Comparing Measures of Perceived Challenge and Demand in Video Games: Exploring the Conceptual Dimensions of CORGIS and VGDS

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Measuring perceived challenge and demand in video games is crucial as these player experiences are essential to creating enjoyable games. Two recent measures that identified seemingly distinct structures of challenge (Challenge Originating from Recent Gameplay Interaction Scale (CORGIS) - cognitive, emotional, performative, decision-making) and demand (Video Game Demand Scale (VGDS) - cognitive, emotional, controller, exertional, social) have been theorised to overlap, reflecting the five-factor demand structure. To investigate the overlap between these two scales we compared a five (complete overlap) and nine-factor (no overlap) model by surveying 1,101 players asking them to recall their last gaming experience before completing CORGIS and VGDS. After failing to confirm both models, we conducted an exploratory factor analysis. Our findings reveal seven dimensions, where the five-factor VGDS model holds alongside two additional CORGIS dimensions of performative and decision-making, ultimately providing a more holistic understanding of the concepts whilst highlighting unique aspects of each approach.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI**; *User studies*; • **Applied computing → Computer games**.

Additional Key Words and Phrases: Video games, challenge, demand, player experience, questionnaires

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1 INTRODUCTION

Challenge is a core factor in creating enjoyable gaming experiences [57]. Yet, challenges in video games place variable demands on players' limited attentional resources that can hasten or hinder enjoyment [11]. As such, the player experiences of challenge and demand are not well understood. Furthermore, the games industry currently evaluates these player experiences through unstructured (and often, atheoretical) interviews during manual playtests, which results in an incomplete view of the challenges and demands games present [21]. Without the ability to measure or even understand the full complexity of challenge and demand in digital games, it is difficult to generate a reliable and systematic metric for the discrete player experiences that lead to an enjoyable video game playthrough.

Two measures of perceived challenge and demand in video games have recently been developed using differing approaches rooted in human-computer interaction (HCI) (the former) and media and communication studies (the latter): Challenge Originating from Recent Gameplay Interaction Scale (CORGIS) [20] and Video Game Demand Scale (VGDS)

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[11]. These two measures were developed based on each research team's understanding of the concepts and represent their interpretation of what they deemed essential to measure.

At first glance, these two measures each identified seemingly different dimensions and structures of perceived challenge and demand. This may be because dimensions of challenge and demand are not easily identified or well understood due to the complexity of experiences involved in video games [5]. Differences in dimensions between the measures may also result from the human interpretation required when creating new questionnaires, such as labelling identified factors (in itself, influenced by the disciplinary background of a given authorship team). Despite appearing different at first glance, Bowman et al. [9] recently proposed that the measures may instead be comparable. Their model presents a five-factor structure (Table 1) that proposes the latent factors on both scales (the root concepts of challenge and demand) might completely overlap.

Table 1. Proposed affinity groupings for conceptual dimensions of recently developed perceived challenge and demand measures.

#	**CORGIS (Denisova et al., 2020)**	**VGDS (Bowman et al., 2018)**
1	Cognitive Challenge (e.g. problem solving)	Cognitive Demands (e.g. problem solving)
2	Emotional Challenges (e.g. narrative tensions)	Emotional Demands (e.g. unexpected feelings)
	Decision-making Challenges (e.g. tension & consequences)	
3	—	Controller Demands (e.g. device mapping)
4	Performative Challenge (e.g. reaction times)	Exertional Demands (e.g. reaction times)
5	—	Social Demands (e.g. relationships with others)

Note: Examples in parentheses are simplified explications of each dimension as proposed by Bowman et al. [9].

Although a model of overlap between the two scales has been suggested, the model has not yet been empirically tested. Therefore, to explore the potential overlap between these two scales, we compared the proposed five-factor model suggesting a complete overlap of the concepts with a nine-factor model suggesting no overlap. We asked 1,101 players to complete an online survey recalling their last gaming experience before completing CORGIS and VGDS. We conducted confirmatory factor analysis to investigate model fit for the two *a priori* five and nine-factor models. After failing to confirm both the five and nine-factor models, we conducted an exploratory factor analysis that suggested three candidates. Therefore, six, seven and eight-factor structures were further compared for parsimony.

Ultimately, our results reveal seven dimensions, suggesting some overlap between the two scales. The five-factor VGDS model of cognitive, emotional, controller, exertional and social demand held alongside two additional CORGIS dimensions of performative and decision-making challenge. This solution suggests that players use a combination of assessments about (a) what is required of them during gameplay (perceived demands, via VGDS) and (b) their

performance in the face of those requirements (perceived challenges, via CORGIS) when evaluating an overall gaming experience.

The core contribution of this work is that it provides a more holistic understanding of two conceptually similar metrics that can measure a broad range of specific player experiences but that are not specific to any one game or genre platform (or technology, given emergence of similar factor structures in virtual reality gaming [8, 39]). This new comprehension of CORGIS and VGDS highlights unique aspects of perceived challenge and demand as broader concepts whilst drawing on the strengths of each measures approach to assessing player experience. Related to this, the current study reconciles perspectives on player experience from two different areas of scholarship (HCI and media and communication studies) and through this, highlights the benefits of using a more integrated scholarly approach. Finally, to aid future researchers and developers in applying our findings and method to their own work, we also discuss the challenges, benefits, and limitations of the current study.

2 BACKGROUND

We survey related work on (a) field-specific approaches and definitions of perceived challenge and demand in video games, and (b) the conceptual dimensions identified by CORGIS and VGDS. We also discuss the potential convergence and divergence of the scales throughout.

2.1 Measures of Perceived Challenge and Demand in Games

The CORGIS and VGDS scales were created to operationalise and measure perceived challenge and demand regarding four facets (cognitive, emotional, physical, and social), although the approaches are not isomorphic. To begin exploring the potential for an overlap in the dimensions of perceived challenge and demand measured by CORGIS and VGDS, we must understand how these concepts are defined and understood by each measure.

2.1.1 ***CORGIS.*** CORGIS bases its understanding of perceived challenge as a player experience on an in-depth analysis of HCI literature concerning games user research, design, and AI. Early models of challenge in video games focused on two distinct categories: cognitive and physical [2]. Cognitive challenges referred to spatial reasoning, memorisation, decision-making, comprehension, and planning. Whilst physical challenges involve the accuracy and speed of actions as well as the player's endurance. Neuropsychological research into perceptual challenge has also been applied to challenge in games relating to pattern recognition and locating hidden objects [55]. This could be argued to be a sub-dimension of cognitive challenge, as late perception used to consciously identify in-game objects would be a cognitive process [49]. More recent work has introduced a third facet of challenge: emotional, which involves resolving ambiguous, emotional narrative tensions [15]. Furthermore, Bopp et al. [3] have provided compelling evidence supporting emotional challenge as a separate individual facet of challenge, manifesting in multiple ways. Previously, social challenge was incorporated into cognitive challenge due to cognitive requirements to read an opponent and predict their moves [42]. However, recent support for social challenge as a distinct dimension has been provided, as players experience negative emotions when struggling to coordinate with teammates or losing to other players [3]. In order to understand how CORGIS defines perceived challenge in relation to these dimensions we must first note the distinctions between challenge and difficulty.

Challenges are characterised as a game objective, task or problem [20, 33] that is always non-trivial with an uncertain outcome [35]. Additionally, challenges are associated with positive valence due to their use in describing stimulating experiences [20]. Likewise, when faced with a challenge, players are motivated to respond to tasks as they feel in

control of the outcome [38]. Challenges can thus be regarded as key motivating factors for gameplay, as they stimulate players' interactions with the game system [37]. Aarseth [1] refers to these player interactions as negotiations where challenges prompt the player to exert effort, while the player drives the game toward a desirable outcome. Juul [34] further supports this theory of negotiation stating challenges require increased effort to influence the outcomes of the game.

Difficulty is the probability of task failure, which can be objectively measured in the game [41]. It can be represented in game as the barriers that prevent the player from achieving their goals or completing tasks (i.e. challenges) [20]. Hence, the difficulty of a challenge depends on the player's skills, abilities, motivations, and prior knowledge [33]. Additionally, where challenge is seen as having positive valence, difficulty is associated with more negative experiences, such as feelings of discomfort and frustration due to struggling with tasks [22, 45].

Perceived challenge emphasises capturing both the positive and negative valence associated with challenge and difficulty. Perceived challenge in CORGIS is therefore defined as *"a player experience that arises from one's interaction with a game's intrinsic challenges at a particular skill level"* [20].

2.1.2 ***VGDS.*** VGDS instead utilises interactivity-as-demand theory first popularised in the field of media and communication studies to understand and measure perceived demand in video games. Early theories argue for an interactivity-as-product approach, where users employ system features and affordances to alter the system's content and form [52]. This former approach was favoured by user-centred models [54] as it placed the system at the heart of the interaction whilst emphasising that system features are constant and unchanging compared to human users with different skill levels, motivations, and knowledge. However, this approach assumes that all users will experience the system the same way, which is highly unlikely due to the individual differences between users [12]. Therefore, Stromer-Galley [53] argues instead for an interactivity-as-process approach. Here, interactivity is theorised as a two-way dialogue between a user and a system [24] or co-authorship [58] between a player and a game. Ultimately, the interactivity-as-process theory was adapted by Bowman [4] to apply to video games as interactivity-as-demand theory. The theory argues that perceptions of demand relate to four player requirements for gameplay identified in media and communication studies literature (cognitive resources, emotional responses, physical inputs, and social interactions).

Perceived demand in the VGDS is therefore defined as *"a requirement placed on the user to actively and constantly respond to on-screen displays in order to continue the digital experience"* [11]. Demands have also been described in some literature as trivial with a specific inevitable outcome [35].

2.1.3 ***Convergence of Perceived Challenge and Demand in CORGIS and VGDS.*** On a superficial level, the notions of perceived challenge and demand appear to describe a similar player experience. As previously discussed, both perceived challenge and demand impose requirements on the player in order to continue their interaction by eliciting responses from the game. Challenges require effort from players for them to overcome barriers to tasks and influence the outcome of the game via negotiation [1, 34]. Alternatively, the game demands cognitive resources, emotional responses, physical inputs, and social interactions from players to create a dialogue of co-authorship between the player and the system [24, 58].

It is possible for players to reach a 'flow' state [18, 51] when optimal levels of challenge [18] and/or demand [10] are reached. This state of flow leads to high levels of engagement on the task at hand. However, if this balance is broken, it can lead to players feeling anxious and frustrated (over-challenged/demanded) or bored (under-challenged/demanded) [14, 16].

Finally, both CORGIS and VGDS measure players' perceptions of a recent gaming experience as individual differences between players — skills, abilities, motivations, and knowledge — are thought to impact perceptions of challenges and demands [12, 33]. However, VGDS also asks players to rate gameplay across six categories as per Oliver et al. [47] and then explain their ratings to ground the participant's responses to VGDS items in their experience of the game.

These strong similarities between the two concepts of perceived challenge and demand raise the question of whether CORGIS and VGDS measure the same or different player experiences through their identified dimensions. Nevertheless, there are subtle differences in the language used to describe each concept and dimension as evidenced by Karhulahti et al. [35] suggesting they may not be the same. However, it can be argued that perceived challenge and demand are too conceptually similar to be perceived and interpreted as discrete concepts by players when evaluating previous gameplay and that their divergence is purely semantic.

2.2 Dimensions of CORGIS and VGDS

The notion that there are at least four higher-order facets of perceived challenge and demand in video games (cognitive, physical, emotional, social) now seems generally accepted [3, 6, 20, 21]. However, both measures seem to have identified additional dimensions or components outside of the four-dimension model. One explanation is that during measure creation, each research team appeared to place an *a priori* emphasis on a different dimension of challenge (CORGIS - emotional, VGDS - physical). It could be that this enhanced focus on specific dimensions led to sub-dimensions of higher-order facets of challenge and demand being identified rather than new discrete dimensions. This theory is partly supported by the proposed five-factor structure (Table 1), as two dimensions of CORGIS are theorised to come together under emotional challenge. However, for VGDS, the physical dimensions of controller and external demands are theorised to remain separate.

CORGIS and VGDS also seem to differ in terms of focus. CORGIS emphasises on-screen experiences, whereas VGDS deals with more external off-screen experiences [9]. At the same time, there is considerable overlap in the identified dimensions of challenge across these two scales concerning cognitive, emotional, and physical dimensions. These differences and similarities are discussed below.

2.2.1 ***Cognitive.*** All VGDS cognitive items are general and associated with the consumption of cognitive resources in relation to direct and purposeful thinking (CogD2 - "I had to think very hard when playing the game", CogD3 - "The game required a lot of mental gymnastics"). Only one item (CogD6 - "The mental challenges in this game had an impact on how I played") directly addresses the player's interactions with the game as a result of the cognitive demand (on-screen experience), versus the game's effects on the players cognitive resources (off-screen experience).

In comparison, most CORGIS cognitive challenge items relate to specific on-screen examples of cognitive challenge including a players memory (CogC2 - "I had to memorise a lot of different things when playing the game"), observation (CogC9 - "I had to constantly keep track of what was going on in the game"), planning (CogC1 - "Succeeding in the game required much planning", and problem-solving/co-ordination capabilities (CogC7 - "The game made me manage several tasks at the same time"). A small number of items refer more generally to cognitive challenge and the use of mental effort (CogC10 - "I had to think actively when playing the game").

2.2.2 ***Emotional.*** VGDS emotional demand items focus entirely on game-induced affect (EmD1 - "The game tugged at my heartstrings"), including player-centred emotions (EmD3 - "I was moved by the game") and context-centred emotions (EmD5 - "I had a lot of unexpected feelings during gameplay"). Moreover, much of this induced affect tends to focus on more pensive and eudaimonic experiences, with neutral valence and with no specifically named emotions.

Similarly, CORGIS items also related to the aspects of game-induced affect (EmC2 - "The things that happened in the game made me sad"), including player-centred emotions (EmC1 - "This game is more than just a game to me"), and context-centred emotions (EmC5 - "The game made me think about real-life issues"). In comparison to VGDS, CORGIS does name a specific emotion within its items. Additionally, CORGIS also contained items regarding narrative tensions (EmC8 - "The game had moral dilemmas in it where the choice was not obvious"), resolving ambiguities (EmC7 - "I felt a sense of suspense when playing the game"), and identifying with characters (EmC4 - "I felt a sense of responsibility for characters and events in the game").

Decision-making challenge items are theorised to also fall within the emotional dimension. Originally, during CORGIS measure creation, decision-making challenge items were originally incorporated with cognitive challenge [20]. However, due to the focus on players' experiences of making difficult choices that could lead to regrettable outcomes (DMC4 - "I had to think about possible alternatives for my actions in the game") the CORGIS decision-making items reflect both cognitive and emotional decision making. However, Bopp et al. [3] found that in-game decisions are inherently emotional, finding that the decision and action component of emotional challenge was characteristic of anger, fear, sadness, and tension. Demands research regarding moral decision-making instead suggests that longer more deliberative decision-making may be more cognitively demanding. Whereas decisions made in a shorter timespan may be more intuitive and similar to emotional reactions [28], again suggesting that decision-making comprises of cognitive and emotional components.

2.2.3 ***Physical***. VGDS identified two off-screen physical dimensions: controller and exertional demand. Controller demands relate to the physical input required to interact with the game. Items focus on how intuitive and easy to handle the controls are (ConD1 - "The controls were very natural to me"). Exertional demands relate to physical activity required by the player, with items referencing physical exhaustion and feeling drained (ExD3 = "My body felt drained after gameplay").

CORGIS identified one physical dimension – performative challenge – where items describe player speed and reaction time in response to on-screen stimuli (PC2 - "I had to act quickly when playing the game"). Performative challenge is theorised to reflect exertional challenge (Table 1), which is logical as rapidly reacting to on-screen stimuli is likely to increase physical activity off-screen. However, performative challenge could just as easily reflect controller challenge as rapid reactions will require an understanding of the game controls. Hence, natural, easy-to-use controls are likely to lead to quick reaction times.

2.2.4 ***Social***. VGDS social demand items reflected a variety of social interactions, including: game-induced sociality (SD1 - "Socialising was an important part of playing the game"), player-initiated sociality (SD4 - "I felt obligated to others, while playing"), awareness and response to others (SD5 - "Being around others in the game had an impact on how I played"). It is important to note that the items do not indicate if 'other' is human or non-human in order to cover the broad range of social experiences within games. Additionally, this is the only dimension where more than one item relates to on-screen player experiences where the player acknowledges engaging with the game as a result of social interaction. This may be due to the nature of social communication requiring a two-way interaction which in this case is aided by the technology.

In contrast, CORGIS deliberately did not include items related to social connection between players and therefore did not measure social challenge. This reasoning was threefold; first, social connection is complex, and not all social connection may be related to perceptions of challenge for a video game itself. Second, during interviews with players, social play was not reported as a distinct aspect of challenge but instead enhanced the other three facets of challenge

(cognitive, emotional, and physical), making them more meaningful [20]. Third, existing questionnaires measure social connection in games in depth [19, 32].

3 METHODS

We conducted an online survey study to understand if the CORGIS and VGDS scales measure the same or different dimensions of perceived challenge. Supplementary materials – including a full copy of the survey, a complete list of video game titles, *R* code used for the data analysis, and other files – are available online at: https://osf.io/ysazd/.

3.1 Survey Instrument

The survey was deployed using Qualtrics software between July 13^{th} and July 24^{th}, 2022 and administered online via a shareable link. Prior to taking the survey, participants were asked to give informed consent. Survey responses were anonymous, and participants were able to skip any questions they did not wish to answer. The median time to complete the survey was just under 12 minutes (*Mdn* = 719 seconds). All questions were in English and were grouped as follows:

Demographic information: Participant's age and gender.

Last gaming experience: We asked participants about their last gaming experience, including game title, platform, controller type, session length in minutes, and if they played the game alone or with other players either in the same room or online. As per Oliver et al. [47], participants were also asked to rate the game on a scale of 0-100 in six categories — story/narrative (M = 63.83, SD = 31.69), gameplay (M = 84.21, SD = 14.65), controls (M = 79.96, SD = 16.38), sound (M = 81.77, SD = 19.46), graphics (M = 78.05, SD = 18.88), overall rating (M = 86.20, SD = 11.97) — and then briefly explain the ratings they gave. The open-ended data were not used as part of our analyses but were instead intended to prime participants for the perceived challenge items in the next stage of the survey by asking them to think about their experience of the game in a meaningful way.

Perceived challenge and demand: We asked participants to rate 56 statements from the CORGIS (30 items) and VGDS (26 items) measures in relation to their last gaming experience on a 7-point Likert scale anchored at each end with 'Strongly Disagree' and 'Strongly Agree'. To avoid order effects, statements were presented in a randomised order.

3.2 Participants

Participants were a volunteer sample recruited via social media and online gaming forums, including Reddit, Twitter, and Discord. Participants were required to be at least 18 years old and received no inducement for participation. The survey link was accessed 2,340 times, with 1,248 participants completing the entire survey. We removed: participants who did not consent, as they were automatically routed to the end of the survey (n = 25); participants who self-reported to be under the age of 18 (n = 10); and participants who entered meme and/or offensive responses into open text fields (n = 7). Furthermore, participants who reported playing more than one game (n = 4) or playing on more than one platform (n = 1) in their last gaming session were removed. Lastly, we removed participants without complete responses for CORGIS and VGDS items (n = 103).

Of the N = 1,101 respondents in the retained sample, there were 759 men (68.9%), 268 women (24.3%), 61 non-binary (5.5%), 10 who wished to self-describe (0.9%) including 3 trans and 7 other, and 3 not specified (0.3%). The average age of the sample was 27.86 (SD = 8.08), ranging from 18 to 81.

In regards to last gaming experience participants reported playing 346 titles, with the most played being: *Hades* (n = 92, 8.4%), *Final Fantasy XIV* (n = 64, 5.8%), *Disco Elysium* (n = 41, 3.7%), *Animal Crossing: New Horizons* (n = 35, 3.2%), *World of Warships* (n = 29, 2.6%), and *Star Citizen* (n = 27, 2.5%). We note that participants were asked to name the last

Table 2. Frequency of video game genres played by survey respondents.

Video game Genre	No. of Games	Video game Genre	No. of Games
Action RPG	42	Real-time strategy	4
Action-adventure	50	Rhythm	4
Adventure	21	Roguelike	12
Boardgame	2	Roguelike deck builder	1
Casual	3	Role-playing	18
Fighting	11	Sandbox	6
Grand strategy	3	Shooter	41
Interactive fiction	4	Simulation	5
Life sim	10	Sports	7
Management sim	9	Strategy card game	2
MMORPG	10	Survival	9
MOBA	4	Survival horror	14
Party	1	Tactical RPG	3
Platformer	16	Turn-based strategy	10
Puzzle	13	Vehicle simulation	1
Racing	8	Vehicular combat MMO	2

game they played, and naturally, some games are more popular than others. Therefore, fewer games were listed (346) than the total number of participants (1,101) – similar patterns were observed during the development and validation of both CORGIS [20] and VGDS [11]. Participants played video games from a diverse range of genres (32 in total) with the most favoured genres being action-adventure (n = 50), action RPG (n = 42), and shooter (n = 41). The full list of genres is detailed in Table 2, whilst the complete list of game titles within each genre and their related player frequencies is available in the supplementary tables.

Participants most recent gaming sessions ranged from 5 to 900 minutes, with the average session length being 143.41 minutes (SD = 115.91), and a modal score of 120 minutes. The most popular platform was PC/Mac gaming (n = 633, 57.5%), followed by PlayStation consoles (n = 169, 15.4%), the Nintendo Switch (n = 159, 14.4%), and Xbox consoles (n = 86, 7.8%). The majority of players used a mouse and keyboard (n = 492, 44.7%) or a gamepad controller (n = 462, 42.0%). Participants mostly played alone (n = 721, 65.5%) or online with other players not in the same room (n = 345, 31.3%), with only a small number of participants playing with other players in the same room (n = 35, 3.2%). Although these data are not used for analysis, they are provided to highlight the diversity of games and players in the sample and indicate our findings are generalisable across a range of video games.

4 RESULTS

Investigation of the dimensional overlap between the CORGIS and VGDS scales is presented in three stages: (a) item analysis to ensure the whole data set and individual items were suitable for factor analysis, (b) confirmatory factor analysis (CFA) of the *a priori* five-factor (complete overlap) and nine-factor (no overlap) structures, and (c) on reflection of a failed CFA a *post hoc* exploratory factor analysis (EFA) to assess the lack of fit.

4.1 Sample Adequacy

Firstly, Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy and Bartlett's Test for Sphericity were applied to the data, KMO = .942, Bartlett's $\chi^2(1540) = 39156.305$, $p < .001$, suggesting that the full data set was suitable for factor

analysis. Secondly, individual items were assessed with KMO. No item had a KMO < .75 suggesting that all individual items were suitable for factor analysis.

4.2 Confirmatory Factor Analysis

The LAVAAN package for R statistical software [50] was used to conduct a CFA for the two *a priori* models. The data was compared to accepted thresholds for model fit defined by Bowman and Goodboy [7]; including root mean square error of approximation (RMSEA), standardised root mean square residual (SRMR), comparative fit index (CFI), and Tucker–Lewis index (TLI).

Five-factor Model: The data did not fit three of the four thresholds for model fit - $\chi^2(1474) = 11842.71$, $p < .001$, RMSEA = .081, SRMR = .113, TLI = .718, CFI = .730,. Both CFI and TLI scores were below the suggested parameters of greater than .950 and the SRMR fell above the suggested threshold of below .080, whereas the RMSEA score fell on the borderline of the acceptable parameters of below .080. All 56 perceived challenge and demand items were inspected and seven were found to have weak loadings below .400: one item from the CORGIS emotional challenge dimension (EmC6 - "Playing the game was stimulating"), two items from the CORGIS decision-making challenge dimension (DMC1 - "There were some decisions in the game that I regretted" and DMC4 - "I had to think about possible alternatives for my actions in the game"), and all four items from the VGDS exertional demand items dimension (ExD1 - "I was physically exhausted after playing", ExD2 - "I felt strained after playing", ExD3 - "My body felt drained after gameplay", and ExD4 - "The game was physically demanding"). Removing all items from the VGDS exertional demand dimension was not deemed reasonable as CFA is a hypothesis test. Hence, post hoc alterations to the CFA model would convert the test from a CFA to EFA, whilst strongly capitalising on sample-specific variance (chance) merely for the sake of model fit [7, 23]. Thus, the *a priori* five-factor model could not be confirmed.

Nine-factor Model: The data did not meet two of the four acceptable thresholds for model fit - $\chi^2(1448) = 6586.08$, $p < .001$, RMSEA = .057, SRMR = .076, TLI = .858, CFI = .866. Both CFI and TLI scores were below the suggested threshold, however, SRMR and RMSEA fell within the acceptable parameters. Once again, all 56 perceived challenge items were inspected and only one was found to have a weak loading below .400 which was an item from the CORGIS emotional challenge dimension (EmC6 - "Playing the game was stimulating"). Thus the *a priori* nine-factor model could not be confirmed.

As neither the five-factor or nine-factor *a priori* models could be confirmed, both models were compared against a univariate model using Akaike information criterion (AIC) and Bayesian information criterion which suggested a multivariate solution would better fit the observed data - five-factor model AIC = 223896, BIC = 224507; nine-factor model AIC = 218692, BIC = 219432; univariate model AIC = 239169, BIC = 239729. Therefore, we further investigated the underlying factor structure of the CORGIS and VGDS scales. Table 3 reports model fit for all four-factor models.

Table 3. Model fit statistics for five-factor, nine-factor, and one-factor solutions.

Factor Model	χ^2	df	RMSEA	SRMR	TLI	CFI	AIC	BIC
Five-factor	11842.71	1474	0.081	0.113	0.718	0.730	223896	224507
Nine-factor	6586.08	1448	0.057	0.076	0.858	0.866	218692	219432
One-factor Univariate	27134.96	1484	0.125	0.149	0.306	0.331	239169	239729

4.3 Exploratory Factor Analysis

As previously discussed, CFA can only test a predetermined factor structure as it is a hypothesis test. In contrast, EFA reports on observed patterns of shared variance that create as many factors as needed. As a result, EFA allows for (a) fewer or more underlying factors to arise than theorised in the *a priori* models and (b) for items to load onto factors other than the ones proposed in *a priori* models. These two scenarios are highly possible as the CORGIS and VGDS have never been used in combination before, and merging the items may have led participants to interpret some items differently than when the scales are used individually. For example, the item CogD7 - "The game stimulated my brain" within the VGDS cognitive demand dimension may have primed participants to interpret the CORGIS emotional challenge item EmC6 - "Playing the game was stimulating" as relating to mental challenges. Therefore, due to the lack of model fit for the two specified *a priori* models, EFA was conducted using SPSS Statistics 28.0.

Maximum likelihood estimation with oblique, direct oblimin factor rotation was used to allow factors to correlate with one another [48]. The first iteration provided a simple nine-factor solution with 21 items showing poor primary loadings. It was noted that one factor had only two items and neither of the items loaded strongly (> .400) onto this factor. Therefore, a parallel analysis was conducted using R statistical software, alongside examining a scree plot to determine the number of factors to retain [13, 27]. The analysis suggested the retention of seven factors; hence, six, seven and eight-factor solutions were investigated. Additionally, it was established *a priori* that items should have primary factor loadings greater than .600, with no cross-loadings greater than .400. We used these stringent cut-offs suggested by Bowman and Goodboy [7] rather than more common and liberal cut-offs (i.e. .40 - .30 - .20 rule [31]) to reduce the amount of error introduced into the model. Therefore, items were removed based on these criteria to produce six and seven-factor solutions which were then compared to select the most parsimonious model [56].

Table 4. Primary loadings for the initial seven-factor solution of combined CORGIS and VGDS items.

Dimension	Item	Loading
1. Cognitive		
	VGDS CogD1 - The game was cognitively demanding.	.750
	VGDS CogD2 - I had to think very hard when playing the game.	.739
	VGDS CogD4 - This game doesn't require a lot of mental effort. (R)	.718
	VGDS CogD5 - The game made me draw on all of my mental resources.	.618
	CORGIS CogC10 - I had to think actively when playing the game.	.613
	VGDS CogD3 - The game required a lot of mental gymnastics.	.609
	VGDS CogD7 - The game stimulated my brain.	.607
	CORGIS CogC3 - I had to think several steps ahead when playing the game.	.604
	CORGIS CogC6 - I felt challenged when playing the game	.596
	CORGIS CogC7 - I had lots of different things to think about at once in the game.	.588
	CORGIS CogC1 - Succeeding in the game required much planning.	.580
	CORGIS EmC3 - I invested much thought into the game.	.531
	VGDS CogD6 - The mental challenges in this game had an impact on how I played.	.506
	CORGIS CogC2 - I had to memorise a lot of different things when playing the game.	.490
	CORGIS CogC11 - Playing the game required me to do my best.	.486
	CORGIS CogC5 - Playing the game requires great effort.	.468
	CORGIS CogC8 - The game made me manage several tasks at the same time.	.451
	CORGIS EmC6 - Playing the game was stimulating.	.419
	CORGIS CogC9 - I had to constantly keep track of what was going on in the game.	.414
	CORGIS CogC4 - I had to prepare for the things that the game threw at me.	.404

Dimension	Item	Loading
2. Emotional		
	VGDS EmD3 - I was moved by the game.	.888
	VGDS EmD2 - The game gave me the feels.	.882
	VGDS EmD1 - The game tugged at my heartstrings.	.873
	VGDS EmD4 - I had a strong emotional bond with the game content.	.832
	VGDS EmD5 - I had a lot of unexpected feelings during gameplay.	.678
	CORGIS EmC2 - The things that happened in the game made me sad.	.654
	CORGIS EmC1 - This game is more than just a game to me.	.603
	CORGIS EmC4 - I felt a sense of responsibility for characters and events in the game.	.585
	CORGIS EmC5 - The game made me think about real life issues.	.584
3. Controller		
	VGDS ConD1 - The controls were very natural to me. (R)	.902
	VGDS ConD2 - The game's controls were like second nature to me. (R)	.869
	VGDS ConD3 - The game controls were easy to handle for me. (R)	.851
	VGDS ConD4 - The game controls tripped me up.	.694
4. Performative		
	CORGIS PC1 - I had to react quickly when playing the game.	-.944
	CORGIS PC2 - I had to act quickly when playing the game.	-.930
	CORGIS PC4 - Quickly responding to things that I saw was an important part of the game.	-.870
	CORGIS PC3 - Thinking fast was an important part of the game.	-.861
	CORGIS PC5 - I had to make snap decisions when playing the game.	-.796
5. Exertional		
	VGDS ExD3 - My body felt drained after gameplay.	.867
	VGDS ExD1 - I was physically exhausted after playing.	.864
	VGDS ExD2 - I felt strained after playing.	.733
	VGDS ExD4 - The game was physically demanding.	.649
6. Social		
	VGDS SD2 - While playing, I was aware of others in the game.	.803
	VGDS SD5 - Being around others in the game had an impact on how I played.	.781
	VGDS SD1 - Socializing was an important part of playing this game.	.769
	VGDS SD3 - I was compelled to interact with others in the game.	.722
	VGDS SD4 - I felt obligated to others, while playing.	.655
	VGDS SD6 - This game was socially demanding.	.590
7. Decision-making		
	CORGIS DMC3 - I had to make difficult choices in the game.	-.702
	CORGIS DMC1 - There were some decisions in the game that I regretted.	-.701
	CORGIS DMC2 - I wonder how different the outcome in the game would be had I chosen a different option.	-.691
	CORGIS DMC5 - The game made me think hard about my decisions.	-.562
	CORGIS EmC9 - The game involved making moral choices that I didn't agree with.	-.545
	CORGIS EmC8 - The game had moral dilemmas in it where the choice was not obvious.	-.538
	CORGIS DMC4 - I had to think about possible alternatives for my actions in the game.	-.514
No primary loading >.400		
	CORGIS EmC7 - I felt a sense of suspense when playing the game.	

The initial eight-factor solution (Appendix A) reflected the same split in cognitive items affecting the initial nine-factor solution described above. These two factors were mainly composed of CORGIS and VGDS cognitive items reflecting mental effort and planning. Additionally, these two cognitive factors were strongly correlated (r = .643), and all but one item (CogC8 - "The game made me manage several tasks at a time") correlated with both factors (r > .400). This split in cognitive items seemed to reflect the planning factor identified and subsequently eliminated in the creation of the CORGIS scale due to the two factors being deemed too conceptually similar to warrant that level of complexity

[20]. Moreover, in the final iteration of the eight-factor model (Appendix B) only two items for the planning factor had strong primary loadings (> .600). It should be noted that factors with fewer than three strongly loading items are generally considered weak and unstable [17]. Consequently, the eight-factor solution was rejected.

Table 5. Primary loadings for final seven-factor solution of combined CORGIS and VGDS items, including factor loadings, internal consistency, and descriptive statistics.

Dimension	Item	Loading
1. Performative — Eigenvalue = 6.914, ω = .951, M = 5.043, SD = 1.841		
	CORGIS PC1 - I had to react quickly when playing the game.	.945
	CORGIS PC2 - I had to act quickly when playing the game.	.934
	CORGIS PC3 - Thinking fast was an important part of the game.	.875
	CORGIS PC4 - Quickly responding to things that I saw was an important part of the game.	.872
	CORGIS PC5 - I had to make snap decisions when playing the game.	.797
2. Emotional — Eigenvalue = 4.919, ω = .926 , M = 3.878, SD = 1.807		
	VGDS EmD2 - The game gave me the feels.	.899
	VGDS EmD3 - I was moved by the game.	.892
	VGDS EmD1 - The game tugged at my heartstrings.	.890
	VGDS EmD4 - I had a strong emotional bond with the game content.	.816
	VGDS EmD5 - I had a lot of unexpected feelings during gameplay.	.692
	CORGIS EC2 - The things that happened in the game made me sad.	.668
3. Controller — Eigenvalue = 3.350 , ω = .894, M = 2.461, SD = 1.329		
	VGDS ConD1 - The controls were very natural to me. (R)	.900
	VGDS ConD2 - The game's controls were like second nature to me. (R)	.869
	VGDS ConD3 - The game controls were easy to handle for me. (R)	.847
	VGDS ConD4 - The game controls tripped me up.	.692
4. Cognitive — Eigenvalue = 2.881, ω = .875, M = 4.314, SD = 1.355		
	VGDS CogD1 - The game was cognitively demanding.	.811
	VGDS CogD2 - I had to think very hard when playing the game.	.776
	VGDS CogD4 - This game doesn't require a lot of mental effort. (R)	.770
	VGDS CogD5 - The game made me draw on all of my mental resources.	.662
	VGDS CogD3 - The game required a lot of mental gymnastics.	.639
	CORGIS CC10 - I had to think actively when playing the game.	.604
5. Social — Eigenvalue = 2.594, ω = .866, M = 3.864, SD = 1.790		
	VGDS SD2 - While playing, I was aware of others in the game.	.824
	VGDS SD5 - Being around others in the game had an impact on how I played.	.784
	VGDS SD3 - I was compelled to interact with others in the game.	.738
	VGDS SD1 - Socializing was an important part of playing this game.	.737
	VGDS SD4 - I felt obligated to others, while playing.	.648
6. Exertional — Eigenvalue = 2.124, ω = .874, M = 2.411, SD = 1.413		
	VGDS ExD3 - My body felt drained after gameplay.	-.881
	VGDS ExD1 - I was physically exhausted after playing.	-.860
	VGDS ExD2 - I felt strained after playing.	-.723
	VGDS ExD4 - The game was physically demanding.	-.634
7. Decision-making — Eigenvalue = 1.292, ω = .815, M = 3.902, SD = 1.831		
	CORGIS DMC1 - There were some decisions in the game that I regretted.	.797
	CORGIS DMC2 - I wonder how different the outcome in the game would be had I chosen a different option.	.756
	CORGIS DMC3 - I had to make difficult choices in the game.	.628

The initial six-factor (Appendix C) and seven-factor (Table 4) solutions had similar simple structures, with the main difference being that CORGIS decision-making challenge items were absorbed into the cognitive factor on the six-factor solution. Furthermore, for the six-factor solution one CORGIS emotional challenge item (EmC6 - "Playing the game was stimulating") did not load (> .400) onto any factor. Both of these solutions had a simple structure and good conceptual coherence in regard to the items contained within each factor. With the aim of creating a strong unified scale it was established that items should have primary factor loadings > .600, with no cross-loadings > .400. Therefore, items were removed based on these criteria to produce six and seven-factor solutions which were then compared to select the most parsimonious model [56]. The third and final iteration of the six-factor solution resulted in a 32-item scale (Appendix D). In contrast, the fourth and final iteration of the seven-factor solution resulted in a 33-item scale (Table 5). The two solutions were quite similar, with cognitive, performative, controller, exertional, and social factors mirroring one another in terms of items. The only differences lay in the decision-making and emotional factors.

Concerning decision-making, in the final six-factor solution, all decision-making challenge items were removed due to poor primary loadings (< .400) on the cognitive factor. However, in the final seven-factor solution, three decision-making challenge items were retained within their own decision-making factor. In regards to the emotional factor, for the six-factor solution, two additional items from the CORGIS emotional challenge dimension were retained (EmC4 - "I felt a sense of responsibility for characters and events in the game" and EmC5 - "The game made me think about real-life issues"). Although these two items did not cross load (> .400) onto the decision-making factor, they correlated with the decision-making factor in the first iteration of the seven-factor solution before they were removed (EmC4 r = -.450, EmC5 r = -.409), suggesting the items may be related to emotional decision-making. Additionally, as the cognitive factor was the same for both the six and seven-factor solutions, this suggests that no cognitive decision-making items were included in the six-factor solution, meaning the cognitive aspect of decision-making may not be well represented in the six-factor solution. Furthermore, the decision-making factor in the final seven-factor solution correlates with both the emotional (r = .317, $p < .001$) and cognitive (r = .438, $p < .001$) factors (Table 6), further suggesting that decision-making has both an emotional and cognitive aspect. Therefore, the seven-factor solution was selected as the most parsimonious model due to the inclusion of the additional decision-making factor, which encompasses both emotional and cognitive decision-making. Table 5 reports the final seven-factor structure and loadings for each item, as well as eigenvalues, internal consistency, mean and standard deviation. Internal consistency was calculated using Hayes' Omega Macro for SPSS Statistics [25]. Table 6 shows bivariate correlations between factors.

Table 6. Pearson's correlation r between dimensions in the final seven-factor solution.

r	1	2	3	4	5	6
1. Performative	—					
2. Emotional	-.052 (.085)	—				
3. Controller	-.020 (.507)	.054 (.073)	—			
4. Cognitive	**.263 (<.001)**	**.175 (<.001)**	**.079 (.009)**	—		
5. Social	**.219 (<.001)**	**.184 (<.001)**	.007 (.828)	**.173 (<.001)**	—	
6. Exertional	**.290 (<.001)**	**.090 (.003)**	**.153 (<.001)**	**.357 (<.001)**	**.156 (<.001)**	—
7. Decision-making	-.007 (.816)	**.352 (<.001)**	.048 (.155)	**.430 (<.001)**	**.190 (<.001)**	**.088 (.003)**

5 DISCUSSION

In this article, we compared two recent measures of player experience with differing approaches to scale development that seemed to identify similar dimensions. CORGIS, developed in the realm of HCI, measures perceived challenge and VGDS, developed in the sphere of media and communication studies, measures perceived demand. We theorised that these scales would completely overlap following the five-factor VGDS demand structure as both perceived challenge and demand seemed to represent the same player experience. However, we were unable to confirm both the five-factor (complete overlap) and nine-factor (no overlap) model, as well as a one-factor univariate model. Instead, we found a revealing seven-factor structure of perceived challenge and demand — cognitive, emotional, physical (comprised of: performative, controller, and exertional), social, and decision-making. This new understanding of the measures highlights the overlap of the two scales whilst calling attention to the unique dimensions identified by CORGIS and VGDS due to their differing approaches to measuring player experiences. Ultimately, we present a more holistic view of perceived challenge and demand as player experiences.

5.1 Seven Dimension Model of Perceived Challenge and Demand

Due to the exploratory nature of the research, we examine the items of each dimension individually to understand the overlap and divergence of perceived challenge and demand further.

Regarding the cognitive dimension for the final seven-factor solution, only one CORGIS item was retained. Incidentally, the retained item pertained to more general cognitive challenge (CogC10) in line with the VGDS items. Furthermore, the VGDS item that reflects on-screen experiences (CogD6) was removed due to low primary loadings. Therefore, all retained cognitive items reflected off-screen player-centred experiences centring around the consumption of cognitive resources or exertion of mental effort in relation to direct and purposeful thinking.

Retained items in the emotional dimension are similarly all related to game-induced affect. Interestingly, all but one CORGIS emotional challenge item (EmC2) were removed due to poor primary factor loadings despite CORGIS items reflecting similar themes to VGDS items (player-centred and context-centred emotions). One reason for this may be that the CORGIS items for these types of emotions were more context-specific and 'extreme' than VGDS items of the same type meaning the more general VGDS items applied to a broader range of emotional experiences. For example, "I was moved by the game" (EmD3), representing player-centred emotions refers to a less intense form of emotion and experience than "This game is more than just a game to me" (EmC1). Similarly, CORGIS items referring to narrative tensions, resolving ambiguities, and identifying with characters also refer to very specific experiences that may not apply to all player's experiences leading to lower primary loadings. The retained CORGIS item adds experience of a specific negative emotion (sadness) to the mostly eudaimonic and pensive emotions reflected by VGDS items.

All items for the three physical dimensions (performative, controller, exertional) were retained within their respective dimensions. Rather than combining with exertional demand as expected, performative challenge remained separate, forming its own dimension suggesting challenges of speed and reaction time are experienced independently from other physical demands. Interestingly, performative challenge was associated with exertional demands but not controller demands. This suggests that challenges of speed and reaction time are not influenced by controller mapping or vice versa. An explanation for this may be that performative challenge and controller demands are instead linked via the cognitive dimension with which they both have positive associations. Additionally, exertional demand was associated with all other dimensions. This may be because all types of challenges and demands are perceived to be inherently tiring. For example, cognitive tasks are known to cause mental fatigue, which can then lead to higher perceptions of

effort [44]. It may be that the presence of other challenges and demands (emotional and social) also lead to a feeling of physical fatigue.

The social demand dimension retained all but one item (SD6 - "This game was socially demanding"). We offer the explanation that this item may have been interpreted as relating to negative experiences where the player was forced to interact socially more than they would have liked. All other items seem to have neutral valence. Social demands are associated with all dimensions but controller demand, most notably performative challenge. The association with performative challenge may be due to the need to react faster than the opponent in competitive games.

Decision-making challenge originally contained two emotional challenge items relating to resolving narrative tensions (EmC8 - "The game had moral dilemmas in it where the choice was not obvious" and EmC9 - "The game involved making moral choices that I didn't agree with"). These two emotional items did not cross-load with the emotional dimension but were correlated. Although this finding does not align with previous CORGIS work [20], it is also not surprising and supports findings from Bopp et al. [3] who found decision and action challenges were emotionally challenging. Holl et al. [29] also found support for the link between moral decision-making and influencing factors such as emotional engagement and social agents. Other decision-making challenge items that were removed pertained to thinking about decisions (DMC4 - "I had to think about possible alternatives for my actions in the game" and DMC5 - "The game made me think hard about my decisions"). Although these two items did not cross-load onto the cognitive factor, they did strongly correlate with the cognitive dimension. These correlations may have been the reason for these four items' poor primary loading and subsequent removal from the decision-making challenge dimension. However, it does provide support for the notion that decision-making has a cognitive and emotional component [20, 28]. The three retained items seem to reflect decision-making in general rather than focusing on the emotional or cognitive aspects like the removed items. As expected, decision-making challenge is associated with the emotional, cognitive, exertional, and social dimensions in line with previous work [20, 28, 29].

5.2 Divergence of Perceived Challenge and Demand

Even though we found that CORGIS and VGDS items for the cognitive and emotional dimensions merged together (indicating overlap of the concepts), only items reflecting off-screen experiences were retained in the final measure. Additionally, all unique dimensions identified by the two scales remained separate, suggesting the two scales do not measure the same player experiences. Overall, the seven-factor structure, therefore, seems to reflect the five-factor demand structure of VGDS — cognitive, emotional, controller, exertional, social — alongside two additional CORGIS challenge dimensions — performative, decision-making. Taken together, these findings suggest that perceived demands measured by VGDS reflect player perceptions of technology (i.e. 'the requirements that the game placed on them') which occur mostly off-screen. Whereas perceived challenges measured by CORGIS reflect the player's perceptions of their ability to engage with the technology via mostly on-screen interactions (i.e. 'what they did' and 'how they did'). Contrary to our initial beliefs, perceived challenge and demand are similar but discrete player experiences that complement one another when combined. Our findings, therefore, offer remarkable clarity to how players use a combination of assessments when evaluating their overall gameplay experience. First, about what is required of them during gameplay (perceived demands, via VGDS) and second, their performance in the face of those requirements (perceived challenges, via CORGIS).

5.3 Contributions to HCI

Research regarding perceived challenge and demand is still ongoing. Rather than becoming increasingly nuanced, we took a broad approach by bringing together two theoretical perspectives from different fields (HCI and media and communication studies). We learned that two independent groups found similar structures of player experience and provide replication and extension of the phenomenon in a new sample by combining the measures [30, 59] and empirically testing a previously untested model. Our approach also provides a more comprehensive understanding of the black-box space between players and the CORGIS and VGDS measures across a broad range of games, platforms, and technologies, as evidenced by our large and diverse sample. Additionally, our findings expand not only our comprehension of the similarities and differences between the two scales but also our understanding of the similarities and differences between perceived challenge and demand as player experiences.

The findings of this study provide valuable insights for multiple parties within academia and the games industry, including researchers, game developers, and players themselves. This research benefits academics who stand to learn more about the role of perceived challenge and demand in not only video games but also gamified systems and services. Furthermore, researchers looking to utilise the CORGIS or VGDS measures to investigate perceived challenge and/or demand or their various dimensions would also benefit from a greater understanding of these scales and their relationships with one another. Additionally, a greater understanding of perceived challenge and demand also allows game developers to cultivate the balance between player skill and game challenge and demand, allowing players to more easily enter the flow state [14], leading to fervent player experiences. For example, CORGIS has previously been utilised to explore how biofeedback systems can improve the player experience through dynamic difficulty adjustment [46].

We also believe our findings may be useful to the broader field of HCI beyond the realm of games, including developing and researching interactive interfaces and media. Given the emergence of similar factor structures in virtual reality gaming [8, 39], we believe virtual and augmented reality, including the metaverse, would be an area of particular interest. Additionally, research exploring the challenges of entering the metaverse and its associated workload may benefit from a greater understanding of perceived challenge and demand [60]. Finally, our findings could potentially contribute novel insights for products providing users with eudaimonic, meaningful experiences.

5.4 Limitations and Future Research

Our research should be interpreted with a few notable limitations in mind. Perhaps the primary limitation is that the current manuscript reports the results of an EFA. As an inductive and exploratory analysis method, EFA relies on sample-specific variance that is not guaranteed to replicate. EFA solutions should be further validated in future research, which is broadly in line with calls from within the HCI community for replication and extension of novel findings [30, 59]. That said, the dimensions that emerged in our sample are from two scales with prior published validation data – with VGDS being validated in three languages (English [11], German [36] & Mandarin-Chinese [9]) – provides us with confidence that the structure here should be observed in replication.

Additionally, we emphasise that this study aims to compare the overlap between CORGIS and VGDS rather than develop a new combined metric of perceived challenge and demand. Therefore, although our findings lay the groundwork for developing a new combined measure or improving CORGIS and VGDS as individual scales, this work is beyond the scope of the current paper. Future research in this area should first consider if a combined metric of perceived challenge and demand would be appropriate and valuable, considering the distinctions uncovered between the two

player experiences in this research. An alternative approach would be to adapt the individual questionnaires based on the findings of this study. For example, future iterations of CORGIS may focus on reworking emotional items to encompass a broader range of emotional experiences rather than mainly representing powerful context-specific emotions.

Participants were asked to recall a "recent gaming experience". That said, we did not specifically define for participants what a "recent" experience was (i.e., a few hours ago compared to a few days ago). Likewise, it is possible that variance in time elapsed could influence the richness of players' recollections on our measures. Future research should consider collecting data immediately after a focal gaming session. Indeed for further validation of the measurement approach, researchers could consider systematically varying key features of a video game as potentially predictive of challenge and demand perceptions. That said, a strength of the current study is the broad type and setting of games that participants reported on, which provides confidence that the perceptions measured should be widely applicable to almost any type of gaming experience.

Finally, the study sample skews towards self-identified males (nearly two-thirds of the sample). Especially on reflection of problematic and toxic masculinity in online gaming communities [43], future research should more purposefully seek more representative samples of myriad gaming populations. Included in this focus should be a consideration for avoiding so-named "WEIRD" samples (Western, educated, industrial, rich, and Democratic; see [26] – again here, addressing calls from within the HCI community [40].

6 CONCLUSION

We presented an analysis of the overlap between conceptual dimensions of the two different measures of player experience in video games developed in two different areas of scholarship (1) CORGIS, measuring perceived challenge from the field of HCI, and (2) VGDS, measuring perceived demand from the field of media and communications studies. Our study builds on previous work [9, 11, 20] and demonstrates the advantages of using a more integrated scholarly approach. Our method included surveying 1,101 players and asking them to complete the CORGIS and VGDS scales concerning their last gaming experience. We failed to confirm *a priori* models reflecting a complete overlap (five-factor) and no overlap (nine-factor) between the CORGIS and VGDS dimensions. Instead, we reveal a seven-factor structure of perceived challenge – performative and decision-making – and demand – cognitive, emotional, controller, exertional and social. Based on this data, we provide a more comprehensive understanding of the overlap between perceived challenge and demand that draws on the strengths of each scales approach to measuring player experiences. Despite our focus on video games, we believe our findings may be applicable to a broader range of interactive and eudaimonic experiences.

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APPENDIX A: INITIAL EIGHT-FACTOR EFA SOLUTION

Table 7. Primary loadings for the initial eight-factor solution of combined CORGIS and VGDS items.

Dimension	Item	Loading
1. Cognitive		
	VGDS CogD1 - The game was cognitively demanding.	.749
	VGDS CogD4 - This game doesn't require a lot of mental effort. (R)	.730
	VGDS CogD2 - I had to think very hard when playing the game.	.661
	VGDS CogD5 - The game made me draw on all of my mental resources.	.639
	CORGIS CogC6 - I felt challenged when playing the game	.574
	VGDS CogD3 - The game required a lot of mental gymnastics.	.518
	CORGIS CogC11 - Playing the game required me to do my best.	.501
	CORGIS CogC10 - I had to think actively when playing the game.	.476
	VGDS CogD6 - The mental challenges in this game had an impact on how I played.	.469
	VGDS CogD7 - The game stimulated my brain.	.427
2. Emotional		
	VGDS EmD3 - I was moved by the game.	.892
	VGDS EmD2 - The game gave me the feels.	.887
	VGDS EmD1 - The game tugged at my heartstrings.	.872
	VGDS EmD4 - I had a strong emotional bond with the game content.	.842
	VGDS EmD5 - I had a lot of unexpected feelings during gameplay.	.674
	CORGIS EmC2 - The things that happened in the game made me sad.	.647
	CORGIS EmC1 - This game is more than just a game to me.	.614
	CORGIS EmC4 - I felt a sense of responsibility for characters and events in the game.	.585
	CORGIS EmC5 - The game made me think about real life issues.	.582
3. Performative		
	CORGIS PC1 - I had to react quickly when playing the game.	-.938
	CORGIS PC2 - I had to act quickly when playing the game.	-.924
	CORGIS PC3 - Thinking fast was an important part of the game.	-.860
	CORGIS PC4 - Quickly responding to things that I saw was an important part of the game.	-.856
	CORGIS PC5 - I had to make snap decisions when playing the game.	-.789
4. Controller		
	VGDS ConD1 - The controls were very natural to me. (R)	-.901
	VGDS ConD2 - The game's controls were like second nature to me. (R)	-.866
	VGDS ConD3 - The game controls were easy to handle for me. (R)	-.852
	VGDS ConD4 - The game controls tripped me up.	-.699
5. Exertional		
	VGDS ExD3 - My body felt drained after gameplay.	.874
	VGDS ExD1 - I was physically exhausted after playing.	.868
	VGDS ExD2 - I felt strained after playing.	.723
	VGDS ExD4 - The game was physically demanding.	.651
6. Social		
	VGDS SD2 - While playing, I was aware of others in the game.	.815
	VGDS SD5 - Being around others in the game had an impact on how I played.	.773
	VGDS SD1 - Socializing was an important part of playing this game.	.754
	VGDS SD3 - I was compelled to interact with others in the game.	.733
	VGDS SD4 - I felt obligated to others, while playing.	.666
	VGDS SD6 - This game was socially demanding.	.584

Dimension	Item	Loading
7. Decision-Making		
	CORGIS DMC3 - I had to make difficult choices in the game.	-.707
	CORGIS DMC1 - There were some decisions in the game that I regretted.	-.704
	CORGIS DMC2 - I wonder how different the outcome in the game would be had I chosen a different option.	-.696
	CORGIS DMC5 - The game made me think hard about my decisions.	-.570
	CORGIS EmC9 - The game involved making moral choices that I didn't agree with.	-.542
	CORGIS EmC8 - The game had moral dilemmas in it where the choice was not obvious.	-.537
	CORGIS DMC4 - I had to think about possible alternatives for my actions in the game.	-.520
8. Planning		
	CORGIS CogC8 - The game made me manage several tasks at the same time.	.696
	CORGIS CogC7 - I had lots of different things to think about at once in the game.	.615
	CORGIS CogC1 - Succeeding in the game required much planning.	.540
	CORGIS CogC3 - I had to think several steps ahead when playing the game.	.502
	CORGIS CogC2 - I had to memorise a lot of different things when playing the game.	.480
	CORGIS CogC9 - I had to constantly keep track of what was going on in the game.	.458
No primary loading >.400		
	CORGIS CogC4 - I had to prepare for the things that the game threw at me.	
	CORGIS CogC5 - Playing the game requires great effort.	
	CORGIS EmC3 - I invested much thought into the game.	
	CORGIS EmC6 - Playing the game was stimulating.	
	CORGIS EmC7 - I felt a sense of suspense when playing the game.	

APPENDIX B: FINAL EIGHT-FACTOR EFA STRUCTURE

Table 8. Primary loadings for final eight-factor solution of combined CORGIS and VGDS items.

Dimension	Item	Loading
1. Performative		
	CORGIS PC1 - I had to react quickly when playing the game.	.955
	CORGIS PC2 - I had to act quickly when playing the game.	.938
	CORGIS PC3 - Thinking fast was an important part of the game.	.881
	CORGIS PC4 - Quickly responding to things that I saw was an important part of the game.	.870
	CORGIS PC5 - I had to make snap decisions when playing the game.	.797
2. Emotional		
	VGDS EmD2 - The game gave me the feels.	.896
	VGDS EmD1 - The game tugged at my heartstrings.	.893
	VGDS EmD3 - I was moved by the game.	.890
	VGDS EmD4 - I had a strong emotional bond with the game content.	.809
	VGDS EmD5 - I had a lot of unexpected feelings during gameplay.	.691
	CORGIS EC2 - The things that happened in the game made me sad.	.670
3. Controller		
	VGDS ConD1 - The controls were very natural to me. (R)	.900
	VGDS ConD2 - The game's controls were like second nature to me. (R)	.864
	VGDS ConD3 - The game controls were easy to handle for me. (R)	.848
	VGDS ConD4 - The game controls tripped me up.	.698
4. Cognitive		
	VGDS CogD4 - This game doesn't require a lot of mental effort. (R)	.791
	VGDS CogD1 - The game was cognitively demanding.	.786
	VGDS CogD2 - I had to think very hard when playing the game.	.683
	VGDS CogD5 - The game made me draw on all of my mental resources.	.635
5. Social		
	VGDS SD2 - While playing, I was aware of others in the game.	.817
	VGDS SD5 - Being around others in the game had an impact on how I played.	.769
	VGDS SD3 - I was compelled to interact with others in the game.	.742
	VGDS SD1 - Socializing was an important part of playing this game.	.731
	VGDS SD4 - I felt obligated to others, while playing.	.651
6. Exertional		
	VGDS ExD3 - My body felt drained after gameplay.	-.890
	VGDS ExD1 - I was physically exhausted after playing.	-.873
	VGDS ExD2 - I felt strained after playing.	-.724
	VGDS ExD4 - The game was physically demanding.	-.634
7. Decision-Making		
	CORGIS DMC1 - There were some decisions in the game that I regretted.	.781
	CORGIS DMC2 - I wonder how different the outcome in the game would be had I chosen a different option.	.754
	CORGIS DMC3 - I had to make difficult choices in the game.	.621
8. Planning		
	CORGIS CogC7 - I had lots of different things to think about at once in the game.	-.792
	CORGIS CogC8 - The game made me manage several tasks at the same time.	-.672

APPENDIX C: INITIAL SIX-FACTOR EFA SOLUTION

Table 9. Primary loadings for the initial six-factor solution of combined CORGIS and VGDS items.

Dimension	Item	Loading
Performative		
	CORGIS PC1 - I had to react quickly when playing the game.	.946
	CORGIS PC2 - I had to act quickly when playing the game.	.933
	CORGIS PC3 - Thinking fast was an important part of the game.	.870
	CORGIS PC4 - Quickly responding to things that I saw was an important part of the game.	.868
	CORGIS PC5 - I had to make snap decisions when playing the game.	.778
Emotional		
	VGDS EmD3 - I was moved by the game.	.906
	VGDS EmD1 - The game tugged at my heartstrings.	.904
	VGDS EmD2 - The game gave me the feels.	.892
	VGDS EmD4 - I had a strong emotional bond with the game content.	.842
	VGDS EmD5 - I had a lot of unexpected feelings during gameplay.	.740
	CORGIS EmC2 - The things that happened in the game made me sad.	.736
	CORGIS EmC4 - I felt a sense of responsibility for characters and events in the game.	.657
	CORGIS EmC5 - The game made me think about real life issues.	.648
	CORGIS EmC1 - This game is more than just a game to me.	.590
	CORGIS EmC8 - The game had moral dilemmas in it where the choice was not obvious.	.522
Controller		
	VGDS ConD1 - The controls were very natural to me. (R)	.897
	VGDS ConD2 - The game's controls were like second nature to me. (R)	.870
	VGDS ConD3 - The game controls were easy to handle for me. (R)	.843
	VGDS ConD4 - The game controls tripped me up.	.696
Cognitive		
	VGDS CogD2 - I had to think very hard when playing the game.	.740
	VGDS CogD1 - The game was cognitively demanding.	.722
	VGDS CogD4 - This game doesn't require a lot of mental effort. (R)	.708
	CORGIS CogC3 - I had to think several steps ahead when playing the game.	.669
	CORGIS CogC10 - I had to think actively when playing the game.	.639
	CORGIS DMC5 - The game made me think hard about my decisions.	.638
	VGDS CogD3 - The game required a lot of mental gymnastics.	.637
	CORGIS DMC4 - I had to think about possible alternatives for my actions in the game.	.628
	CORGIS CogC1 - Succeeding in the game required much planning.	.628
	VGDS CogD5 - The game made me draw on all of my mental resources.	.611
	VGDS CogD6 - The mental challenges in this game had an impact on how I played.	.597
	CORGIS CogC7 - I had lots of different things to think about at once in the game.	.593
	CORGIS DMC3 - I had to make difficult choices in the game.	.574
	VGDS CogD7 - The game stimulated my brain.	.526
	CORGIS EmC3 - I invested much thought into the game.	.517
	CORGIS DMC2 - I wonder how different the outcome in the game would be had I chosen a different option.	.513
	CORGIS CogC6 - I felt challenged when playing the game	.496
	CORGIS CogC9 - I had to constantly keep track of what was going on in the game.	.486
	CORGIS CogC2 - I had to memorise a lot of different things when playing the game.	.461
	CORGIS DMC1 - There were some decisions in the game that I regretted.	.460
	CORGIS CogC8 - The game made me manage several tasks at the same time.	.451
	CORGIS CogC4 - I had to prepare for the things that the game threw at me.	.424
	CORGIS CogC11 - Playing the game required me to do my best.	.419
	CORGIS CogC5 - Playing the game requires great effort.	.406

Dimension	Item	Loading
Social		
	VGDS SD2 - While playing, I was aware of others in the game.	.805
	VGDS SD5 - Being around others in the game had an impact on how I played.	.786
	VGDS SD1 - Socializing was an important part of playing this game.	.755
	VGDS SD3 - I was compelled to interact with others in the game.	.715
	VGDS SD4 - I felt obligated to others, while playing.	.658
	VGDS SD6 - This game was socially demanding.	.589
Exertional		
	VGDS ExD1 - I was physically exhausted after playing.	-.862
	VGDS ExD3 - My body felt drained after gameplay.	-.861
	VGDS ExD2 - I felt strained after playing.	-.721
	VGDS ExD4 - The game was physically demanding.	-.676
No primary loading >.400		
	CORGIS EmC7 - I felt a sense of suspense when playing the game.	
	CORGIS EmC9 - The game involved making moral choices that I didn't agree with.	
	CORGIS EmC6 - Playing the game was stimulating.	

APPENDIX D: FINAL SIX-FACTOR EFA STRUCTURE

Table 10. Primary loadings for final six-factor solution of combined CORGIS and VGDS items.

Dimension	Item	Loading
1. Performative		
	CORGIS PC1 - I had to react quickly when playing the game.	.946
	CORGIS PC2 - I had to act quickly when playing the game.	.934
	CORGIS PC3 - Thinking fast was an important part of the game.	.869
	CORGIS PC4 - Quickly responding to things that I saw was an important part of the game.	.868
	CORGIS PC5 - I had to make snap decisions when playing the game.	.778
2. Emotional		
	VGDS ED3 - I was moved by the game.	.895
	VGDS ED1 - The game tugged at my heartstrings.	.891
	VGDS ED2 - The game gave me the feels.	.889
	VGDS ED4 - I had a strong emotional bond with the game content.	.818
	VGDS ED5 - I had a lot of unexpected feelings during gameplay.	.733
	CORGIS EC2 - The things that happened in the game made me sad.	.724
	CORGIS EC4 - I felt a sense of responsibility for characters and events in the game.	.657
	CORGIS EC5 - The game made me think about real life issues.	.642
3. Controller		
	VGDS ConD1 - The controls were very natural to me. (R)	.901
	VGDS ConD2 - The game's controls were like second nature to me. (R)	.870
	VGDS ConD3 - The game controls were easy to handle for me. (R)	.846
	VGDS ConD4 - The game controls tripped me up.	.691
4. Exertional		
	VGDS ExD3 - My body felt drained after gameplay.	.875
	VGDS ExD1 - I was physically exhausted after playing.	.865
	VGDS ExD2 - I felt strained after playing.	.709
	VGDS ExD4 - The game was physically demanding.	.648
5. Social		
	VGDS SD2 - While playing, I was aware of others in the game.	.827
	VGDS SD5 - Being around others in the game had an impact on how I played.	.795
	VGDS SD3 - I was compelled to interact with others in the game.	.735
	VGDS SD1 - Socializing was an important part of playing this game.	.726
	VGDS SD4 - I felt obligated to others, while playing.	.653
6. Cognitive		
	VGDS CogD1 - The game was cognitively demanding.	.796
	VGDS CogD2 - I had to think very hard when playing the game.	.793
	VGDS CogD4 - This game doesn't require a lot of mental effort. (R)	.761
	VGDS CogD3 - The game required a lot of mental gymnastics.	.659
	VGDS CogD5 - The game made me draw on all of my mental resources.	.656
	CORGIS CC10 - I had to think actively when playing the game.	.633