joueur, mais moins du spectateur. Ce qui nous permet d'utiliser les données physiologiques est la synchronisation des données. Le fait d'avoir, en plus de l'article écrit, une représentation visuelle de la méthodologie, aide à la reproductivité de l'expérience (voir annexe 1).

La deuxième question répond à des auteurs tels que Downs, et al. (2015) et Tekin & Reeves (2017) qui recommandent à la communauté de recherche de trouver de nouvelles façons d'impliquer les spectateurs dans les jeux. Cette recherche teste une nouvelle façon d'impliquer le spectateur et ainsi propose que l'interactivité permet un meilleur engagement.

Implications pour l'industrie

L'importance grandissante des spectateurs de sport électronique ou plus largement des expériences digitales (dans les musées ou espaces publics), requiert une reconsideration du design pour permettre à tout type d'utilisateur d'avoir une bonne expérience.

Cette recherche propose comme première implication une solution de design qui pourrait être utilisée par les designers de jeux pour permettre aux spectateurs, qui ne font pas partie du jeu directement, d'être plus engagés. Ainsi, un apport interactif pourrait être déployé dans des championnats de sport électronique où les spectateurs présents physiquement et

en ligne pourraient être impliqués dans le jeu en influençant le sort des joueurs à l'aide de leur téléphone mobile. Ceci ouvre une multitude de possibilités d'ajout aux mécaniques de jeux actuelles.

Notre deuxième implication est la méthodologie utilisée. Des entreprises qui désirent pousser plus loin la compréhension de leurs utilisateurs pourraient se l'approprier. Le coût majeur serait la location d'équipement physiologique, mais avec la méthode présentée à l'écrit et en vidéo, ils pourraient utiliser les outils eux-mêmes, sans avoir recours à des chercheurs. Elle peut aussi être déployée ailleurs que dans un environnement contrôlé grâce à la flexibilité des outils portables. Cette recherche permet donc de démocratiser l'évaluation de l'expérience du spectateur dans l'industrie et ainsi de sortir du cadre académique tel que suggéré par (Nacke, 2015b).

Limites et futures recherches

Cette recherche gagnerait à être reproduite à plus grande échelle. C'est-à-dire avec un plus grand échantillon et une meilleure validité écologique. Grâce à la synchronisation des données, cette recherche pourrait être recréée en dehors d'un lieu contrôlé (laboratoire ou un studio). À l'aide des outils physiologiques portables, il serait possible d'aller chercher ces données dans le réel contexte du jeu soit un centre d'achat ou un festival. Ainsi, on pourrait tenir compte de d'autres facteurs importants tel qu'un plus grand nombre de participants qui peuvent être dérangés par des facteurs externes. Les gens seraient libres de décider s'ils participent ou non et auraient aussi la possibilité de partir quand ils le décident ce qui permettrait de ne pas omettre l'importance de la transition d'un rôle à l'autre tel que mentionné par Wouters et al (2016). En effet, les gens présents dans les espaces publics sont libres de leurs mouvements, il est donc nécessaire de penser à ce fait durant le design et donc l'évaluation de l'expérience (Rico, Jacucci, Reeves, Hansen, & Brewster, 2010).

Cette méthode pourrait aussi être utilisée dans d'autres domaines de recherche qui s'intéressent à l'engagement émotionnel tels que l'éducation ou encore le magasinage. En effet l'engagement est un concept utilisé pour mieux comprendre l'expérience des étudiants et ainsi offrir des améliorations appropriées (Fredricks et al., 2004). L'activation physiologique est corrélée à l'engagement émotionnel (Charland et al., 2015). Ainsi, on

pourrait utiliser cette méthode pour évaluer l’engagement d’étudiants dans un réel contexte de classe. Le domaine du magasinage s’intéresse aussi à l’activation émotionnelle pour comprendre le comportement de l’acheteur (Lam, 2001). Notre méthode pourrait être reproduite dans un réel magasin pour évaluer l’effet de certains produits sur les acheteurs. Bref, le développement de cette méthode pourrait bénéficier à plusieurs autres domaines de recherche.

Recommandations méthodologiques pour les futures recherches

Certaines recommandations peuvent être tirées de cette recherche pour guider les prochaines études utilisant cette méthode:

- S’assurer de bien tester les outils physiologiques avant la collecte de données (la boîte de synchronisation, les boîtes de lumière et la boîte EDA)
 - Parfois, les signaux ne sont pas envoyés à cause de problèmes techniques donc il faut bien tester la connexion Bluetooth avant de commencer l’expérimentation
 - Par le fait même on vérifie s’ils sont bien chargés étant donné qu’ils seront ouverts pour une longue durée de temps
- S’assurer que les électrodes tiennent bien sur la main des participants en utilisant une bande adhésive médicale et/ou un brassard
 - Comme les participants bougent et sont en groupe (contrairement à une expérimentation en laboratoire où les participants sont assis et souvent seuls), il est plus difficile pour le chercheur de vérifier que les électrodes sont bien en place
- Transmettre les données physiologiques sur l’ordinateur directement après l’expérimentation
 - Étant donné que les données ne sont pas présentées en temps réel sur un ordinateur, mais plutôt enregistrées sur une micro SD, il est important de vérifier entre chaque séance d’expérimentation si les données ont bien été enregistrées pour éviter de perdre les données de plus d’un participant si c’est le cas

- Ceci permet aussi d'éviter les erreurs d'association des données au bon participant
- Utiliser une grande profondeur de champ pour les caméras
 - Étant donné que la boîte de lumière est en avant-plan et les participants sont en arrière-plan, il est important d'avoir une lentille et des réglages de la caméra qui permettent une grande profondeur de champ pour éviter que l'un ou l'autre soit flou
- Avoir accès à un lieu calme pour remplir les questionnaires post-expérience et faire l'entrevue
 - Étant donné que l'expérience se déroule dans un lieu avec beaucoup de gens et donc beaucoup d'action, il est important d'offrir un lieu plus calme avec des chaises et des tables aux participants pour qu'ils puissent prendre le temps de bien se concentrer pour répondre aux questionnaires et entrevue s'il y a lieu.

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Annexes

Annexe 1 : Lien vers la vidéo méthodologique JoVE

<https://youtu.be/hzc1ZtACBVU>

