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Assessing the Comprehensiveness of the Co-operative Performance Metric: A mixed-method analysis using Portal 2

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Abstract. The Co-operative Performance Metric (CPM) is the only existing tool for evaluating co-located game play experiences but has not yet been extensively studied. To observe how effectively the CPM captured co-located and co-operative player behaviour, this study investigates the comprehensiveness of the CPM by comparing a CPM analysis of co-located gameplay with a much more time-consuming video ethnographic analysis. Five pairs of participants played the puzzle game *Portal 2* for one hour, while their interactions were video recorded and analysed. Results indicate that the CPM successfully captures many co-operative behaviours relating to player experience, with some exceptions. The most important missing components were the social effects; 1) prior experience playing the game, and 2) whether players were friends. Thus, with some small modifications, the CPM can function as a quick but comprehensive assessment of co-operative player behaviour, social effects, and game genre.

Keywords: Co-located Gameplay, Co-operative Gameplay, Evaluating Co-operative Game Design, Mechanics, Dynamics and Aesthetics, Video Ethnography.

1 Introduction

Co-located play refers to two or more players occupying the same physical space while playing a game together.We do not yet have well-validated instruments for measuring and visualising the quality of co-located player experiences. One promising tool that could achieve this is the Co-operative Performance Metric (CPM) [1]. The CPM is a brief and easy to administer tool that allows game designers and researchers to describe co-located player behaviour, and to link the frequency of different behaviours to features of game design and player experience [1]. Game designers can use the tool to evaluate whether their designs are promoting the intended player

experiences, and to assess what might need to be changed to create a desired player experience.

In the small number of studies where it has been used, the CPM has evidenced both utility and construct validity. For example, in a pilot study for the development of the CPM [1], the authors demonstrated that varying game designs were reliably scored as distinct based on observed behaviours, indicating different experiences for player groups based on game design. Secondly, in a study of the platform game 'Geometry Friends' (2015), the CPM, and in particular, in the metric component 'worked out strategies', reliably discriminated between varying extents of cooperative behaviours that were influenced by how challenging level designs were and whether levels necessitated cooperation to complete [2]. Emmerich & Masuch [3] utilised components within the CPM components to detect discrete patterns of cooperative behaviour in a 2D platform game, where interdependence was manipulated. Findings suggest that interdependent game designs resulted in better communication and less frustration, and shared control schemes increased frustration and lowered perceived competence and autonomy [3], with each of the conditions being reflected in distinct CPM scores.

Beyond the mentioned studies, the CPM has not been extensively evaluated and since the CPM is relatively brief and simple, it is possible that a CPM-based evaluation of a game may miss a lot of the rich character of interpersonal interaction during co-located and co-operative gameplay. Thus, this paper sets out to examine whether a CPM analysis comprehensively captures data on interpersonal interaction. We do so by comparing results of a CPM analysis with those derived from a much more detailed video ethnography. Additionally, this research will comment on the strengths and limitations of the CPM and suggest potential improvements.

2 Background

To better understand the factors impacting player behaviour/experience and the results of both the CPM and video ethnographic analyses, the following section will review literature on; 1) game design, 2) puzzle game design, 3) co-operative gameplay and player experience, 4) social effects, 5) the Co-operative Performance Metric.

2.1 Game Design

Games are comprised of interaction patterns, wherein implemented game elements produce intended in-game behaviours and experiences [4], and many scholars have attempted to catalogue specific game elements to indicate the effects they have on player behaviour. For example, games have been described in terms of design patterns [5], narrative [6], skill scaffolding [7], design features [8] and lenses [9].

'The Mechanics, Dynamics and Aesthetics (MDA) Framework' [10] is useful for analysing game design by ignoring distracting details, while still accounting for numerous game elements that capture general player activity and player affect. The MDA framework separates games into hierarchical elements constituting player experience [10], breaking games down to 1) their core gameplay mechanics (the obstacles, objects, abilities, rules and goals), 2) how they combine to form in-game dynamics/behaviours and; 3) how together they shape aesthetics [or player experiences; see figure 1]. This framework was utilised in this study to supplement the video ethnographic analysis with compact descriptions of *Portal 2* game design, and player behaviour/experience.



Fig. 1. Game elements/mechanics culminate to impact player behaviour and experience [10].

2.2 Puzzle Game Design

Since *Portal 2,* a co-operative first-person puzzle game is examined in this study, it is important to understand how puzzle game genre and related game designs impact player behaviour. Previous research has analysed and documented common features in the design of puzzles. Iacovides et al, [11] suggest that puzzle games create their unique player experience through presenting challenges that encourage problem solving behaviours, such as breakdowns, breakthroughs, trial and error and hypothesizing. They suggest that a 'breakdown' begins when a player does not know how to progress or solve a puzzle. In attempting to surmount the obstacle, a player usually begins problem solving, i.e. 'trial and error,' to see if anything of consequence occurs from actions taken, 'hypothesizing' a solution when players increase their understanding of game mechanics which is followed by a 'breakthrough' once a new strategy is adopted and a problem is solved [11].

Lundgren et al [12] described 7 aesthetics as gameplay ideals (i.e. gameplay that produces a type of player experience), 2 of which, *camaraderie* and *emergence* could aid understanding of how co-operative puzzle games are experienced by players. *Camaraderie* refers to how players work together to achieve mutual goals while adopting a shared perspective and *emergence* refers to consistent rules enable players to understand and utilize to progress. Bergström et al [13] expanded on the aesthetic of *camaraderie* and associated co-operative gameplay dynamics such as: coordination, strategising, playful mischief and 'guilting' (to stop certain activities) [13].

2.3 Co-operative Gameplay & Player Experience

Co-operative gameplay relies on game design patterns that establish how the game elements cause intended co-operative interactions among players [14]. For example, Beznosyk et al [15] identified typical co-operative game mechanics in casual co-operative games and identified them as either being 'closely-coupled games' or 'loosely coupled games'. Closely-coupled games' relied on game mechanics such as limited resources, complementary abilities and interaction with the same object, while 'loosely coupled games' utilised shared puzzles that were solved individually, or shared goals while acting independently to complete them. To illustrate the impact of co-operative game design on player experience and interaction, Beznosyk et al [15] compared several player outcomes for closely and loosely coupled games which led to different reported levels of enjoyment and in game behaviours [15].

Additionally, game design patterns impact how players communicate to accomplish goals, as seen in previous work on co-operative first person shooters that found information is often communicated within the virtual space itself using the in-game objects, and interface [i.e. visual pings highlighting a point of interest; [14 ,16], or if players are co-located, through bodily gesturing and pointing [14]. However, much of the communication was verbal (oftentimes with the use of tactical "call-outs" and was enhanced through pinging locations [14, 17].

In our study, we anticipate that *Portal 2* will adhere to a closely coupled game design, with frequent verbal communication that makes use of pinging. Beyond game design, the social context may change how a game is played. We refer to social contexts influencing player experience/behavior as 'social effects'.

2.4 Social Effects

Social effects refer to behavioural outcomes that are impacted by social contexts and are an often-overlooked aspect of player experience frameworks [18]. Poels et al [18] developed a broad categorization of player experience, that included 'social presence', which comparatively, the CPM does not incorporate [1]. Additional considerations known to impact player experience/behavior are the history the player has with the game, the attitude of the player (casual or hard-core) and whether or not players are friends [19]. As such whether pairs of players are friends or have previous experience playing the game are considered in this study.

2.5 The Co-operative Performance Metric

Numerous techniques have been developed to evaluate 'Game User Experience' (GUX). However, the Co-operative Performance Metric (CPM) is one of the only measures that attempts to evaluate GUX by gauging co-located behaviour to evaluate co-operative game designs by analysing recorded game sessions [1]. To create the

CPM, Seif El-Nasr et al [1] conducted an analysis on the design of popular co-operative video games at the time and based CPM components on the identified co-operative game designs and co-operative designs identified by Rocha et al [20] before them. The pilot study was conducted utilizing the CPM and attempted to gauge the impact to cooperative game designs had on player behavior from documented player responses. The CPM succeeded in displaying divergent frequencies, means, and confidence intervals of observed player behaviours between games, which enabled discussion about the influence of co-operative game designs on behaviour [1].

Despite the merits in successfully delineating different player behaviours and experiences as seen in previous studies [1-3], there are limitations in the pilot study [1]. Firstly, in relying on broad co-operative design differences between game genres to illustrate the utility of the metric, it is possible that the CPM loses data that is specific to game genre, since genre influences game designs and player experience. Secondly, the study inconsistently had 2 to 4 players per session, meaning social effects were not controlled (i.e. certain behaviour/player experience outcomes that occur because of social effects). Further indicating potential shortcomings in the metric was Emmerich & Masuch's [3] research which combined CPM with other metric components on social behaviours which the CPM remits. In building from Seif El-Nasr et al's study [1], this research will only examine one game (and game type) along with more fixed social contexts by only having two people play together at one time. This study aims to: 1) evaluate the comprehensiveness of the CPM by comparing output to a video ethnographic analysis, 2) comment on the strengths and limitations of the CPM and, 3) suggest improvements to the metric.

3 Methods

3.1 Participants

10 participants (9 men, 1 woman; M age = 23, SD = 4.1) were conveniently sampled from a university and were recruited with in-class announcements, with the selection criteria being that they played at least one hour of video games per week. Participants were assigned into pairs using a random number generator. There were a total of 5 trials, with each trial consisting of two participants. To assess social effects, participants' were identified as either having previous experience playing *Portal 2* or not and each pair was identified as either being friends or not (see Table 1).

Table 1. Descriptive characteristics of participant pairs in each trial.

Trials	Categories of experience and friendship	Genders
Trial 1	One experienced and one inexperienced participant who are friends	Two men
Trial 2	Two inexperienced participants who are not friends	Two men
Trial 3	Two inexperienced participants who are friends	Two men
Trial 4	Two inexperienced participants who are friends	One man and one woman
Trial 5	Experienced and inexperienced participant who are not friends	Two men

3.2 Portal 2

Portal 2 [21] is a first-person puzzle platformer game from Valve which supports co-operative multiplayer. In co-operative mode, players inhabit the robots P-Body and Atlas and embark to solve physics-based puzzles set as a series of obstacle courses.

3.3 Study Design

This experiment was set up in a quasi-natural environment. Two chairs were placed in front of a desktop computer within a computer lab and individuals were seated and given a joy pad to play *Portal 2* for an hour within a computer lab, while their backs faced the camera. Before recording, players were given 5 minutes to become familiar with the controls and recording began at the start of the first co-operative level.

3.4 The Co-operative Performance Metric

Recordings were first analysed using the CPM. The CPM is a tool to detect co-operative game design impact on player experience by observing co-located behaviours that are influenced by game designs [1].

These scored observed behaviours are: 1) Laughter and Excitement Together**:** when players laugh simultaneously, express enjoyment or excitement at the same game event; 2) Worked Out Strategies: verbal expressions of plans and problem solving and navigating the game world together; 3) Helping: when players teach each other's how to play, use controls or save/rescue others and giving unreciprocated instruction on how to navigate the world/obstacle; 4) Global Strategies: events where players take different roles during gameplay that complement each other's responsibilities and abilities; 5) Waited for Each Other and; 6) Got in Each Other's Way: events where one player leads and the other lags behind, or when both players want to

do different actions. An inter-rater agreement was performed in El-Nasr et al's (2010) pilot study and kappa values were produced; four of the CPM components had almost perfect agreements ranging from .84 (Helping) to .94 (Laughter and Excitement Together), and two of the CPM components had substantial agreements ranging from .69 (Worked Out Strategies) to .71 (Waited for Each Other) [22].

3.5 Video Ethnographic Analysis and The Supplementary MDA Analysis

There were two steps in the video ethnographic analysis; 1) an MDA analysis of the game in order to produce a concise description of the game context with which our participants were interacting, and 2) the analysis of players interacting with that game. The first author (GG) conducted the MDA analysis by playing through the first hour of the game 4 times with a friend, and writing out a formal MDA analysis after each playthrough. Gameplay was described according to Hunicke et al's [10] hierarchical elements of mechanics, dynamics and aesthetics which enabled the generation of descriptive patterns between gameplay and behaviour without overwhelming data. The broad description of gameplay was vital since there are currently no established methods for succinctly describing video games in a video ethnographic analysis.

Video ethnography observes people and technology in complex environments, to provide naturalistic (i.e. nonexperimental or quasi-experimental conditions) analyses of work and Human Technology Interaction [23]. Since co-operative co-located game play shares many characteristics as co-operative co-located work, this method was deemed appropriate to gather nuanced data on how social contexts and the video game being played impact behaviour. The use of recordings provides access to specific conduct, conversation, and participant engagement with technology, objects, and artefacts [24], which provides insight into how contextual artefacts can shape behaviour, therein obtaining nuanced findings to compare with the CPM results. This analysis broke down: conversation, actions, the context and time [see figure 2]. The video game dynamics and aesthetics that were coded for in the MDA analysis were used in the video ethnographic analysis. Game dynamics (reoccurring behaviours with game elements) were CAPITALISED and game aesthetics were *italicised*.

Conversation	Michael: We were struggling so much at the beginning… what's that doing? George: wait press it.. look these signals are corresponding to the button.. from X to dot..It looks like we have to go upstairs..What happens when I press that? Michael: I can go up and press that…. George: oh they were orange now blue they change colour, press it again. Yeah see… oh a timer?... what? Michael: So they all need to be clicked
Action	Both players EXPLORE, TRIAL & ERROR with mechanics and DISCOVER/ INVESTIGATE cause and effect.
Context	The introduction of a new mechanics brings both players to INVESTIGATE what the mechanics (buttons) do. Once they learn it is a timer, they quickly HYPOTHESIZE a correct solution *reasoning* and *emergence*
Time	11:55-13:51

Fig 2. An example of trial 3 from the video ethnographic analysis, to demonstrate how conversation, in-game action/behaviour, context, and time were each documented across a horizontal table as they co-occur. The entireties of all trials were documented in this format.

3.6 Synthesizing Results

This mixed-methods analysis was designed to detect frequently occurring player dynamics that are shaped by both game design and social effects leading to diverging aesthetics/experiences in each of the paired participants. In order to synthesize results across both analyses, we compare and consolidate results from the CPM and video ethnographic analysis (which is facilitated with the MDA framework, see figure 3).

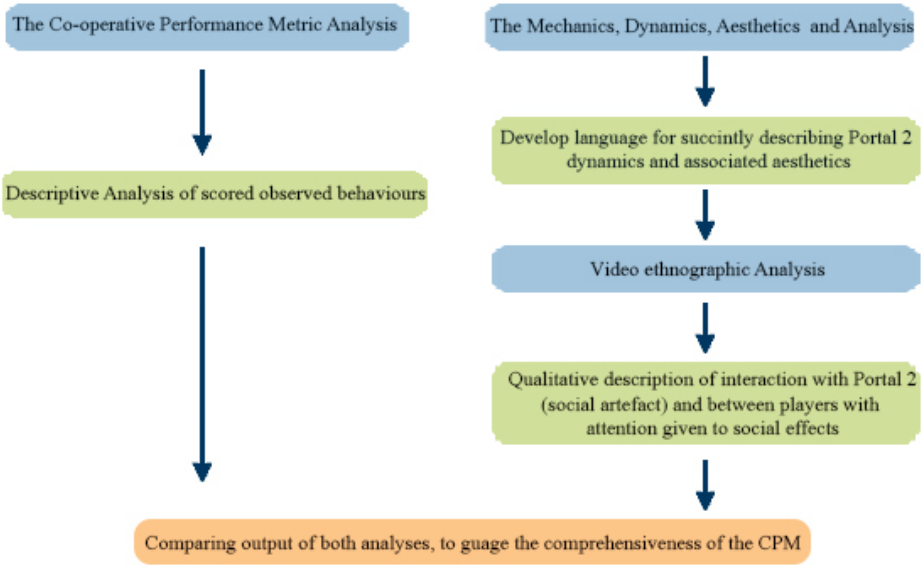


Fig 3. Blue signifies the analyses, green the output, and the orange, the synthesis of outputs.

3.7 Ethics

Ethics was obtained from the School of Applied Psychology's Ethics Committee board on 18/02/2020. Once transcriptions were complete, the original video files had been deleted and only the transcript files were kept on encrypted university servers. Pseudonyms were given to participants to ensure anonymity in transcripts.

4 Results and Discussion

4.1 CPM Results

Video footage was scored by each individual pair according to the six CPM behavioural metrics, as seen in Table 2.

Table 2. Scores, Means and Standard Deviations of each metric component across all trials.

	Laughter & Excitement together	Worked Out Strategies	Helping	Global Strategies	Waited for Each Other	Got in Each Other's Way
Trial 1	59	51	60	2	15	12
Trial 2	15	108	40	1	1	0
Trial 3	37	116	70	2	1	0
Trial 4	28	80	63	2	2	1
Trial 5	3	38	81	0	2	0
M	28.4	78.6	62.8	1.4	5.6	2.6
SD	15.0	34.2	23.2	0.5	5.9	5.3

The two highest scoring metrics are Worked Out Strategies (M= 78.6) and Helping (62.8), both of which successfully capture frequently occurring dynamics elicited by the game's design. The metric Worked Out Strategies captured when players navigated the world together or spoke aloud about it and how to solve a shared obstacle/puzzle. Helping mostly occurred with players unreciprocated instruction about the correct sequence of actions to take, which was particularly frequent if that player had prior experience of playing *Portal 2*, as seen in Trial 1 and Trial 5 scoring the higher in Helping than in Worked Out Strategies when pairing experienced players with inexperienced players. While the CPM was very functional in identifying Worked Out Strategies and had a very clear definition for it, the component of Helping was less clear in the original study whether a single instruction or a string of instructions are scored differently on the metric [1]. This analysis scored Helping with every conjunction used (e.g. Do X and then do Z after Y would count as three scores).

Laughter and Excitement Together was most prominent among friends with one player having experience of playing the game (Trial 1 scoring 59), as opposed to friends without experience scoring (Trial 3 scoring 37, and Trial 4 scoring 28). It was much lower amongst those who weren't friends (Trial 2 scoring 15) and was lowest among strangers when one player had experience and the other did not (Trial 5 scoring 3). These results indicated that behaviour was socially mediated, with both experience and friendship status playing important roles.

Global Strategies refer to in-game mechanics wherein player roles and abilities complement each other, and players strategize around that and scored low in this analysis since the game gave players identical abilities. Waited for Each Other and Got in each other's scored lowly and highlighted the lack of 'loss' condition or skill requirement, since problems could be overcome through instruction of a sequence of actions rather than waiting on a player if the game demanded high skill execution.

4.2 MDA Analysis

The aesthetics identified in the MDA analysis are repeatedly referred to throughout video ethnographic results, and described as a combination of behaviours/dynamics which are CAPITAISED, while the aesthetics are *italicised*. These aesthetics are:

Camaraderie: How players achieve more working as a group than individually. Especially important in forming this experience are MUTUAL GOALS and a SHARED PERSPECTIVE, although somewhat abstract when observing this game alone, it becomes more salient when considering research on 'closely-coupled games' or 'loosely coupled games' based on their co-operative game design, with reliably different experiences based on mechanics that require close team play, such as, INTERACTING WITH THE SAME OBJECT (which occurs in *Portal 2*) compared to distant teamplay when solving problems independently [15]. Given that Portal 2 is a 'closely coupled game', the *Camaraderie* experience is similar to the *Co-operative Challenge*, however there are loosely co-operative puzzle games could score these differently if players have independent goals when working apart.

Co-operative Challenge: The LIMITED RESOURCES (only one exit and entrance portal per player) along with SIMULTANEOUS CHALLENGES ensures that both players must understand their tasks. This encourages INTERACTION for player success as players must each perform the correct sequence of actions to solve puzzles (this is related to *Emergence* as RULE CONSISTENCY is needed for communication and verbalized HYPOTHESES to be meaningful). This meant players had to overcome the same obstacles to reach the same goals through team strategy and interpersonal communication with players providing feedback and information to one another.

Emergence: as an aesthetic ideal stresses the importance of simplicity and RULE CONSISTENCY wherein players predict the consequences of actions and understand

cause and effect of mechanics. *Emergence* is made evident with players forming HYPOTHESES and achieving BREAKTHROUGHS.

Fellowship: refers to social affiliative behaviours that are not goal orientated. This was the least prominent aesthetic but did consistently result from participants reflecting on shared game related experience during DOWNTIME or made comments unrelated to the game and resisted the incorporeal and mocking AI named GLaDOS.

Humour: refers to how game designs facilitate *Humour* (both GAME GENERATED, and PLAYER GENERATED). Game generated humour referred to uncontrollable or scripted game events that made players laugh (in this case, character designs and dialogue from the AI GLaDOS), while player generated was more linked to player behaviour, especially when players PLAYFULLY SABOTAGED one another, made MISTAKES when LEARNING about new game mechanics or witnessed something unexpected or RANDOM.

Reasoning: The game has consistent mechanics to navigate puzzles that use momentum, gravity, objects, and portals. In order to LEARN these mechanics, a process of EXPLORATION, ANALYSIS, TRIAL & ERROR and BREAKDOWN occurred until eventually mechanics were UNDERSTOOD, and *Emergence* could occur.

4.3 Ethnographic Analysis of Each Trial

Video ethnographic results are presented with a short account of each trial and document the behaviours that were impacted by social effects in this experiment.

Trial 1. Brendon and Carlos were friends and Brendon had previous experience playing the game while Carlos did not. This opened up the possibility for Brendon to engage in PLAYFUL MISCHIEF with prior knowledge of how to utilise the game mechanics. Game design supported PLAYFUL MISCHIEF with a LACK OF PENALTY upon player death and NO TIME PRESSURE, which resulted in the trial with the most *Humour*. There was intermitted DISTRUST, but MUTUAL GOALS reinforced by game mechanics that utilized LIMITED RESOURCES kept them playing co-operatively despite frequent MISCHIEF. It is also worth noting that Brendon never betrayed his co-player's trust excessively and did not subvert the lusory attitude. At times, Carlos' playfully GUILTED, Brendan for his PLAYFUL SABOTAGE [laughing] *"What the hell man!"*

Brendan's previous experience also negated a lot of EXPLORATION, DISCOVERY, TRIAL & ERROR, HPYOTHESISING and BREAKDOWN and BREAKTHROUGHS since he was already familiar with the game, thereby changing Carlos's experience of the game through a lot of INSTRUCTION, as evident with the frequent series of directions given by Brendon *"Now right hit the thing"*, resulting in less LEARNING and UNDERSTANDING (less *Reasoning* and *Emergence*) compared to other trials. DOWNTIME, like other trials led to REFLECTION on perfor-

mance, but since they were friends, they also JOKED about the MISCHIEF during the level which increased *Fellowship*. This trial had higher levels of *Humour* and *Fellowship* and moderate *Camaraderie, Co-operative Challenge, Emergence* and, *Reasoning*. The one-sided INSTRUCTION lowered the experience of *Co-operative Challenge*, *Emergence*, and *Reasoning*.

***Trial 2*.** Stephan and Tim were strangers and both were inexperienced at Portal 2. Being strangers impacted how the game was played, with both players strictly trying to solve puzzles. As every new puzzle began, they EXPLORED, ANALYZED, set about TRIAL & ERROR and HYPOTHESIZED before achieving the correct sequence of actions. They LEARNED the mechanics as the game intended through puzzles slowly increasing in difficulty. DOWNTIME featured silence or comments on game quality or comments in response to the AI. The response to the AI encouraged some *Fellowship* in resisting the AI's attempts to, as Tim put it "*to pit us"* against each other, and facilitated *humourous* interactions between the two *"watch by the end of the hour we'll be killing each other. [Laughing]"*. In this trial, the game is functional but other aspects of game dynamics are not present due to the social context, such as the opportunity for playful sabotage since both players are strangers and inexperienced to the game which kept the lusory attitude related to in-game goals [13]. Here the aesthetic experiences were high in *Camaraderie*, *Co-operative Challenge, Emergence, and Reasoning,* moderate in *Fellowship,* and low in *Humour.*

Trial 3. George and Michael were both friends and new to the game. Almost every puzzle involved EXPLORATION, ANALYSIS, TRIAL & ERROR, HYPOTHESIS, LEARNING, TEAM STRATEGY IDENTIFACTION and MUTUAL GOALS. The process of co-operatively solving problems and using newly introduced game mechanics contributed to an experience of *Camaraderie, Co-operative Challenge, Reasoning,* and *Emergence*. *Humour* and *Fellowship* were facilitated by their friendship which enabled a more light-hearted play through with self-deprecating jokes during DOWNTIME, and some MISCHIEF. However, there was less *Humour* when compared to the first trial, since in that trial, one player had prior experience and engaged in a lot more MISCHIEF due to his familiarity with game mechanics, suggesting an interaction between the effect of 'experience' and 'friendship' and game design.

Trial 4. Ryan and Sinead were both friends without previous experience of playing Portal 2. This was a similar social context to trial 3 with George and Michael and resulted in similar behavioural outcomes. Their friendship enabled a more light-hearted play through with exaggerated resistance to GLaDOS during DOWNTIME, achieving both *Fellowship* and *Humour*, "*They're trying to break down our teamwork. Don't listen to her [GLaDOS][Both laughing]".*

***Trial 5*.** Sean and Brian were both strangers and Brian was new to the game while Sean had previous experience. This resulted in moments when Sean would knowingly progress or instruct Brian, while Brian did not get the opportunity to UNDERSTAND

game mechanics *"I have no idea what is going on"*. Many of Sean's attempts to converse were not reciprocated resulting in a lot of silences or one-sided laughter (which does not score on the CPM as a 'laughter' event) [1]. It is very plausible that the game experience of *Camaraderie, Co-operative Challenge, Emergence,* and *Reasoning* was disrupted due to Sean's history of playing *Portal 2* which contributed to his excessive INSTRUCTION. Furthermore, they did not have a base to socially relate on since they were not friends which reduced experiences of *Humour* and *Fellowship*. As the game progressed and Brian got more experience and was able to help Sean during a BREAKDOWN and began ANALYZING and HYPOTHESIZING more; resulting in a slightly more engaged co-operative experience as the experience gap was lessened.

4.4 The Impact of Social Effects

The social factors in this analysis were explored in the video ethnographic analysis and summarised in figure 4 below.

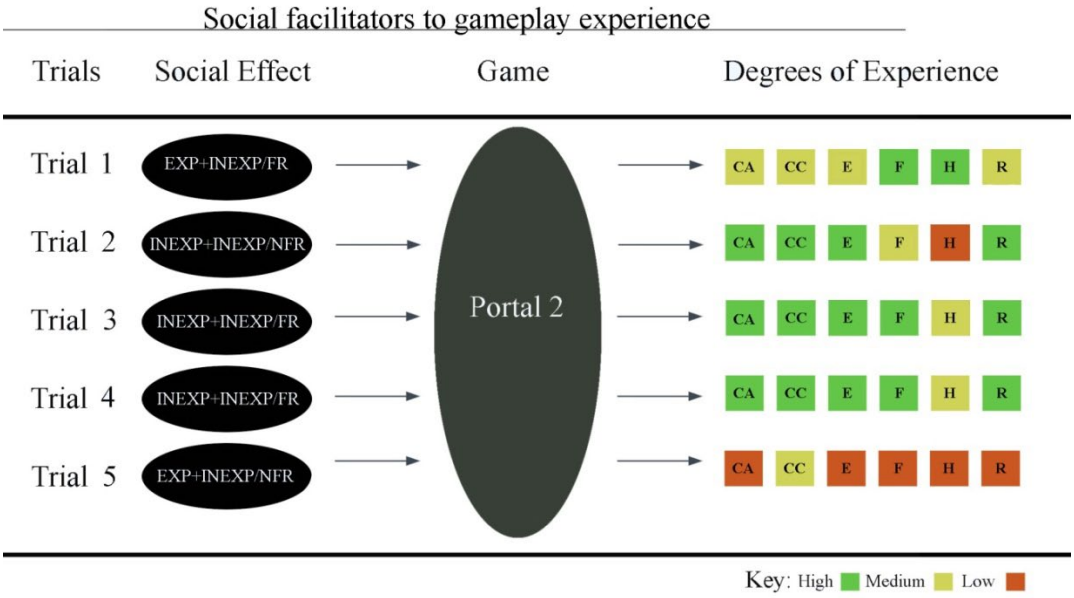


Fig 4. The social factors incorporated in this analysis were EXP/INEXP (Experienced/Inexperienced) and FR/NFR (Friends/Not Friends) which seemed to have impacted how participants engaged with the game and therein, the six types of aesthetics and associated behaviours detected in the MDA analysis. These aesthetics are: *Camaraderie (CA), Co-operative Challenge (CC), Emergence (E), Fellowship (F), Humour (H)*, and *Reasoning (R).* The interpretation of 'high', 'moderate' and 'low' degrees of experience was subjectively judged, based on the video ethnographic analysis.

4.5 Comparing the CPM and Video Ethnographic Results

This section compares and synthesizes both CPM and video ethnographic findings, then identifies the strengths and weaknesses of the CPM in detecting co-located behavioural data relating to player experience and co-operative game design. As such, this section discusses what the CPM detected and what puzzle specific behaviours were missing in the CPM. We recommend referring to figure 5 to visually consolidate this synthesis as we describe how CPM scores relate to gameplay behaviours/aesthetics.

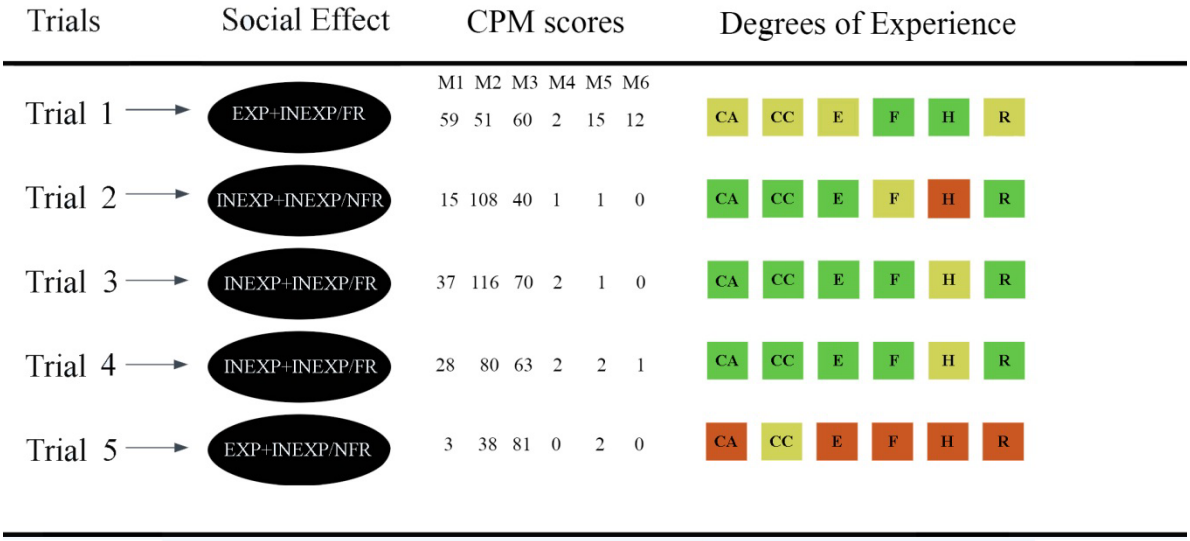


Fig 5. CPM items: M1= Laughter & Excitement, M2= Worked Out Strategies, M3 = Helping, M4 = Global Strategies, M5= Waited for Each Other and M6 = Got in each other's way.

The CPM component Helping detected dynamics revolving around unreciprocated INSTRUCTION about gameplay mechanics or controls, and was associated with *Co-operative Challenge*, while Worked Out Strategies detected dynamics surrounding EXPLORATION, MUTUAL GOALS, SHARED PERSPECTIVES, TEAM STRATEGY IDENTIFICATION and SIMULTANEOUS CHALLENGES and was tied to feelings of *Camaraderie* and *Co-operative Challenge*. The CPM component Worked Out Strategies successfully detects dynamics relating to the aesthetic of *Camaraderie* that results in a 'closely coupled game', relying on dynamics like VIRTUAL CO-PRESENCE (as opposed to not occupying the same virtual space), MUTUAL GOALS and SHARED LEARNING [12]. CPM scores that were high in Worked Out Strategies and low in Helping were associated with numerous experiences of *Camaraderie* and *Co-operative Challenge* (trials 2, 3 and 4) whereas those scoring high on Helping but low on Worked Out Strategies were associated with high *Co-operative Challenge* but low *Camaraderie*, indicating a less fun experience (trial 1and trial 5). The video ethnographic analyses suggests these divergent results manifested

due to previous experience playing the game (social effects) wherein the SHARED EXPERIENCE of LEARNING game mechanics is restricted due to excessive INSTRUCTION, and resulted in lower *Camaraderie*, *Co-operative Challenge, Emergence*, and *Reasoning* (trial 1 and 5). Zabal et al [25] noted a cooperative game degenerates into a single player game when one player begins performing or directing all the games' actions and consequently becomes boring; these results suggest gaps in player experience with a game could exaggerate this tendency in co-operative games.

The component Laughter and Excitement Together captures the several dynamics that shaped player behaviour to encourage *Humour*, which were GAME GENERATED HUMOUR (often through refuting or enjoying the snarky AI, GLaDOS and humorous avatar design and animations) or PLAYER GENERATED HUMOUR which occurred through a variety of non-goal orientated behaviour (PLAYFUL MISCHIEF and PLAYFUL SABOTAGE) or RANDOMNESS when engaging with novel mechanics. This could justify splitting CPM component of laughter and excitement as either player generated or computer generated.

Humour as scored in the MDA analysis or 'Laughter and Excitement Together' in the CPM analysis was mostly mediated by the social effects, with the highest score being achieved in Trial 1 (EXP+INEXP/FR group). This was mediated by prior knowledge of game mechanics and a friendship that allowed for MISCHIEF and non-goal orientated behaviour to alter the lusory attitude and a game 'well-played' for mostly humorous aesthetic ideals [19]. Those who were friends without experience still utilised game mechanics with *humorous* intent, especially compared to those who were not friends (trials 1,3,4 compared to trials 2 and 5). These results support research that found social norms are adhered to less when players are more familiar with one another, allowing for more fun and 'bending of social rules' [19].

The remaining three metric components, Global Strategies, Waited for Each Other, Got in each other's way each scored very lowly, but still highlight game mechanics that did not provide complementary roles, had low skill execution requirements, and lacked the possible tension of getting in one another's way since there was unlimited time and no punishment when making mistakes.

The behaviour reflecting *Reasoning* reoccurred across all trials and is an indicator of the process involved with LEARNING the rules to navigate puzzles, these were: 1) EXPLORATION AND ANALYSIS; 2), TRIAL AND ERROR and 3) BREAKDOWNS. *Emergence* also reoccurred across trials and was a demonstration of behaviours that reflected UNDERSTANDING, these were 1) HYPOTHESIS and 2) BREAKTHROUGH, which manifested as actions and verbal explanations (or planning) that show the players' understanding of the game and ability to estimate cause and effect based on the rules established in the game. *Portal 2* engaged both of these processes and are worth including in the metric when analysing puzzle games.

In the CPM, the metric component worked out strategies could comprise both *Emergence* and *Reasoning* however, we recommend breaking the component worked out strategies into two aspects, '*Emergence'* and '*Reasoning'*, which could be more revealing in a game analysis. High scores in *Reasoning* and low scores in *Emergence* could also serve as an indicator for frustration, due to excessively random TRIAL & ERROR along with a lack of UNDERSTANDING and BREAKDOWN; whereas high scores in *Emergence* and a low score in *Reasoning* could indicate that the game is too easy with puzzles that do not necessitate LEARNING.

Moreover, the aesthetic of *Fellowship* was facilitated by the lack of punishment for failure (lack of frustration) and mechanics supporting PLAYER GENERATED HUMOUR. Furthermore the antagonistic AI encouraged positive social interaction between players and DOWNTIME encouraged REFLECTION or more personal communication unassociated with problem solving.

Put briefly, the strengths of the CPM lie in its success in capturing dynamics associated with *Camaraderie*, *Co-operative Challenge*, and *Humour* with the metric components worked out strategies and laughter and excitement together. However, improvements could be made by adding social categories that impact game experience, such as previous experience with the game and whether players are friends. Additionally, splitting the component worked out strategies into *Emergence* and '*Reasoning'* could be useful to capture the experience of different stages of solving puzzles.

5 General Discussion

This research set out to evaluate the comprehensiveness of the CPM by comparing output with a video ethnographic methodology across five pairs of participants playing *Portal 2.* Ideally, the CPM could be used to document consistent co-located co-operative behaviours with associated game designs, and to effectively analyse how a game orchestrates behaviour, and assess what might need to be changed to create a desired player experience. CPM results were compared to a video ethnographic analysis which had descriptive game data organised using an MDA analysis, so moment-to-moment video game contexts could be succinctly described. Six aesthetics were observed in the MDA analysis: *camaraderie, cooperative challenge, emergence, fellowship, humour* and *reasoning*. No new aesthetics were identified in follow up playthroughs by different players, suggesting that the identified aesthetics from the MDA analysis were valid and reliable for these trials.

This study identified strengths of the CPM, wherein the components could successfully detect co-operative aesthetics and game designs based on the six observable behaviours it was scored on. The fact that there were parallels between the CPM and video ethnographic results in detecting *camaraderie*, *co-operative challenge* and *humour* demonstrates impressive efficacy, despite being such a brief and easy to use

tool. However, some shortcomings in the CPM were identified, the first being the lack of consideration for social effects. The 'social effects' identified in this study were 'previous experience' (playing the game) and 'friendship status', and should be considered if game designers wish to evaluate co-operative game designs, since outcome behaviours are not isolated from social context and seemed to impact how the game was played in this study. Additionally, the CPM did not account for social behaviours relating to solidarity between players which was covered in the aesthetic of '*Fellowship'*. Furthermore the CPM did not differentiate '*Humour'* as being computer generated (i.e. scripted events in game) or player generated (scenarios that encourage humour through gameplay), which could be useful to inform which elements of Humour a game designer might wish to improve upon.

Moreover, co-operative puzzle game behaviours were found to be related to the CPM component worked out strategies. However this component could be improved by splitting the component into two aspects, '*Emergence'* and '*Reasoning'*. This way, game designers could more easily identify which aspect of a puzzle game design is functioning as intended, with '*Reasoning'* capturing the behaviours around the learning process and '*Emergence'* relating to behaviours when a puzzle is understood. Worked out strategies alone does not capture these differences, and they are useful in documenting if puzzles are too difficult (i.e. too high in '*Reasoning'* and associated behaviours of breakdown and trial and error) or too easy (too high in '*Emergence'* or understanding of rules/game elements). Future research could conduct MDA analyses on different game genres and appropriately factor these components into a modified version of the CPM to capture associated niche behaviours relating to game genre. For example, incorporating '*Emergence'* and '*Reasoning'* into a modified version of the CPM to detect niche behaviours for puzzle games could be named the CPM-PZ (The Co-operative Performance Metric-Puzzle).

Finally, it is worth noting that Emmerich & Masuch's [3] previous research used both CPM components and social components items to annotate videotaped gaming sessions and included friendly behaviours such as 'shared success and failure' and 'off-topic' that could arguably be included under the single construct of '*Fellowship'*. Their work also included several other useful items to indicate player frustration, with behaviours like swearing. We recommend including these additional behaviours into a metric for increased accuracy. For example, when all aspects are included for a puzzle modified CPM, the metric would include: game generated humour, player generated humour, excitement, worked out strategies (scored aspects beingreasoning and emergence), waited for each other, got in each others way, global strategies, fellowship and frustration, along with nominal categories on the social effects of friendship and experience with the game. Furthermore, there was little physical behaviour during the gameplay sessions, with players almost exclusively behaving in the game, meaning this metric could be applied to online gaming sessions in future studies.

6 Strengths, Limitations and Recommendations

This study utilized a mixed methods design to view whether the CPM was a comprehensive metric by comparing CPM and video ethnographic outputs to identify the CPM's strengths and weaknesses in detecting player experience and associated behaviours. The video ethnographic analysis succeeded in uncovering puzzle game effects and social effects that mediated player behaviour and experience.

This research has a potential limitation in the hour-long trial format which could have exaggerated the impact of a disparity of experience with the game, wherein hour-long trials would not observe how inexperienced players would behave as they familiarised themselves with the game. Additionally, due to the scrupulous nature of video ethnography, only a small sample size was obtained, meaning that observations in this study can only infer a possible pattern, and not describe an established pattern between social effects and niche game designs that cause reliable behavioural outcomes. Future research can investigate whether social effects and game genre explain statistically significant variance by incorporating them into a modified CPM as nominal variables and analysing data from larger sample sizes which could be conducted online using voice communications and recordings of in-game behaviour.

7 Conclusion

Overall, the six CPM components captured aspects of behaviour that was influenced by co-operative game design. However, to effectively compare games within the same genre, as indicated by video ethnographic results, it is important to distinguish behaviours that are unique to specific game genres, as highlighted by the suggestion to split the CPM component 'worked out strategies' into two aspects, *reasoning* and *emergence* for puzzle games. Furthermore, the social context (prior experience playing the game and whether players were friends) has a pronounced impact on behavioural outcomes and we recommend adding these as nominal categories to the CPM (e.g., EXP/INEXP and FR/NFR) in future studies along with a humour component that discriminates between player generated and computer-generated humour, and finally the inclusion of *fellowship*, indicating behaviours of solidarity.

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